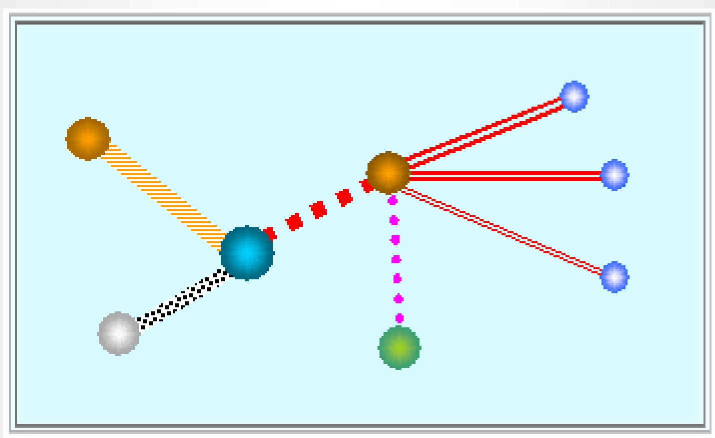
Yuri Tarnopolsky

INTRODUCTION

TO

PATTERN CHEMISTRY



2009-2011

Yuri Tarnopolsky

INTRODUCTION TO PATTERN CHEMISTRY

Parts 1 to 4

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UNEDITED

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MY STORY

In 1977 I divorced my wife, left Siberian Institute of Technology in the city of Krasnoyarsk, where I taught organic chemistry and supervised postgraduates, and returned with our 6 year old daughter to my native city of Kharkov in the Ukraine.

The fake divorce was a part of our plan to emigrate to America. By that time I had discovered, under rather dramatic circumstances, that the KGB (Soviet secret police) was following my every step. The immediate reason was my personal correspondence with my friend, a former schoolmate, in Kharkov, who applied for exit visa but had been under surveillance himself for his antipathy to the Soviet regime and inability to keep his mouth shut and pen restrained. A deeper reason was that I had been involved in a research work for a top secret chemical plant for which I developed a system of liquid extraction of rare metal cesium. My correspondence was routinely checked. The conjunction of both reasons was a guarantee of unpleasant changes in my life. As for the divorce, to be single was a legal condition for the residence permit in my parents' apartment in Kharkov.

I found a job at a patent office and re-married my own wife, who joined us. Now she got entitled to a residence permit.

By 1977, the Jewish emigration from former Soviet Union was practically free. In 1979, however, when we had already applied for exit visa and both quit our jobs, the Soviets invaded Afghanistan and closed emigration. Tens of thousands of applicants were refused visas. We could not imagine that we would be stuck in the "refusal" for eight years with no chance of employment. Fortunately, the KGB took care of me by providing shelter, food, and work in a Siberian labor camp for three out of those years. Meanwhile, American Jews helped my family.

Barred from a chemical lab, I kept thinking about the question that had been nagging me for two decades. How was it possible that such an absurd and entirely bogus system as Russian communism could exist and how could it end up? As a chemist, I thought in chemical terms and this is how I came to an idea of generalized chemistry applicable to complex social formations. I even managed to publish some ideas in a popular science magazine. Ulf Grenander's books on Pattern Theory, translated by that time into Russian, gave me a strong impetus and one of them even helped me maintain my sanity—one thing not guaranteed by KGB—in the labor camp. I sent home a long series of notes in letters.

When after ten year long break in professional activity I came to America, the way to academia was closed to me. Although I returned to research work in the lab, pattern chemistry remained my main obsession. I cared little about Russia, but America became an inexhaustible source of intriguing mysteries and astonishing discoveries.

My personal website spirospero.net contains a significant volume of results summarized in this text. They are duplicated on SCRIBD. My website also reflects some other details of my story.

This text consists of three chronologically consecutive but otherwise dissimilar parts, quite like my life. Initially, I had no plans for two last parts, but the financial crisis offered me a unique opportunity of observation of two concurrent large scale events in economy and political life.

The chronological order is preserved inside the parts, too. I do not think that any dogmatic quasi-theoretical form could be appropriate for this venture. Besides, I have no time for anything else. Therefore, it is, in essence, a stretch of a raw personal history. I come to its roots in **Part 3**.

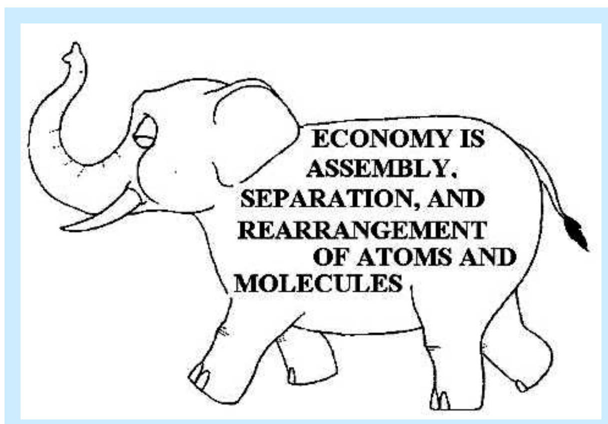
Since my youth I have been deeply imprinted by Michel Montaigne's *Essays*. This text continues my own Essays. I switched to it from *Essays* when I had noticed that economics became a true "THEORY OF EVERYTHING."

This is not so much e-book as a web-book and its form is experimental. I sincerely apologize for my blunders of grammar, style, and taste.

May, 2009

INTRODUCTION TO PATTERN CHEMISTRY

PART ONE: FUNDAMENTALS



FOREWORD

My website, spirospero.net, has been reflecting, in scattered fragments, a chemist's view of the world.

After almost thirty years of observing the world in this peculiar manner, I have a feeling that the often frivolous fragments tend to fuse into a coherent picture.

I begin to assemble a relatively consistent Introduction to Pattern Chemistry, which will summarize the **Essays** and pdf files in complexity and simplicity. (See also Essays Part 1, 2, and 3). Although I intend to be rather serious, I am not going to suppress the poetic perception of the world which is an inherent part of my personality. Poetry is inconsistent with seriousness, and, some believe, with science, but there is nothing I can do about it, except to signal by the layout or a vignette whether I am in murky depths or on the wavy surface.

Today, when science is a fully incorporated part of economy, I am ambivalent about the very word **science**. My views are certainly not what can be called today academic science, but more what was called natural philosophy in the nineteenth century.

After the last one hundred years, nature looks no more as the landscape populated by plants, animals, and "savages" in jungles and deserts, contemplated by the refined civilized man, the conqueror of nature and dweller of great cities. It is the background of breeding, cohabitation, and symbiosis of humans, animals, and man-made things on the globe of a dangerously limited size, where **who is who and what is what** is too early to say. All the more, this is absolutely the most intriguing question for me.

I am not sure whether I will be able to complete this project: the chemical view of the world, going back to the Greek philosophers, assumes that we cannot—and should not—complete anything, apart from the natural limits of life. Because of that I will publish this project as it develops, step by step, with a life of its own. I will try to avoid referring to the Web, which is too fluid for that. Until Google turns unquestionably evil, **googling** will do the job of referencing, including the printed sources.

I will freely use and repeat other materials of my website, as I do by repeating my late discovery: we are rewarded for the losses of old age by two unexpected gifts: grandchildren and sense of history.

Dum spiro spero.

November 29, 2007

Section 1. CHEMISTRY ON HUMAN SCALE

NOTE ON TERMINOLOGY

Chemical view of the world is not a household expression. It is, potentially, a part of **integral understanding of the world**, including human condition, through **study of complex evolving systems**.

All the above groups of words in bold type are too long for recurrent use.

I use the word **meta-science** as a provisional term for **integral understanding of the world**, until I find something better. In search for a term, I feel dissatisfied with the words *metascience* (there is an online magazine so named), *meta-science*, *systems theory*, *theory*, and even *science* itself, the latter appropriated by some non-traditional American religious movements. Some reasons will be explained further. Still, **systems theory** is the least objectionable term for my purpose. In any case, meta-science is not a science of knowledge or science of science, or hard science of any kind. By no means it is either a guide to success in any sense or anything spiritual, moral, and esoteric.

The best candidate to replace meta-science is omnistics, science of Everything (with humans present, I must add).

As far as the possible contribution of chemistry to systems theory is concerned, I will stick to **pattern chemistry**. It is based on most general ideas of Pattern Theory developed by Ulf Grenander, to which I add the chemical concept of transition state. But the term "theory" is something I try to avoid. Theory belongs to science. Meta-science is about understanding the world in most general terms. It cannot compete with science, from which it extracts most general ideas. What is it, then?

1.1. SCIENCE, META-SCIENCE, AND HUMAN SCALE

Traditionally, our knowledge falls into sciences and humanities. The sciences further divide into natural and social sciences. This division is most probably outdated, but the taxonomy of knowledge is not that important for a professional who works in a certain field, be it history, chemistry, linguistics, or law. Only when a professional looks over the fence, it may seem strange to a chemist that historians, economists, and lawyers have a full range of opinions on almost all subjects. On the contrary, biologists, chemists, and physicists, while capable of disagreements, have the consensual standardized methods of verifying the truth. There are, of course, intermediate areas, like astrophysics and evolutionary biology, where the majority and a minority may agreeably disagree.

It may seem strange to a social scientist that a man can study an ugly sea mollusk all his life and be rewarded with a Nobel Prize in the end, but Eric Kandel's book about how he did it is one of two best scientific autobiographies I know. The other, quite different one, belongs to François Jacob.

Not accidentally, many great scientists of the twentieth century lived lives enriched by art and philosophy and left at least fragmentary pages of high universality, well beyond their immediate fields. Norbert Wiener and Werner Heisenberg come to mind. To philosophize is one of most subtle human instincts.

The possibility of consensus depends, in my opinion, on the position of the object of study on the human scale. Objects, events, and processes that are commensurate with direct human perception of the world—social life, large areas of psychology, economics, and politics, as well as shapes and behavior of living beings, personal progress, household economy, and interpersonal relations—are part of common human experience. The art and science of life can be practiced by anybody. Why then do people disagree about what they can touch, hear, and see with naked eyes? And what can science tell to a politician, businessman, or stock market trader? Answering the second question, I would reverse it: what politics, business, and stock market can tell to a scientist? In one word: competition. As for the direct question, I do not know any answer. The basics of thermodynamics for everyday life have been in public domain at least since King Solomon.

The prospects for consensus in human matters could greatly improve if, further along the road, human society became as solid, regulated, ordered, and predictable, as the ideal world according to stern ayatollahs, Stalin breed of tyrants, thunderous evangelical preachers, ultra-orthodox rabbis, and, on the good side, Swiss watchmakers.

In modern times the word **scientist** means **academic scientist**, a member of a complex system with its own economy, psychology, sociology, and politics. It is intricate, but essentially as rough as any politics. The desire to advance and stand out is the consequence of the human nature of the scientist who, constrained by the system, can often do it by promoting a new interpretation of facts available to a wide pool of experts and even to the lay audience. Scientists who deal with objects and phenomena which are not directly accessible and tangible do it often by uncovering **new** facts, all the more, by developing a new framework (theory or paradigm) of their explanation, destined for collective test.

Philosophy in Antiquity, best personified by Aristotle, was not separated from human experiende. With the divergence of natural and social sciences, philosophy had to adapt to the growth of its own powerful progeny. It did it mostly in two ways: by mimicking either sciences or humanities. There is, however, a new somewhat incestuous hybrid of all three: theory of abstract systems (systems theory), which combines objects of social sciences with the logic of mathematics, generality of philosophy, and subject matter of social sciences, never betraying the Aristotelian logic, however, as humanities are prone to do.

Systems theory is a meta-theory. It aims at a panoramic, although blurred, picture of the world as a whole by ignoring the human scale and focusing on general properties of systems, in particular, information. It turns out, however, that information without human presence, either direct, or behind the scene, or in the past, is an unworkable situation. Systems theory welcomes disagreements, which are more appropriate for social sciences and humanities, but its creators are mostly natural scientists who work successfully in their professional fields within the academe and industry. They dislike ambiguity. Economy is brutal with dreamers: it rewards very few of them to tantalize the rest into insomnia.

Not only I refuse to criticize systems theory in any way, but I would not mind getting my own foot into the door to the hall where chemists are conspicuously absent—or I just do not see them. Systems theory is a fragmented domain—a kind of club—frequented by mathematicians, physicists, computer scientists, and biologists. I believe that chemists would benefit the crowd. What is chemistry, then?

1.2. WHAT IS CHEMISTRY

By chemist I mean here primarily an organic chemist who studies chemical transformations of complex molecules.

Chemistry seems mysterious to most non-chemists, but common people still use the word *chemistry* to describe human relations. They do it, surprisingly, as if they truly understood the essence of chemistry. Thus, good chemistry means stable relations—intimate or political—and bad chemistry means pending problems, turbulence, and instability.

Chemistry is based on the very ancient idea of atomism developed by the Greeks long before chemistry itself. The best window into the mind of ancient atomists is the long poem *On the Nature of Things* by Lucretius (Titus Lucretius Carus, ca. 99 BC- ca. 55 BC). The following excerpts from Book I give you the entire idea of chemistry in a nutshell.

> This ultimate stock we have devised to name
> **Procreant atoms,** matter, seeds of things,
> Or primal bodies, as primal to the world.

A touch might be enough
To cause destruction. For the slightest force
Would loose the weft of things wherein no part
Were of imperishable stock. But now
Because the fastenings of primordial parts **[chemical bonds]**
Are put together diversely and stuff **[atoms combine into molecules]**
Is everlasting, things abide the same **[combinations are stable]**
Unhurt and sure, **until some power comes on** **[energy drives change]**
Strong to destroy the warp and woof of each:
Nothing returns to naught; but all return
At their collapse to primal forms of stuff.

Atomism beyond physics and chemistry means representation of the world in terms of distinct entities. I would illustrate the idea with two examples that have nothing to do with physical atoms: human face is a combination of nose, ears, eyes, lips, etc. ; fingerprint is a combination of atomic elements: arch, loop, and whorl, each having their own classification.

Each face and each fingerprint is a **combination** of atomic elements. It is a combination in which the spatial order matters. The positions of the elements, although following a stable pattern, vary within some limits, which Pablo Picasso largely expanded for the woman's face and Francis Bacon for his own. The same can be said about anything that exists in at least two variations, and if something varies, it means that it is **complex**.

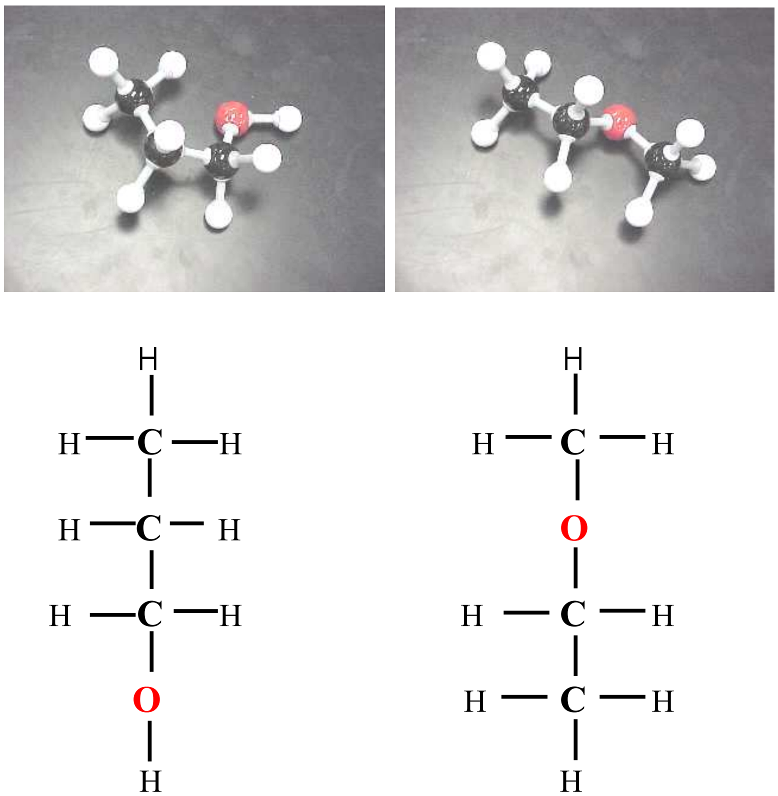
In the receipt from a supermarket, also combinatorial, order of items does not matter. Nevertheless, fingerprint, face, and receipt belong to the same abstract type of an object: combination. They possess the property of complexity.
This is, in my opinion, the core of the idea of atomism: the explanation of variety by complexity and the explanation of complexity by combination of simple objects.

Applied to molecular chemistry, atomism, inseparable of combination, means that a molecule consists of particular atoms connected in a particular way, see **Figure 1.2.1**. The photos of the molecular models give an idea about the angles between **bonds**, i.e., connecting lines, while the formulas below the photos ignore them and show only the **topology**, i.e., pure connectivity or **structure**.

The structure of molecules, i.e., the way the atoms are connected by bonds is what the chemist wants to either find out (analysis), or change (synthesis), or explain and predict the behavior of molecules (theory). Another aspect of chemistry, which draws it close to engineering, business, and politics, is how to manipulate the transformation and push it in the desired direction when it resists—or restrain if it goes astray. This characterization of chemistry brings it closer to the art of romantic seduction,.

The transformation of Russia from absolute monarchy to constitutional monarchy in 1905, to republic in February 1917, to dictatorship in October, 1917, to totalitarian system after

1936, to chaotic democracy in 1991 to authoritarian but otherwise opaque system after 2000 is a dramatic story of a **system** consisting of essentially the same atomic human entities.



Propyl alcohol　　　　Methyl ethyl ether

Figure 1.2.1. **Propyl alcohol and methyl ethyl ether have the same atomic composition but different structure and, consequently, properties**

Within the twentieth century, starting from 1917, Russia lost big chunks of territory and population (Poland and Finland), changed the connectivity of its large and small blocks, as well as global rules of connection and modes of behavior, lost and reinvented private property bonds, acquired and lost social temperature approximately measured by social freedoms, from freedom of speech to pressure on corruption. Russia went from one stage of stability to another through periods of turmoil, confusion, and oppression, apparently, following the same patterns, but never the same configurations.

What is the chemistry of Russia (or America, or France, or Saudi Arabia, for that matter)?

As it turns out, the chemistry of Russia looks pretty close to the chemistry of France, see History as Points and Lines. More about it later.

IMPORTANT: At this point I would switch from using the term chemistry as applied only to molecules to an abstract term that applies to all systems composed of structured objects.

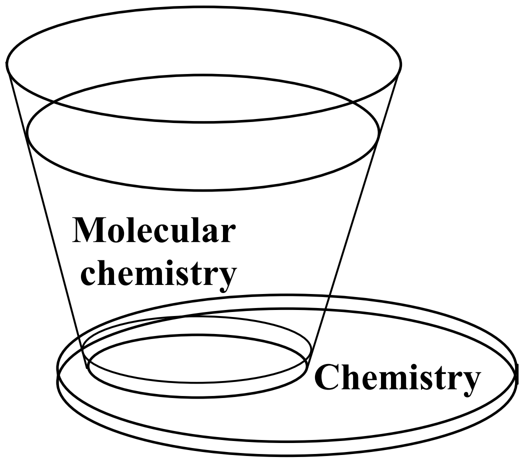


Figure 1.2.2. **Molecular chemistry is part of chemistry, but the part is larger than the whole.**

Molecular chemistry is part of generalized chemistry. This part, however, is much larger than the whole; see **Figure 1.2.2.** I would say that chemistry, as any meta-science, is more shallow than molecular science, but it contains a denser matter, the granite stuff of foundations.

If I mean molecules, I will use the term *molecular chemistry*, but I am not going to use it in that sense with any significant frequency. Any meta-science can tell professionals very little about their subjects and even about themselves. The systems theory, into which I am trying to sneak, is not an exception. If so, why do we need meta-science?

NOTE: From the point of view of Lee Smolin, whose philosophical ideas I instinctively and enthusiastically support, chemistry could be classified as **purely relationalist** science. I reproduce in **Figure 1.2.3** a fragment from his Against Symmetry, Slide 19.

In my youth I was deeply imprinted by ideas of Leibniz, whom Smolin regards as one of the founders of relationism.

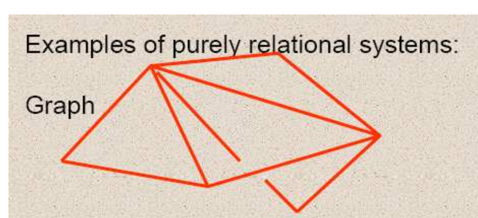


Figure 1.2.3. **Relationism (Lee Smolin)**

In *Molecules and Thoughts* I distinguished between Aristotelian and Heraclitean systems, roughly similar to Smolin's distinction between Platonism and Relationalism.

1.3. WHY DO WE NEED META-SCIENCE?

Charles Percy Snow was the first to formulate the phenomenon of the rift between sciences and humanities that has been continuously growing since Aristotle. Innumerable publications have been following his compact essay on two cultures. They vary in spirit from a purely instinctive urge to restore the lost unity of world view to an ultimate reductionism, i.e. explanation of the world starting from its physical picture. From mysticism to quantum mechanics—everything has been tried.

My motives are not sentimental.

Because of the immense and growing volume of knowledge and increasing specialization of science, as well as the loud and pervasive information noise of the media, entertainment, games, market, and traffic, we fail to achieve the main goal of education: to reveal the **hidden** coherent picture of the world to the new generation. None of the technical subjects seems to be relevant for orientation and life in the postmodern society in which if you need something you either buy it or hire somebody to make it. Moreover, if one such subject attracts a child, others become irrelevant and cannot compete for attention. Since sciences and humanities are too complex for high school, the real education starts at a college and remains professionally oriented.

Obviously, we fail to create the picture of the world as a whole because science has become too complex for understanding and irrelevant for making important personal decisions such as electing leaders and anticipating the future.

In addition to teaching the properties of the world through a set of separate disciplines, we can try to start it from a general picture and universal properties, and thus prepare a foundation for both a world view and an individual's place in the world. If this is not done, the Bible or the Koran or the Communist Manifesto or *Mein Kampf* or US Constitution will have no competitors except each other.

To put it differently, we can make the world and our lives more **stable** if we have a **consensus** regarding the world view, even though our personal views of ourselves and other people contradict each other. Can we? We will not know until we try.

Our world consists of evolving complex systems. All we need to care about in this kind of world is order and stability because the very nature of the world guarantees us chaos and turmoil free of charge. It would be naïve to expect consensus in human matters, all the more, in humanities. Consensus and economy are incompatible. If our battles are inevitable, at least let us fight on a firm foundation that will not open wide under our feet.

> There is a third—and the oldest—philosophical alternative: evolutionary (or religious, or animal, or capitalist) fatalism. Let evolution and selection decide what happens with the world. An individual should care only about personal decisions, as far as they are required.
>
> "Take therefore no thought for the morrow: for the morrow shall take thought for the things of itself. Sufficient unto the day is the evil thereof" (Matthew, 6.34).

Meta-science, focused on the center of the human scale, i.e., human condition, is supposed not to unite sciences and humanities in a chimera, but to create a space where both could speak common language.

To summarize, pattern chemistry as part of a larger area of study, call it systems theory or meta-science, could contribute to easing the stress of incomprehensible knowledge which leads to the paradoxical anti-intellectual tendency in the world created by the development of science and technology.

My personal attitude can be characterized as a blind instinctive urge to understand the world. It includes a fatalistic element as a lack of enthusiasm to improve it as a whole because evolving complex systems do not have any measure of good and evil. What they have is the measure of **stability**. Stress is the opposite of stability.

1.4. EVOLVING COMPLEX SYSTEMS

System is an object that goes through a sequence of states. Chemistry describes the states as configurations of atomic entities and characterizes the configurations as stable and unstable.

Before I explain what I mean by generalized chemistry, I need to introduce the notion of **E**volving **C**omplex **S**ystem, **X-system** (i.e., ECSystem) or **exystem** for short. The term "evolving complex system," which I did not invent, is still rarely used, but it is in the title of a series of important publications of Santa Fe Institute. It looks, however, that I can claim "exystem." It is a very large system with many subsystems, which consumes energy, exchanges matter, dissipates heat, never comes to equilibrium, but instead goes through a **unique** sequence of alternating stable and unstable states. Its structure is in a constant flux, whether fast or slow.

How large is an exystem? As a rule of thumb, so large that no human can keep it all in memory.

It is unreasonable to hone definitions of exystem because it is open to **novelty** and any definition, most probably, will be out of date soon. Instead, I will give examples.

> Nobody is surprised by the fact that books, papers and texts in natural sciences, as well as in sociology, psychology, history, and even in politics are illustrated with diagrams , plots, schemes, and photos. So are books for children. A cartoon can be worth a hundred words. Chemistry is unthinkable without structural formulas, although there is a verbal expression for any structure in an artificial language, see Molecules and Thoughts: Pattern Complexity and Evolution in Chemical Systems and the Mind. Science and knowledge in general comes from observing the world, mostly through vision.
>
> I was recently impressed by Zen Buddhism through a few second-hand references. It relies on direct (probably, intuitive) understanding through sensory input, and the powerful effect of illustrations, as well as parables and metaphors, on our understanding of complex subjects. Zen is hostile to words, theories, and philosophy. I am by no means hostile, but I believe that a theory about an exystem evolving in time is a contradiction in terms. We can understand a phenomenon, especially, if it is close to us on human scale, even though no consensus can be reached. Anyway, if I widely use illustrations, it is because to draw pictures is a typical habit of the chemist. I record my vision of the world.
>
> Since my youth I have a tender attraction to Buddhism: Dhammapada was the very first religious book in my life and it forever enchanted me with the concept of simplicity.

The basic archetypal exystem is life of cells and organisms. I call it Bios. It comprises life of an organism, species, and biosphere, although they could be considered separately.

> The documentary "*Death by Design*" by Peter Friedman and Jean-Francois Brunet (1995) is a striking visual representation of the pattern essence of exystem, which is only one of the high merits of the film.

Valdimir Vernadsky (biosphere and noösphere) and James Lovelock (Gaia) should be mentioned as pioneers of a generalized approach to life as a pattern. Stuart A. Kauffman is a necessary reading on this subject and the **Santa Fe Institute** is an umbrella for the entire field of Complex Adaptive Systems, which I will compare with Evolving Complex Systems later.

Other exystems evolve on the basis of life: society, language, mind, culture, science, economy, art, and more. We can only guess how the list of exystems will look in two hundred years.

Since chemical interactions constitute the very fabric of molecular life, chemistry is entitled to a special position in study of exystems. The basic assumption of pattern chemistry is that all exystems that evolve from molecular life are in a way **similar**.

The fundamentals of chemistry are rather simple. All I need is to expand Lucretius.

1. Chemical system consists of atomic entities connected with bonds of varying strength in varying order.

2. A lot of understanding how exystems behave can be obtained from comparison of **two stable states separated by an unstable transition state** (when "some power comes on strong to destroy…").

3. Given the initial stable state, the next stable state is the **result of a few fastest** changes.

4. The **speed of change** is determined by the **stability of transition state**: the higher stability, the faster change.

5. For exystems, the change in stability of a state is **roughly a sum of local** increments participating in the change, a purchase receipt, so to speak, with items and prices.

6. The more complex the system, the smaller it changing part. When a large chemical system changes, each stage of change is local. Most of the system does not take part in the change. This property of molecular systems is well known to chemists. It dramatically simplifies the chemical explanation and prediction.

Lucretius saw only a full destruction as a stage of change, but molecular structure most often (there could be exceptions) changes locally, unless it is hit with an impact of high energy. To give an example, let us mentally transform the model **(not the real molecule)** of propyl alcohol into the model of methyl ethyl ether, **Figure 1.2.1**. We can do it in two extreme ways:

(1) Forcefully smash the model so that it would split into atomic fragments and then reassemble it ("revolution" or "global riot").

(2) Conduct the transformation in small steps, one bond at a time ("local reform").

It is easy to see that four minimal "atomic" steps will be sufficient for the intended transformation:

1. CH3-CH2-**CH2-O**H → CH3-CH2- + **-CH2-O**H

2. –CH2-OH → -**CH2O**- + -H

3. CH3-CH2- + **-CH2O-** → CH3-CH2**-OCH2-**

4. CH3-CH2**-OCH2-** + -H → CH3-CH2**-OCH2-H**

The elementary steps consist of either **breaking** (**1, 2**) or **locking** (**3, 4**) a bond. In open systems, atoms could be added to or removed from the system.

> In some molecular transformations all steps occur simultaneously, somewhat similar to a barter exchange. Political deals are probably of the same pattern.

Pattern chemistry is my attempt to render some principles of molecular chemistry in a language of meta-science.

1.5. THE CHEMISTRY OF TIME

Human imagination is a fine powerful tool for looking into future. The image of a looming catastrophe, a vision of paradise, or a promise of rich loot, especially when eloquently depicted, triggered movements of large number of people, often to their own or neighbors' peril. A picture of future gains and losses drives investors, voters, and criminals. Global warming, suicidal industrialization of food, and dangers of viral infections gradually creep from academic debates into politics because they excite imagination.

The Iraq War is the most recent catastrophic example of manipulating the future. With the current art, science, and industry of manipulation, it is much easier to do than to manipulate the present. The New Orleans catastrophe is an example of old predictions having come true. The future comes without an appointment, unless in American Presidential Election.

Molecular chemistry starts with imagination and deals with time. I believe that this is potentially the most important contribution of chemistry to meta-science. In terms of recombination of atomic entities, anything we can imagine can happen, at a price, of course. The central question is **when**. Apart from the question **at what price**, two other questions deserve attention, too.

First, molecular chemistry did not invent the apparatus to predict and manage the future of a particular chemical transformation. It picked up an idea left on the roadside by physics, but developed it into a major chemical paradigm. The reason why chemistry was able to profit from it is a separate curious **balance sheet** issue. It connects molecular chemistry with economics; see **Chapter 1.6.**

Second, what is imagination? I tag it as **combinatorial issue**. As I believe—acknowledging Spinoza among the forerunners—we can manipulate the images in our mind and compare them to the images in the outside world because both are molecule-like configurations of atomic entities. The mathematical theory of combinatorial atomism was developed by Ulf Grenander in **Pattern Theory** , whose reference point was also Plato. The theory was the major source of ideas for this publication, as well as for **complexity**.

Ilya Prigogine was one of the first to connect natural sciences—chemistry and physics—to the idea of time in history. Much earlier, Leibniz formulated the profound idea: **time is the sequence of events**. That eliminated the clock and calendar time from evolution of complex systems and left astronomical time to hard sciences and encyclopedias.

What is event? My chemical answer is: **event is a change of a configuration** of atomic objects connected with bonds in a certain order. To notice an event, all you need is to distinguish between long time and short time. Event is what happens in the short run: becoming. What happens in the long run is being. The distinction between being and becoming, emphasized by Prigogine, goes back to the Greeks and, since Heraclitus, never disappears from philosophic and even physical debates. Strangely, nobody disputed atomism. The other great Greek idea was forgotten outside its confinement in molecular chemistry.

What is long and what is short? The yardstick for that is human life with its natural notches. Now we are out in the colorful **world on human scale**.

1.6. CHEMISTRY AND ECONOMY

If time is a sequence of events, what is the order of events, i.e., their preferred natural direction? Can we predict events? Can they go astray and under what circumstances? Can we control the direction of events and at what price? These are not simple questions because of the problem with the term "natural." Everyday human experience answers with "possibly" or "sometimes" to all of them, but "at what price" and "natural" do not go well together.

The above questions find simple and clear answers in **thermodynamics**. This archaic and misleading term traditionally applies to an area of physics which is a set of most universal principles of everything and, therefore, a basis for any meta-science, from molecular chemistry to life to sociology to economics and beyond.

> Economics is quickly becoming a science of everything; see Essay 54, Growth and Anti-growth.

Theoretically, all possible molecular transformations with a given set of connected atoms run simultaneously, like the runners in a marathon. A big difference, however, is that the **molecular** runners constantly collide and push each other around, **exchanging**, in human language, their water, food, and body resources. They compete for the **joint**

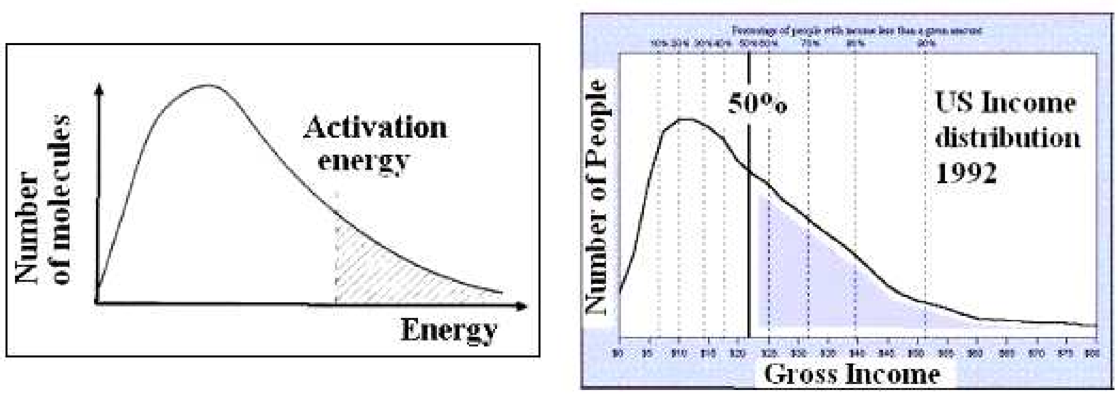
limited resource of energy and stamina, which stays approximately constant, but they do it by drawing lotteries at each event. If one **chemical** runner makes a dash ahead, the rest lose energy and lag behind more. There is always a leading group, although its composition may change.

> It reminds me the American primaries in which most runner-up candidates drop off after the leader becomes evident: they compete for the limited resource of votes. But until the very end, somebody is always ahead of the rest, although the leader may change. Remarkably, even in the national elections with two candidates, the situation can change by the hour. Is that "natural?"

Since molecules do not have ambitious goals, there must be some reason for their unequal distribution of energy. It is their exchange of energy in collisions, of course. As result, they naturally distribute over a skewed bell curve, see **Figure 1.6.1 A**. It is the same for candidates: they naturally vary in their abilities and qualities, on which random fluctuations are superimposed.

> Unlike molecules, candidates do not automatically exchange their secrets, talents, and sins, all the more, wealth, although they can be swiftboated. Neither can they share the ultimate outcome of elections, which is "winner takes all."

It is markets, not politics, where the similarity between molecules and people was first noticed by econophysics, see **Figure 1.6.1 B .** See also [Essay 55, The Chemistry of Money] and Essay [56, From One, Many] , from where **Figure 1.6.1** is taken.



A B

Figure 1.6.1. Distributions of molecules by energy (A) and Americans by income (B).

In economy people exchange goods (matter, information, labor, physical energy, political power). The question arises: what is a possible counterpart of energy in economic exchange? The tentative answer of a chemist is: money. The parallel between money and energy is not my invention. It originally came from biochemists who liked to compare **ATP** (adenosine triphosphate), one of the main carriers of energy in living systems, with currency. See also H. G. Wells, *A Modern Utopia*, Chapter 3, §2.

> **[EDITING REMARK:** This text preserves the chronology of my search for econochemistry. By the end of it I became disappointed in the concept of money as energy. Still, it can serve as a surrogate.].

Figure 1.6.1 illustrates, I hope, how a unified view of seemingly disparate domains of the world could be possible. Truth to be told, this is not chemistry, in spite of the word in the chapter title. Everything starts with energy, but chemistry starts with structure. I have not yet shown any structure in this example. But it suggests that energy might be the universal glue that can hold meta-science together.

> **NOTE**: Whenever I mention economy, I would like to refer the reader to my **Essays 50 to 56** (see simplicity or Essays Part 3) as a whole without a specific reference.

1.7. ENERGY, STABILITY, AND STRESS

It is hard to imagine molecular chemistry without graphic symbols and representations of connectivity. In this text I will use pictorial symbols and letters to emphasize the universality of chemical ideas. Chemistry is not just about atoms. With a few exceptions, I will avoid chemical symbolism.

The universality of chemical concepts did not escape the attention of scientists who tried to simulate living systems by operating symbols instead of atoms. Starting from simple games (Manfred Eigen), the computer experiments evolved into such significant, but more and more hermetic, areas as Artificial Life and Artificial Chemistry. The main achievement of Artificial Life, in my opinion, is the generalization of biology and its induction into systems theory. As chemistry is not just about atoms and mathematics is not just about numbers, life is not just about cells and organisms.

Let us consider symbolic transformations in which square, triangle, and circle signify abstract structures. They can transform into each other, which is possible only if they are not atomic objects, but we ignore their fine structure.

Let us assume that the transformation is a random event and squares are more likely to turn into circles that into triangles. We describe the two transformations as fast and slow.

We start with a system of nine squares, **Figure 1.7.1A**. Obviously, after some time, all squares will turn into circles and triangles. The ratio of products at finish (**B**) will depend on the speed ratio, but, most probably (i.e., in most "experimental" runs), the circles will dominate because the transformations are irreversible.

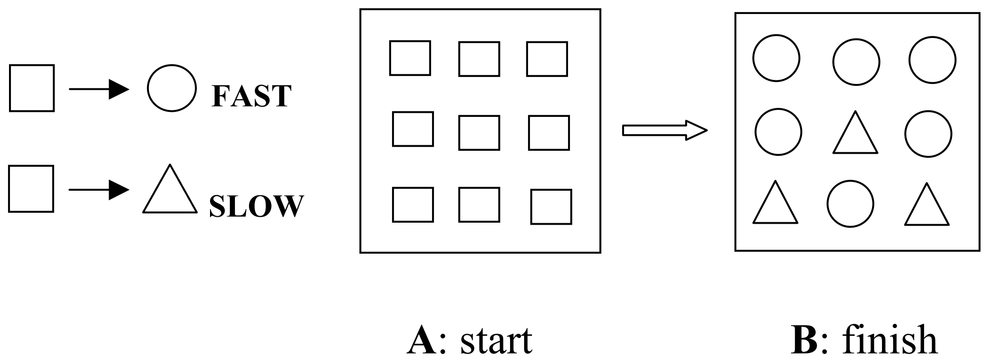


Figure 1.7.1. **Concurrent irreversible transformations**

When the transformation is reversible, the final result, after an indefinite time, is known as **equilibrium**. The position of equilibrium will depend on the **stability** of the co-existing structures, **Figure 1.7.2**.

If we start with equal numbers of structures **A** and **B**, the more stable one (**A**) will prevail in equilibrium.

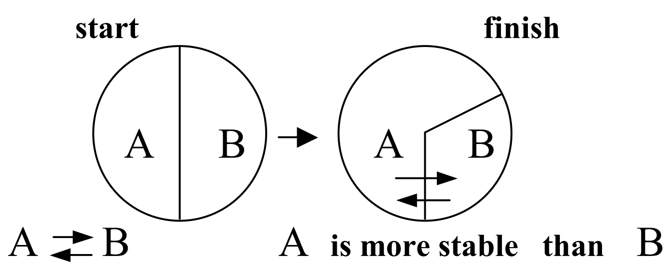


Figure 1.7.2. **The more stable structure prevails in equilibrium**

Molecular chemistry and natural sciences use the concept of energy along with the concept of stability and in the same meaning. Energy is a quantitative property of material systems and it could be exactly measured on a chosen scale. Stability is measured by energy: the higher energy, the lower stability.

The two notions do not coincide in usage, but somehow bridge physics and human condition. Consider an example of a suicidal killer with a strapped on bomb who is set out for his mission. As a system, he is unstable for at least two reasons: the bomb concentrates high energy in a small volume and his mind is in the state of high instability. To activate the bomb one needs to apply a negligible quantity of physical energy.

> For a suicide bomber the transition barrier is high, but the initial state is highly unstable, too. A different situation: a thirsty person contemplates drinking a glass of water. The transition barrier is low and the initial state is highly unstable, too. Everybody can drink water, but not everybody can be a suicide bomber.

Being a suicidal murder is by no means a matter of daily routine. The likelihood that something is going to happen sharply spikes in systems with high instability. It is the fuzzy notion of the likelihood of an event that brings together physical and human instability under a larger conceptual umbrella.

> As a non-mathematician, I dare say that probabilities can be calculated while likelihoods can only be compared. This is not what likelihood means in mathematics. It is more like possibility, but not quite the mathematical possibility, either. "Chemical" likelihood is more like mathematical inequality ("a statement about the relative size or order of two objects") and it has a meaning only for two similar objects. I still do not have a clear idea of this matter, however.

The enormous concentration of wealth in oil producing nations is a sure omen that the events that were unimaginable or unlikely can indeed happen. Any concentration of wealth—the equivalent of potential energy in physics—means the increase in the likelihood of economic or political shocks.

> This line of thought leads to the perception of democracy as delocalization of energy, well known in physics and chemistry as a stabilizing effect from purely theoretical considerations. I believe that was the core of the American political design, commonly called "separation of powers."

If we start looking for a definition of energy in physics, we will go in circles because there is no more general physical concept (see Essay 55, The Chemistry of Money). Spontaneous processes in closed systems run toward the state with minimal energy. We generally cannot say that about the open exystems. Energy is what decreases in spontaneous events. Processes run spontaneously if energy can decrease. And so on. Energy is the indicator of the preferred direction of events.

Energy is an axiomatic notion: it is declared, not defined. We do not know what energy is, but we know how it changes and what follows from that. Of course we know what forms energy can take.

If we started to talk in terms of physical energy, most humanities would be excluded from discussion. In order to take energy out of the narrow physical usage, I prefer to use the term **instability** instead of energy, but **stress** would be even better. What we need is a term more general than both physical energy and socio-economic energy. This is how I would define the stability with human face:

> High energy (high instability, low stability, high stress) means roughly that something is about to happen, although we may not know when, and low energy (low instability, high stability, low stress) means that a change is unlikely, although we may not know for how long.

I see stability as a convenient term for both the equilibrium of classical thermodynamics and the steady state of non-equilibrium thermodynamics. I am not aware of another term at this level of generality. I regard physical energy measurable in a physical system as a particular case of a more abstract notion of "energy" which cannot be measured in exystems, but can be compared for two states or two systems in terms of MORE and LESS. Whether we call it energy, stability, instability, or stress, it indicates the naturally preferable direction of events—a term too vague for hard science, but better than nothing for human systems. Thus, we expect the more energetic presidential candidate to generate more change than a washed-out rival.

Speaking of exystems, "equilibrium" is inappropriately used in biology, economics, and even politics. Some use "steady state." Exystems, however, do not even have steady states. In the long run, exystems move from one stable state to another, but never to the same state twice. The homeostat of William Ross Ashby comes close, but it has a limited, however large, number of states. Heterostasis sounds better, but Hans Selye proposed it in the meaning of a temporary atypical stable stage of physiological homeostasis, such as fever. I am satisfied with **stability,** when applied to exystems.

Figure 1.7.3 illustrates what can happen in a system with reversible transformations, **although we do not know when**. In a **short** run, the result of the fastest transformation will prevail in the system. It happens not just because its speed is high, but also because each transformation of a square into a circle snatches a square out of the stock of precursors for the triangles. Concurrent transformations compete for a limited—and declining!—resource of their precursors.

We can start with nine triangles, or nine squares, or nine circles, or with any compositions of the three, the short run result could be different, but the long run result will be the same: equilibrium.

The system is moving, but not because it knows how it can ease its stress, but because its components "know" what to turn into and the "smarter" (faster) components do it ahead of the others. With time, however, it all comes to a halt at a **different** composition because the system as a whole reaches the lowest stress and the highest stability.

I use the anthropomorphic energy not for the sake of vulgarization, but to illustrate that the very fact of (1) complexity of the system and (2) its internal mobility (**lability** is a better term) implies the chemical behavior. All evolving complex systems can be described in the same language.

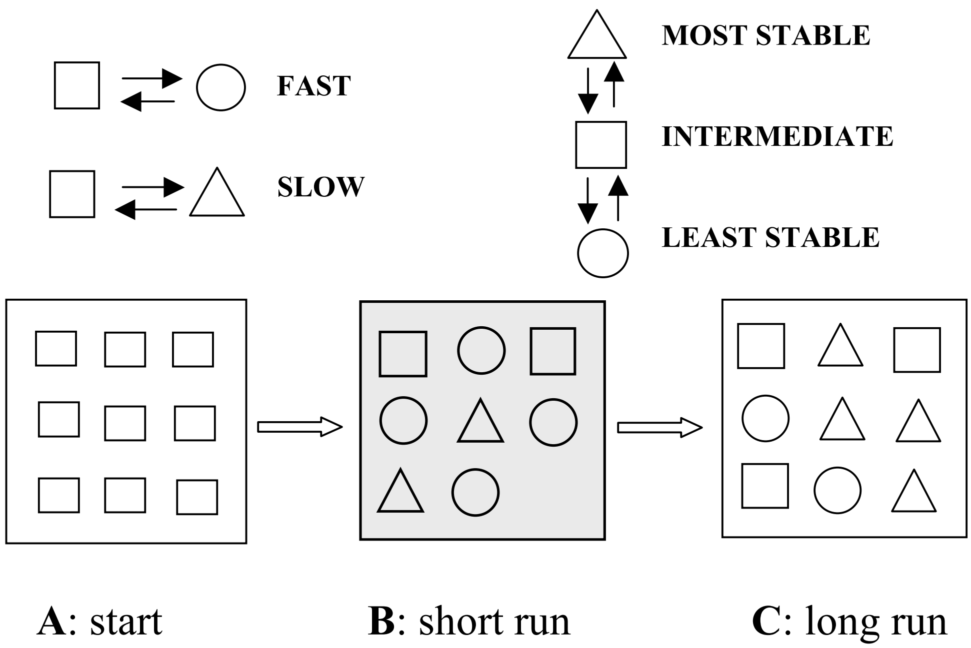


Figure 1.7.3. **Concurrent reversible transformations**

The system on the left in **Figure 1.7.3**, if it is molecular, spontaneously shifts toward the unequal ratio of its components because its instability ("energy") is higher that the instability ("energy") of the system on the right. This time, unlike in **Figure 1.7.2**, we visualize the complexity of the system, however low, with its nine components. It cannot move back on its own and the reason for that is another good opportunity to define what abstract chemistry is. It is the study of the behavior of systems, the "energy" of which is approximately additive, i.e. equals the sum of energies of its parts. Note that additivity is the fundamental premise of economy, as well as fraud, discovered by ancient inventors of bookkeeping. Millennia later, it was formulated as the principle of conservation, but economics and physics went different ways until most recently.

The simple and self-obvious but powerful premise of chemistry is that the stability of the system is, approximately, the sum of the stabilities of its components. If the components are building blocks of the structure, they contribute to the stability of the structure. In other words, global instability is, approximately, the sum of local increments. Now we can truly appreciate atomism: it makes chemical accounting possible. Similarly, mathematics is possible because 1 = 1 no matter what.

Chemistry is a property of complex objects. Or, to put it differently, all complex atomistic systems possess chemistry. Simple systems (the favorite object of physics) do not. Complexity and chemistry are two fundamental concepts locked in a Platonic embrace.

The distinctions between local and global, stable and unstable, fast and slow, short run and long run sounds like from an introductory chapter of a theory of human history because all that is applicable to human condition. History and society are complex evolving systems and, therefore, they have chemistry. And indeed, the *Annales* school of history in France treated history as a system with two different scales of evolution: the short run and long run (*la longue durée*), with the emphasis on the latter but without too much theoretizing.

However little the above definition of chemistry tells us, it legitimizes chemistry as a universal method, possibly, fit for humanities. To give another example, it establishes relation between chemistry and economics because economics studies objects that could be represented in terms of balance sheets, bills, and receipts. Thus, my bank account is a changing day to day balance sheet that lists and adds up all transactions, debits, credits, and interests. The state of a company is represented by an often complicated balance sheet with the bottom line, either black or red. In essence, market indices are also sums of numbers contributed by their components.

> To compare, econophysics considers markets as large numbers of simple objects—individual participants—and operates with statistical analysis of their behavior.

The significance of this vision is that the social system in which economy is all-encompassing (should we say **totalitarian**?), from manufacturing to service, from banking to election campaigns, from environment to art, and from science to religion, becomes more and more chemical, and the mores global, the more so. With computerization, it yields more easily to analysis by traditional scientific means, at least from a bird's eye view.

Chemistry encourages imagination. New questions could be asked and attempted to be answered outside the humanitarian pandemonium of opinions and passions.

For example, what is the dynamic relation between democracy, oligarchy, and strongmanship (when dictatorship is too strong a word)? Which one is more likely for America and the world in the future? What is the purpose and price of social stability, the main promise of strongmen? What is actually changing on global and national scale regardless of private means and intentions? After over two hundred years, is the invisible hand or involuntary conspiracy (**emergent synchronization** is a more cautious word) beginning to rule the globe? Are Russia plus China or India plus Brazil converging or diverging in global evolution? Who is going to prevail in the conditions of declining energy resources? What about limits to intellectual resources, by the way?

I do not know the answers, but I begin to feel that these problems can be discussed within meta-science, or, more specifically, systems theory, if it opens the doors to the chemical view of the world.

Not only “from the sublime to the ridiculous is only a step” (Napoleon), but so is from the local to the global. The limited resource is typical for a molecular chemical transformation in a closed system, but it can also be conducted continuously in a through-flow system, which requires an unlimited supply of reactants, **Figure 1.7.4**.

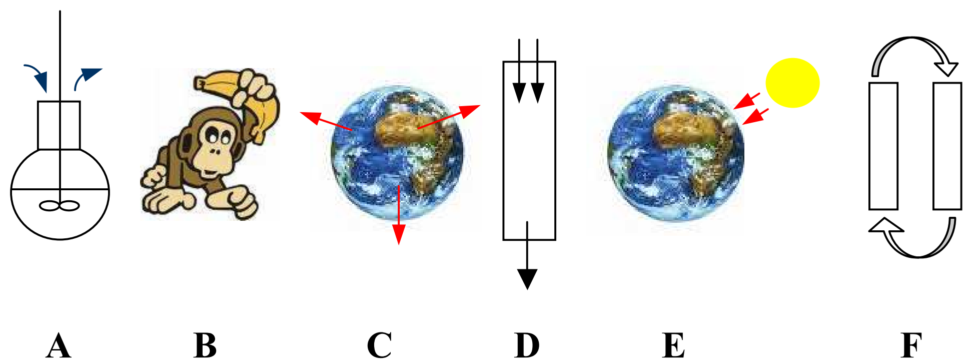


Figure 1.7.4. **Batch (A, B,C) , continuous (D) , and cyclic (E, F) modes of chemical technology. C: extraction and processing of mineral resources; E: photosynthesis.**

The chemical flask and living organism (**A** and **B**) work in the batch mode: reagents or a banana are loaded, transformed, and unloaded, the mineral fuel resources of the Earth are loaded, burned, and disposed of (**C**) . In the continuous mode, reagents are continuously pumped into a reactor and the products are released from it (**D**). The natural chemical technology of the Earth, however, is a continuous cyclic reactor (**F**) powered by the energy of the Sun (**E**). It involves a complicated web of batch and continuous processes.

> When the vision of a bigger banana started tempting physicists and the vision of an even bigger banana kept luring economists, the former knocked on the door of the latter and pretended they did not know about the principle of conservation of matter. The principle reminded about itself by the oil crisis. The era of the Industrial Revolution based on mineral fuel is only a short episode in the history of the planet, but humans will adapt, of course, using their highly developed organ of adaptation sitting on their shoulders.

Regarding **exystems**, there is no alternative to chemical thinking. Our first round of acclimatization to it is still far from reality, however, because exystems do not come to equilibrium. Classical thermodynamics says nothing about systems that can in the long run exist far from equilibrium. But what else is there in thermodynamics except energy?

1.8. IS THERMODYNAMICS A THEORY?

I ask this question because thermodynamics deals with the fundamental concepts which escape definitions exactly because of their fundamentality. Energy, work, temperature, order, and chaos cannot be defined (or can they?) within physics in terms of more general concepts. When we say that a system moves toward a state with minimal energy, it only means that minimization of energy is the preferred direction of spontaneous events in the system. Again, what is an event, then? One **event** is a change in energy during a transition from one state to another. Really? Why cannot two states have the same energy? Because if they have, it is one state and not two. Two configurations with the same energy can always coexist indefinitely. Really? But what about entropy? Answer: by energy we mean the **Gibbs energy**, which includes the entropy factor. Catch me if you can.

Thermodynamics is a set of **axioms** about the world, and they are true until proven false by facts or by inference from other axioms. Axioms, in turn, are a condition for consensus in science. As soon as we agree on axioms, we can test different views with Aristotelian logic.

Unfortunately—or fortunately, if we realize that—Aristotelian logic has a weak point which has been exactly its strength for millennia: axiom of identity (this point has been disputed). In mathematics it takes form of the axiom of closure. Roughly, it means that the subject of discussion is always the same, understood in the same way by everybody involved, and does not change during discussion.

> Obviously, politics is inherently illogical. I would not lament over the fact: if not for that, history would not move ahead. The first antagonist of Aristotle was Alexander the Great, who cut the Gordian knot instead of undoing it. As it commonly happens in history, Alexander was the pupil of Aristotle.

Evolving complex systems are logically open and always incomplete. Moreover, they often exist in single copies and do not allow for statistics, even as time series, because they never repeat themselves. Elsewhere I distinguish between logically closed Aristotelian systems (Ar-systems) and open Heraclitean systems (He-systems) that can change overnight and even while we speak.

I am reluctant to use the word theory in connection to exystems. Even thermodynamics does not look like a theory. It simply ascertains that when something happens, energy changes, if something happens on its own, energy decreases, in order to induce an event that could not happen on its own, we have to spend energy—the more chaotic the system, the more energy, but not in the form of heat—and temperature is the measure of chaos in the system. The higher the temperature, the faster the chemical process runs, but it scatters in more directions. It is not theory, but just the summary of what is possible in the world and what is not.

Thermodynamics becomes a theory when it shows how to calculate energy, temperature, and entropy (measure of disorder) for particular systems. It does it by using methods of classical or statistical mechanics.

Statistical thermodynamics is a theory applicable to both molecules and, partially, markets, but why? Because it starts with simple individual objects populating a system in very large numbers. We, humans, are not historically accustomed to dealing with such systems, especially if they are not directly observable. We are used to deal with individuals, unless we are politicians or bureaucrats. Theory in this case is an apparatus that places our mind and mostly intangible world into the same system by creating a theory: a representation of the world in terms comprehensible by humans.

Now let us return to the example of a suicidal killer in the previous chapter. The fact that the energy needed to trigger the explosion is incomparably smaller than the energy of the bomb is lost in the story. There is a very low barrier on the way to the execution of the intent. In the mind of the killer, the powerful inborn instinct of self-preservation is a much higher barrier to action. What is happening in the mind of the bomber between the moment he begins to contemplate his act and the moment he pulls the trigger? We cannot see it. Neither can we see what happens in the short, almost instantaneous act of transformation of molecule **A** into molecule **B**? This is where we need a theory: to see the invisible.

Statistical mechanics draws its power from dealing with simple objects in very large numbers. As soon as physics encounters the enormous complexity of objects, chemistry, much less powerful, but more pragmatic, takes over, using a less sophisticated mathematical toolkit, but adding something which physics has little use of: the concept of transition state, i.e., the intimate mechanism of transformation.

The theory of transition state in chemistry helped to answer the question **when**. It fully complies with thermodynamics, but contains an additional postulate: the higher the relative stability of transition state—the lower the barrier on the way of transformation—the more likely the event. This is how it pulls the rabbit of time from the magic hat of energy.

> **NOTE: T**his chapter is a flagrant simplification and probably distortion in a polemic with myself. It looks like philosophy, i.e., the cradle of all discord. But see Essay 45. The Place of Philosophy in Science . Philosophy paves the road to consensus by discovering, inventing, and naming new species of extremely general ideas and notions the same way first biologists and mineralogists, called naturalists, did to pave the road toward theoretical science. If you read post-famous works of many outstanding scientists, you can see the shadows of Plato, Spinoza, Kant, Descartes, and Wittgenstein. If a scientist does it before fame, grants could be more problematic.

1.9. THE CHEMISTRY OF SIZE

Consider a fresh historical example .

The terrorist attack on USA in September 11, 2001 brought the entire country, including the stock market, into the state of extreme stress. For the following seven years, looking back, the system has been moving to a new state with surprisingly little changes as compared to the pre-war state. Not even the border security has been improved in any dramatic way.

Overall, the economy has shown little sensitivity to the ongoing war, and even the war itself begins to excite less political fervor on both sides of political divide. In the (relatively) short run, the one-party system was effectively established under the drumbeat of war, but in the longer run, it was defeated, remarkably, without any dramatic results but a chance of the next one-party system.

And yet during that historically short period the USA as a system is not the same. The trends include unprecedented concentration of private wealth, extraordinary for a developed country inequality, polarization of society, resurgence of religious fanaticism, loss of political leadership and administrative competence, loss of trust and influence in the world, growing obscurantism and bureaucracy, paralysis of legislation, growing fear of economic competition, loss of manufacturing and even service jobs, decline of education, proliferation of self-indulgence and sybaritism, indifference to open violations of the laws, as with illegal immigration, violation of basic principles of sound banking, massive threat of electronic crime, addiction to electronic devices, suicidal treatment of natural food, etc.

The picture of the world has changed dramatically, too, with the rise of China, India, Russia, and Islamism, as well as with the decline of new oil resources, but why do we not feel any catastrophic change of the American life? Economy is working, people seem happy, children go to school, supermarkets are full, demonstrations and strikes are extremely rare, photos and videos of mutilated in the Iraq war soldiers are rare, most people are good-natured and friendly, inflation is not exorbitant, etc. On the contrary, life in Iraq is a complete wreck.

I see in the fact of the resilience of the American way of life the property of a large system: the events in a large system are local. They can be considered fluctuations in space and time. The local events do not change the global regularity of life. Only small systems experience dramatic change of structure. Power in America is significantly decentralized: that was the very idea of the New World. Iraq, on the contrary, is governed *de fa*cto by a small body of people who occupy it. Before, it was governed by an even smaller body of dictatorship.

Because of the preservation of the global regularity of life, quite different views of the current situation oppose the above exaggerated pessimistic perception, which is entirely my own, although it has nothing to do with chemical view of life.

The question is: what are the factors that accelerate or inhibit large scale transformations of big systems? I ask this question in order to outline the scope of the chemical view of the world.

The next, more imperative, question is: which design of power structure—centralized or decentralized—will be more successful in global competition? Democratic capitalism has buried autocratic Soviet socialism. Will autocratic power bury democracy? What is the relative stability of oligarchy as compared with dictatorship and democracy? For that matter, how does stability correlate with the size and complexity of social systems?

Finally, what is the chemistry of unification and fragmentations of large systems? On zipper-effect, see Essay 25: On Zippers.

The questions can be summarized: what is the chemistry of the future?

> **[EDITING REMARK**: **Chapter 1.9** and others to follow was written before the first signs of the financial crisis of 2008—an illustration of the way the future assaults the present. Since the fall of 2008 events became global.].

1.10. THE CHEMISTRY OF THE FUTURE

Our view of the world loses all its relevance unless it has some prediction power.

> One of the reasons why religion retains it powerful grip on many societies is its doctrine of reward and punishment by supernatural forces, afterlife, and final judgment. Without stick and carrot religion becomes a collection of fables. Even the ethical teachings of Confucianism and Buddhism presume a reward in terms of either success or at least stability and peace of mind. In this aspect religion and politics are similar and violence is the continuation of both by extreme means. Advertising is at the other end of the scale.

Prognosis for exystems loses any likelihood with distance in time. The reason why it is so was one of the initial points of discussion in the physics of complex dynamic systems far from equilibrium, from the universe itself to human history, from Ludwig Boltzmann to Ilya Prigogine, from probability theory to insurance industry.

Complex dynamic systems are inherently chaotic. This subject was the core of a batch of popular books on chaos and "science of complexity" in the 1990s, with which chemical complexity had little to do. In modern economy, the future and its uncertainty (risk) is for sale. Probably this is why physicists are in demand there.

I do not believe in grand theories of everything and for a very simple reason: everything evolves. Our knowledge of everything perpetually lacks something we have no hint what it could be.

A theory of everything is a contradiction in terms. While physical world changes negligibly, if at all, during the human presence on earth, human history is a record of new and unanticipated events. What we can do is to explore borders between the certain and the possible, as well as the expected and the astonishing. **We cannot predict the future, but where does the future start? We cannot know the unknown, but where does the known end?** (Essay 54: Growth and Anti-Growth).

While we cannot know the future, we still may know something. For example, we know that the future will be somewhat different, which is already a lot, as compared with "nothing new under the sun" and "you cannot step into the same river twice." We also know that the future will be more or less like the present because patterns have longer life than configurations. Actually, patterns are ideas and this is why they never die. They can step out of the shadows and back..

I believe that the questions about the borderlines between possible and impossible and the nature of novelty are legitimate as the point of departure for neology, the study of the future. The central problem is the representation of past, present, and future for complex systems.

The fundamental question of neology is what is new and what is different. On that subject, see The New and the Different , which connects the problem with Pattern Theory as generalized chemistry. Pattern Theory will be the subject of **Section 2** of this text.

SECTION 2. PATTERN CHEMISTRY

2.1. CONFIGURATIONS AND PATTERNS

The seed of Pattern Theory (PT), first planted by Ulf Grenander in 1967, has since then grown into a tree. The first extended presentation of Pattern Theory appeared in: Ulf Grenander, ***Pattern Synthesis: Lectures in Pattern Theory***, Vol. I, Springer-Verlag, New York, 1976. This book, which I first saw in Russian translation in 1980, defined my most intense interests for the rest of my life, i.e., already for almost 30 years. For the initial story, see *Introduction* to The New and the Different.

Other books and publications followed, among them ***Elements of Pattern Theory***, Johns Hopkins University Press, 1996, a more accessible popular version, intended for students of mathematics and computer science.

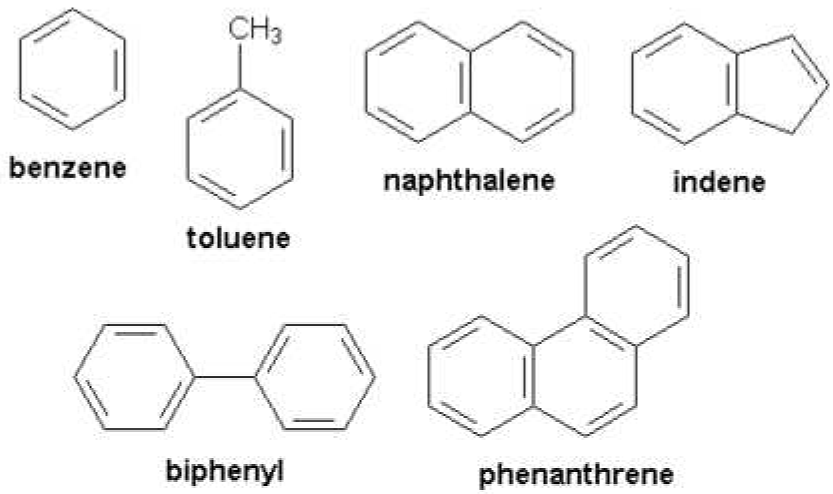
> The way of Pattern Theory toward recognition was not painless. The acceptance is still limited by applied and technical aspects, but at least Ulf Grenander is not alone today and the field attracts other people. See, for example, his latest book with Michael Miller *Pattern Theory: From Representation to Inference*, Oxford University Press, 2007, watch for upcoming David Mumford's book; PT is in Wikipedia; more materials and names (note Anuj Srivastava) pop up on the web. The significance of PT as a science of everything and a complementary part of the science of complexity is not yet appreciated, however.

I have a very limited background in mathematics and the technical mathematical aspects of Pattern Theory are of limited intelligibility for me. Nevertheless, even Ulf Grenander's most technical publications contain universally accessible and important ideas. What I present here as pattern chemistry is just a single tendril of a growing vine, far from the central stem.

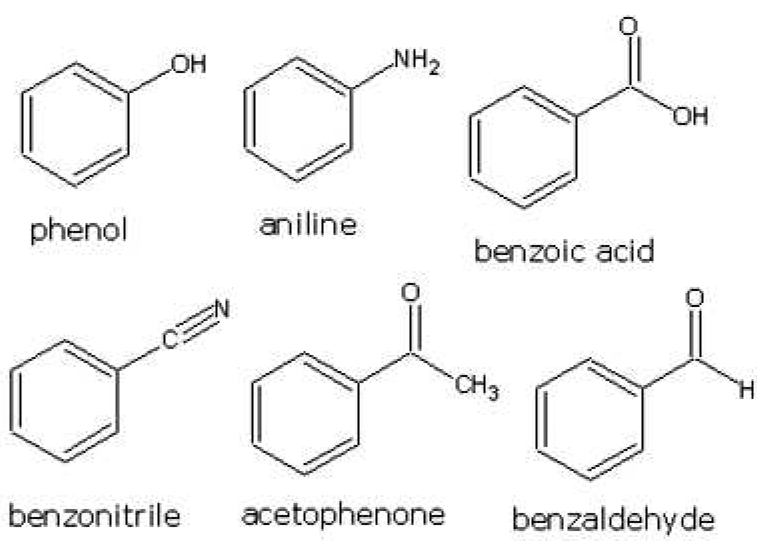
It is easy to see even from superficial browsing that PT deals with complex objects from all spheres of human existence. Moreover, it is as much a phenomenon of culture as of science. This by no means exhausts the richness and significance of PT, but I believe this is where its central impact could be in the future.

Section 1 of this text makes most of my interpretation of PT redundant. All which is needed to make the first step from molecular chemistry into PT is to label atoms as **generators**, molecules as **configurations**, and molecular patterns (i.e., types and classes of molecules) as **patterns** (i.e., classes of similar configurations).

For example, a class of molecules of a general type R—OH , where R is a carbon atom connected to atoms of hydrogen or other carbon atoms, is known as alcohols. The class of molecules consisting only of carbon and hydrogen is known as hydrocarbons. They fall into separate or mixed classes depending on the type of bonds in the molecule: single, double, triple, with particular ring structures, or mixed. Thus, all molecules with a benzene ring form a class of aromatic hydrocarbons:



The aromatic hydrocarbons are a basis for a much larger pattern of **aromatic compounds**:



Various groups can be combined with each of aromatic hydrocarbons and the derivatives linked between themselves. This is how the enormous chemical complexity emerges: it is result of explosive combinatorial productivity.

Outside college textbooks, molecular chemistry has little interest in rigorous classification of complex molecules. Chemistry deals with a complex structure as a builder, not as a historian of architecture. It uses the general atomistic paradigm and pays attention to standard blocks of molecules that combine with each other and form the entire endless variety of chemical substances. Such blocks—hydrocarbon radicals, hydroxyls, double bonds, other functional **groups**, and various cycles—indicate possible behavior of molecules. Besides, the science of molecular chemistry consists as much of rules as of exceptions and special cases. Overall, modern organic chemistry is less about atoms and more about stable groups and intimate details of their transformations through unstable states. I would say, metaphorically, that a complex organic molecule is a society of groups. If this echoes with "society of mind" of Marvin Minsky, I like the sound.

Generators in PT are atomic entities that combine with each other and form configurations according the rules of regularity. Generators have a set of potential bonds with selective affinity to potential bonds of other generators and they form bonds (**bond couples** in PT) by locking two potential bonds together.

Configurations made of generators are **regular** if they follow the rules of regularity. The best example of tangible generators is Lego: a set of blocks which can stick to each other if combined correctly, but not in other ways. In Pattern Theory generator can be literally anything, provided it has an identity, a set of potential bonds, and the compatibility of potential bonds for locking up as an actual bond couple. A stable block of generators can be regarded itself as a generator, which is typical of chemistry.

Generators and configurations, therefore, are "atoms" and "molecules" of everything: physical atoms, monomers, molecular fragments, repeating details of ornaments, pixels of a digital image, repeating fragments of the image, repeating blocks of pixels, recognizable elements of an image, letters, words, phrases, structure of a business presentation, plot of a novel, people among other people, small groups, organizations, institutions, army units, parts of a machine, flow charts, structure of the Web, historic events, networks of philosophers, genealogies, economies, markets, cells, bones of animal and human skeletons, positions of human extremities, shapes of plants, thoughts, ideas, theories, doctrines, and anything that can be represented as points and lines :

movement and behavior,
growth and decay,
mathematical logic,
grammars,
mathematical functions,
automata,
industrial processes,
weave patterns of fabric,
handwritten manuscripts,
spectral data,
cockroach's legs,
human hands,
the Earth crust,
genealogy,
fairy tales,
motion of planets,
kinship relations,
botanical systematics,
scientific hypotheses,
patterns of domination,
natural scenes,
revolutions,
wars,
everything.

Pattern Theory studies understanding of the world, representation of knowledge, recognition of objects, relation between appearance and hidden structure, and change and transformation of objects and our thoughts about them—for as long as all that can be represented as combinations of primitive entities: generators. It never claims to be a substitute for particular sciences, however.

The representation of structure alone would not be sufficient to draw a close parallel between chemistry and PT. It is the **quantitative** measure of probability or likelihood applied to configurations that does the job and turns PT into universal chemistry.

The bonds between generators have different **strength** (as chemists and sociologists like to say), measured either as probability or as abstract energy, which are two different ways to express stability. The stability of configurations is a sum of stability increments (or product of probabilities) of its generators and bonds.

I find it unnecessary to repeat here a popular presentation of PT which can be found elsewhere in the complexity section of this website, in books on PT, and on the Web. The comparison with Lego or with molecular chemistry will do to give an idea. I prefer to focus on what is most relevant for pattern chemistry and use chemical language instead of mathematical one.

The most developed part of PT , driven by the stimulus of computer vision, deals with images in geometrical space, for which explicit mathematical methods and numerical measures of distance exist.

There is a big part of the world that could be understood with closed eyes. Nevertheless, even our thoughts exist in a space: discrete topological space of points and lines without lengths, in which we distinguish between connected, i.e., **close** points, and more remote **distant** points. Such mathematical objects, known as graphs, can be represented by square matrices. They serve as **connectors** for configurations, but by no means exhaust the concept of PT.

Ulf Grenander calls that domain **non-numerical pattern theory**. He was the initiator of a project resulted in History as Points and Lines. I also have had the privilege of watching his work on project GOLEM and **Patterns of Thought** , see Publications of Pattern Theory Group at Brown University. A new advanced and interactive version appeared in 2008.

While atoms and molecules exist in geometrical space, chemists usually think about molecules as topological (i.e., characterized by connectivity) combinations of atoms. Practically all graphic chemical formulas preserve only topology, not the actual shape. Only for particular aspects of chemistry the exact position of atoms in molecules is important. It is reflected in 3D models, whether material or digital.

Chemistry can be very liberal and approximate in dealing with values of energy and temperature for rough but reliable estimates of the direction of chemical events. The most essential knowledge in chemistry is the comparative and differential values in terms of **more** or **less** instead of absolute ones. The calculated and computer-generated picture, nevertheless, can be essential in molecular biology.

A chemist may see history or sociology more like a kindred area than a historian bumping into chemistry. Nevertheless, while browsing through literature in humanities, I sometimes saw explicit comparisons of social or cognitive structure with molecular structure, accompanied with appropriate illustrations. One of them is reproduced in **Figure 21.2**, of History as Points and Lines , p. 271.

I believe that as soon as an object has a distinct structure in terms of points and lines, it becomes an object of hard science. As Ulf Grenander often said, mathematics is not just about numbers.

From the mathematical point of view, PT is **a study of regular structures**. Pattern is a set of configurations with the same regularity. In graphic images regularity can be expressed as a set of **similarity transformations**, usually in a mathematical form, which turn one configuration into another with preservation of regularity. For example, one triangle can be turned into all the other triangles by operations that change length of the sides and/or angles between them.

Ulf Grenander compares pattern with a Platonic idea. How far this approach can go, the following example shows. If we start with a typical potato shape (template) and define all operations that produce another potato shape from the initial one, all possible combinations of such transformations will generate all possible potato shapes, the same way all deformations of a triangle produce another triangle. This is a very rough explication of one of main PT ideas, but it points to a design for image recognition: if the shape is transformable into typical potato with preservation of regularity, it is a potato indeed. The computer can perform the transformations as long as they are presented in mathematical form.

> The effect of art may have pattern nature. The reader or viewer selects the piece of art as a template and finds similarity between his or her own life and the template. It can be done the other way around, starting from the personal configuration and depending on its stability. Modern art breaks the pathways to human condition and leaves only internal similarities and contrasts to contemplate. Shocking dissimilarity, as well as Nora-Roberts-kind of brand pattern, becomes an economic asset.

My view of Pattern Theory (PT) is entirely chemical: PT is a generalized chemistry and a keystone of meta-science. It is centered on individual perception, understanding, and recognition of the world. The choice of generators, rules of connectivity, regularity, and the **template**—the typical configuration—is based on a particular human perception and knowledge of the world.

The tacit assumption of Pattern Theory is that we understand the world in the same way that we understand what potato shape is and whether this particular object is a potato.

How do we understand something that we have never seen or what happens **for the first time**? Moreover, is it possible to encounter something really new under the sun? What does it mean to be new? The problem of this kind should never arise for a molecular chemist, unless a new element of the Periodic Table is discovered, because what consists of atoms is never new, it is just a **different** combination. Although chemists discover new molecular structures every day, occasionally very unexpected ones, they are not new in the same sense *homo sapience* was a new species or a steam engine was a new tool. The problem is most relevant for exystems. I tried to solve it The New and the Different.

While PT is interested in regularity, molecular chemistry is more interested in the opposite end of the scale: irregularity. I would describe **pattern chemistry** as the study of **irregularity** of configurations. It includes the problem of novelty, evolution, and complex evolving systems existing in a single copy, like life on earth, France, Internet, German language, Bulgarian folk music, or literary works of Philip Roth (heavily patterned, by the way).

Because of the very nature of mathematics and logic, novelty has no place in the traditional axiomatic systems of reasoning. I see the problem of novelty as the core of the larger problem of origin of exystems, including the mind. I do not see any alternative to atomism, i.e. pattern chemistry, in the study of the novelty, genesis, and evolution. I perceive novelty as an irregularity in patterns of history of a system.

> **[EDITING REMARK**. Dramatic social and economic events make analysts look for past patterns. As far as the USA is concerned, the fall of Roman Empire and the Great Depression became templates (and platitudes). It is only most recently that the problem of new and unprecedented events began to draw attention as itself a new and unprecedented problem. I would name Nassim Nicholas Taleb and Joshua Cooper Ramo].

The cardinal chemical concept which has not yet been covered by PT is **kinetics**, but PT already contains all prerequisites for that. It does it by investigating the nature of **regularity** in atomistic systems. Transition state, another fundamental concept of chemistry, refers to a system in an irregular or less regular state, but there is only one scale for both regularity and irregularity. To draw attention to the importance of irregularity for the direction of change is my only possible contribution, as I see it, and I do not see how it could come easily from a non-chemist.

I am certainly not in any way capable of systematic work in this direction. My purpose is to narrate, mostly through illustrations, what kind of picture the chemical view of the world can display for those who are looking for a consensus, not a victory over the opponent. I limit that picture to the fluid area covering the individual's relation to society, economy, and history, i.e., the least consensual areas of knowledge .

2.2. IRREGULARITY

Just because they are central in molecular chemistry, two particular problems of pattern chemistry are: (1) interaction between configurations and between patterns and (2) kinetics of pattern transformation, which includes the concept of transition state. They become identical if we regard configurations that consist of disconnected domains, as in **Figure 2.2.1.** As illustrations from history, the American Civil War, collapse of the British Empire and the Soviet Union, as well as the annexation of Austria by Hitler and the Baltic states by Stalin, can be mentioned.

> A time to cast away stones, and a time to gather stones together; a time to embrace, and a time to refrain from embracing (Ecclesiastes, 3:5).

But how do we switch from one time to the other? What happens between the times?

Suppose, the regularity of the system requires that all generators have two potential bonds connectible in any order. Two cyclic configurations, **ABC** and **DEF** (**I**) fuse into cyclic configuration **II**. How can this fusion happen?

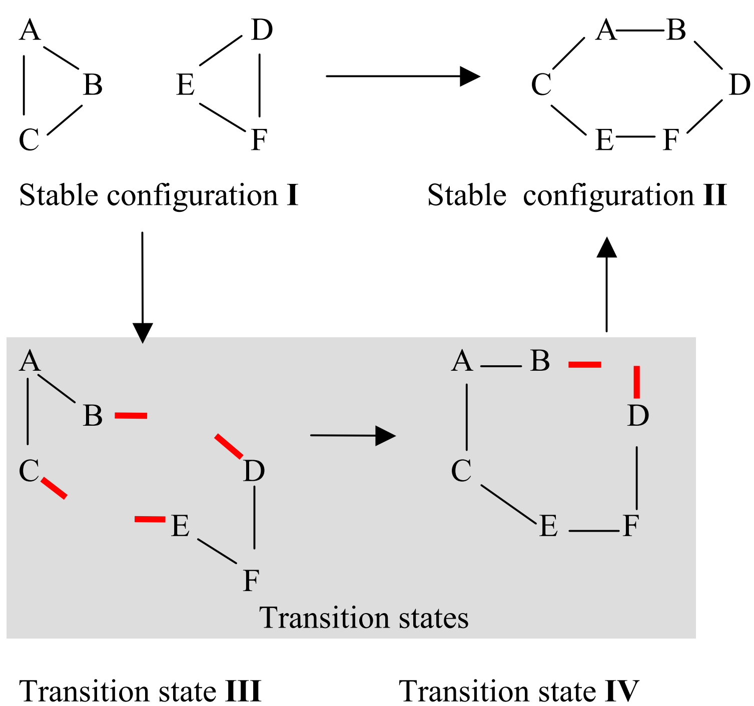
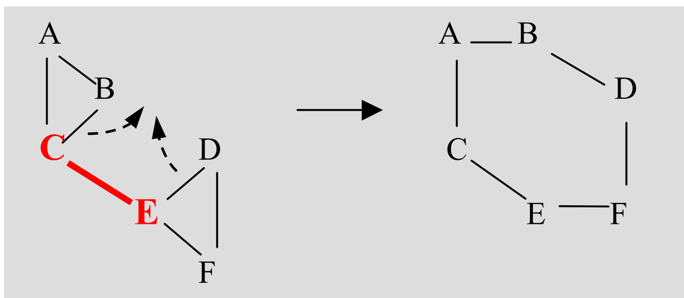


Figure 2.2.1. **Mechanism of a transformation**

There is a multitude of **mechanisms**, one of which is shown at the lower part of **Figure 2.2.1**. The gray background symbolizes the instability of the transition configurations and the fog of uncertainty over them. Bonds **BC** and **DE** break up, which is irregular and, therefore leads to unstable configuration (**III**). Next, bond **CE** closes and bond **BD** is ready to follow (**IV**). In **Figure 2.2.2**, an alternative mechanism is shown. This time, the irregularity comes from extra bonds over the regular two. The irregularity is local, i.e., involves not more than one bond. It is shown in red.

> **NOTE:** local events happen in the immediate neighborhood of a generator, i.e. all connected generators.



Transition state **V** Stable final state **II**

Figure 2.2.2. Alternative mechanism of transformation, compare to **Figure 2.2.1**

If this example raises doubts in the very concept of irregularity, the effect was intended. Since the price of a violation of regularity is instability, this itself is dynamic regularity of a kind. There is no such thing as regularity distinct from irregularity. As with order and chaos, likelihood and impossibility, stability and instability, the coupled opposites are just the opposite ends of the same scale.

2.3. STATES AND EVENTS

Regularity and stability appear to be synonymous with high probability and low energy, as well as with each other. They are just different ways to express two fundamental properties of the world: some **events** are more likely than others and some **states** are more likely than others.

Event is a transition from one state to another. State, from chemical perspective, is a configuration. The world is a configuration with states as generators and events as links between them.

Obviously, there is little practical value in an overcomplicated comprehensive picture of the world, unless it is considered as pattern, applicable to all **exystems** of the world. Even then, however, it is useless regarding particular exystems unless there is some cardinal simplification. And there it is: the **locality** of events (see **Chapter 1.9**). All events are local, to paraphrase Tip O'Neil, a grandmaster of political chemistry.

> [**EDITING REMARK**. Is the global financial crisis really global? The irreversible changes are local. We assume that most changes are **almost** reversible.]

In physics, the state is a set of constants and variables. The descriptive representation of the state—whether it is a state of a stone falling from the Tower of Pisa or of an asteroid on collision course with the Earth—remains behind the physical scene. Physics achieves its great generality by stripping the world of its individuality. The individuality is the crucial distinction which chemistry brings into the scope of understanding and cannot neglect.

There are different ways to measure the likelihood of events along different scales. Probability changes from zero to one. Energy changes from zero to infinity, but there is a difference between "zero energy" for macroscopic and quantum objects. Infinity is something out of this world.

Because of the sharply defined limits of the scale, probability looks like a natural measure, but it requires the knowledge of the event space. Thus, for tossing a coin, there are only two possible states. In exystems, however, we never know either all possible states or all possible events. It is like we are trying to predict the events with a coin in the hands of a magician or toss the coin over deep sea.

The following is a circle of transitions from physical systems to exystems.

> Physics expresses the likelihood of **states and events** in terms of energy.
> Chemistry expresses the energy in terms of elements of **structure**.
> **Structure** supports the notion of likelihood because it generates the **space of possible events** by combinatorial means, starting with **generators**.
> Pattern theory generalizes the approach over the "middle kingdom" of human knowledge: systems in which individual humans are themselves **generators**.
> Because humans are individual agents with **different** goals and interests, this domain of knowledge is least consensual.
> The individuals are **different** because of their past **history**.

The **history** of an individual includes his or her genetically and socially inherited **patterns** of behavior.
The socially inherited **patterns** start with early life, education, and independent life.
Life is a sequence of **states and events**.

The chemical picture of an event is shown in **Figure 2.3.1.**

A stable initial state transforms into a stable transition state through an unstable transition state about which we do not have any certainty. All we know about the transition state is by definition that it is less stable than either initial or final states. This is why the transition area is darkened. The bell curve of the transition is entirely arbitrary. If we know its shape, we are within the domain of physics, not chemistry. This may change with future development of chemistry, however.

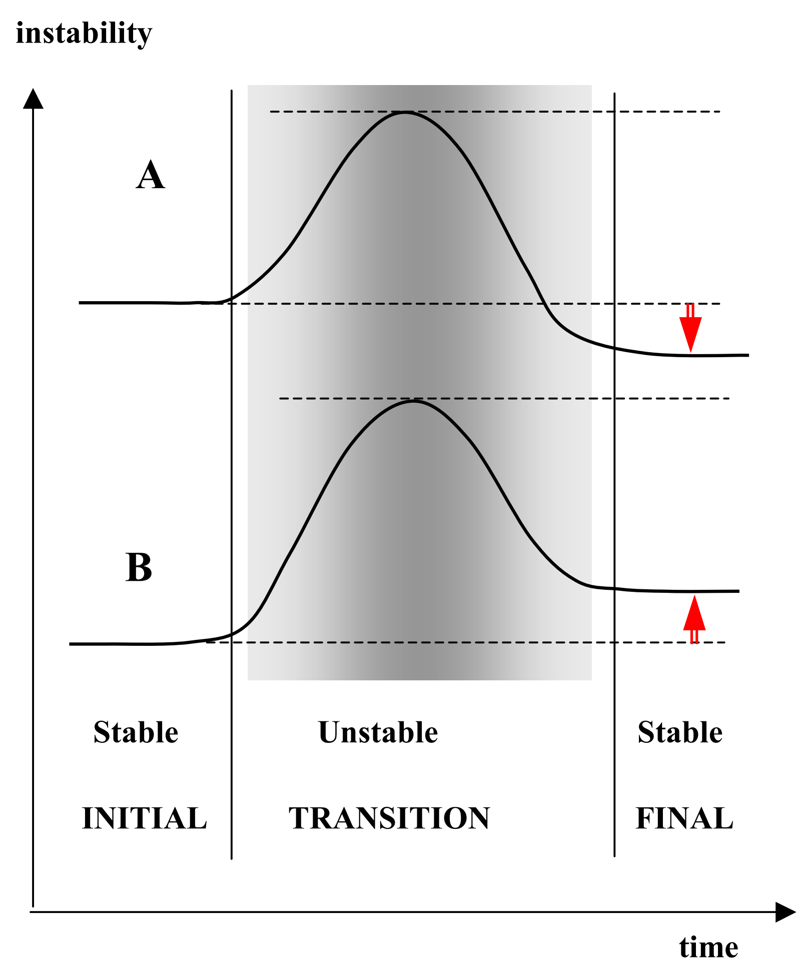


Figure 2.3.1. States of event

Chemistry does not start with the question "what is transition state?" In fact, we start with the question "what is the least stable state of transition?" We call it "transition state" and note that it is irregular. All that is entirely the matter of definitions. Then we ask, "what is transition state in terms of generators and bonds?" This is a more sophisticated matter.

The contribution of chemistry into the investigation of event consists in the representation of regularity, **as well as irregularity** in atomistic and combinatorial terms, which is one of the central principles of PT.

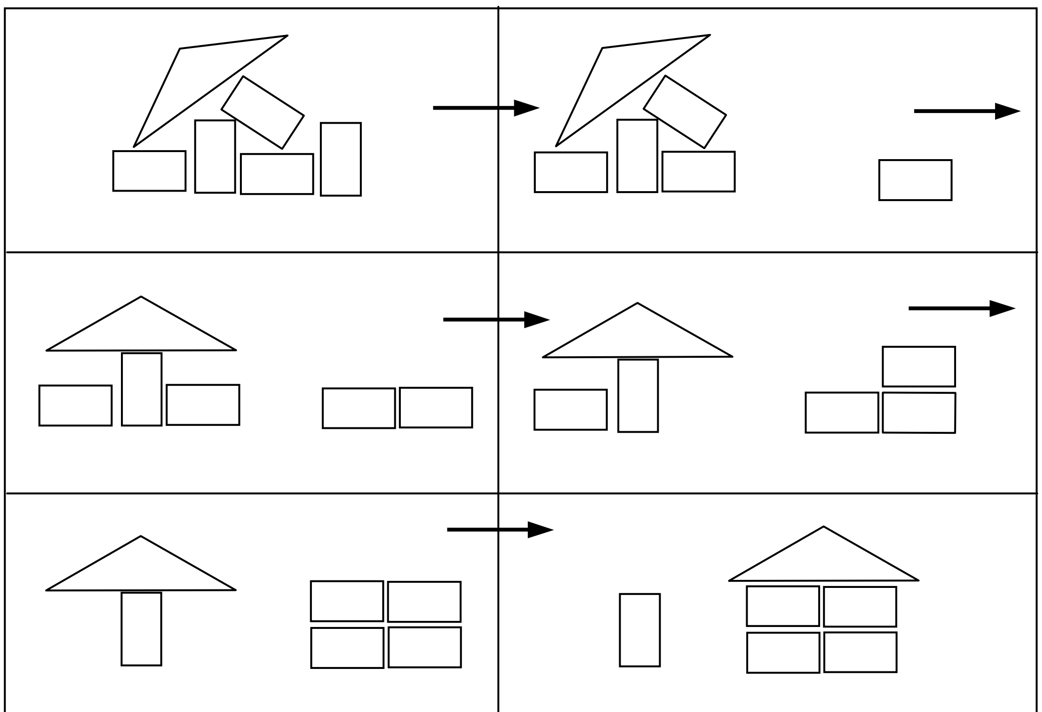


Figure 2.3.2. Sequence of relatively stable intermediate states

It may seem that the transition from a set of building blocks to a model of a house in **Figure 2.3.2** consists of a sequence of definite block-by-block steps, each of somewhat different stability, resulting in a stable intermediate state, but we do not know what happens in our mind and body between the movements of our hands. We can only hypothesize that the parts have their doppelgangers in our mind and some mental state are more stable than others. This hypothesis—very old one—is not much, but still something to start with. We will return to the natural question whether chemistry can help us with advancing this hypothesis (the preliminary answer is: thought **catalyzes** one action out of several concurrent ones and manual action realizes one event out of several possible).

> In pattern chemistry as part of Pattern Theory we are not supposed to discriminate between atoms, wooden bricks, and our thoughts.

> Regarding transition state, pattern chemistry deals not with our knowledge of transition, but with an absence of it. Knowledge and ignorance are on the same scale, like order and chaos. We may not know something, but could be still able to separate what we know from what we do not know.

Regarding the initial and final states in an event, there are two situations, A and B, **Figure 2.3.1.** The final state can be **more** or **less** stable than the initial state. In molecular chemistry, events are multiple and reversible and the relative energies of the states define the position of equilibrium. The change of an exystem is irreversible. It can be postulated in pattern chemistry of exystems that only very small and very local events are reversible, but this is also doubtful. "Almost" or "mostly" reversible is more realistic.

> **Example of a small reversible event**. Narragansett Town Beach is open to dogs from September 15 to May 1. The dogs are exceptionally friendly and their presence pleases both dog owners and passers-by. Couple years ago the Town Council decided to require leashing the dogs on the beach at any time. The decision caused a real revolt of the population and was quickly cancelled. It may seem that the event was reversed, but in fact it created a precedent for the future and made a new similar decision less likely …until possibly some other irreversible event. We cannot enter the same river twice.
>
> And in fact, just this summer (2008) a newly built restaurant (the ugliest building in Narragansett) annexed a large part of public parking previously used by the patrons of the nearby Narragansett Library. The petition of the patrons (myself included) partly reversed the injustice. The ugly restaurant stays. My prediction is: there is a **likelihood** that it will be repainted to fit the neat color ensemble of the Narragansett Pier. [It does not look likely during the crisis].

Our first glimpses of the chemical picture of the world may perhaps make "hard" natural scientists feel uncomfortable about the "middle kingdom" of knowledge: the picture of human matters is inseparable from the observer because the observer analyzes the images of the world in terms of generators and chooses the template, i.e., the typical configuration associated with the pattern.

> All this is investigated in detail by Ulf Grenander in PT. However difficult PT may seem to somebody interested only in human matters, it is worth trying, especially because the initial chapters of his books are more accessible than the bulk of the technicalities.

There is, however, a much more significant distinction of PT and, therefore, pattern chemistry from the traditional hard science: PT is open to novelty.

2.4. THE NEW AND THE DIFFERENT

Our world is getting more complex, but why? Apparently, because it generates **new** things. While the word *complexity* flies around, there is no universally accepted definition or measure of complexity. Algorithmic complexity—the length of the shortest representation, description, program, etc.—is widely used, especially, in computer science, in spite of obvious problems (what is "the smallest giant"?). Algorithmic complexity is nothing but a measure of time needed to transmit a representation of the system. Obviously, not all sequences of 0 and 1 of the same length need the same time. This kind of complexity, however, is alien to evolutionary time. It is indifferent to the history of the system.

In order to estimate complexity of exystems, I would compare the configuration **spaces** instead of configurations. In terms of PT, I would describe the phenomenon of novelty as an expansion of the generator space, i.e., addition of a new generator. It sounds like a tautology, but the novelty of the generator can be **checked against the list** of generators. Pattern complexity, as I would call it, is closely tied to novelty: novelty increases complexity on the condition that the system remembers its history.

"**New**" means here simply that something has been recorded for the very first time, for which "novel" could be a more appropriate term. A new configuration of known generators is a **different**, not novel, configuration.

> **[EDITING REMARK**: Is suicidal bomber a new generator? The pattern goes back to the biblical Samson. Yet the **less abstract** pattern of dozens, even hundreds, of people like you and me, mixing into a crowd, with the explosives under the clothes, is certainly as new as nuclear bomb or contraceptive pill were. The total expropriation in Soviet Russia was new, too.]

A new generator cannot be constructed from known elements as just any combination. It must be a relatively stable combination.

As an example, television can be regarded as combination of cinema and radio. Was television new? The linearization of a 2D image by scanning seems to be a novel element. It was, however, just an inversion of the "two-dimensionalization" of the linear speech in writing and book printing. We read a page like we scan a picture. What makes TV the major universal "one way street" factor of human life on global scale is its stability as pattern of culture. Is Internet new? It adds the two-way interaction to TV. Culturally, it is new, but at some level of pattern abstraction it is just a new combination. The unlimited ability to create, post, and store content by individuals on a global scale looks new and unprecedented to me.

The approach I suggest for estimating complexity means, figuratively, to compare not the texts, but the languages: the richer the language, the higher the complexity. The growing complexity of human condition finds its reflection in the growing glossary and sophistication of grammar. Note that grammar is itself a system of patterns and patterns are themselves configurations.

In pattern terms, complexity applies to the size of the configuration space, not to the configuration. For example, all random sequences of 0 and 1 have the same complexity, regardless of the length, because they are statements in the same language with a "glossary" of two digits and same linear grammar. As soon as **we attribute** different meanings to different short sequences of 0 and 1, complexity increases depending on attribution. Then, however, **we, the attributors**, find ourselves immersed in human condition.

The concept of pattern complexity has an important implication: the complexity of large exystems does not necessarily grow with size. This is why the world is understandable.

This is an appropriate moment to compare the concept of **exystem** with **complex adaptive system** (CAS), although neither is well defined. Chemical complexity is inseparable from the history of the system because it requires a changing with time representation of the system. Only living systems possess this kind of memory and humans, especially, aided with computers, have it at an incomparably high degree of sophistication. Yet in the **chemical** picture of the world, nothing complex can emerge from anything simple other than by simple steps. Also, unlike CAS, exystems do not require at all large numbers of interacting agents. Thus, individual human life is a chemical system—and I do not mean molecular chemistry.

For a chemist, structure and its transformation are Platonic ideas. They are visualized on a blackboard as single images. The chemist rarely remembers the fact that there are zillions of real molecules of the same set of structures in a test tube.

Chemistry is not about statistical ensembles and mathematics of the markets is certainly not its trade. Chemistry is about simplicity from which complexity is assembled, day by day, stone by stone, as an old cathedral. This view does not compete with the concepts of dynamic systems and Complex Adaptive Systems (CAS): it complements them. Nevertheless, comparing both approaches, I see CAS as a study of complexity and pattern chemistry as a study of simplicity, both of them preoccupied with complex systems. I will return to CAS in **Chapter 2.11.**

For more about novelty, including how stabilization can be achieved from unstable and weak bonds, see The New and the Different. (Hint: **many** weak bonds make up a single strong **one**, like in Velcro fastening).

2.5. THE ARCHEOLOGY OF STRUCTURE

Transformations of structure are in the focus of chemistry. Structure is something that can be built of parts and is capable of holding together, at least for a while. It is not so obvious that economics, for example, or language can be in any way related to chemistry. The subject of this chapter is the most primitive form of structural complexity from which others could have possibly evolved. This may help us see the chemical aspects of PT, or, more ambitiously, the unity of the world.

Graph in mathematics has two meanings: function graph (graph of a function) and graph of graph theory (connectivity graph). To approach chemical complexity we have to start with the graph as a collection of points, some or all of which are connected (connectivity graph).

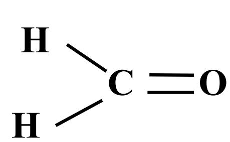
> For all our purposes, Wolfram MathWorld and Wikipedia provide sufficient references to graph, matrix, function, partial order, group, mapping, and other mathematical concepts throughout this text.
>
> It is not definitions and rigor that interest me in mathematics, but its generality. Mathematics is about our conventions and agreements regarding the world. It is the main instrument of consensus. Mathematics is about any object and not just numbers, and it can be as loose and fuzzy as the world itself, provided we do not mind ambiguity. I realize that this may not be how the absolute majority of people see mathematics.

Graph of the function (plot) is a visual representation of a function. Nevertheless, both connectivity graph and function graph express the same fundamental idea of binary relation, for which **square matrix** is the basic representation. In the connectivity graph, two elements of a set either have or do not have the relation. The connectivity graph focuses on which elements have the relation and the function graph focuses on the kind of relation.

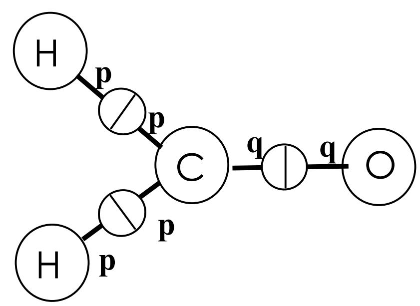
The simple connectivity graph with **yes/no** (1/0) binary relation is the most primitive kind of structure (structure has yet another meaning as mathematical structure). It can be diversified by distinguishing between more than one kind of relation and by limiting the variety of connections a point can have, i.e., distinguishing between kinds of points.

In **Figure 2.5.1**, a simple chemical compound formaldehyde, CH_2O is presented in three notations: as a common chemical formula (**A**), as its connectivity matrix (**B**), and a configuration (**C**) of PT. The numbers in the matrix show what kind of bond exists between any pair of atoms, if any. Zero means the absence of any bond, **1** is the single bond, and **2** the double bond.

The molecule of formaldehyde includes four atoms of three different kinds: **C**, **H**, and **O**. There are two kinds of bonds: single and double. The double bond is not just two single bonds but a separate entity.
As compared with connectivity graphs, mathematical functions, and molecular formulas, configuration in PT attributes a certain bond structure to generators, instead of points, introduces the selective affinity of bonds from two generators, and makes a really revolutionary step toward realism by introducing the quantitative measure of the bond "**strength**" in terms of either probability or energy. Unlike molecular chemical bond, the **bond couple** of PT has a variable strength (affinity A). Moreover, generators are attributed a certain variable probability/energy (Q) , too. As a consequence, the probability /energy of a configuration is additive over the increments of generators and their bond couples. It is a **product** of local increments in terms of **probability** and a **sum** of local increments in terms of **energy**.



	H	H	C	O
H	0	0	1	0
H	0	0	1	0
C	1	1	0	2
O	0	0	2	0



A **B** **C**

Figure 2.5.**1. Formaldehyde; *p* and *q* are bond values**

As compared with mathematical function, PT attributes a numeric measure to a matrix built on an unordered or partially ordered set of generators. Generators could be partitioned into groups or classified as a hierarchic structure. Therefore, the taxonomic classification of generators can impose on them a partial order, for example, in terms of levels of abstraction.

Terminal generators which symbolize concrete individual objects, such as my toothbrush, my friend XYZ, "Dead Ringers" movie, and pain in the third phalange of my right index finger. Other generators represent classes of objects, like tangible thing, person, movie, or sensation and classes of events and states, like walk, write, and being sad. Pattern Theory deals with a fractal structure of Everything and no atom is really indivisible, not even my friend XYZ.

Pattern Theory has image processing as its major application. Two-dimensional configurations can be subjected to independent **similarity transformations** that convert one configuration into another, such as resizing, rotation, stretching, distortion of the shape without a loss of “smoothness,” etc.

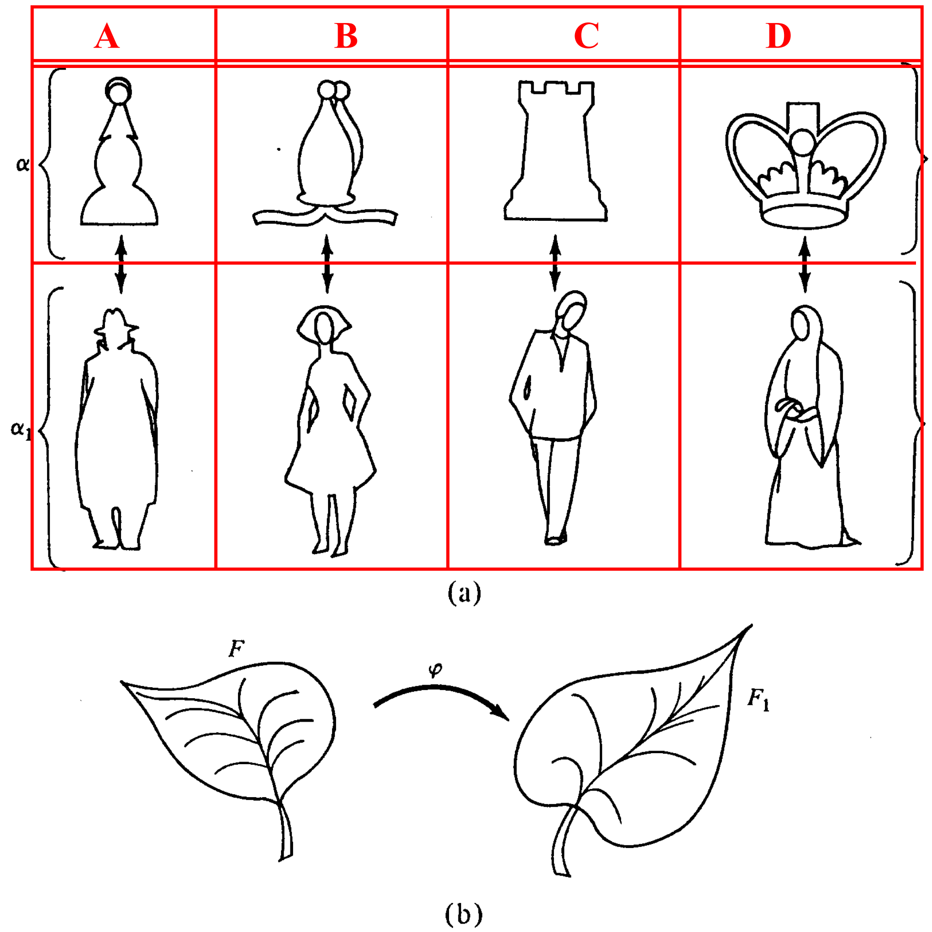
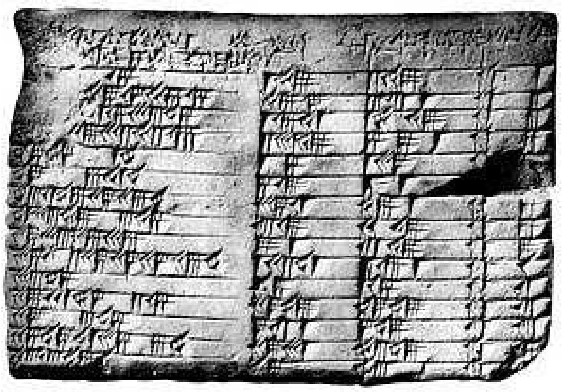


Figure 2.5.2. **One-to-one correspondence (a, a_1) and isomorphic deformation (b).**

Source: I. M. Yaglom, *Felix Klein and Sophus Lie : Evolution of the Idea of Symmetry in the Nineteenth Century*. Boston: Birkhäuser, 1988.

Without the underlying geometry it is hardly possible to have a set of independent similarity groups of transformations. The only available transformation seems to be mapping. For example, social revolution is a pattern, but we cannot describe the transformation of the configuration of the French Revolution into the configuration of the American Revolution in geometrical terms. It might be possible, but I do not know how to do that. Instead, pattern can be seen as a configuration of generators at higher levels of abstraction, in which “country” can stand for both France and American Colonies, or for that matter, Russia, China, and what not. This problem is discussed in History as Points and Lines, *Chapter 7. The King and the Pear*, from which I borrow **Figure 2.5.2** , but it has not been thoroughly investigated. In short, whether it mathematics or not, arguments and functions of pattern transformations can be shaped simply as tables, i.e., matrices in which either rows or columns can be permuted, but not individual cells.

I place a table in red lines over the original drawing to illustrate the structure of similarity transformation. The generators are organized as lines of the table, so that one-to-one correspondence is preserved. The lines are configurations. The head of the table with letters **A** to **D** is the pattern, which is itself a configuration similar to its variables in the lower lines.



A mathematician may not find much mathematics in a table, but it is one of the evolutionary oldest mathematical objects. It is also the most relevant representation of an abstract **chemical pattern**. I reproduce here the image of **Plimpton 322** **(**color photo**)**, the famous Babylonian mathematical tablet from around 1800 BC and refer for details to the Web.

I hope to expand the concise declarations in this Chapter through illustrations rather than systematic reasoning.

I borrow the next illustrations from **Appendix 2** to **Essay 55, The Chemistry of Money**.

A. Structure of money

PRICE STRUCTURE OF PETROLEUM PRODUCTS IN BANGKOK
8 JUNE 2005
UNIT:BAHT/LITRE

	EX-REFIN. (AVG.)	TAX* B./LITRE	M. TAX** B./LITRE	OIL FUND (1)	OIL FUND (2)	CONSV. FUND	WHOLE-SALE PRICE (WS)	VAT	**WS&VAT**	MARKETING MARGIN	VAT	**RETAIL PRICE**
ULG 95R ; UNL	15.1404	3.6850	0.3685	1.2000	0.0000	0.0400	20.4339	1.4304	**21.8643**	0.6315	0.0442	**22.54**
ULG 91R ; UNL	14.6508	3.6850	0.3685	1.0000	0.0000	0.0400	19.7443	1.3821	**21.1264**	0.5735	0.0401	**21.74**
GASOHOL	15.1161	3.3165	0.3317	0.0400	0.0000	0.0360	18.8402	1.3188	**20.1590**	0.8234	0.0576	**21.04**
KEROSENE	15.5270	3.0550	0.3055	0.1000	0.0000	0.0400	19.0275	1.3319	**20.3594**	2.5239	0.1767	**23.06**
H-DIESEL(0.035%S)	17.3254	1.3050	0.1305	0.5000	-1.7600	0.0400	17.5409	1.2279	**18.7688**	-0.0736	-0.0052	**18.69**
L-DIESEL	16.9405	1.4050	0.1405	0.5000	-1.9600	0.0400	17.0660	1.1946	**18.2606**	0.2050	0.0144	**18.48**
FUEL600 (1) 2%S	9.2207	0.5632	0.0565	0.0600	-	0.0400	9.9424	0.6960	**10.6384**	3.5249	0.2467	**14.41**
FUEL1500 (2) 2% S	8.1727	0.5246	0.0525	0.0600	-	0.0400	8.8498	0.6195	**9.4693**	4.0567	0.2840	**13.81**
LPG-SMALL(B/KG.)	12.6768	2.1700	0.2170	-2.6069	-	0.0000	12.4569	0.8720	**13.3289**	3.2566	0.2280	**16.81**
LPG-LARGE(B/KG.)	12.6768	2.1700	0.2170	-2.6069	-	0.0000	12.4569	0.8720	**13.3289**	3.2566	0.2280	**16.81**
PG-CARS(B/KG.)	12.6768	2.1700	0.2170	-2.6069	-	0.0000	12.4569	0.8720	**13.3289**	3.2566	0.2280	**16.81**

Figure 2.5.3. Structure of price . Source (Ministry of Energy, Thailand)

Note the second and third lines from the bottom. They relate to LPG, Liquefied Petroleum Gas, usually, propane and butane. The retail price is a sum of increments.

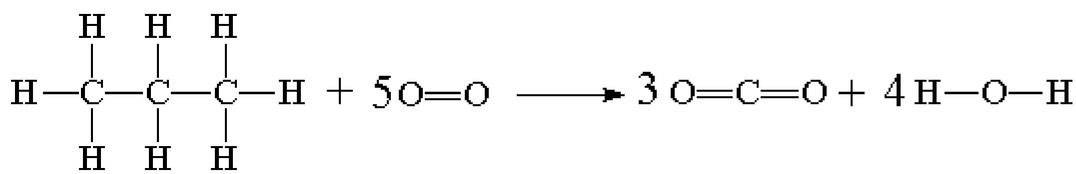
B. Structure of energy

Source: Bond enthalpy and mean bond enthalpy

The complete combustion of propane can be represented by the following equation:

$$CH_3CH_2CH_3(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O$$

Or we could redraw it to represent the bonds present:



We now need to work out how many of each bond type we have broken.

- 8xC-H
- 2xC-C
- 5xO=O

And then how many bonds have been formed!

- 6xC=O
- 8xH-O

So using data tables we can look up then average bond enthalpies from, and calculate the enthalpy change of the reaction.

Bond Type	Average bond enthalpy /kJ mol^{-1}
C-H	+413
C-C	+347
O=O	+498
C=O	+805
H-O	+464

Notice they are all endothermic.

So we can now do the sum, remember, sum of bonds broken - sum of bonds formed.

$\Delta H_r° = [(8x413)+(2x347)+(5x498)] - [(6x805)+(8x464)]$ $\underline{= - 2054 \text{ kJ mol}^{-1}}$

- 8xC-H
- 2xC-C
- 5xO=O

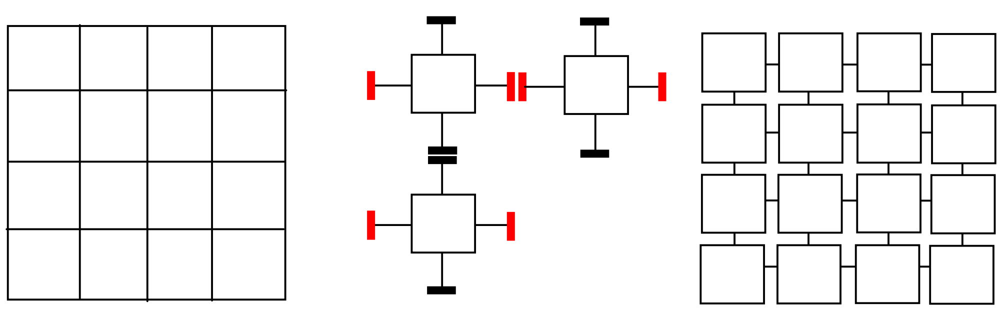
And then how many bonds have been formed!

- 6xC=O
- 8xH-O

Fuel	**+ 8 x C—H**	**+ 2 x C—C**	**+ 5 x O==O**	**- 6 x C==O**	**- 8 x H—O**	**Energy output**
LPG (propane)	3304	694	2490	-4830	-3712	- 2054 kJ/mol (minus means out of the furnace)

Figure 2.5.4. **Structure of energy**

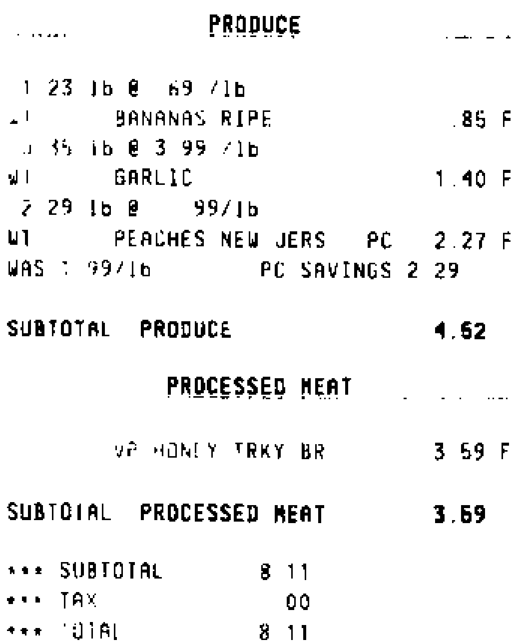
In **Figure 2.5.4** I present the "structure of energy" generated by burning a mole (44g) of propane in a way similar to the price structure of fuel in Bangkok.



A B C

Figure 2.5.5. **Balance sheet as a configuration.**
A: Table grid; B: Generators; C: Configuration.

Note that any table is a configuration built of identical generators; see **Figure 2.5.5**. The bottom line is a function of generator values. The columns are local increments.


PRODUCE

1 23 lb @ .69 /lb
BANANAS RIPE .85 F
.35 lb @ 3 99 /lb
GARLIC 1.40 F
2 29 lb @ .99/lb
PEACHES NEW JERS PC 2.27 F
WAS 1.99/lb PC SAVINGS 2 29

SUBTOTAL PRODUCE 4.52

PROCESSED MEAT

HONEY TRKY BR 3 59 F

SUBTOTAL PROCESSED MEAT 3.59

*** SUBTOTAL 8 11
*** TAX 00
*** TOTAL 8 11

Figure 2.5.6. **Supermarket receipt. Chemistry is about representing complexity by simple local increments**

Any multi-item balance sheet, bill, and receipt may have a connectivity structure, however trivial, as in the grocery receipt in **Figure 2.5.6** , in which the purchases are lumped in two categories.

This is how "financial structure" is defined:

---

financial structure
Definition

The right side of a firm's balance sheet, detailing how its assets are financed, including debt and equity issues.

Cite this definition

"financial structure" InvestorWords.com. WebFinance, Inc. July 14, 2008 <http://www.investorwords.com/1958/financial_structure.html>.

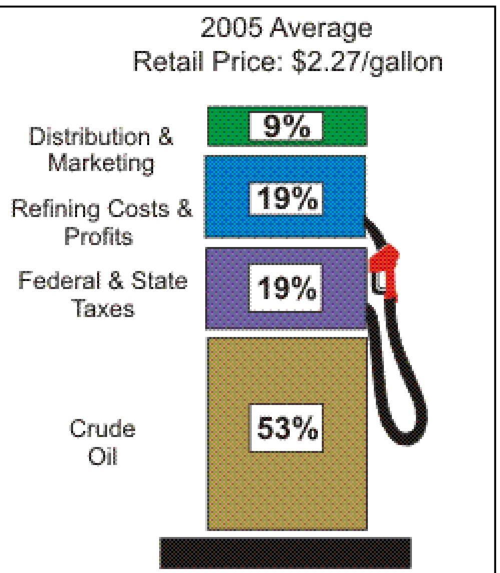


Figure 2.6.7. **Econochemistry of the pump**

The structure is even more visible in a tax return.

The greatest chemical (but not mathematical) secret is that in all such itemizations, including the calculation of energy of a molecule, **the order of lines (added items) does not matter** whatsoever. It is the total energy, price, amount, stability, etc., that matters. But the numbers matter, too, especially, the largest and the smallest ones.

Chemistry and economics both use accounting. (But who doesn't? Think about purgatory).

The archeology of structure—the search for the simplest specimens of structure—leads us, unexpectedly, to the simplest mathematical operation of addition. The balance sheet reveals its connection to the basic physical principle of conservation.

Note that the grocery receipt could be even more structured, like the real balance sheet. Thus, I could pay part of it with credit card and the remainder in cash.

See also **Figure 2.6.7**. (Source : US Energy Information Administration)

2.6. PATTERN CHEMISTRY CREDO

How far back to simplicity can archeology of structure go? What are the elementary entries in the balance sheet?

The list of elementary operations of complexification is very short:

1. **ADD** one bond
2. **BREAK** one bond
3. **ADD** one generator to the set
4. **REMOVE** one generator from the set

NOTE that it is the same set of operations as in LEGO game. The loose blocks, not used for the structure, are still within the system and they prompt the further **possible** steps of evolution. Adding and removing new isolated blocks will have the same effect, although no bonds are formed. This is done because of the expansion or contraction of the event space. We meet a stranger in the street and our life takes a new direction.

All chemical transformations, however complex, can be presented—and mostly occur—as a sequence of the above simple steps.

This is, probably, a too far-fetching insight, but the ultimate answer to the question about the limits of the generator set, i.e., limits of simplicity, is that the number of atoms in our environment is more or less constant—less so after the emergence of nuclear technology, but not much less. Some new related problems, such as representation of thoughts, may be discussed further. Until then, all we can say with the faith in chemistry is that there must be atoms of thought, whether neurons, or molecules, or something else. Thus, nucleotides are generalized **atoms** of heredity.

The significance of the observations on the structure of price in **Chapter 2.5** is that it bridges molecular chemistry with the rest of world and, most importantly, human matters, and provides support for generalizations across the interdisciplinary borders. It can be also seen that the overall value of a configuration (energy, probability, price, or anything else) is a table of values related to terminal generators, partially ordered by rows and columns.

Line and grid (**lattice**) are two of major typical connectors of natural configurations. The other one, crucial for mental representations (as if there were non-mental ones) , is **tree**. A **cyclic** connector is typical for natural geological and biochemical processes. Ulf Grenander includes the global type of connector in the concept of regularity, together with generator set, similarity transformation, and bond value relations (affinities).

Regardless of the organization and order of the generator space, pattern is a set of configurations which can be transformed into each other with preservation of regularity of a certain kind. Often it is the connector only.

To summarize:

Chemical view of the world

> **(1) identifies regularity of configurations with their stability,**
>
> **(2) identifies transformation with transition trough instability,**
>
> **(3) associates the likelihood of a transformation with stabilization of the unstable transition state,**
>
> One can probably feel immediately that this kind of language smells of revolutions.
>
> **(4) evaluates relative stability of a complex system in terms of simple local increments, and**
>
> **(5) represents complex states in terms of generators and bonds between them.**

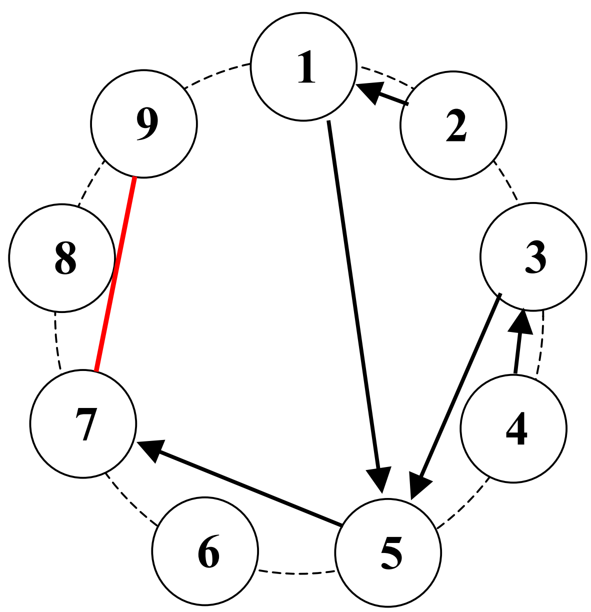
This credo suggests a certain renunciation of the power of prediction that the traditional physical approach to dynamical systems claims and in many cases possesses. Indeed, what can we predict if our analysis includes the final state which is still in the future? Let us leave this question hanging in the air, together with the question about the smallest giant (the most stable unstable state).

2.7. THE STRUCTURE OF STRUCTURE

The observations that a representation of structure is a structure itself, see **Figure 2.5.5**, and representations can be as different as table (matrix), graph, and lines of text, raise the question about comparing and converting different representations. The millennia old question about reality and its representation, apparently, insoluble, should be left alone, at least for a while.

> Molecular chemistry has no philosophical qualms about reality not only because atoms and molecules have become directly observable, but also because it has clear criteria of reality of atoms and bonds. Whatever we do in chemical lab, atoms remain unchanged and can be combined and recombined. If they are connected by chemical bond, a sufficient quantity of energy as heat or radiation breaks up the bond. The restored bond releases the same quantity of energy. Several elementary acts of breaking or locking bonds can be bundled into a fast single composite act of chemical reaction that leads from one set of stable molecules to another stable set.

G	1	2	3	4	5	6	7	8	9
1	0	0	0	0	1	0	0	0	0
2	1	0	0	0	0	0	0	0	0
3	0	0	0	0	1	0	0	0	0
4	0	0	1	0	0	0	0	0	0
5	0	0	0	0	0	0	1	0	0
6	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	1
8	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	1	0	0



L R

Figure 2.7.1. **Example of configuration: matrix (L) and connector (R). G: generators; A: affinities.**

If generalized chemistry is ready to deal with Everything, both representation and the underlying reality (or fantasy) should be its equally legitimate objects. The transformation of a set of observable appearances into a thought and the coding of the thought into a verbal or written message have the same status as a molecular chemical reaction: they are natural processes driven toward higher stability from one stable state to another.

I will discuss in this Chapter some problems regarding representation of structure because the representation is a structure itself, **Figure 2.7.1**.

An informal description of how structure itself is structured starts with a set of generators and the connector graph that ties some of them together.

Chemistry represents the configuration (state) of the system as matrix of binary relations between generators.

Figure 2.7.1 shows an artificial example of a matrix over nine generators. The connectivity matrix **A** implies the identity of generators **G** labeled by their numbers**.**

For the sake of illustration, we distinguish between two types of bonds: arrow, i.e., directed bond, and line, i.e., mutual connection without direction. There could be other types of bonds, directed or not.

The matrix can be "unpacked" line by line into a **linear** (i.e., textual) representation below.

Line 1. Generator 1 (**G1**) is connected to generator 5 (**G5**). This bond has a direction. **G5** is not connected to **G1**. Social structures are typical medium for such bonds.

Line 2. **G2** is connected to **G1** by arrow.

Line 3. **G3** is connected to **G5**, by arrow.

Line 4. **G4** is connected to **G3**, by arrow.

Line 5. **G5** is connected to **G7**, by arrow.

Line 6. **G6** has no connections.

Line 7. **G7** and **G**9 are interconnected.

Line 8. **G8** has no connections

This representation does not indicate whether configuration is regular or not. To find out, it should be checked against the rules of regularity for each generator.

The bonds between generators are of yes-or-no type, denoted by 1 and 0.

The matrix, as any table, is itself a configuration, see **Figure 2.7.1**. If we take it as a **template**, i.e., typical configuration of a matrix, we can **deform** it, in the spirit of PT and generate other matrices and, therefore, configurations of nine generators.

The deformations are:

1. Put a different number (can be also other than 0 and 1), into any cell or all of them. The number will be a quantitative measure of affinity, i.e., bond strength.

In **Figure 2.7.1 R** the type is denoted by color, but the direction of the bond is naturally represented in the matrix by asymmetry of the cell respective the diagonal.

2. **ADD** generator.

3. **REMOVE** generator

The two last operations are characteristic of exystems: new things appear and old things die away. It seems that we remember everything that ever happened, even if it is dead like Ancient Egypt, but we remember only what we remember, and not what we have forgotten without a trace.

> **NOTE**: Two questions should be answered: (1) How irregularity is possible? (2) How can new generators emerge or disappear. HINTS: (1) It is possible as an unstable—and therefore short-living—state. (2) They are frozen (or melted) configurations of lower level generators.

The matrix representation in **Figure 2.7.1** does not distinguish between regular and irregular configurations. We have no way to know that a deformed matrix will produce a regular structure. This imaginary experiment with an artificial configuration and its deformations has a hidden agenda: to emphasize the difference of the approach of PT from the traditional mathematical treatment of combinatorial systems. Instead of axiomatically defining the space of all possible configurations, PT, speaking figuratively, lets generators combine at will, according to their regular individual properties, like a chemist who mixes the reagents and lets nature run its course. Generators are, in terms of Complex Adaptive Systems (CAS) paradigm, agents, too. Only we do not need large crowds of them. Let us say that generators are more general than agents of CAS . True four-star generals of complexity?

If so, how can we know the properties of a singular exystem without statistical data, all the more, try to project its evolutionary drift into the future? We cannot. What we can is to predict what is going to happen to the stability of the system if its current local properties change in terms of MORE or LESS. We can distinguish between MORE and LESS prone to change (more and less labile) neighborhoods of generators.

This is something we hope to do because of the principle of locality of change.

The **NOTE** above also points to the importance of generalized temperature (intensity of chaos, in other words, the cost of stability) as a non-structural property. Of course, this happens each time history changes its course by jumping a barrier, but as an example from my personal stock, I would mention the history of the suffragist movement in America as portrayed in the movie *Iron-Jawed Angels*, 2004. It was the mere intensity of passions and protests, the hue and cry, and not any rational causes, violence, or big mass actions, which melted the permafrost of old perceptions.

Other people would probably refer to other episodes of history as examples of the same process, using them as **typical configuration of a certain pattern**, i.e., **template**, in terms of Pattern Theory.

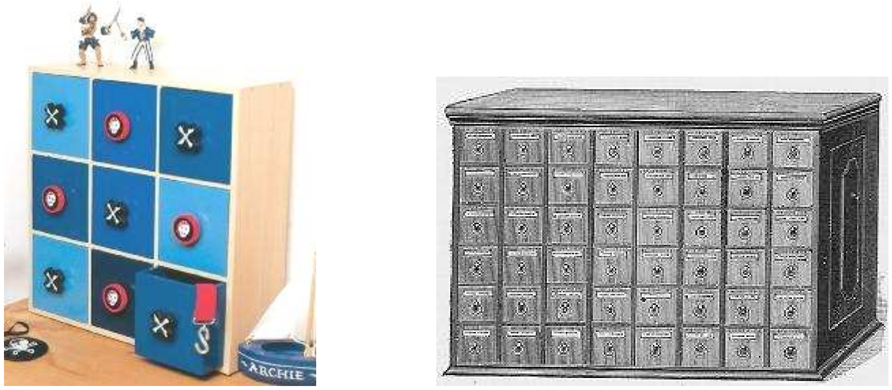


Figure 2.7.2. **Ideograms for matrix representation of configuration space**

Getting ahead of the story, I am going to suggest a particular kind of template for exystems: **ideogram**. It is a visual metaphor that works across the apparently forbidding chasm between sharply different exystems. Thus, chest of drawers or filing cabinet, **Figure 2.7.2**, could be ideograms for matrix representation of configurations. See more about ideogram in:

The Rusty Bolts of Complexity: Ideograms for evolving complex systems.
The visible hands: Homo Faber and the Chemistry of History .
Ideogram : A Simpleton in a Complex Family.

Donald A. Schon (Schön), whose other views are also interesting in the context of exystems, introduced "generative metaphor, " a concept close to ideogram.

From Wikipedia: "…the idea of a "generative metaphor", figurative descriptions of social situations, usually implicit and even semi-conscious but that shape the way problems are tackled, for example seeing a troubled inner-city neighborhood as urban "blight" and, hence, taking steps rooted in the idea of disease."

We can describe the contents of a filing cabinet in natural language, but why would we need it?

2.8. LINEARIZATION

I start with the following question: what is understanding? The common definition of image understanding in image processing is generation of a description of the image.

> Image understanding (IU) algorithms create a "description" of the world from sensor images, suitable for particular purposes. Thus, for autonomous vehicle navigation, a description may be an indication of road edges or of obstacles in the path. For an intelligence application, the description might be a synopsis of changes of military significance to a site. This translation from an array of numbers to constructs meaningful in the world must be carried out despite object occlusion, shadows, reflections, and other disturbances. Contextual information such as knowledge of the domain being sensed must often be used to accomplish this translation.
>
> Thomas M. Strat, *Image Understanding Program*; DARPA Information Systems Office http://www.fas.org/irp/program/process/iuprogr.htm

There are two extreme cases of understanding by a student. In simple cases (driving directions), we can just observe the behavior of the student, but with more complex descriptions, such as a scientific, legal, or political doctrine, the only way is to put the student into the position of a teacher and to see how much the doctrine remains preserved in the transfer. There is a close analogy with the transfer of genetic information to posterity, with its dramatic mutability and divergence. Understanding, therefore, is a process under the same pattern as biological life: it consists of ontogenesis and phylogenesis. Using a risky metaphor, biological evolution is a perpetual understanding of the world in terms of DNA. The correct understanding survives.

The central question is how do we know that the description is understood?

Understanding is inseparable from a language shared by both sender and receptor. Looking for patterns on human scale, we have two major universal languages: linear human language and 2D graphic illustrations to make a long story short. We can anticipate at least one problem of understanding: the conversion of the 2D graphic representation into a linear and back: linearization. The intermediate case is the conversion of a graph, often of tree-like topology, into a linear sequence.

It seems that all written languages in ancient cultures started with graphic illustrations arranged in a line. Only the Chinese writing has managed to preserve this principle to some extent.

Even the apparently chaotic saccadic eye movements seem to perform the same function of linearization of 2D image, although in seemingly a non-ordered manner. **Figure 2.8.1** is borrowed from *The New and the Different* (**Fig**. **1.1**). See also.

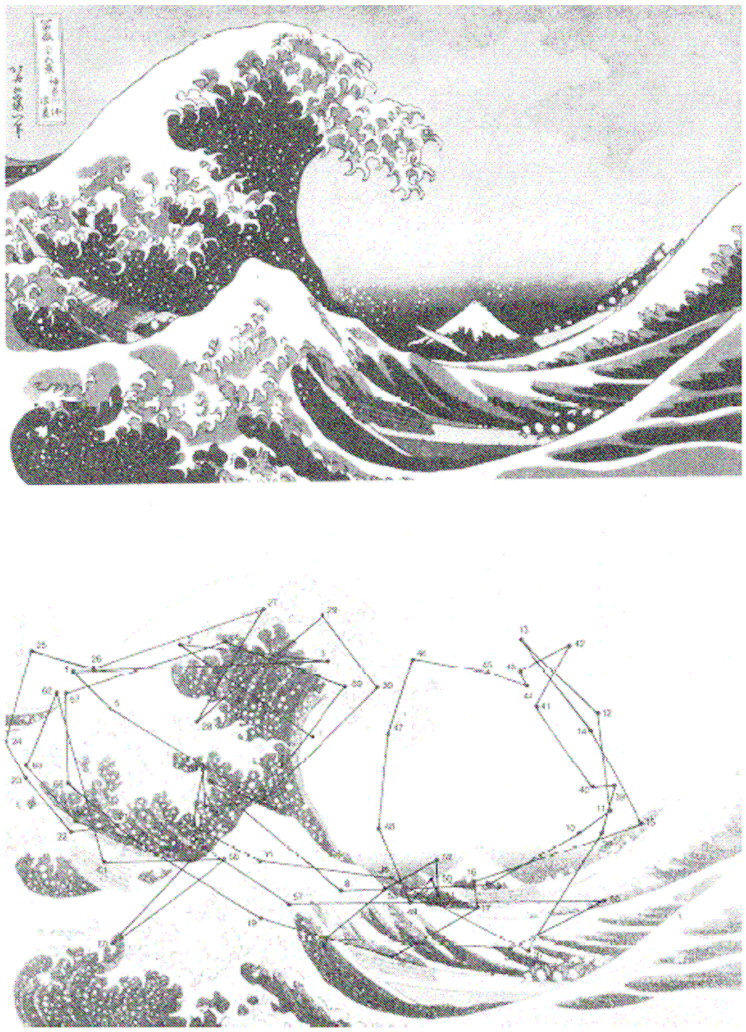


Figure 2.8.1. **The bottom diagram shows the pattern of eye movements and fixations made by an observer viewing *The Wave* by Katsushika Hokusai**. Source: Goldstein, E. B. (1984) *Sensation and Perception*. Belmont, Calif.: Wadsworth Publishing Company. The photo is from: Buswell, G.T. (1935). *How People Look at Pictures*. Chicago: Chicago University Press.

Consider an **example**. Divergence is one of fundamental patterns of exystems:

$$A \rightarrow A(b, c) \rightarrow B—C \rightarrow B + C$$

I believe that the above line of symbols is understandable in current context without further explanations. But why? Some time ago I came to the conclusion that the function of consciousness was linearization of our perception of the world. It did not seem like a wide-spread idea. Later I found out that a close conjecture had been made by **Ernest Lawrence Rossi** in 1998:

> We conclude that a major function of consciousness may be to transform the nonlinear, irrational and difficult to predict dynamics of unconscious nature into the more linear, rational and predictable psychodynamics that make human experience and social life possible (source).

Why do we need linearization? Because the perception of the world as a sequence of events synchronizes the internal human world and the external world in Leibniz time: as sequence of events.

What has chemistry to do with that all? Linearization of a non-linear connector can be performed only at the expense of breaking some bonds and forming others. Therefore, the measure of stability can be applied to such ethereal phenomena as language and thinking.

More about linearization: TIKKI TIKKI TEMBO: The Chemistry of Protolanguage , and **Chapter 3.17** , **The Chemistry of Language**.

What follows is a hypothesis that the **chemistry** of linearization of thought into language can have its own thermodynamics. Languages could be more or less suitable for expressing and understanding thoughts, and *vice versa*, which calls for re-evaluating the occasionally ridiculed Sapir-Whorf hypothesis.

Chemistry is the study of structured events.

2.9. WHY COMPLEXITY GROWS

Between the Great Flood of the Bible and the future Great Flood of Global Warming the world is sinking in the Flood of Complexity.

Complexity starts with the Byzantine intricacy of law, legal language, and fine print. It swirls in the fraud and theft sewers of internet, spurts through the computer monitors, and rises from the laptop level to the tall home appliances which were universally comprehensible just a few years ago. The complexity of the world, with its languages and cultures, breaks the back of even the most pampered intelligence agencies, and threatens the human intelligence itself, making fundamentalist religion and the gut

TITLE 27--

INTOXICATING LIQUORS

CHAPTER 2--PROHIBITION OF INTOXICATING BEVERAGES

- Sec. 11 to 40. Repealed.
- Sec. 40a. Repealed.
- Sec. 41 to 43. Repealed.
- Sec. 43a, 43b. Omitted.
- Sec. 44 to 57. Repealed.
- Sec. 58 to 60. Repealed.
- Sec. 61, 62. Repealed.
- Sec. 63. Repealed.
- Sec. 63a to 63d. Transferred.
- Sec. 64. Repealed.

simplicity of hate increasingly seductive. The invisible hand that used to guide the world economy drops in desperation.

← Occasionally, complexity just evaporates. When I looked at TITLE 27--INTOXICATING LIQUORS of the US Code, CHAPTER 2--PROHIBITION OF INTOXICATING BEVERAGES , I found nothing but the list of repealed sections. The whole TITLE 27 had vanished, leaving its ghost..

Complexity of exystems, with a few biological exceptions, correlates with size. A band of hunter-gatherers, guerillas, or robbers **needs** (which means**: is more stable with**) a single leader, but a large army needs a complex organization for supply and communication. The evolutionary space between a single cell organism and a large mammal is filled up by the increasing number of cells, tissues, organs, blood vessels, and nerves, not to mention the evolving central control organ in the head. It is the same pattern as the evolution of state, army,

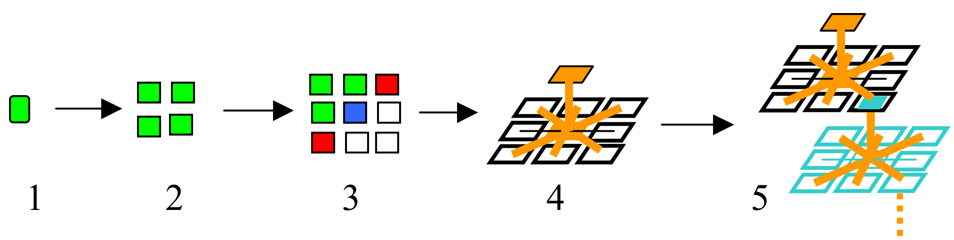


Figure 2.9.1. **Topological evolution: emergence of nearness (2); distance (3), neighborhood (3), and hierarchy (4, 5).**
Green: close units; red: distant units; blue: core; orange: tree.

business, and organization. Social systems develop a hierarchy of control.

Complexity growth follows a very abstract pattern of topological evolution, **Figure 2.9.1**. Complexification of material exystems seems to be a consequence of multiplication of generators that occupy limited geometrical space. When a material exystem grows by multiplication of units, it loses bonds between geometrically distant units and develops the asymmetry of the center and periphery, as well as other asymmetries and gradients. See Essay 43. The Cold Civil War in America.

Stability seems to be compatible with increasing complexity. The developed Western nations follow America in importing ethnically and culturally diverse labor to maintain economic stability, although it is not clear whether the expectations are well founded. This stands in sharp contrast to the aspirations of ideologically purebred societies, such as religious and social orthodoxies of past and present. I can only guess that the gradient of complexity is the driving force of evolution in the long run, but no generation thinks in terms of the long run.

It is a separate intriguing question whether we can see any simplification in non-material exystems such as language, art, and ideology. Watching the American presidential campaigns, I find the simplification of the message in striking contrast with the complexity of issues. The polemic tirades are comparable with the simplicity and resulting deadly efficiency of a virus (check "idea is a virus" on the Web). The advantage of piecemeal simplicity is entirely kinetic: it embeds into the host easier, spreads faster, and has lower probability of viable mutation than consistent and sophisticated arguments.

> Simplicity and complexity coexist in the noösphere as well as in the biosphere: the single cell organisms and large mammals, the airport books and Philip Roth's novels, "buy-low-sell-high" and equations of econophysics, the Amish and the Hollywood stars. Note, however, that the simple things have a numerical, as well as kinetic advantage.

In **Chapter 1.9**, *The Chemistry of Size*, I suggested that large size makes exystems more stable because from the chemical (and only from the chemical) point of view the structural change is always local. If it is not local on one scale, it is on another. This effect is known in Chinese economic strategy as "growing the denominator," i.e., overall size, in order to decrease the fraction of a backward sector of economy.

Invoking Leibniz's "time is an order of successions," there is no such thing as simultaneity: every event is a sequence of smaller events, until we come to the bottom of the micro-scale pertaining to our paradigm.

The role of size follows from the interpretation of local change as a sequence of elementary events, each occurring around a single generator, moving from one generator to another. New and yet unanswered questions follow from this assumption.

Indeed, a larger system shows more stability even without any competition with another large system. A tree survives its leaf, a herd its antelope, and society its individual. The situation may change with high complexity and specialization: a single failing organ can let down a whole organism, an interrupted supply of a single component can stop production, and, incredibly, a piece of insulating foam can destroy a space shuttle.

> The modern car, ridiculously over-computerized, over-mechanized, power-accesorized, and remotized, gives the owner much less control over his machine: if the power window is stuck, it cannot be opened by hand, and if the tagged key is not recognized, the engine will not start. In a way, the modern car is an ideogram of society: bureaucracy is incompatible with common sense, powerful organization is wrecked by a political appointee, a computer virus disables a communications system, the hell is paved with good intentions.

> It is useless to lament and look back to great historical figures and saviors of nations because the current complexity would crush them, too.

In competition with other similar systems, complexity can turn fatal. A dispersed primitive guerilla army beats the most powerful sophisticated armies in the world, the richest nation loses a big city to flood, and science loses by default to religious zealots.

Simplicity of mind and body wins in the short run, but the overall complexity of exystems, from organisms to machines, and from language to finances, steadily rises, sometimes, spasmodically, but mostly slowly, because it happens against the background of many other events of shorter span. It is troublesome, however, that while biosphere maintains a balance of simple and complex systems, the social evolution seems to drive out simple alternatives. On can make a good living on complexity.

> From the chemical angle, no complex reasons why complexity increases are acceptable. Chemical systems can be complex, but chemical reasons are always simple.

The simple explanation why complexity grows in exystems is that **evolving** complex system by definition includes evolution, which is impossible without **replication** as the mode of reproduction. Growth by replication in a limited area of metric space increases distances between generators (units, components), leads to unequal environment, and needs specialization of generators to sustain connectivity. There is no bond without nearness and new conformations maintain the **connectedness** of the system. Thus, the space ship and Earth form a connected (in common and mathematical meaning) system if there is a communication between them. Moreover, they form a connected system if the space ship has no communication, but has a space map and can navigate. The alternative to growth is break-up and disintegration.

> [**EDITING REMARK**. There is a point of view that social complexity never goes down (Joshua Cooper Ramo). I believe, defiantly, that growth is the best vehicle of simplification. When an economic or political institution is “too big to fail,” the failure is coming and simplification follows. “Too big” does not mean “too strong.” However incredible the breakup of America, China, and India may seem today, it is definitely a possible pattern-chemical transformation. Same applies to the US Tax Code, European Union, and has been happening in science and technology in the form of specialization. Complexity is not ”too strong to fail.” This subject, however, needs a better argumentation. See Essay 34, On Loss]

If this is not simple enough (and I believe, it is not), here is a simpler version: complexity of exystems grows because of the replication under the constraint of connectedness.

Crystals grow by addition of layers to the existing ones and all **events** there happen only on the interface between the solid and the liquid. In a dramatically different way, events in exystems happen—and processes run—in every building bloc. Generators of exystems are immersed or embedded in the system.

The growing crystals do not need any access to their inner area, **Figure 2.9.3 A**. The

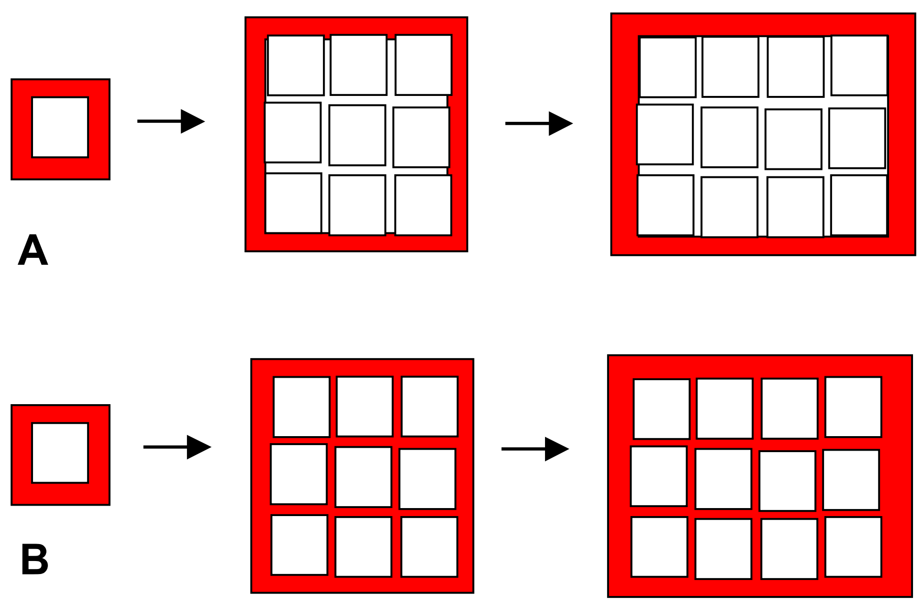


Figure 2.9.3. Growth of a crystal (A) and an exystem (B). The area of events is shown in red. It can be interpreted as the interface for the movement of matter, energy, and information.

citizens of a nation, however, expect their daily bread and circus supplied and delivered (**Figure 2.9.3 B**). The cells of their organisms expect their glucose, hormones, and nervous signals.

Since complexity can grow if there is a sufficient supply of energy and information, connectedness can be maintained by the same means.

It may seem mysterious that **old** information is needed to create **new** information, and indeed it has been a controversial issue since the emergence of the very concept of information in 1948.

> **HINT:** If we need to take apart old Lego structures to build new ones, we have to **remember** which ones were built first. The best way is to take photos in advance.

To clarify this and other points, we need to look into intimate details of bonding.

2.10. CHEMICAL BONDS

Chemical bonds in the title are, of course, pattern-chemical bonds. Chemistry is about bonds and simplicity. The neighborhood of a single generator is the atom of simplicity. With this kind of approach, emphasized in *Pattern Theory: From Representation to Inference* , complexity is a combination of atomic objects.

Molecular chemistry borrows the theory of bonding from physics. Molecular chemical bonds require energy to dissociate the atoms. The same energy evolves when they form the bond again. Two distant atoms do not interact and are completely independent.

> **NOTE** the distinction between **nearness and interaction**. In Euclidean space atoms need to be close in order to interact.

The physical approximation known as molecular orbital theory gives a series of energy levels for the interacting (valent) electrons of two atoms brought together close enough. Some levels are lower than the energy of separated atoms (**bonding**), some are about the same (**nonbonding**) , and others have a higher energy (**anti-bonding**).

Figure 2.10.1 illustrates the interaction of electrons and the appearance of new energy levels when hydrogen fluoride forms from atoms of H and F.

> The pairs of arrows show the orientations of electron spins. Molecular chemistry and, all the more, quantum chemistry, cannot be discussed in the context of pattern chemistry without extreme simplification.

Positive bond results in increased stability of a configuration and negative bond has the opposite effect. If so, can we call the negative bond a bond? A positive answer to this question marks the point of emergence of exystems from chemical systems.

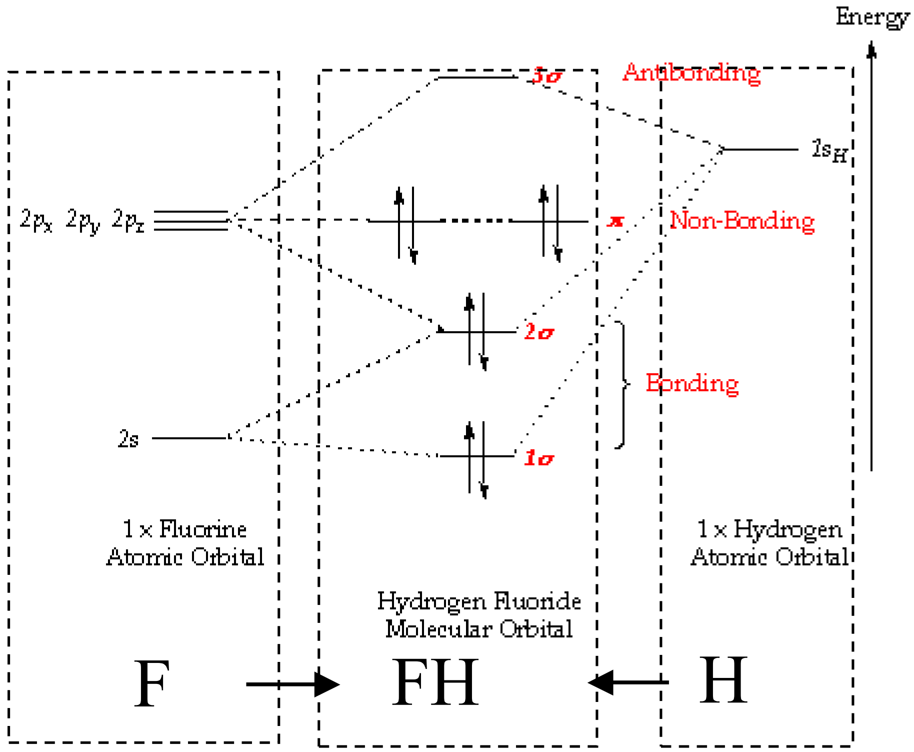


Figure 2.10.1. **Formation of molecular bond between atoms of fluorine** (F) **and hydrogen** (H). Source.

It is not the subject of pattern chemistry to inquire into the mechanisms of **bonding** (attraction), **nonbonding** (indifference), and **anti-bonding** (repulsion) of generators in particular exystems. The three analogous terms—positive, neutral, and negative bonds—seem appropriate for the three basic situations of interaction or lack of it between generators. In terms of stability, they mean that the positive bond is more stable and the negative bond is less stable than disconnected (distant) generators. The two cases are illustrated in **Figure 2.10.2**, which repeats **Figure 2.3.1** in a modified form.

The stability of a negative bond means the stability of the nearness. It can be maintained by a constant supply and dissipation of Gibbs energy. The examples are trivial: from dysfunctional marriage to a telephone line and from the territorial unity of Canada to a prison.

The formal Pattern Theory in its current state does not consider negative bonds, although it is completely fit to accommodate them, as it was done in History as Points and Lines.

Exystems are a ground for the interplay of positive and negative bonds. Rivalry for the position of animal alpha-male, cohesion and rivalry in human family and society (Cain and Abel), philosophical and scientific schools, competition, cooperation, and acquisition in economy, party politics, small social groups, and cognitive dissonance in the mind are examples.

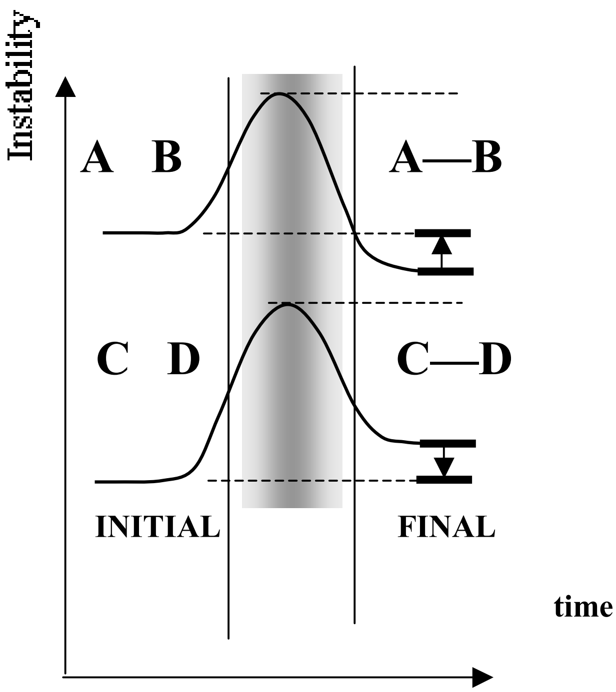


Figure 2.10.2. Formation of positive (AB) and negative (CD) bonds

The exystems of world economy and culture could be only partially connected. When the Native Americans and Europeans had no idea about each other's existence, the system of continental cultures was not connected. The ideologies of a scientist and a preacher are usually disconnected.

> Centralization of power is one of the ways to ensure connectedness of a nation. A decline of central power results in a separation. It happened to all major empires in the twentieth century, twice to Russia (which lost Finland and Poland after 1917) and to Yugoslavia and Czechoslovakia, which were themselves fragments of Austria-Hungarian Empire. It almost happened to the USA in the Civil War and still remains, in my opinion, a possibility in the future. The consolidation of opposing fractions is not what is called diversity.

A political figure in modern democracy is torn apart by the following contradiction: in order to define enemies, the simplest ideological configuration is ideal, but in order to embrace friends, a more inclusive and complex one attracts a wider audience. An excess of complexity repels everybody. As result, a politician, however intelligent, may feel compelled to sound primitive and chameleonic.

Nonbonding as the attitude of deliberate indifference is a kind of interaction, too. It is not a complete absence of interaction, however, as between people who do not know about each other's existence and live on different continents. Non-bonding is the absence of interaction between generators which are close enough to form a positive or negative bond.

When a chemist says that atoms of carbon and hydrogen, C and H, are connected by bonds in the molecule of methane, CH_4 , it means neither any concrete marked atoms nor a concrete molecule, but a molecular configuration. The chemist is aware that two real, not symbolic, atoms interact only if they are close enough to each other, but he is interested only in patterns. The symbolic abstract atoms C and H in the mind of a chemist who thinks about methane are **always close** regardless of any bonding, stability, energy, etc., which is exactly what bond means. They are close in chemist's mind.

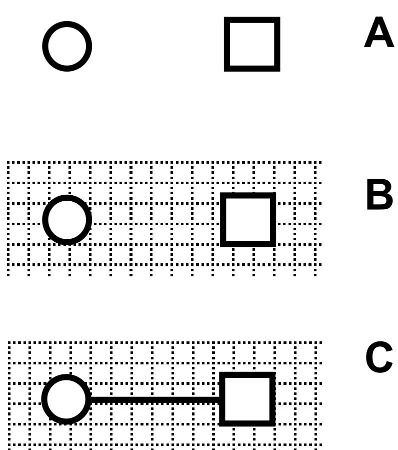


Figure 2.10.3. **Origin of bond between generators: presence (A), nearness (B), and bond (C)**

Pattern chemistry considers three types of relation between two generators, see **Figure 2.10.3 , A** to **C**.

1. Presence in the generator set (A).

2. Nearness (B) , i.e. ability to bond.

3. Actual **bonding** (C) , whether positive or negative.

Bond in pattern chemistry can be interpreted as is **stable nearness**, thus comprising equilibrium and non-equilibrium systems.

Chemical bonds can be also classified as strong and weak, as well as single and multiple. Multiple weak bonds play a crucial role in biochemistry. On multiple weak bonds and zipper-effect, see The Rusty Bolts of Complexity: Ideograms for Evolving Complex Systems, p.29, The New and the Different, pages 350, 351 and Essay 25. On Zippers.

For an example of negative bond, see **Chapter 3.1**.

2.11. MATTER, MIND, AND MACHINE: A DIGRESSION

This is time to return to **Chapter 2.4** and again compare **Evolving Complex Systems** (**exystems**) of this text with **Complex Adaptive Systems** (**CAS**) of the Santa Fe Institute domain.

> For the purpose of search, the abbreviation CAS should not be mixed up with Chemical Abstract Service of chemistry (as in "CAS number").

They seem to be extremely close, but how close or how distant? I am not going to judge the CAS approach, about which I have always been enthusiastic. I use this as an opportunity to overview exystems in the light of the previous chapters.

Here is a partial but representative list of CAS compounded from Web sources:

.--.

weather	brain	scientific enterprise
biosphere	manufacturing	stock market
ecosystem	human body	computing system
bacterial adaptation	language learning	communication network
insect society	social endeavor	neural network
ant colony	cultural system	evolving algorithm
immune system	social system	open software
cell	political party	business venture
developing embryo	community	Tierra program
complex organism	city	Internet
nervous system	traffic	economy

. --.

Interestingly, language, science, art, ideology, and technology, which are typical exystems, did not seem obvious examples, and neither did mind itself. Nevertheless, all examples depend on some activity of living organisms, directly or obliquely. Even weather, better to say, climate, until recently beyond human intervention, has joined the club of life.

All CAS in the list dissipate energy, which follows from their biological or technological pedigree. Computation consumes and dissipates energy, too, although relatively little and in a peculiar way: to form or to break up a bond takes the same energy.

The degree of complexity in the above CAS is very different. Thus, stock market traders are counted by millions, but they come in faceless multisets (batches) and one million more or less would not add or remove a generator from the Periodic Table of traders, if such table existed. In terms of Pattern Theory it means that the complexity of the system would not change with the change of size because the generator space remains the same.

> The traders capable of extremely large block trades occupy a cell of the imaginary Table far apart from the hundred-share traders. Hedge funds, sovereign funds, and CEOs selling shares by millions have already left their imprint on the market climate.
>
> In the times of Adam Smith (1723-1790), the market consisted of large number of local transactions between people with limited information. It would be naïve to expect that the same benevolent invisible hand rules the world over two hundred years later, when people are informed in close to real time—or try to guess—about what is going on in the invisible brain that moves the invisible hand.
>
> The trader today is the cunning Odysseus against the blinded Polyphemus. The problem is, in the cave there is a whole stampeding herd of heroes like he. But when Odysseus grows to the size of Polyphemus, he is not a hero anymore, but just another Cyclops.

The following example illustrates the difference between physics and chemistry, which may be relevant for their economic avatars. Hydrodynamics assumes that the behavior of fluids is a result of incessant collisions between identical particles. If the flow exceeds a certain limit under rising pressure, the smooth laminar behavior can dramatically change into a turbulent one. Econophysics infers the behavior of the market, in a similar way, as the result of a large number of individual interactions. For a chemist, however, water is H_2O, whether a droplet, or a lake, or a tsunami, and legitimate subjects are, for example, its interaction with proteins or participation in the photosynthesis.

Lets us now imagine that there are one hundred different kinds of particles and they can combine with each other and recombine into whimsical, but stable structures of unlimited size. This is how you step over the borderline between physics and chemistry. Contrary to popular belief, molecular chemistry is not about atoms and molecules as physical objects (this is the turf of physics), but about the Platonic ideas of atoms and molecules.

The entries in the CAS list differ regarding long and short term memory. The genetic memory of the cell or ant colony is hardwired and changes very slowly. The acts of behavior repeat in time and space. More importantly, an ant colony has no historical memory, while even a tribal society has at least a myth about the origin of the world and the tribe. The zoologists can build the genealogy of whales and elephants back to the point of divergence, which the animals themselves do not remember. The species run through their history only once.

The world of adaptive systems from the adaptation perspective alone is mostly circular, reproducible, and repetitive, while the world of exystems is not: it is the world of patterns. Once recorded, they are as imperturbable as the Platonic ideas.

Adaptive systems are the closest relatives of machines and they can pull the trick of adaptation again and again, like the molecules pulling the tricks of their transformations. In other words, adaptive systems are much closer to molecular chemical systems than exystems are. Adaptive systems are part of the fabric of exystems, for which they do daily toil.

Traffic, for example, is a sequence of very large number of small scale events. It is a fluctuating system with yearly, season, and daily cycles. If the traffic evolves from year to tear, as it happens right before our eyes, it is because economy and technology evolves. Traffic is not quite predictable but its degree of independence is negligible. The same applies to man-made artificial computing systems.

I feel ready now to outline the sphere of exystems: it is a class of CAS with a stable structural pattern evolving on a larger event scale than the circular, multiple, and repetitive micro events that populate the timeline of CAS. The exystem goes through a series of stable structures separated by unstable transitional ones. In other words, exystem is a system with embedded, i.e., recorded and accessible **history**, which usually ignores mass micro-events and pays attention only to large unique shifts. Exystem, therefore, is a specific way to see complex systems. The chemical view of the world is complementary to the mainstream science of dynamic complexity. What the science of complexity for the first time discovered was the inherent ability of complex dynamic systems to lose stability even without external reason.

An exystem does not "adapt" to anything: it regains stability after a disturbance. Exystem does not return to a previous state because it remembers and cannot unremember it. What we call "adaptation" is stabilization and by the time of stability the target of adaptation may not even exist anymore.

For better or worse, the guardianship over history is not only an exclusive license granted to humans, but, in my view, the very starting point of *homo sapiens*. It is impossible to keep history without transferring it through generations, for which language and not DNA is equipped.

When I speak vaguely about human scale, I mean that exystem is a large complex **slowly** evolving system, which has no meaning without a long term observer whose longevity transcends mortality—this is what **slowly** means. Slow motion in Leibniz time means that there are also fast short events, which history ignores. Obviously, this is not a position of a physicist, molecular chemist, or a complexity scientist.

> It is noteworthy that the idea of deity starts with the creator, as in tribal mythologies, but ends up with the idea of reward and punishment for the completed life, as if somebody or something keeps the record of human life even in non-monotheistic religions, like Hinduism and Buddhism. The next step, the ideology of liberal individualism, is the doctrine of self-judgment by the individual alone, according to an individually and voluntarily accepted set of rules, for the most part, inherited from traditional religions. The individual alone,

> if not God, remembers all circumstances of his or her life. The trick to ease possible stress is to decide who is human (Us) and who is not (Them).

I would not draw, however, a sharp borderline between centralized (like political dictatorship or oligarchy) and decentralized or distributed (like the Internet or the free market) systems. I intuitive believe that they are mutually convertible, depending on the circumstances, and this is, probably, the most interesting practical problem for long-term neology (study of novelty).

> My intuition is based on personal observations of the unique Soviet system of completely centralized economy with planned production, distribution, **and consumption**. If the free market economy of czarist Russia was able to collapse and submit to this transformation, if the Soviet economy could, to some extent, attempt the reversal to free market, and if the current reversal in Russia is being stifled by state expropriation and corruption, it means that **very large patterns of civilization could be reversible.**
>
> What is going to happen in times of scarcity of natural resources and the increase of global economic and informational connectedness? In a very long run, the humanity will probably regain stability, no matter what. But what is the series of large scale events between today and the very long run, say, in the middle run? Regarding medium scale events, what is going to happen to information technology systems with monopolistic potential and tendency: to the Cyclops like Amazon, Google and Microsoft? God bless them for the wonders of accessible IT. Can political democracy be monopolized through the American style Yin-Yang political organization which to me looks like a marriage of two people who may hate each other's guts but cannot live without each other?
>
> Those are the kind of questions where pattern chemistry could contribute something more than a trivial digest of hard-earned solid academic science. These expectations are based on the thermodynamic foundation for chemical reasoning, which is solid and hard enough to support mental constructions.

The three major families of exystems labeled as **Bios**, **Infos**, and **Technos**, otherwise **Matter**, **Mind**, and **Machine**, if catchwords are needed, comprise everything that the humans can experience as input and output. Historically, life appears first, humans and society come next, carrying their ideas and cultures, and finally the man-made machines explode into the latest large exystem. All three are inseparable in modern civilization, but their weight, role, and patterns of interaction keep evolving.

What brings together the CAS approach and the chemical view of the world is the idea that there is knowledge to mine from transcending all interdisciplinary borders. See the recent *Origin of Wealth: Evolution, Complexity, and the Radical Remaking of Economics* by Eric Beinhocker's (Harvard Business School Press, 2006), the best manifesto of interscience that I know. Ancient Greek philosophers were the earliest heralds of this general idea, each in his own way, from Thales of Miletus to Democritus.

The basic properties of exystems, such as non-equilibrium, openness, dissipation of energy, replication, multiplication, growth, novelty, competition, selection, memory, and exchange of information are all covered by economy, which is turning into an overwhelming form of all human activity on earth, with its freedoms and constraints, involving even biosphere.

> More on economics, see Essay 54, Growth and Anti-Growth. On the ideas of Vladimir Vernadsky, see Essay 51, Potato as Food for Thought and Essay 52, A Supper with Birds and Planes . From the functional point of view, there is a single exystem on earth, for which **pattern life** is the best term. As soon as we accustom to this view, the evolution of complexity does not look as monotonous complexification because the blotches of loss are clearly seen in the past, as well as in the future (Essay 34, On Loss).

While the mainstream of PT is supported and stimulated by urgent problems of image processing, such as face, person, and target recognition, charismatic and often unsympathetic world leaders tweak history without consulting any mathematics and thus, in an oblique way, support PT. Pythia would answer the question "what is going to happen to America?" with a resolute "victory," without, of course, telling for whom. Yet victory and defeat are typical **patterns** of history. Same is true about stunning reversals of fortune after either victory or defeat, exemplified by USA, Germany, Japan, and Russia on memory of my generation.

The area of my personal interests in pattern chemistry has no ties to statistical analysis of data. I am interested in answering the questions similar to those addressed by the Greeks to Pythia at the Delphic Oracle:

> **What events are possible from now on and which one is more likely in near and distant future?**

The very first attempts to look at the world from this angle have been described in Patterns of Thought by Ulf Grenander (in process) and *History as Points and Lines* . See also *Transition State in Patterns of History*.

Section 3. EXAMPLES AND ILLUSTRATIONS

3.1. VIVA FiOS! EXAMPLE OF NEGATIVE AND POSITIVE BONDS

I have recently (2008) got **FiOS**, a fiber optic line from Verizon company. Before ordering it, I studied reviews and personal impressions on the Web. I was amazed by a cult-like enthusiasm of the happy subscribers, who shared their experiences of installation and work of the FiOS line in minute detail. In my case, it took the young and knowledgeable technician a whole day, during which three other colorful personalities appeared in my house to assist him.

Figure 3.1. **Verizon FiOS terminal**

Now, with Internet, TV, and phone connection through a tiny glass fiber, I wholeheartedly share the excitement of other FiOS users. The following, therefore, is in no way a criticism of the company, technology, and performance, **of which I have absolutely nothing negative to say**, but just observations of a real world **negative bond**.

The individual FiOS line, which is a bond between me and the company, unlike the traditional telephone and the coaxial cable of digital TV, needs **constant supply of energy** right on the spot of entry into my house, which it gets from the regular electric outlet on the basement wall. Optical Network Terminal (ONU), see **Figure 3.1**, which is the interface between the fiber line and my computer and appliances, is a device of a considerable size and complexity In case of power outage, a large battery inside the ONU supplies energy for 4 hours of telephone conversation (obviously, the cordless phones would not work). The smallest of the three sections of the ONU is warm on touch because it dissipates energy into heat.

The common low voltage telephone line is no different in principle. It needs its external maintenance all the way to the telephone station and the FiOS master cable needs it too. From my window, for example, I can see the occasional tree trimming. More importantly, the **energy for the conversion** of electric signals into sound and back is supplied by the analog phone company through the same telephone wiring, independently from the commercial electrical power supply. Finally, the cordless phones and answering machines, vulnerable to power outages, need additional electrical power for conversion of sound into electromagnetic waves and then into electric signals, as well as back. The cell phone is no different, but it carries its energy source inside.

What came as a small revelation to me was the cable that connected the ONU and the router, supplied by the company and placed near my computer: it was a common coaxial cable, only of nice white color. The signal that came to my basement through the glass fiber had to be converted into electric signal, delivered through the coaxial cable to the TV set and the router, and then passed through the short **common** (if I am not mistaken) telephone cable plugged in the phone socket in my computer.

Therefore, I concluded, there is no difference to me whatsoever whether I get all my signals, TV, phone, and Internet, through the coaxial cable alone or the glass fiber line. **It matters for the provider company** because it can serve a **larger number of customers** with a much wider range of demands and choices and at a much higher level of quality, including speed. The advantage of glass fiber is the incomparably larger frequency bandwidth of light as compared with electric and radio signals. Before FiOS, I had a cable TV from COX company and a DSL line from Verizon to my computer over the common telephone line. I could get the same or close enough quality as FiOS from COX through the coaxial cable if COX agreed to have less customers and less profit. With the old combination of COX TV and Verizon DSL, I had a less vulnerable and requiring less energy to maintain bond between myself and the ocean of information, the absolute majority of it completely irrelevant. It is the effort of fishing out what I need that forces me to seek higher Internet communication speed.

I hope this example illustrates that the chemical view of the world is trans-disciplinary, compatible with the human scale, inseparable from thermodynamics, and related to the problem of managing the future, i.e., economy. Economics is as much a science about the future as chemistry. While we can see and recognize bonds, energy is invisible and so is the future. Science starts with invisible things.

Remembering the four day long outage during the hurricane Bob of 1991, I can appreciate the reliability of any power supply. The phone line, by the way, worked fine in the raging weather. Needless to say, I believe that FiOS is well worth its quite reasonable price. But the abstract uncertainty of the future becomes a larger increment into the economics of communication lines. Of course, if somebody could not survive four days without TV and Internet, the future security can be bought for the price of an emergency generator (starting at $500). If there is no major war, blockade, or riots, that will do.

I call the communication bond **negative** to distinguish it form the **positive** bond, like the bond between two welded together pieces of metal, or inter-atomic chemical bond, or the bonds between the parent and the child, or a nerve in a body, or **any copper or fiber glass cable** that can be disrupted by cutting. All those bonds need energy to break up, but all are, in essence, reducible to bonds at the atomic level, some of them in human neurons.

The positive bond between two passionate lovers can become a negative bond in a dysfunctional marriage. The copper line of communication can become physically vulnerable if the social turbulence—or the price of copper—rises (there are already signs). The bonds between the atoms of ideas in our mind can freeze or melt, depending on the price of human life and the level of noise and irrelevancy of information. The humans can flock together or flaunt individuality, depending on the supply of energy from the sun, food, wood, coal, and oil. This is part of chemical view of the world.

Amazingly, FiOS is, in a way, a resurrection of the most ancient pattern of long distance communication by light or smoke. Patterns are historically stable, but why? Because the bond is a universal concept beyond novelty: it is as old as atomism. Positive bonding is a universal property of matter, while negative bonding emerges and joins the interplay with positive bonds as the property of life and society.

The question "what is life from the point of view of chemistry," in which both life and chemistry are generalized, should be answered: negative bonds. They cost energy.

> **NOTE 1**: On April 8, 2008, FiOS was down in our area for 8 hours: telephone, TV, and Internet.
>
> **NOTE 2**: "In 2006, electricity consumed by servers in U.S. data centers (including cooling and auxiliary infrastructure) represented about 1.5 percent of national electricity use."
>
> "According to AFCOM's Data Center Institute (AFCOM 2006), power failures and limits on power availability will interrupt data center operations at more than 90 percent of all companies over the next five years."
>
> US EPA Report, 2007, page 21. The said energy consumption is expected to double by 2011 , page 52.
>
> **NOTE 3**. LCD TV and monitors work reliably only in a certain temperature interval. The Ethernet converters and small Set Top Boxes for FiOS TV dissipate obscenely large amounts of heat.

3.2. READING ERIC BEINHOCKER: WHAT IS WEALTH?

The Origin of Wealth by Eric Beinhocker (Harvard Business School Press, Boston, 2006) attracted my attention by the mere number and diversity of reviews on Amazon.com and the rest of the Web. Although they varied from shallow compliments to unfulfilled expectations, I bought the book with a sense of urgency and was not disappointed.

I have no intent to either criticize or eulogize the book, but I am certainly of a very high opinion of Eric Beinhocker's work along my own homespun criteria.

> I value a work not for the answers that it provides, which are always in flux for an evolving subject, but for the questions it prompts. I do not expect it to be illuminating, persuasive, or useful, but I want it to stimulate doubts and questions in my own mind, as well as pose them publicly, in the spirit of Socrates.

The book is a gateway not into the art of getting rich, as some readers might have expected, but into a vast and controversial literature which is comprehensible only to professionals in the field. The book is exceptionally wide in scope, readable, stimulating, thoughtfully composed, and with lots of chinks in author's intellectual armor to test the reader's analytical strength.

Since my own interests focus on application of chemical ideas in non-chemical areas (a chemist's view of the world), I will use *The Origin of Wealth* as either supporting or contrasting background for the chemist's view of economy, partly shared in my Essays:

51. Potato as Food for Thought
52. A Supper with Birds and Planes
53. Power: Hidden Stick, Shared Carrot
54. Growth and Anti-growth
55. The Chemistry of Money
56. From One, Many

See also Essays Part 3.

Wealth is a very unsettled notion and there is no consensus on it, except that wealth is good for you.

It is my impression that wealth in *The Origin of Wealth* avoids an analytical definition and means, approximately, two things: (1) the traditional totality of **marketable** things and assets in possession, so to speak, the **body** of wealth, and (2) knowledge how to make and market things as the **DNA of the body**.

The book is an extended biological analogy focusing on the evolution of wealth. It uses the arguments of the science of complexity, the "experimental" part of which consists in computer models of relative simplicity and little relevance in the real world.

> Computer experiments have the roots of their own pattern genealogy in antiquity as *reductio ad absurdum* (**reduction to impossible**) argument. A more modern but still pre-computer form is thought experiment (*Gedankenexperiment*), which tests a hypothesis for implausibility by deriving absurd conclusions from it. Computer experiments inverted **reduction to impossible** to the **reduction to possible**, thereby, in my opinion, losing a lot of logical power when we do not know what else is possible. In case of exystems, we never do.
>
> An opinion has been already expressed (supported by Paul Volcker) that mathematical models are partly responsible for the market plunge of 2007-2008. For example: (Charlie Rose, March 18, 2008)

> **Charlie Rose:** Somebody said to me that we entered a period in which they were worshiping mathematical models … And mathematical models had no business sense.
>
> **Paul Volcker:** The market was being run by mathematicians that didn't know financial markets. And you keep hearing, you know, God, that event should only happen once every hundred years, according to my model. But those every hundred years events are coming along every two or three years, which should raise some questions.

Without any counterarguments, I will further use some of Eric Beinhocker's topics and questions as prompts for my own chemical answers.

For example, wealth is created by economic activity and is, according to Eric Beinhocker, fit order, i.e. , result of an evolution similar to biological evolution. I really do not see how it is different from my notion of Technos or technosphere, and I believe the book is an excellent treatise on Technos. It complements my own fragmentary **Essays 32, 34, 42, 46, 51, 52**, (also Essays Part 1, 2, and 3) texts **The Rusty Bolts of Complexity** and **The Visible Hands**, as well as, for minds tuned to poetry, **TECHNOS.html** .

Are non-technical books about technical matters and technical books on non-technical matters worth reading at all? Isn't economics "the dismal science" (Thomas Carlyle)?

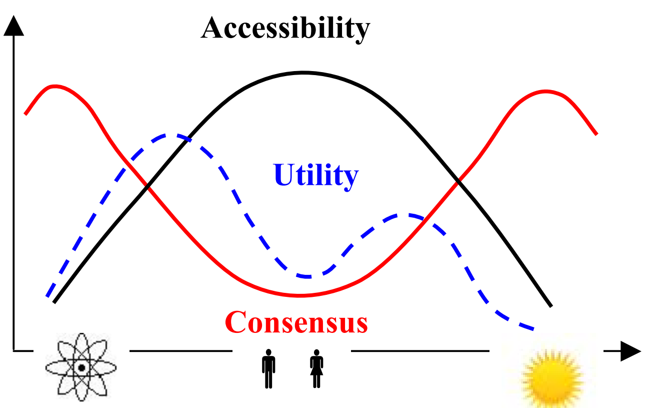


Figure 3.2.1. Accessibility, utility, and degree of consensus of knowledge on human scale, from micro to macro objects. Ideology is excluded.

Without expanding on this important and intriguing subject, I illustrate with **Figure 3.2.1** the relation between accessibility to non-professional audience, practical utility ("what should I do tomorrow morning?"), and degree of consensus. This may change, however, because unexpected evolutionary novelty is the main disturbing factor in all our grand theories, including econochemistry.

Human matters are, in large part, accessible to direct observation and understanding, whether we use the words greed or motivation. I place them in the center of human scale, with wings stretched to the extremes of subatomic and extra-solar realms.

I see economy as an exystem (actually, a life form, a hyper-kingdom) that emerged as soon as humans woke up one morning with a pair of hands itching to take apart or connect something, or put a seed into the soil. Hands are an ideogram not just for economy, but also for biochemistry and molecular chemistry, see **The Visible Hands**.

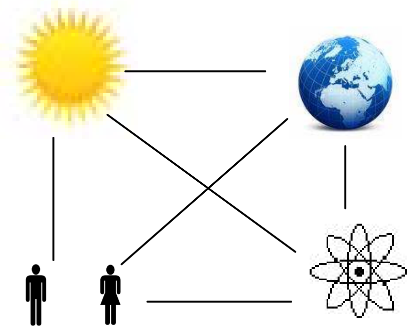


Figure 3.2.2. **Inseparable components of modern economy: Sun, Earth, humans, and atoms.**

It was not always so, but it is impossible in the modern world to expect much value from any theoretical treatment of economy in which its components, **Figure 3.2.2,** are separated or omitted. What can unite them is the acceptance of some universal function that would take the place occupied by energy in physical sciences. I mean, of course, stability. On the firm (and stable) footing of stability, economics looks to me as the true science of everything.

What I have been most interested in is the place of humans in Technos, which I. address elsewhere. In short, I believe that, in terms of generalized chemistry, the humans play the roles of (1) enzymes or catalysts that lock and break bonds and (2) source of chaos, especially, for mutations in knowledge, without which no system can be called dynamic. Those two chemical factors, (1) and (2), oppose and counteract each other.

Whether we call it knowledge or metaphoric DNA, information cannot be “expressed” without enzymes, and this is what humans do in the exystem (hyper-organism) of economy.

But what is wealth? Here is a preliminary reconnaissance.

3.3. IS INEQUALITY NATURAL?

I see wealth not as possessions, but as their inherently unequal distribution. If wealth is distributed equally, it is not wealth anymore because nobody is either wealthy or poor. Beinhocker writes: “Economic wealth and biological wealth are thermodynamically the same sort of phenomena, and not just metaphorically,” (p. 317). The biological analogy—apparently with biomass—is limited, however, because of the absence of market exchange in **biological wealth**, whatever is meant by it. Male and female animals may congregate, compete, and show off at a sex market place, but whatever genetic exchange follows, it is, as we tend to believe, strictly random and not for the sake of the traders themselves, but for the species. It is very different for humans exactly because of the phenomenon of wealth. If you are a moos, you cannot either sell your majestic antlers or exchange them for the giraffe's neck.

The inequality of wealth is maintained by a wealth pump. The pump is an ideogram , too. How this pump works is a separate topic, but in a nutshell, the wealth pump works because of the bond of property and the ability of the owner to control it. In physical language, wealth pump works as Maxwell's demon.

> For a physicist's perception, see, for example, short, but weighty: *Andrei Khrennikov, Financial heat machine*, from which I quote:
>
> > Since in the situation we mentioned above profit is obtained due to using the difference in prices during the market cycle, which means that one sells and buys exactly when it will be profitable. Such an agent works as the Maxwell demon.
>
> From the chemist's view, the demon works because he has hands that can snap and tie up bonds. And, of course, Andrei Khrennikov hits the point: the demon works in economy because he is cool (i.e., colder than the environment).

Here I am concerned with the outcome of the pumping.

It is of cardinal importance that economics faces two sharply distinct types of inequality, sometimes unreasonably pitted against each other, as Nassim Nicholas Taleb does in his *Black Swan*. One is **normal distribution** and the other is **power law distribution,** of which Pareto distribution is of primary interest.

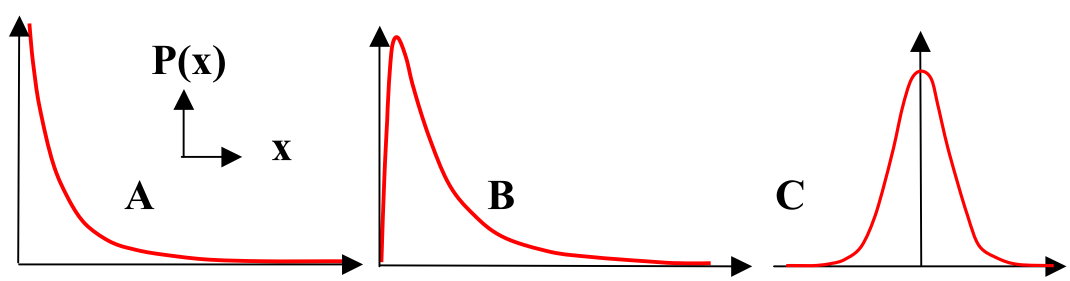


Figure 3.3.1. **Probability distributions.**
A : power law; B: lognormal; C: normal.
Logarithm of lognormal function has normal distribution.

How is it possible to have a wealth distribution not of the same symmetrical bell shape (**Figure 3.3.1 C**) as human height, intelligence, and errors of their measurement, but as in **Figure 3.3.1 A** and **B** (or their combinations, as some research, see below, suggests)? Why does the *natural* (normal, or Gaussian, bell-shaped) inequality coexist with the so different economic (to avoid the word *unnatural*) inequality shaped as skateboard ramp?

But why to shun the loaded term *unnatural*? The question ***Economic Inequality: Is it Natural ?*** is the title of the recent (2007) paper by Arnab Chatterjee, Sitabhra Sinha, and Bikas K. Chakrabarti (see also).

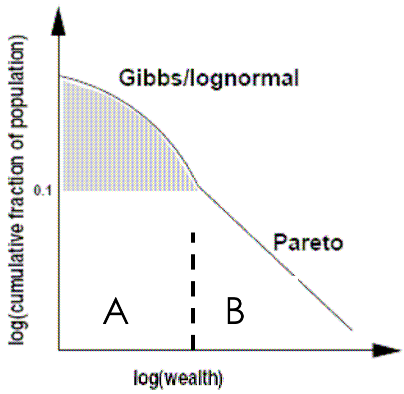


Figure 3.3.2. **Subsistence (A) and wealth (B)**

The authors focused their attention on the available data of wealth distribution across both historical time and geographical space, starting with Ancient Egypt. The curve consists of low wealth segment, which is normal or lognormal (**Figure 3.3.1 B** and **C**, compare with **Figure 1.6.1**), and the segment with power law distribution (Pareto distribution).

Figure 3.3.2 is a modified illustration from the above paper, where it is, in turn, a modified diagram from *Statistical Mechanics of Money, Income, and Wealth: A Short Survey*, by A. A. Dragulescu and V. M. Yakovenko (2002).

The paper by Chatterjee *et al* is one of many studies of income and wealth distribution. There are other data and simulations (for example) on the transition from the "natural" lognormal distribution to "man-made" Pareto distribution with the growth of income/wealth. I have chosen the paper because of its suggestive title and unprecedented scope of data sources. Thus, one of the sources was the distribution of the size of the houses in an excavated 14th century BC Egyptian city Akheaten. The size was considered the measure of wealth (A. Y. Abul-Magd, *Wealth distribution in an ancient Egyptian society* , 2002).

There was an exciting discussion on the mystery of wealth distribution in Kolkata, India, in 2005, exemplified by flashy titles like *The Rich Are Different! Pareto law from asymmetric interactions in asset exchange models*, by Sitabhra Sinha (ppt presentation).

There are different explanations of the two-segment curve. I am not an expert to judge them, except for making a note of a close relation of some suggested there mechanisms to chemical kinetic, while others take to account the propensity either to thrift or to elementary greed, gently called motivation. Dieter Braun's paper is based on the non-equilibrium character of the economy—from a surprisingly rare angle.

> "For profit rates of 10 % / year, less than 50 years are needed to concentrate 50 % of the wealth into the hands of 1 % of the population. "
>
> Dieter Braun, *Nonequilibrium Thermodynamics of Wealth Condensation*, **Physica A**: Statistical Mechanics and its Applications, Volume 369, Issue 2, 15 September 2006, Pages 714-722.

Why does it look like *homo economicus* is in fact two species, probably, even two genera or taxonomic families? The rich are different, but in what sense? See **Chapter 3.6**.

The difference and interaction between the rich and the poor has been constantly explored in literary fiction with an interest almost as steady as the interest in the difference—and interaction—between the two sexes.

> The story of a young poor/dropout man/woman coming to a big city/corporation/tycoon to become rich is one of the traditional real life and fictional patterns. The airport bookstand is an exemplary shop window of sex-and-money mayonnaise.

I am looking for a non-molecular chemical interpretation of the wealth distribution to satisfy my own curiosity, not to illuminate the world.

My answer, quite self-obvious, is that natural properties of *homo sapience*, as well as of all other living beings, cannot be separated from them and exchanged for other similar or different properties. They cannot be accumulated and stored. We possess intelligence not in the same sense as we possess money. Our genes are reshuffled and divided at random. Wealth, however, as Beinhocker rightfully emphasizes, is made by introducing order into the game, and **the price of order is energy**, which is somewhat underemphasized not only in his book, but in the entire economics, and even econophysics.

The act of production starts with energy and matter. It ends with disposing of waste and heat. As a chemist, I find the omission of non-equilibrium thermodynamics from economics to be the most un-chemical trend. In the eyes of a chemist, production is nothing but creating and reordering bonds between pattern-theoretical generators, including atoms. If the bonds are negative, you need energy. Moreover—this is a very neglected and esoteric subject—you need it for both locking and breaking negative bonds.

> Obviously, science today is as much part of economy as any business. Truth has its cost. The history of FDA and American Pharmaceutical industry is a *Decameron* of our time.
>
> The specter of global warming opens a new truth market. When I see a **BMW Hydrogen 7** car commercial, I know that today this could be a more polluting car than any regular BMW because in order to make hydrogen, electricity must be produced from burning fossil fuel, which only adds losses along the way from fuel to the useful work. Moreover, in order to pay for the hassle of hydrogen, which is known as the most treacherous, volatile, and explosive gas, the wheels of economy must spin faster to spew out the wads of money for the green BMW buyers, together with the carbon dioxide that economy exhales. Unless hydrogen is made by renewable energy, like wind, sunlight, and tide, hydrogen technology is chemically as dirty on the global scale as any other.
>
> Searching my over 18 MB collection of relevant papers on wealth distribution from the Web, I could not find the following words: **private property, surplus value, Marx, energy dissipation , productivity, production (as source of wealth), source of wealth.** It seems that econophysics of wealth focuses on

models of interaction, exchange, and redistribution, paying little or no attention to the production of the material body of wealth, all the more, knowledge.

The anti-intellectual trend in econophysics has already been noticed:

> Models which focus purely on exchange and not on production cannot by definition offer a realistic description of the generation of income in the capitalist, industrialized economies.
> Mauro Gallegati, Steve Keen, Thomas Lux, and Paul Ormerod. **Worrying trends in econophysics ,** Physica A 370 (2006) 1–6. http://www.debunking-economics.com/Papers/Econophysics/GallegattiKeenLuxOrmerod2006WorryingTrendsInEconophysics_PhysicaA370pp1-6.pdf . See response by Joseph L. McCauley.

But what is exchange, the very stuff of economy? It is the consequence of the institution of property, for which chemistry offers a very clear vision: **property is a positive bond** (i.e., requiring energy to break up) between the owner and the possession. But is it? This is a delicate subject, however, which should be considered separately. Let us assume that it is as a hypothesis.

> You need a Soviet-style political system to break up the bonds of ownership, while in a free market economy bonds rearrange in the process of exchange.
>
> That Communism in Russia allowed for personal property (exchangeable in flea markets) but not for the means of production, was its very openly proclaimed premise, the main commandment, studied at school since childhood. I grew up with it. But looking at **Figure 3.2.2**, I for the first time began to realize that the main principle of Soviet Communism was to discriminate between segments **A** and **B** of the curve and to hack off the Pareto part clean. Naturally the Gini coefficient of Russia, one of the lowest in the world before the collapse of Communism, at least doubled after 1991, although the data about Russia are never reliable.
>
> With a hindsight, after the dead have been buried and borders opened, we should be grateful to Lenin, Stalin, and Brezhnev for the greatest economic experiment on earth. The next experiments in Russia and China will reveal if capitalism really needs political freedom.

The borderline between subsistence and wealth segments of wealth distribution is a demarcation line between biology and human economy as much as language is the demarcation line between humans and animals.

I conclude this Chapter with *quasi una fantasia*.

> **From the chemical angle**, throughout history of civilization, there have been two economic classes or, if you wish, econo-races, econo-sexes, econo-parties, econo-kingdoms—big, fundamental divisions of non-biological nature. I see a good reason to name them G-class and P-class (from Gibbs and Pareto). A limited number of people can move between the classes back and forth.

The G-class earns its bread by the sweat of the brow, while the P-class hovers in the skies, playing golf through the eye of the needle. The P-class has its living on tap because it owns the money pump working on the principle of the Maxwell's demon (i.e., a pair of pattern hands and a pattern brain with pattern memory). The two classes are patterns and not tied to an individual. Warren Buffet earned his money pump by the sweat of his brow. Moreover, any human being is a Maxwell's demon by definition. The so-called middle class is a continuous human transition from G to P, but the economic difference between G and P is sharp: either your demon is inside, or **also** outside yourself (read Philip Pullman).

I begin to suspect that Karl Marx intuitively anticipated the profound **natural** division between economic classes, but saw it from the ideological angle. Ideology is based on the distinction between good and bad, while science knows only true and false. As for chemistry, it knows only stable and unstable. The Good, Bad, True and False are no exception and what is true today may be false tomorrow, and vice versa. The most stable truth on earth comes from mathematics. Physics counts next.

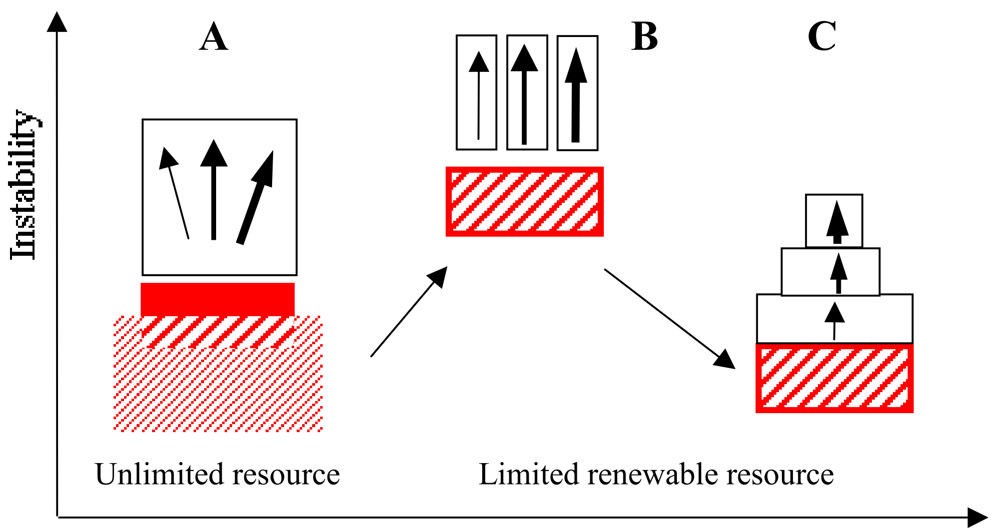


Figure 3.3.3. **A hypothetic pattern transition when resource becomes limited: the exystem of economy fragments and rearranges.**

For a chemist, neither past nor present prove anything for the future. The big question is: are the G and P classes antagonistic, as Marx believed? Do they compete or cooperate?

Figure 3.3.3 is purely hypothetic and intuitive. When the resource of energy looks unlimited, i.e., there is no visible end to expansion, the exystem goes from cooperation (A) to fragmentation and competition (B) and stabilizes as a hierarchy (C). What should not be overlooked, this is how we came to current A: from hierarchy to fragmentation and competition to cooperation. Figure 3.3.3 is a pattern. It is its reversibility that is hypothetical.

This is all fantasy, but I will return to the problem in Chapters 3.6 and 3.12.

Answering the title question, the G-inequality is natural, the P-inequality is supernatural, which means: even more natural.

3.4. BONDS OF ELECTRONS AND BONDS OF INK

The key to the origin of wealth is, as economists always assumed, the institution of property, which is nothing but a system of bonds. They require a lot of energy to be broken (which the Russian Revolution of 1917 brutally did) or to be created, which economy (or violence) does, but much less energy to redistribute them at a market place.

The cardinal question, to which I am anxious to find an answer, is whether the transformation of long term patterns is reversible. I see it as the central problem of generalized chemistry. More specifically, what are the factors of transition between democracy and authoritarian rule, if any?

The very possibility of social and economic prognosis—not at the level of individual events, companies, and stocks—follows from the limited number of combinations of a limited number of atomic entities. To give a molecular example, butane, C_4H_{10}, consists of 14 atoms. They give only two **stable** combinations:

$$\mathrm{CH_3{-}CH_2{-}CH_2{-}CH_3} \qquad\qquad \begin{array}{c} \mathrm{CH_3} \\ | \\ \mathrm{CH_3{-}CH{-}CH_3} \end{array}$$

***n*-butane** ***i*-butane**

The small number of stable molecules here is the result of the properties of the atoms which can combine only by certain rules. Prediction, therefore, becomes possible if the system is small enough. But if exystem is always large and complicated, how can we predict anything? This is possible if we deal with patterns and not configurations of events.

Regarding rules, novelty in exystems always introduces uncertainty, but high level patterns can be very stable over long periods of time.

My reasoning in this segment is utterly speculative. I am trying to formulate a question with half the answer inside and the direction to search for the other half which may or may not be found. This line of reasoning, however wavering, has a foundation in central concepts of Pattern Theory. Therefore, there is not too much hubris in making a next step. I would compare the stability of abstract evolutionary patterns with the stability of the laws of physics (a trendy topic): if our time scale is too short to notice their change, they are **practically** stable.

If so, hypothetically, the abstract historical patterns may be just a set of stable forms transformable into each other under favorable circumstances. The tightly knit society that behaves like a whole—Theocracy, Fascism, Maoism, and totalitarian Marxism—could become, again, hypothetically, the predominant pattern in the West under the conditions of scarcity, depletion of resources, and invasion of alien culture.

The fragmentation of society into tribes and small communities could be another relevant condition. The next intriguing question is what happens when they aggregate into a larger sub-nation. Will it revert to the Western type evolution toward freedom and individualism? Are freedom and individualism possible without ever-expanding access to natural resources of matter and energy? Is a democracy feeding from garbage dumps possible?

> I am unable to find a place for a counterpart of economic **value** in chemistry. It does not mean that there is no parallel. I have an impression that economists agree that value is a property of exchange, but disagree on why value exists and how it is as it is. As a lay outsider, I suspect that value is something like survival of the fittest, which is a tautology. The question why an object is as it is makes sense only if there is a known case of that object being different.

Molecular chemistry knows only that matter and energy are conserved in any transformation, but operates with **prices** of transition from one configuration to another.

The bonds between the atoms of the material wealth are regular physical and chemical bonds. The bonds of property that connect humans with their possessions are drawn in the ink of signatures (if not enforced by threat of violence). The following is my attempt to generalize the concept of bond, preserving its chemical behavior. The question is why the **smooth**, non-violent rearrangement of bonds, whether of ink or of electrons, is possible at all.

Consider two elementary configurations, A—B and C—D , that exchange their "atoms." It would not occur to a molecular chemist, but let us fantasize of A and C as owners and B and D as marketable entities (goods or money). Let us see if there is a pattern similarity between market exchange and molecular exchange.

The molecular exchange leads to a more stable state. In the equation I , ΔE is a change of stability expressed as loss of energy into environment. The reversed exchange (II) needs the same energy to be consumed. ΔE is the measure of the stability difference.

$$\text{A—B} + \text{C—D} \rightarrow \text{A—C} + \text{B—D} + \Delta E \qquad \text{(I)}$$

$$\text{A—C} + \text{B—D} + \Delta E \rightarrow \text{A—B} + \text{C—D} \qquad \text{(II)}$$

An equilibrium is the final state for reversible transformations, which are typical for molecules, **Figure 3.4.1**.

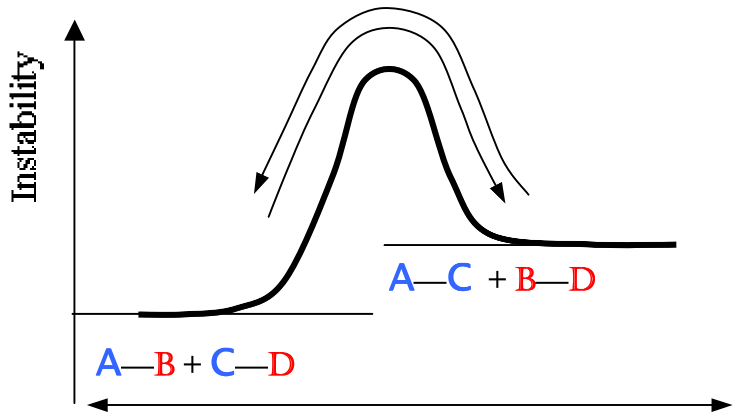


Figure 3.4.1. Chemical exchange in equilibrium

Molecular chemists always deal with very large numbers of molecules. In this case the relative weight of a configuration in a mixture—a soup of configurations—is **concentration**. Equilibrium then amounts to constant **concentrations** of more and less stable configurations. For a single set of interacting molecules concentration translates into relative **time** of existence of a configuration: we can say that the configurations spend more time in the more stable state than in the less stable.

> An individual like you and me exists in a single copy. Yet the configurations such as being at office, bedroom, dinner table, on the road, etc., form an "equilibrium" with average residence times in each. The position of the equilibrium depends on the **longer trends** of life. The same can be said about an economy. Thus, we could regard a stable equilibrium between the bull and bear markets as a sign of a normal mode. The market bubble can become a new normalcy, for example. The economists perfectly realize that and speak a language translatable into chemical one.

This is the same as to say that the probability to catch the system in the more stable state is higher than in the less stable one, which is a blunt tautology. Probability and stability are just different ways to say the same. How different?

The ratio of concentrations or probabilities $\boldsymbol{K}$ (equilibrium constant) in **molecular chemistry** depends not only of ΔE , but also of temperature T. There are some physical subtleties regarding energy that I ignore.

$$\Delta E = - \ RT \ln \boldsymbol{K}$$, where R is constant.

$$K = e^{-\Delta E / RT}$$

In the state of equilibrium, the energy of the system (i.e., instability) is minimal. It follows from the above exponential relation that a relatively small change of energy translates in a significant shift of the equilibrium. For reasons omitted here, the same is true for the speed of a molecular transformation: a small change of the transition barrier results in significant change of the reaction speed. Temperature has the same effect!

But **in the world of exystems**, where energy translates into money, it looks like it takes increasing amounts of efforts (in our times always measured in money) to achieve diminishing effects: **the law of diminishing returns**.

> **DIGRESSION**. Why is that? This needs a separate discussion, but here is the first take at the subject.
>
> Entirely hypothetically, the increasing technological and administrative complexity of the modern economy and its increasing temperature (i.e., frequency of unexpected events, as well as speed of expected ones) speeds up all economic processes, **undesirable, as well as desirable**. It takes more and more resources to suppress the former and to push ahead the latter. In molecular chemistry it is well known: temperature accelerates the desired transformation, but decreases its **selectivity** by enhancing byproducts, i.e., waste.
>
> Ultimately, the law of diminishing returns is a consequence of the very non-equilibrium nature of exystems. **You need increasing efforts to achieve decreasing deviation from the state of equilibrium** , especially, in a system with growing uncertainty as result of growing complexity. The complexity grows because of the expanding generator space, which is exactly what complexity is (see The New and the Different). Each possible configuration, therefore, becomes a shrinking grain of sand, buried in the expanding desert. Or, to look from another angle, you need more force—and more muscular energy—to keep a string in a more compressed state. The Atlas of Economy holds on his shoulders an ever-growing globe.
>
> 
>
> Intuitively, it is pretty clear, but this is my homespun stuff. There must be a simple mathematical explanation, but I am not aware of it.
>
> Totalitarian system, in which the carrot is attached to the stick of threat, works in a different way; see Alexander Solzhenitsyn, *The First Circle* (1968), to which the story of the North Korean nuclear bomb could be a complementary evidence of non-monetarianism.

The next three paragraphs are the essence of chemistry as the science of time, whether time runs or stands still.

> The temperature matters because of the **transition barrier** between the stable states.
>
> The barrier looks higher or lower depending on which side of the barrier you are, but the difference between the heights equals the difference in stabilities. This is why we do not need to know the height of the barrier to predict the position of equilibrium. What we need the barrier for is to predict **how soon** the equilibrium will be reached, or, more generally, how soon something is going to happen.
>
> Temperature is the level of **chaotic** energy. If it is high enough to create sufficient instability, the system can cross the barrier.

The above core ideas of chemistry translate into a warning against reckless application of physics, molecular chemistry, or, for that matter, any hard science to economics and human matters in general. Some reasons are:

1. Physical temperature is not directly applicable to exystems. Neither is the abstract temperature used in theory of dynamic systems.

2. Human exystems are not exactly reversible. Their behavior seems to tell you that if 2 + 3 = 5 today, do not necessarily expect 5 –3 =2 tomorrow.

3. Stability and energy have no exact and unambiguous measures in exystems.

4. Exystems are under strong and not completely accountable influence of environment and larger exystems.

5. The iceberg of world economy has a large invisible underwater bulk: black market, secret deals, hidden budgets, disinformation, disruptions, etc. The politics, though not yet quite global, have their own dark vaults.

Other reasons can be found in *The Age of Fallibility* by George Soros (Public Affairs, New York, 2006). He writes:

> Exactly where the dividing line lies between what can and cannot be known is one of the things that cannot be known (p.4).

Although I completely agree with that, I believe that the chemical approach to exystems can at least help push the dividing line farther into the darkness, illuminating some previously unseen areas of the future. Like the ancient maps of the world, the new maps of the future may be full of errors and fantasies, but they can preserve the topology and even stimulate search for a new New World.

Note, that social instability can be created by ordered action (subversion, terrorism), as well as by market chaos (high food prices). Economic instabilities seem to arise on their own, as well as from external shocks and pressures. Thus, a smooth laminar flow becomes turbulent if too much pressure is applied to it.

Coming back to the chemistry of exchange, another chemical toolbox is on hand.

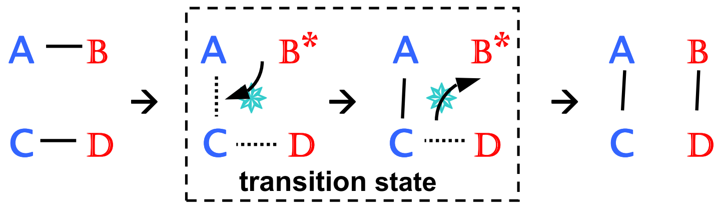
There are two ways of transforming a structure M into another structure N: (1) break up M into peaces and reassemble them into N and (2) use the chemical method of simultaneous stepwise rearrangement which is hardly ever possible outside chemistry.

The following transformations III to VI illustrate the first way.

A—B → A* + B* + ΔE_1	(III)
C—D → C* + D* + ΔE_2	(IV)
A* + C* → A—C + ΔE_3	(V)
B* + D* → B—D + ΔE_4	(VI)
A—B + C—D → A—C + B—D + ΔE	(VII)

A—B is taken apart (III) and so is C—D (IV). The parts are reassembled in steps V and VI. The asterisks indicate instability ("something must be done and better sooner than later"). You can think of A as photocameras and B as specific batteries for them. A stock of cameras without batteries or batteries without cameras are unstable business situations. The aterisk means trouble, and the way (III-VI) has four of them at some moment.

The second way (VIII) is to conduct the exchange as much localized in space and time as possible, like at a farmers market, paying cash. The centres of instability are either minimized in number or delocalized (smeared around), which lowers their instability, most participants do not leave the limited area of the transition state and the transformation completes in an instant, with no futures of any kind (debt, credit) involved. The transformation with the lowest instability of the transition state is the fastest. Since all modern economy runs on credit, the credit crunch slows it to a halt.



(VIII)

$$A{-}B + C{-}D \rightarrow A{-}C + B{-}D + \Delta E \qquad \text{(VII)}$$

I am intentionally using here a mixed pseudo-chemical and quasi-business language because I want to stay at the level of patterns covering both.

To see the pattern of molecular and economic exchange in all their generality, as well as difference, would require going into extra technicalities, which are better be left for another opportunity. While economics, as part of human matters, is significantly open to wide audience, organic chemistry is not. A skeptic in me signals that in human matters what is not open to wide audience is most probably junk.

The initiation into Pattern Chemistry starts with an observation that structure, exchange, stability, bond (whether of ink or of electrons), competition, prediction, speed ("reaction rate" if about molecules), concentration, spreading ("delocalization", if about electrons), catalysis, even creditor and debtor ("donor" and "acceptor," if about electrons), are as much the stuff of chemistry as of economics, sociology, history, politics, culture, and social psychology.

3.5. EVOLUTION AS HIGH WIRE ACT

Obviously, energy and stability/instability are not the same. One is a universal physical concept and the other is raw, fuzzy, cryptic, and out of place in hard sciences, except for some technical areas of mathematics and mechanics. I will proceed to the relation between them after a short overview of some already expressed exystemic ideas.

There is a deep pattern kinship between two exystems: economy and life. They both require supply and dissipation of energy for rearrangement of bonds between generators. Moreover, they are layers of the same global exystem that is ultimately run by solar energy. I have supported this idea by references to Vladimir Vernadsky and Eric Beinhocker. I hope to bring in Robert Reich's *Supercapitalism* later.

That the cow is a "milk factory" is a common metaphor. "Cash cow" links life and business. Where there is life there is chemistry. With this not exactly Aristotelian logic I conclude that where there is economy there is chemistry. Finally, where there are humans, there is economy, which puts us closer to Aristotle.

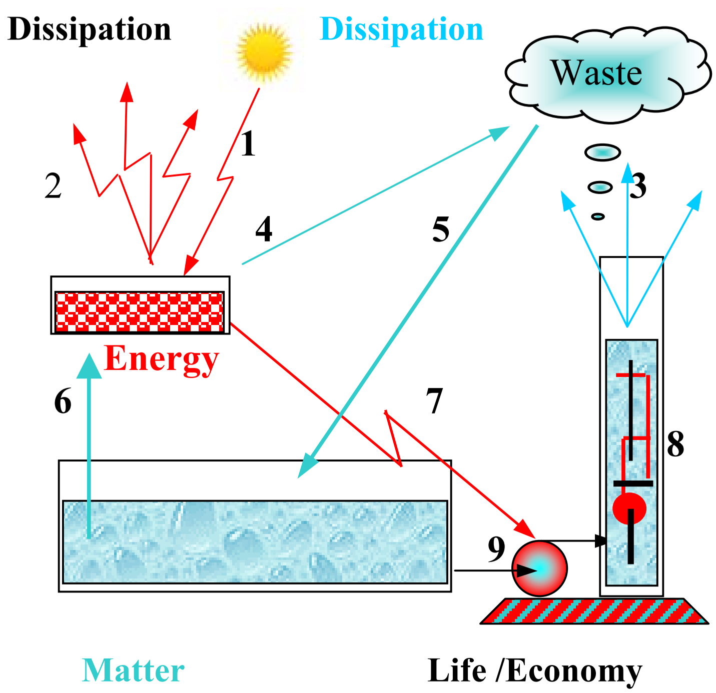


Figure 3.5.1. **Irreversible dissipation of energy, conservative movement of matter, and production of structure in economy and life. Information (not shown) is part of structure.**
1, Solar energy; 2, dissipation of energy; 3, dissipation of matter; 4, energy waste (CO_2); 5, return of dissipated matter; 6, mineral fuel; 7, energy supply ; 8, configuration of life/economy; 9, production of structure ("wealth pump").

In Essay 56, Out of One, Many , I presented several pictorial illustrations of the economics-chemistry parallelism. In **Figure 3.5.1** I am adding another variation on the same idea. The cornerstone idea of natural sciences—global conservation of matter and dissipation of energy—must be, in my opinion, the most fundamental starting principle of **economics as the science of management of the human household in the Universe**. It has been extensively discussed in the geospheric literature, but I am not sure about its recognition in economics. As one of the fundamental principles of chemistry, molecular or not, and, it is the main justification of the very subject of econochemistry.

From the point of view of chemistry, whatever happens on Earth is redistribution of bonds between atoms and is always **accompanied** by dissipation of energy, the main global source of which is the sun, followed by the deep earth itself.

> Physics has a wider view of the world, including all kinds of motion, for example, wind. The border between physics and chemistry is imaginary. To philosophize, bond is a constrained or coordinated motion of objects. There is as much chemistry in a planetary system as in personal relations, but more stability.

What exactly happens in an exystem is its history, also called evolution.

History of an exystem consists of events. Energy is needed for any event in the exystem as far as this event involves a negative bond. Even a dying empire, business, and organism needs energy until the last negative bond goes away.

In order for the exystem to irreversibly evolve, a series of **external formative events** is necessary. This is where the question about energy and instability comes from. To perform an act of change (to induce an event) **against entropy** we need a temporary surge of energy consumption.

The act of change consists of passing through a period of instability. This transitory process, by the very essence of instability, is short, although only on a particular time scale.

There is no energy but physical energy. Exystemic stability, however, is a very general concept comprising equilibrium as well as steady state and homeostasis. The latter is the ability to return to a stable state—the initial or different one—after a disturbance, external or internal. Evolution is a never-ending series of high wire acts with no points of return, in which the acrobat can take a rest on stable platforms.

It is well understood that sunlight is a form of "ordered" energy capable of performing work. But we can go farther by noting that light is a "periodic" form of energy, consisting of photons propagating as waves. My choice of an ideogram for this pattern would vary from waves on water to the newspaper dropped on the lawn daily.

There are other more or less periodic phenomena: **(1) rotation** of the Earth, resulting in the periodic change of temperature and humidity, **(2) tides**, and **(3) seasons**. We can generalize even further by adding **irregular but systematic repeating events**, like **(4) volcanic eruptions, (5) climate changes**, and **(6) winds and other atmospheric events**. It is the repetition or alternation of events that matters more than regularity for driving evolution, provided there is some stable distribution of their probability. This property of evolving systems prompts me to offer an additional definition of exystem: **the evolving complex system that absorbs a series of external events and generates a**

series of internal events, not necessarily in the stimulus-response knee-jerk way and not even in a cause-effect way.

The quantum properties of light are essential for photosynthesis, although daylight is a kind of a quantum mess. The alternation of day and night is equally important for photosynthesis, but it would work even if there were no regularity in light-dark alternation.

Considering human history, we could add **(7) wars, (8) invasions**, and **(9) epidemics** to the above order-creating factors. I realize that this may look far-fetched. Nevertheless, **(10) major discoveries** and **inventions**, coming out of the blue, have since long become formative economic events, regardless of what they are about. I would also add acts of royal succession and democratic elections, but this is already a murky area because they are stages of individual human histories.

Attempting to find a general term for events 1 to 10, I see nothing better than **event**, which is an **atom of change**. From the point of view of chemistry, therefore, atomism of being in space, as well as in time, is the main source of order in evolution. When I label chemistry as a science of time, I mean that its main subject is the event with its beginning, mechanism, and end, even if the end is still in the future. **Pattern chemistry, therefore, is a science of open-ended events.**

In the mostly physical world, events continuously follow each other without interruption, while in the mostly chemical (and, therefore, biological and social world) events start and end, separated by steady states.

> The idea of a god is more chemical than physical. The god mixes the right reagents and watches the result before experimenting further. Greek mythology and Hebrew Genesis are pure chemistry, starting with external formative events.

If we accept the chemical view of the world, we need to substitute **generators** in the sense of Pattern Theory for atoms and make the next step: the chemical change (chemical event) has a combinatorial nature and, therefore, a countable number of outcomes. Although the combinatorics could be explosive and unmanageable, there is a limited number of **patterns**, the higher the level, the lower the complexity. If so, by reducing the number of generators, we can see into the future (better to say, discuss the future), up to a point.

The next step is to accept the idea that, to be one the safe side, at least in the beginning of this millennium, economics comprises all global processes in which structure is created, changed, and destroyed. It does not make sense to study economics at the level of atoms, of course, but the principles do not change with changing the scale.

> It must be noted, of course, that while the ultimate source of energy for life on earth is the sun, economics uses also the exhaustible (so we believe today) resources of mineral fuel. The end of mineral fuel promises to end the current

"economic eon" of industrial growth, but how? This very question suggests a certain direction of thought.

Figure 3.5.1 is a pictorial pattern of both economics and biochemistry. The cow would be a good ideogram, but any individual human life, mine or the reader's, would be even better. Since the discussion is getting personal, it brings us to the central for me question: what is the place of humans in economy? I have already characterized it as the pattern covering humans, enzymes, and ribosomes: bond processor. The bonds fall into the overwhelming open range with atoms near one end and elementary ideas and their verbal expressions near the other.

Figure 3.5.2 from Essay 55, The Chemistry of Money (where it is **Figure 12**) illustrates the pattern of technology in industry and biochemistry as bond processing along a sequence of instructions.

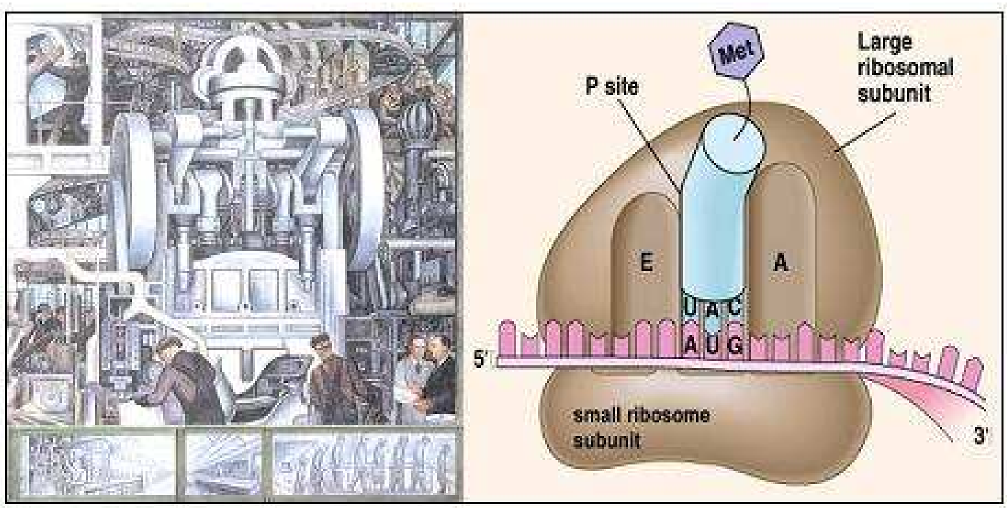


Figure 3.5.2. A fragment of Diego Rivera's mural *Detroit Industry or Man and Machine* and ribosome, the main machine of the protein-making shop. The engineers in the bottom right hand corner of the mural, apparently, check with the DNA script.

Sources: http://www.marxists.org/subject/art/visual_arts/painting/exhibits/muralists.htm ; http://kentsimmons.uwinnipeg.ca/cm1504/proteinsynth.htm

It would be childishly naïve to think that humans can control economy as a whole because economy today comprizes everything under the sun and it incorporates and controls the unruly humans as its functional part. What an individual can do is to navigate the stormy ocean of economy on his or her own risk, alone or as a family, tribe, or ideological cohort.

And yet science starts with childish questions. Yes, we could control global economy (the globe, to be exact) if we had resources of energy exceeding what the earth gets from the sun and mineral fuel. This is a necessary but not sufficient condition. We would also need enough time to develop the necessary knowledge and infrastructure. In short, we would need Archimedes' lever and God's energy. Regarding the latter, if humans are made in God's image, where do they take their energy and what do they do with it? See next Chapter.

3.6. METABOLIC COST

In Diego Rivera's mural (**Figure 3.5.2)** **,** the huge machine stamps out automobile parts, the workers feed it with material and remove the product, and engineers seem engaged in purely mental work. "Metabolic cost" sounds like pure biochemistry with a dash of economics, but it is a subject of industrial engineering, as well as biology and prostetic technology. This hybridization of man, machine, and animal is, in my eyes, an evidence of a truly universal nature of economics.

Here are two definitions:

> **Work physiology** *(Industrial Engineering)* An aspect of industrial engineering that takes into account metabolic cost, measurement and prevention of work strain, and other ergonomic factors in the design of tasks and workplaces.
> **Metabolic cost** (*industrial engineering*) The amount of energy consumed as the result of performing a given work task; usually expressed in calories.

With pattern imagination, which is not bound by the interdisciplinary borders, I am taking off into the skies with the thesis:

Economics of the future will be based not on money, but on energy. It will be counting wealth in currency of calories, not euros, yuans, and not even ounces of gold. Careful, the future Icarus the Economist! Not too close to the sun!

The following few examples illustrate the range of much more numerous objects for which metabolic cost has been measured.

THE METABOLIC COST OF BIRDSONG PRODUCTION
Kerstin Oberweger and Franz Goller, The Journal of Experimental Biology 204, 3379–3388 (2001) 3379.

THE METABOLIC COST OF NEURAL INFORMATION
SB Laughlin, RR de Ruyter van Steveninck & JC Anderson, *Nature Neurosci* **1,** 36-41 (1998).

THE METABOLIC COST OF SWIMMING IN DUCKS
Prange, H. D. and K. Schmidt-Nielsen 1970.. J. exp. Biol. 53: 763-778.

METABOLIC COST OF GENERATING MUSCULAR FORCE IN HUMAN WALKING: INSIGHTS FROM LOAD-CARRYING AND SPEED EXPERIMENTS
Timothy M. Griffin, Thomas J. Roberts, and Rodger Kram, *J Appl Physiol* 95: 172-183, 2003.

EFFECTS OF SUBGRAVITY TRACTION SIMULATION ON THE ENERGY COSTS OF WALKING
Wortz, E.C., and E.J. Prescott, *Aerosp. Med.*, 37(12):1217-1222, 1966.

ENERGY COST AND MUSCULAR ACTIVITY REQUIRED FOR LEG SWING DURING WALKING
JS Gottschall, R Kram , *J Appl Physiol*, Vol. 99, No. 1. (July 2005), pp. 23-30.

There is a metabolic cost of doing nothing, all the more, discussing an industrial process, as the engineers do. There is a cost of inventing and perfecting the process itself. There is a cost of all the passionate and (rarely) apathetic activities in other Rivera's pictures, including both sleeping and observing the sleeping homeless people (**Figure 3.6.1**).

Figure 3.6.1. **Diego Rivera, mural Frozen Assets (1931), fragment.**

It is very characteristic of a living organism, as well as of an exystem, that even when no work is done at all, the energy must be consumed and dissipated. Thus, when we take a book from the table and put it on the floor, we do not perform physical work (its value is negative), but the metabolic cost is always positive.

> *The World Without Us* , by Alan Weisman (Thomas Dunne Books, 2007) is the best illustration that I know of what metabolic cost means for the very large exystem of man-made things, i.e., Technos. It shows what is going to happen when humans disappear and stop paying the metabolic cost of material civilization.

How can we build economics as the science of everything? Without going into details, which I cannot handle from my pattern heights, I would introduce **minimal systemic energy consumption (SEM, systemic energy minimum)**, applicable to exystems. **Metabolic cost**, however, is as good a term. It sounds very human. I am not aware whether this idea is new or old.

A certain amount of food, for example, must be consumed to provide energy necessary to maintain negative bonds on which life is based. An organization will not function if the revenues fall under a certain level. This is the direct consequence of the nature of exystems. Starving for energy and matter, they either die or morph and evolve. I believe that this is the most trivial but most overlooked by economists property of their subject.

SEM is a generalized version of Basal Metabolic Rate (BMR), the energy dissipation necessary for maintaining only absolutely necessary biological functions, or something like the minimal cash flow necessary for the survival of a business. Obviously, it can be sufficient only for a limited time and should be measured by a combination of both energy and time. A human can abstain of food for 50 to 70 days before death (I have done it for 40 days, saving energy as much as I could and. of course, performing no work). It is, more or less, the energy supply for subsistence.

I am far from any practical suggestion how to specify and measure the highly variable and fuzzy SEM. I regard it as a kind of an abstract idealized zero for the energy supply of an exystem. What is above zero constitutes a measure of possible created order.

Thus, families living from paycheck to paycheck could be somewhere near their SEM. The life of unemployed during the Great Depression also comes to mind. **See Figure 3.6.1**, the epitome of metabolic cost.

Part of the chemical paradigm is that **chemistry does not need absolute values**. As a science of time, it compares the likelihood of alternatives in terms of MORE and LESS. The chemistry of it all lies in the structure of MORE and LESS.

> One of the readers of Paul Krugman’s column in The New York Times writes :
>
> 
>
>
> “If you want to be the future’s economic tiger, you have to show that you know how to do as much as possible with minimal energy consumption and minimal environmental impact.”
>
> Paul Krugman refers to California as a positive example of this trend.
>
> I would remark that if economists pursue the goal of powerful “tiger” economy, SEM is the energy supply of a sleeping or hibernating tiger. Tigers do not hibernate, but to mention bear would be economically sacrilegious, even though the bear is on California’s flag. The bears secure their hibernation energy supply in advance and renew every year, but it does not change the principle: you need a minimum to survive until better times. This is much more simpler for a homogenous united nation than for a federation or internally torn apart country or state.

Wealth, in my opinion, is what is produced and appropriated **in excess of SEM**. It is the energy and matter necessary to keep homeostasis in the exystem, whether this is organism or organization. As soon as we accept this, the Marxist economic theory inescapably grabs and pushes us into the red corner. However allergic to Marxism, I begin to see that the theory of **surplus value** (*der Mehrwert*) , formulated originally in strictly economic terms, and only later colored red, could be a conceptual step toward a chemical view of economy in terms of matter, energy, and structure. All I can try to do is to attempt some initial exploration in this dark area.

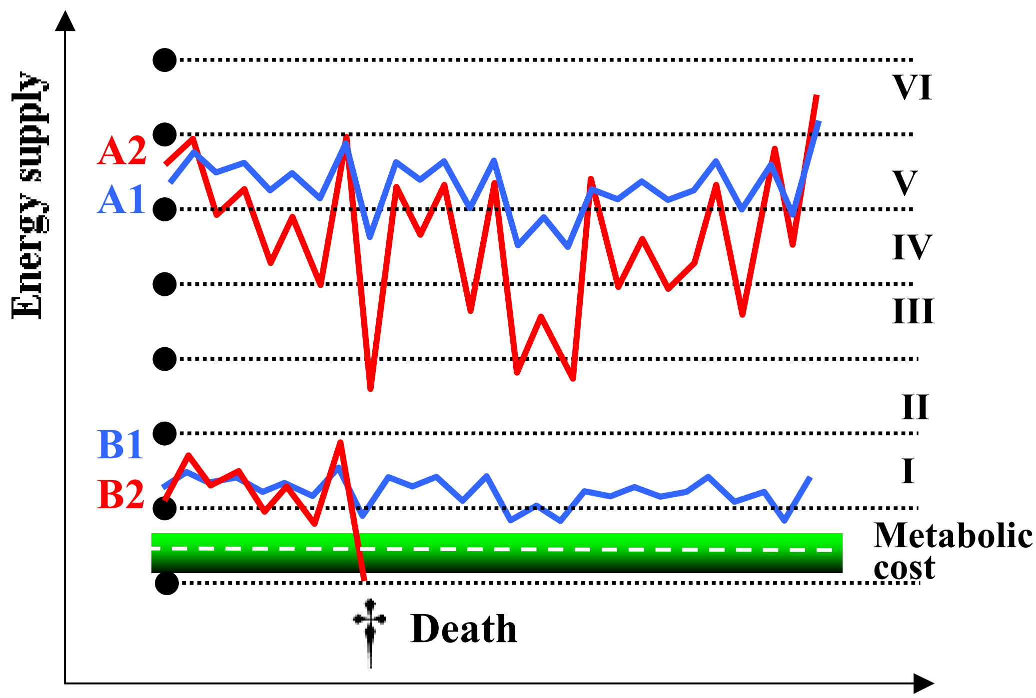


Figure 3.6.2. **Prosperity (A) and poverty (B) at low (blue) and high (red) range of economic fluctuations (temperature).**

Figure 3.6.2 illustrates the idea of the previous paragraph. The scale of energy supply is divided into arbitrary ranges from **metabolic cost** and **I** to **VI**. Energy supply can come from various sources, but it should be uninterrupted, which is the main requirement of open systems with internal order. A subsystem well above the generalized metabolic cost can go very low due to economic fluctuations and "reversals of fortune, " but it is not quite probable that it will drop to the basement ranges of **level I** and **metabolic cost**. While above them, it can always try to climb the ladder.

The range of fluctuations is the measure of the economic temperature. There could be different kinds of temperature for different aspects of economy. The situation is radically different at the bottom, where existence becomes a risky business with the possibility of irreversible death of the subsystem. Welfare economies try to keep their citizens above the SEM. History, even the current one, however, is full of episodes of mass hunger and physical death. In developed countries, "death" means an irreversible or hardly reversible descent. Ascent is possible form any level.

As I interpret the idea of Karl Marx, the human within the SEM range can improve his chances of survival by becoming a component of the employer's household, i.e., accepting the contractual bond of and losing independence. At a better economic situation, the worker can take the risk of breaking the bond and establishing a "better" one. The implications of this simple consideration underlie the semi-hard sciences of human matters. Economics is always throwing predictions around but always dragging behind the present and probably the entire human history. With a full spectrum of prediction, often somebody turns right.

History is the evolution of human stability. Evolution is the history of the tools of stability. As all world fundamentals, evolution can be defined only in a cyclic way. Stability is never stable.

The representation of wealth as the apparatus of stability, of course, is not an eye-opener, although it is not the first thing that meets the eye in wealth. What is more interesting, such terms as temperature, wealth, poverty, metabolic cost, risk, economy, and even bankruptcy and welfare have a very abstract and universal exystemic meaning. Moreover, they are applicable not just to humans, but also to the **products** of economy.

> I resist the temptation to go into technical details, but all those terms, including wealth, poverty, bankruptcy, and welfare, have counterparts in experimental molecular chemistry (excess of reagent, low concentration, reaction halt, add reagent to maintain constant temperature). Economy is a big reaction flask.

What is so chemical about my view of economy? The chemist stands firm on the ground of matter. When it is discussed not in economic terms, but in chemical ones—matter, energy, and structure—economy, which today comprises all human activity on earth, is rearrangement of bonds between atoms, normally, by big batches. Chemistry is the business of guessing how one state comes from another, which possible state comes first, and how to speed up the state we want. What the rest of the world calls information, the chemist calls catalysis. See The New and the Different and other parts of spirospero.net , in which catalysis if discussed on multiple occasions.

To summarize: with all its interdisciplinary fuzziness, **stability in an open system has its energy cost**, after all. So does instability, symbolized today (Spring of 2008) by Iraq, world finances, and Democratic primaries. Unlike physical work, stability is always positive, i.e., sits between zero and an undefined large value. Instability is simply low stability.

Figure 3.6.2 returns me to an unpleasant memory of my school Marxism: the concept of class struggle, which for a very long time was the ideological basis for the internal and external politics of the Soviet Russia. I do not remember when, probably, in the early 70's, the class struggle disappeared from the dayly Soviet propaganda and antagonism toward the West morphed into competition.

I pose here only one question: are there any "classes" from the point of view of chemistry (whatever they are otherwise)? **Figure 3.6.2** leaves no doubt that they are real.

The current (2008) period of American history clearly illustrates not only that, but also that they are economic in nature. They are not exclusively human, however.

There is a class of people, families, assemblies, businesses, and **things for sale** (**Technos**) which are dangerously close to the metabolic cost range area, the middle class that could go to lower or higher ranges, and the upper class that is practically immune to any economic situation.

In a welfare state, which may have nothing to do with liberal democracy, the lower "class" (G-class, see Chapter 3.3) is protected, at least in quiet times. During the great political earthquakes, from which no society can be guaranteed, the upper class (P-class) may suddenly become the most vulnerable layer of society, threatened by expropriation.

It seems appropriate to return to the question in **Chapter 3.3** (IS INEQUALITY NATURAL?): The rich are different, but in what sense? The rich are a different social species in the sense that they can, in principle, stay well above the metabolic cost for periods commesurable with human life span. This is a gift one step below immortality.

3.7. READING ROBERT REICH: WHAT HAPPENED IN 1970?

One of the most intriguing things about America has been for me a mysterious historical change around 1970. It was neither a revolution, nor a reform. It could be clearly seen only couple decades later, when the trend had become established. I first saw it around 2001 (see Essay 4, On the New Overcoats) in the inflation data which **Figure 3.7.1** extends to 2007.

The chart is as indisputable as fossils of ancient extinct animals or the recent chart of carbon dioxide in atmosphere. It is an evidence that something happened, although we do not know yet how it could end.

Robert Reich describes a large cluster of events around 1970 in his *Supercapitalism : The Transformation of Business, Democracy, and Everyday Life* (New York : Alfred A. Knopf, 2007).

I enjoy Robert Reich's books. He cuts the multi-layered cake of American life from top to bottom and along the diameter: from the burned underside to the decorative excesses at the top, from family to high politics and from rank and file consumer to CEO. Most importantly, he asks the right questions ahead of time. One of his books turned prophetic regarding events in my own family.

For those who at some time in life looked into selected pages of Karl Marx and Friedrich Engels, as I was forced to do in my Soviet youth, and especially for those who like me feels at home among metaphors and patterns, some novelties of our times may look like old felt hats with brushed off mothballs. Capitalism has been supercapitalism for about two centuries. It is the meaning of "super" that kept changing.

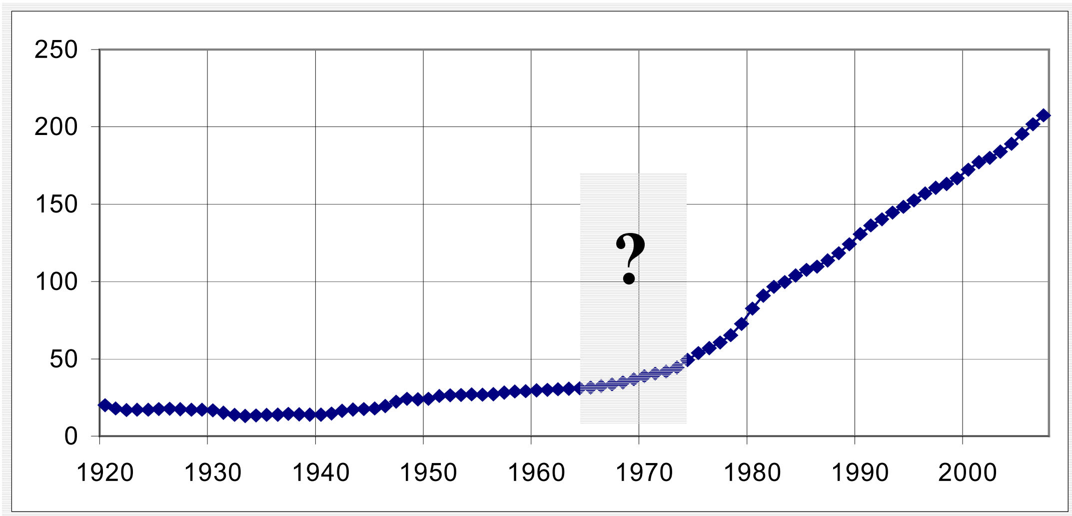
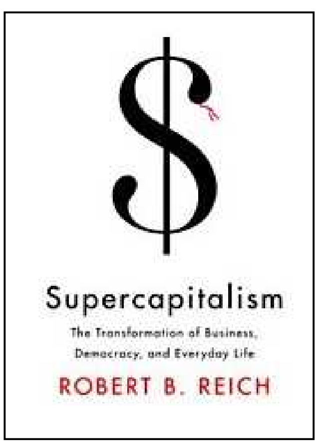


Figure 3.7.1. **US Consumer Price Index (CPI) , 1920-2007.**
Based on tables in InflationData.com.

As with Eric Beinhocker's book, I have neither intent nor qualification to analyze or criticize *Supercapitalism* even as a reader. I only wish to note that his much earlier book *The Next American Frontier* (Times Books, 1983, a quarter century ago!) had posed the same main question about 1970, although many of the present phenomena were only taking shape.



The answers were prophetic, except for two points: (1) what in 2007 Reich calls *democracy*, he called *social justice* in 1983 and (2) Reich predicted (as a pessimistic alternative to a utopian hope) the fight of companies for protection from foreign competitors. His second book, however, masterly chronicles the fight of the companies for protection from each other, while blessing globalization.

The peculiar thing about predictions is that all of them come true if we wait long enough. Robert Reich is most probably ahead of time, but not much. With all the anti-globalization protests and with the current (2008) buzz about sovereign autocratic wealth saving American financial companies, we may get an opportunity to test Robert Reich's prediction sooner than later. I personally interpret the picture on the jacket of his book, with the split tong of the dollar snake, as the split meaning of the word "save."

I am going to use *Supercapitalism* in support of the thesis about the special place of time around 1970 in history. The "1970" actually comprises several years.

I do not know what democracy and justice are from the chemical point of view because there is no consensus on them from any point of view. There is a consensus, however, on how technology works because its chemistry is open to observation and is international. The basics of business and management are as standard as the basics of molecular chemistry.

My initial tentative explanation of the modern inflation, reflected widely in simplicity and complexity, was that we were paying not just for what was necessary for maintaining human life, but for the growing Technos, the parallel exystem of man-made things. After millennia of being just an extension of human body, it began to diverge around 1970 from the human exystem, making full human control impossible in principle. Competition and symbiosis is all that remains in perspective, if not now, then at some point in the future. We are currently in a transition state, long on human scale but short on historical scale. Humans are becoming an extension of technology.

Why is the "1970" such a special point? The explosive growth of Technos was caused by the **digitalization** of its blueprint. This event is comparable with the development of the universal **genetic code** by living organisms. From the pattern-chemical perspective, a code is a code, whether genetic or digital.

Computers not only opened an unlimited combinatorial space for the components of the blueprints, but also made their **expression** into things and their material fragments easy to unprecedented degree. As a side effect, life has being flooded with complexity and junk, but the signs of coming equilibrium with decay are already seen in the form of the loss (see Essay 34, On Loss). To keep it all afloat and make your way through the mess, you have to pay some extra price. I am not sure that time is money, but money is energy and energy is speed.

> Interestingly, a similar process has been running, without any computers, in art since the dawn of the twentieth century, but that is a separate subject. Today art is also computer-enhanced. Art is the weathervane of human evolution.

Today, when automobiles compete with humans for corn, I have no reason to doubt my earlier interpretation. Carbohydrates can be as fattening for economy as for human bellies, provided somebody's bellies are empty. Without empty bellies economy won't work.

In short, the "1970"-to-present trend of economy shares the general evolutionary pattern with life on Earth. This is where I would again turn to Eric Beinhocker for support with his pattern of evolving wealth, whether economic or biological. A as a chemist, however, I can only go ahead alone, only occasionally paying tribute to my conceptual icons.

So, "1970" was a great exystemic change. What is exystemic change, then?

TABLE 3.7.1. THE STRUCTURE OF EXYSTEMIC CHANGE		
	FACTOR	CURRENT CHANGE
1	Energy	Exhaustion of resources; complexity needs more energy to maintain negative bonds; work is inefficient at higher temperature. Exhaustion means coming to a steady state instead of growth.
2	Matter	Exhaustion of resources, theoretically manageable by recycling.
3	Entropy (Uncertainty, disorder)	Collapse of empires, growth of independent powers, concentration of wealth in many centers instead of one or two. All that increases uncertainty (a bird in the hand or many in the bush).
4	Temperature	Temperature is the frequency of events, always higher in democracy than in an autocracy, more globally than locally. High temperature weakens both positive and negative bonds. Increasing quantities of energy are needed to cool the world structure and prevent its melting.
5	Structure	Complexity of the world—number of generators and bonds—is growing because of globalization and bureaucratization. The configuration of economy solidifies and becomes brittle because of large number of bonds. Thomas Hobbes' Leviathan grows global.
6	Transition state	World economy is coming to a new stable state. We are in a transition state comprehensible only with hindsight from the next stable state.
7	Catalysis	The role of humans in the evolution of Technos is catalytical: they work as enzymes in the metabolism of man-made things.
8	Information	Overwhelming, incomplete, noisy, vulnerable, irrelevant, and often deceitful.
9	Competition	Fierce, carnivorous, expensive, destructive, deceitful.
10	Metasystem transition	Growing specialization and interdependence of components of economy. Economy becomes total, all-comprising, and built of "organs" and "tissues," like an organism. The new world does not know autonomy. Economy engulfs art, science, ideology, faith.
11	Time	Exystemic (Leibniz') time is measured in events, not in physical time units. Modern time has a large number of hierarchical scales.
12	Event	Large scale events are on the Cambrian explosion and Permian extinction scale. Medium scale events become predominantly external for the majority of components. Small scale events become irrelevant or unmanageable.
13	History	History turns from the expansion of Technos to the adaptation to the results of expansion.

Table 3.7.1 presents the structure (i.e., list of increments, as in finance, especially, fraudulent one) of current change, for which the term **supercapitalization** would be appropriate, were it not so clumsy. **Globalization** would be fine with me, but it is not abstract enough. **Complexification** is another awkward term. **Leviathanization** would be my

preference, if not so monstrous a word. It is the same evolutionary pattern that brought to existence complex multi-cellular organisms with specialized organs and tissues.

> The pattern has been investigated at the highest exystemic level by Valentin Turchin and Cliff Joslyn , who called it **Metasystem Transition** (see **Chapter 3.8**). It deserves to be called so, but if it is too long, the biological term **differentiation** may look slightly better. And what is wrong with **development**?

The chemical view of the world operates with energy, entropy, temperature (borrowed from physics), matter, structure, transition state, and catalysis (from molecular chemistry), information, competition, and specialization (from biology), as well as with the indigenous exystemic notions of time, stability, event, and history.

The lines in table express my intuitive perception of where history is moving. They should all end with question marks. Here I shall discuss only selected dimensions of change.

A possible interpretation of "1970" is simply an acceleration of the growth of Technos (**Line 11** of the **Table**), for which we must pay, although it does not pay back either for our Systemic Energy Minimum (SEM, see **Chapter 3.6**) or the metabolic cost of most human activities. It pays only for itself and is not biologically (read: humanly, but without any moral overtones) justified.

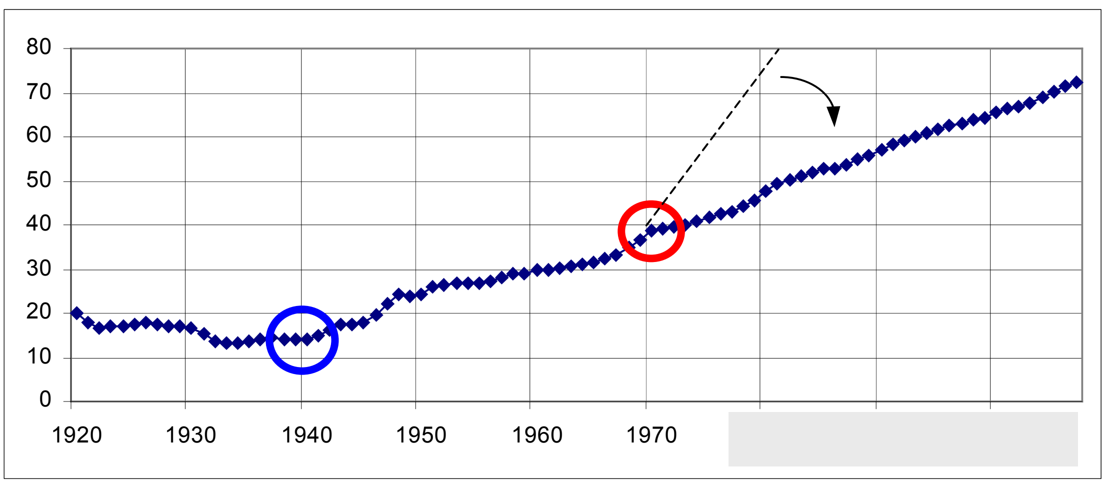


Figure 3.7.2. **Manipulated chart of US Consumer Price Index, 1920-2007. Starting from 1970, the CPI values are divided by 5 and spliced with the previous period. A new special point is seen at 1940.**

The "1970" means that we pay price for the ever increasing technosphere (the man-made counterpart of biosphere) of quickly aging, mostly disposable and biologically unnecessary things having lifespan much shorter than the human lifespan. Technosphere is increasing because man-made products became a life form, a new taxonomic super-kingdom. They have their DNA in the form of blueprints. Around 1970 the blueprint had begun transition to digital form, which made the reproduction, recombination, and propagation of things exceptionally fast. Using Eric Beinhocker's term, after 1970, the material wealth acquired the property of "biological wealth."

Technology today is at an evolutionary stage comparable to viruses. It needs human society with its enzymatic and mutagenic (chaos-inducing) activity, as well as infrastructure to multiply. It invades, eagerly welcome, large countries like China and India, formerly backward, but heirs of sophisticated past civilizations. It invades direct progeny of European civilization, like Argentina, Chili, and Brazil. It invades even the Islamic terrorist movement which is in the business of deconstruction of the Western structure by ultimate breakup of all possible bonds (see Steve Coll, *The Bin Ladens: An Arabian Family in the American Century*, Penguin, 2008)."

As result of new technology (in agreement with Robert Reich) and, especially, digitalization, the entire time scale of economy (in the wide sense, i.e., all human matters) shrank. We could say that time increased its pace in 1970, but how much?

Figure 3.7.2 is a manipulated **Figure 3.7.1**. I simply divided its slope by five after 1970 and spliced it with the previous segment. By doing this, I imitate a slowing of the Leibniz time scale which counts not hours, days, and years, but events. The time ticks after 1970, therefore, are stretched to the right.

Unexpectedly, a new transition point appeared under the magnification of the pre-1970 period: 1940. A hypothetical interpretation of the 1940 (WW2) could be that it was the end of American isolation and the formal beginning of the process of globalization. Paradoxically or not, globalization started with the fragmentation of the world, collapse of land empires, and formation of the global market with many new players.

I must cite here my general disclaimer for this text.

> My statements and conclusions about academic subjects for which I have no qualifications (i.e., outside chemistry) are intended to illustrate the method of discourse and the use of chemical ideas. Although they are my opinions, they do not have any claims for being didactically, factually, and logically true. They are nothing but seeds for a Socratic discourse.

In short, after "1970" the **technology of breeding Technos** ("molecular biology" of Technos) took shape. What exactly changed in **the way Technos lived its new life** is perfectly described by Robert Reich. One of the conclusions I can draw from *Supercapitalism* , as well as from my own direct observations, is that politics has become a sector of economy, as everything else does, including religion. Presidential elections are now an industry, too. Also, a Minotaur , part sophisticated high tech pro swindler, part crude deadly man-eating mud wrestler.

After 1970 Technos began its transition toward a final, not yet completely known, place in the developing **superorganism** of Francis Heylighen. This is a very old but resilient idea. **Figure 3.7.3** (from Essay 43. The Cold Civil War in America , where it is **Figure 2**) offers a glance at the creature. Essay 33. The Corg may be of interest, too.

Robert Reich illustrates the post-1970 trend with a series of impressive charts. They show growth of the US financial sector, productivity versus compensation, distribution of family income growth, ratio of average top executive and CEO compensation to average worker's pay, other indexes of inequality, growth of campaign spending (inflation-adjusted!), and such later trends as the dizzying surge of the lobbyists

Figure 3.7.3. **The fractal Leviathan.**
Modified fragment of the frontispiece in early edition of Thomas Hobbes' *Leviathan*. Original: source1; source2.

The wild Dow, however, looks tame on the logarithmic scale. US productivity on linear scale looks similar, but much steadier, see **Figure 3.7.4**.

At this point I cannot interpret **Figure 3.7.4,** but I may try later.

We cannot expect much from any world view in pragmatic terms, but it is supposed to explain large scale patterns fossilized in statistical and structural data, like in **Figure 3.7.4** . What else can we expect from it, see **Section 4**.

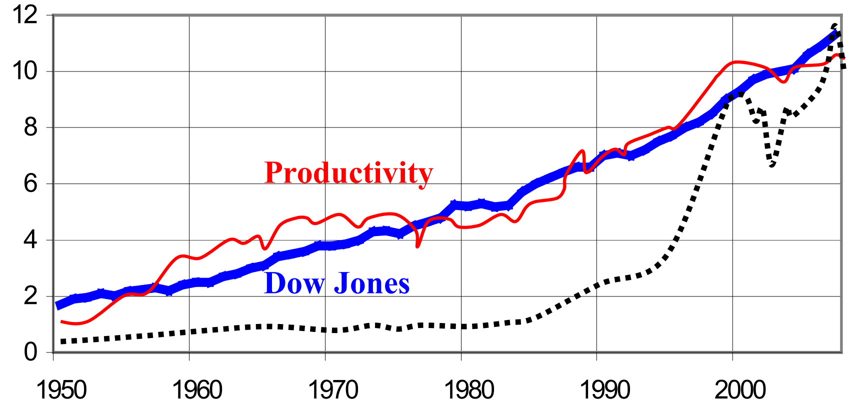


Figure 3.7.4. **US productivity (in year 2000's $$) : blue, linear scale. Dow Jones Index: logarithmic scale, red, and linear scale, dotted.**

What happened in 1970, then? Clearly, America and the world entered a large scale transition state. If pattern chemistry is anything good, it must give some indications regarding the next stable state that has not yet happened. Even if they are Delphic Oracle style, when you are told that a great empire will perish, you need to ask only one more question, and you can answer yourself.

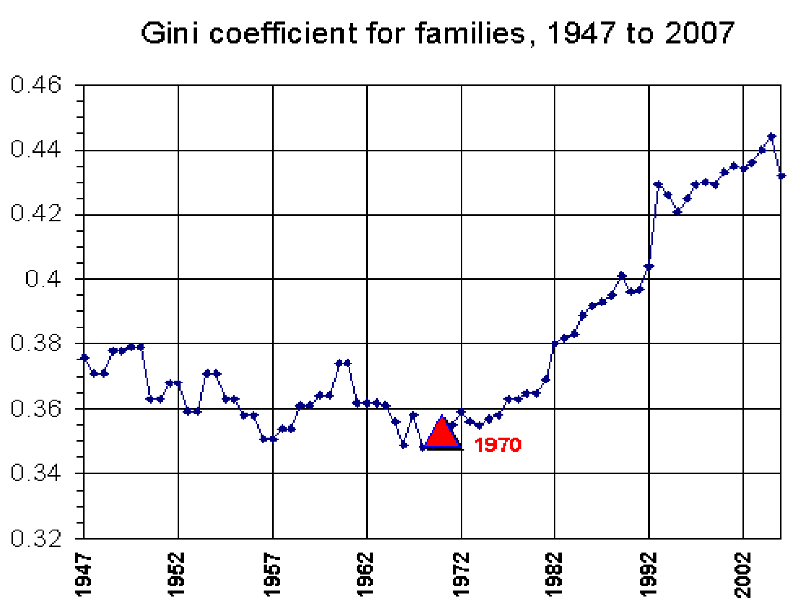


Figure 3.7.5. **Income inequality revolution in 1970**

NOTE (November 17, 2008): **Figure 3.7.5** casts light onto 1970 from the income inequality angle (USA data). A giant wealth pump was launched in 1970, or, to put it differently, a new financial life form emerged. Gini coefficient is a measure of inequality.

Source: US Census Bureau. http://www.census.gov/hhes/www/income/histinc/f04.html

3.8. EVOLUTION: UNSTABLE AT ANY SPEED

The area of complex systems consists of a few centers around which most discussions revolve. Three of them are most relevant for the chemistry of exystems.

The oldest, but probably not the largest field is **evolutionary biology**, going back to Charles Darwin. It was popularized in books by Richard Dawkins and Stephen Jay Gould, but is still full of mysteries. I believe that other exystems, which unlike those from distant eons are open to observation, can actually help complete the field from which system theorists pick the seeds of their ideas. It is time to recognize that there is only one evolving system on Earth. Gaia is not a hypothesis anymore: goddess Gaia married god Mercury, after he had taken her by force, and changed her name to Economy.

The second field surrounds the **Santa Fe Institute of Complexity**, with the roots from physics, in particular, from works of Ilya Prigogine. The third one is centered around **Principia Cybernetica** project founded by Cliff Joslyn and Valentin Turchin. Very large deposits of literature have accumulated on those three platforms fused like Europe and Asia (or Pangaea, actually, Pangaia because Gaea and Gaia are two spellings of the same name), and on a larger number of independent islands, with Pattern Theory of Ulf Grenander on one of them, the size of Australia.

A large peninsula of **Principia Cybernetica** belongs to Francis Heylighen, who is also a compatriot of Ilya Prigogine. With background in mathematical physics, he is interested in the same problem of evolution of complexity which is the core of generalized chemistry.

It is absolutely impossible for me to survey all that planet of knowledge with all its mountain ranges, canyons, and yet unexplored hinterlands and depths. Therefore, I can merely warn that I omit most of it and invoke only what I consider absolutely necessary.

In order to illustrate how chemistry can see systems differently, I will give only one example. Francis Heylighen formulates the Principle of Asymmetric Transitions as follows:

> A transition from an unstable configuration to a stable one is possible, but the converse is not.

From the point of view of chemistry, whether molecular or generalized, this is not so. The whole industry of chemical fertilizers, based on synthesis of ammonia, proves it. Next, however, he relaxes ("generalize" is his word) the principle to the form that looks very chemical:

> This principle implies a fundamental asymmetry in evolution: one direction of change (from unstable to stable) is more likely than the opposite direction.

If so, when we ask what stability means, the only possible answer is that a stable state is more likely than an unstable one. What is likelihood, then? From my point of view, this is not an independent principle, but a circular definition of stability/likelihood. This returns us to the principal problem of novelty in evolution. How can we talk about likelihood of something that does not yet exist? Chemists, however, do that every day. See Molecules and Thoughts: Pattern Complexity and Evolution in Chemical Systems and the Mind.

I would answer with the opposite, apparently paradoxical, statement:

> Evolution is a series of improbable, unlikely, and **unanticipated stable** states separated by probable, **likely, and highly unstable** transition states.

Food riots and market collapses are well known unstable transient states, but what is going to happen after the current ones (2008) is something that we can only expect to be as unexpected *a priori* as the collapses of the Roman, British, and Soviet empires. The next empire has already been named. OK, if not this time, than the next one. Since we have a pattern, we can discuss a configuration.

> I also wish to remind about another large but neglected pattern: **expropriation**. It accompanied all ancient conquests and wars, was practiced by Hitler, refreshed in Zimbabwe, but on an unprecedented totalitarian scale was once reformulated by Soviet Communism: we expropriate not enemies, but ourselves. Once the tiger has tasted human flesh it becomes man-eater. This pattern is to stay. Ideas do not die.

Although I was unable to find there traces of the concept of unstable and spontaneous transition state, Heylighen's work is an excellent inventory of problems that arise with exystems. His *The Global Superorganism: an evolutionary-cybernetic model of the emerging network society* is a review of what I would call a modern version of Hobbesian Leviathan. I wholeheartedly share his ultimate goal of a new world view …as long as there is a forward-looking chemistry. More on Heylighen, see **Chapter 4.1**.

The main reason why I shy away from comparison with other approaches is that my own world view—that of a chemist—is not yet in the form solid enough to stand on its own feet. All I can hope for is a foothold in the Pangaea of complexity. Meanwhile, the global economy, synonymous with world order, is morphing right before our eyes and the Earth is trembling.

3.9. THE TALMUD AND THE TAX CODE

The purpose of this chapter is purely illustrative.

In **Chapter 3.8**, I made the following off-the-cuff and overly polemic statement :

> Evolution is a series of improbable, unlikely, and **unanticipated stable** states separated by probable, **likely, and highly unstable** transition states.

It uses such related to future concepts as anticipation and likelihood. In molecular chemistry it is much easier to anticipate the final stable state than the unstable transition state (this may change in the future). This is why the above statement looks paradoxical. In human matters, however, the mechanism of a process is usually seen in all details. What remains unseen are the workings of individual mind, although they are being penetrated to alarming depths by modern neurophysiology.

In a sense, the Talmud was the first **complete** pattern taxonomy of human matters.

The following illustration of the combinatorial nature of human matters is taken from the Babylonian Talmud, Volume I, Tract Sabbath, Chapter I , **Regulations Regarding Transfer On Sabbath.** (**Other source** is more detailed**).**

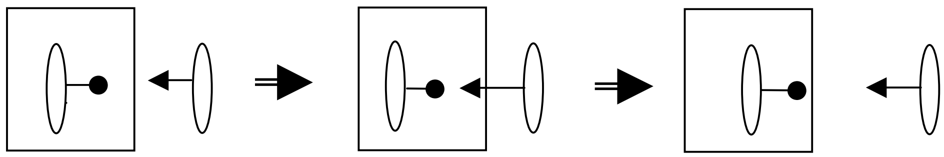
There are 39 activities prohibited on Jewish Sabbath, among them, transferring ("carrying") an object across the line between private (house) and public property (street). I insert in the quotation my schematic pictures. Rectangle is house, ellipse means a person, line from the ellipse means hand, the arrow belongs to the initiator of the transfer , and the dot to the passive receptor. The tractate does not make any difference between giving and taking, although possibility of further fine distinctions is mentioned elsewhere.

In other translations *beggar* or *poor man* is used instead of *mendicant*.

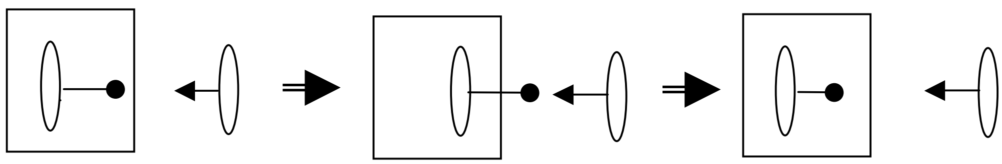
REGULATIONS REGARDING TRANSFER ON SABBATH.

> **MISHNA I.**: There are two acts constituting transfer of movable things (over the dividing line of adjoining premises, based on biblical statutes). The two acts are, however, increased to four on the inside and to a like amount on the outside of the premises (by the addition of rabbinical statutes). How so?
>
> A mendicant stands outside and the master of a house inside. The mendicant passes his hand into the house (through a window or door) and puts something into the hand of the master, or he takes something out of the master's hand and

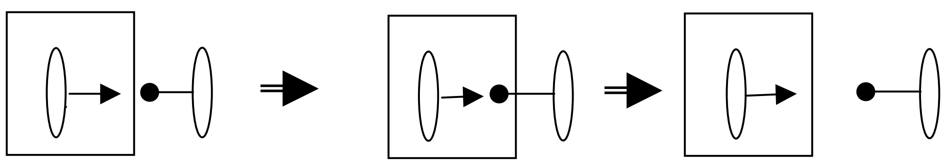
draws it back (toward him). In such a case the mendicant is guilty (of transfer) and the master of the house is free.



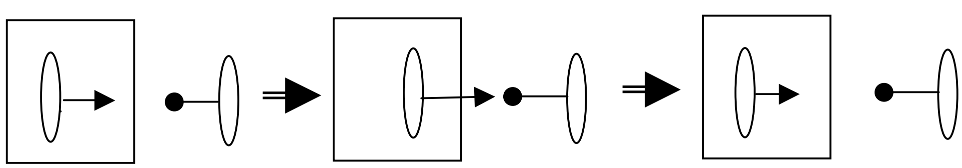
If the master of the house passes his hand outside and puts a thing into the hand of the mendicant, or takes something out of the mendicant's hand and brings it into the house, the master of the house is culpable and the mendicant is free.



If the mendicant extends his hand into the house and the master takes something out of it, or puts something into it which is drawn to the outside by the mendicant, they are both free.



If the master of the house extends his hand outside and the mendicant takes something out of it, or puts something into it which is drawn to the inside by the master, they are both free.



The situation with the beggar on Sabbath is more complicated than that; see [Wikipedia] and [Babylonian Talmud: Tractate Shabbath]. As always, consensus in human matters is hardly possible.

The Talmud consists of *Mishna*, which is a compendium of Biblical judgments on particular subjects, and *Gemara*, which contains rabbinical opinions, arguments, and discussions from the period around 500 AD.

I would not judge the pedantic hairsplitting arguments in the Talmud too harsh. The distance in time between the Talmud and the US Constitution (as secular "Mishna") is big, but in the huge pattern space the transcripts of the US Supreme Court arguments and written opinions (as matching "Gemara") seem to echo the ancient debates.
.

> Rab asked Rabbi: If one's neighbour loads him with food and drink, and he carries them without, what is the law? Is the removing of one's body like the removing of an article from its place, and so he is liable; or perhaps it is not so? He replied: He is liable, and it is not like his hand. What is the reason? — His body is at rest, whereas his hand is not at rest (source).

> JUSTICE SCALIA: Mr. Verrilli, this is an execution, not surgery. The other side contends that you need to monitor the depth of the unconsciousness. When you expect to bring the person back and do not want harm to occur to the person. But they assert that to know whether the person is unconscious or not all it takes is a slap in the face and shaking the person. (US Supreme Court case 07-5439. Baze v. Rees 01/07/08; source)

I selected the examples for their apparently maximal distance regarding timing and the subject matter, but any court case or scientific discussion could also be used. This is how pattern chemistry of history creates its combinatorial space.

Browsing through materials of the US Supreme Court, I was amazed by the great attention and care of the Court regarding the subject matter of the cases under consideration with all their often highly technical minutia. Another example is somewhat closer to the problem of giving and taking on Shabbath. It is Docket No. 03–1238. **IBP, INC v. Alvarez** , about payment for the time of walking to the place of actual performance (workstation) and the time necessary for "donning and doffing," i.e., changing clothes. The role of Mishna is played by *Fair Labor Standards Act of 1938* (FLSA) and *Portal-to-Portal Act of 1947*.

As the debate proceeds, the space of activities becomes finely divided into preliminary, principal, postliminary, and "integral and indispensable part of the principal activities." There is also "post-donning" walking, etc. Walking, donning, and doffing are not principal activities. Should they be compensated? The following exchange relates to page 43 of the Arguments.

> JUSTICE GINSBURG: That wasn't decided below, was it? It was just a question of walking and waiting, and they weren't specific about whether that included waiting or walking, **predonning**.

> MR. GOLDSTEIN: That's right. The reason for that is, there isn't a **predonning** wait in the Alvarez case, where the plaintiffs won, and the Tum plaintiffs lost on an unrelated theory that the actual donning and doffing couldn't start the workday.

> JUSTICE GINSBURG: So, perhaps we shouldn't reach a question that hasn't been aired and decided below.
>
> MR. GOLDSTEIN: And my formulation, which is simply the donning and doffing process, would, in fact, leave to the lower courts the question of precisely when donning begins and doffing ends. That's a fair point.
>
> JUSTICE SCALIA: Mr. Goldstein, since you display such respect for the agency here - [Laughter.] - what do you do about the agency's footnote that flatly contradicts your theory of the case, and which says that the mere fact that donning and doffing may require compensation does not necessarily mean that travel between the clothes changing place and the actual place of performance would be excluded? Source: Arguments.

Nothing NEW has appeared in the workplace since the "quasi-Mishna." Note how the **different** (but not **new**) combination PREDONNING emerges in the configuration space. This notion becomes crucial for the case.

Here is part of the unanimous decision which is, in my opinion, truly refined and inventive. It simplifies the case by introducing a measure of distance in an abstract space!

> However, §4(a)(2) excludes from the FLSA's scope the time employees spend waiting to don the first piece of gear that marks the beginning of the continuous workday. Such waiting—which is **two steps** removed from the productive activity on the assembly line—comfortably qualifies as a "preliminary" activity.

In relatively **simple situations**, all possible configurations can be listed. This, of course, applies to molecular chemistry, provided we do not expect anything **new**. In the above **Baze v. Rees**, the problem of novelty is as conspicuous as the conundrum with the refrigerator in Israel, see further in this Chapter. In times of the founding fathers, hanging and the firing squad were OK, and so became later the electric chair. True, Benjamin Franklin understood something about electricity. What about sodium thiopental and pancuronium bromide? See the Supreme Court decision.

No simple situation has ever reached Rashi (famous Talmudic scholar, 1040-1105), the US Supreme Court, or a forum of astrophysicists. What if the situation is complex? To move the problem from a large and complex configuration space to a smaller one is exactly the function of any problem-solving body. Neither astrophysicists, nor Supreme Justices always come to a consensus, but in the case of the Supreme Court the template of the voting procedure enforces it.

As far as the Talmud is concerned, there are possibilities of expanding the transfer space further, by separating giving from taking, for example. By involving smaller and smaller distinctions, the complexity becomes unmanageable and senseless, as it has happened with the US Tax Code.

The bureaucratic hairsplitting of combinatorial space in both Talmudic scholarship and US Tax Code is a characteristic pattern of history. When it emerges and what it means could be a subject for a separate investigation. I am more interested in its evolutionary and especially political consequences.

The unbearable and senseless complication of life—torture by complexity—is a stressful and protracted transition state. It leads toward some evolutionary divergence or extinction. Thus, in pragmatic America, the Conservative and Reform varieties of Judaism became widely spread and stable. Similarly, among the current (2008) suggestions of the Tax Law reform there is a choice between a simple tax and a complicated one, which mimics the situation with Judaism to a comical degree. In pattern space, however, subject matter distance does not exist.

> "When this reform is enacted, all who wish to stay under the current system could still do so, **but everyone else could choose a vastly less complicated system** with two tax rates and a generous standard deduction. Americans do not resent paying their rightful share of taxes – what they do resent is being subjected to thousands of pages of needless and often irrational rules and demands from the IRS." (Republican presidential candidate John McCain, from multiple media sources)

Novelty, according to pattern chemistry, can come only from the expansion of the combinatorial space. It is too technical for non-chemists, but is worth mentioning that by expanding the registry of bonds to unstable ones, molecular chemistry acquired access to the configurations of transition states and completed the foundation for its theory. That it happened mostly around 1970, which was the period of emergence of many cardinal new ideas in sciences, is not a coincidence.

> This leads us to another possible topic: what was "1970" **from all points of view** and why? I believe it was the time when the abstract ideas and theories, and the universities with them, became part of the market economy. I cannot tell when it happened to debt, religion (also a form of debt), health, and the future itself, but the pattern has been called gambling since time immemorial.
>
>> "But it was only until the establishment of standards for the magnetic strip in 1970 that the credit card became part of the information age" (source).
>> "Late 1970s - The New Religious Right becomes much more involved in politics and media (source)."
>> "When a 1966 article in *Fortune* magazine highlighted an obscure investment that outperformed every mutual fund on the market by double-digit figures over the past year and by high double-digits over the last five years, the hedge fund industry was born. By 1968, there were some 140 hedge funds in operation (source) ."

The Orthodox Judaism, based on ancient writings, has been constantly facing the expansion of the combinatorial space brought about by evolution and especially by technology. Thus, lighting fire ("kindling light") is prohibited on the Shabbat. How about refrigerator lamps that turn on when the door is open? The solution is to turn off the bulb on the eve of Shabbat. A more radical solution is to switch to modern (**economic** is a good term) forms of Judaism that do not make a mountain from a mole hill. Another one is hypocrisy and duplicity, as in Sabbath telephones and elevators in modern Israel, which let people satisfy their desires and needs to do irrationally forbidden things required by the current rational economy.

> "The Institute for Science and Halacha (its logo is on the right) is dedicated to the development of a sound halachic base for dealing with all matters connected with science and modern technology." (Halacha is Jewish Religious Law).

> "A **Sabbath elevator** is an elevator which works in a special mode, stopping automatically on every floor, to allow for the Jewish law for abstaining from using electricity on Shabbat." (Wikipedia)

Yet another evolutionary solution is an indifference to most ritualistic religious matters, characteristic of the secular part of population of Israel.

The universally recognized political polarization and balkanization of America seems to follow the same pattern of "double-think." Religious, as well as political, orthodoxy plays the major role in the process. The chemistry of the process can be yet another test essay on chemical view of the world. It should not be written, however, in political or religious language (unlike **Essays 8, 11, 43**). One thing is clear: pattern chemistry expects a further separation of political tectonic plates while there is enough energy to do that. It is less clear what will happen when energy is scarce.

The main component of the schizophrenic "double-think" pattern is the acceptance of mutually exclusive views, all of them superceded by pure desire and will: a cognitive dissonance without qualms. That was typical, for example, for the entire history of the Soviet Russia (see **Essay 8**, On Buridan's Ass).

There is another, less obvious, but very chemical aspect of the above examples.

The **collective** search for the solution of a problem, whether in religious law, or in modern court, scientific discussion, business, government, and diplomacy consists of building a configuration space, on which consensus is possible, and then synthesizing the most stable **under the circumstances** configuration, which may turn out quite unstable.

I therefore do not hold it against the Supreme Court that presidency was transferred to George Bush in a non-constitutional manner.

Human matters cannot be perfectly solved in a diverse society, but even if the solution results in a terrible mess, the floods of the river of time will someday wash it away for the simple reason: time is a sequence of events with beginnings and ends.

It is the weight of what you cannot end that pulls you down and drowns in the river of time.

3.10. CAVEAT EMPTOR: BUYING THE FLAT WORLD

We live inside a unique exystem and carry another one inside: our unique individuality. Nothing is simpler than one, 1, the unity, even zero is more complex, but a unique individuality is much more fascinating than any multitude and infinity.

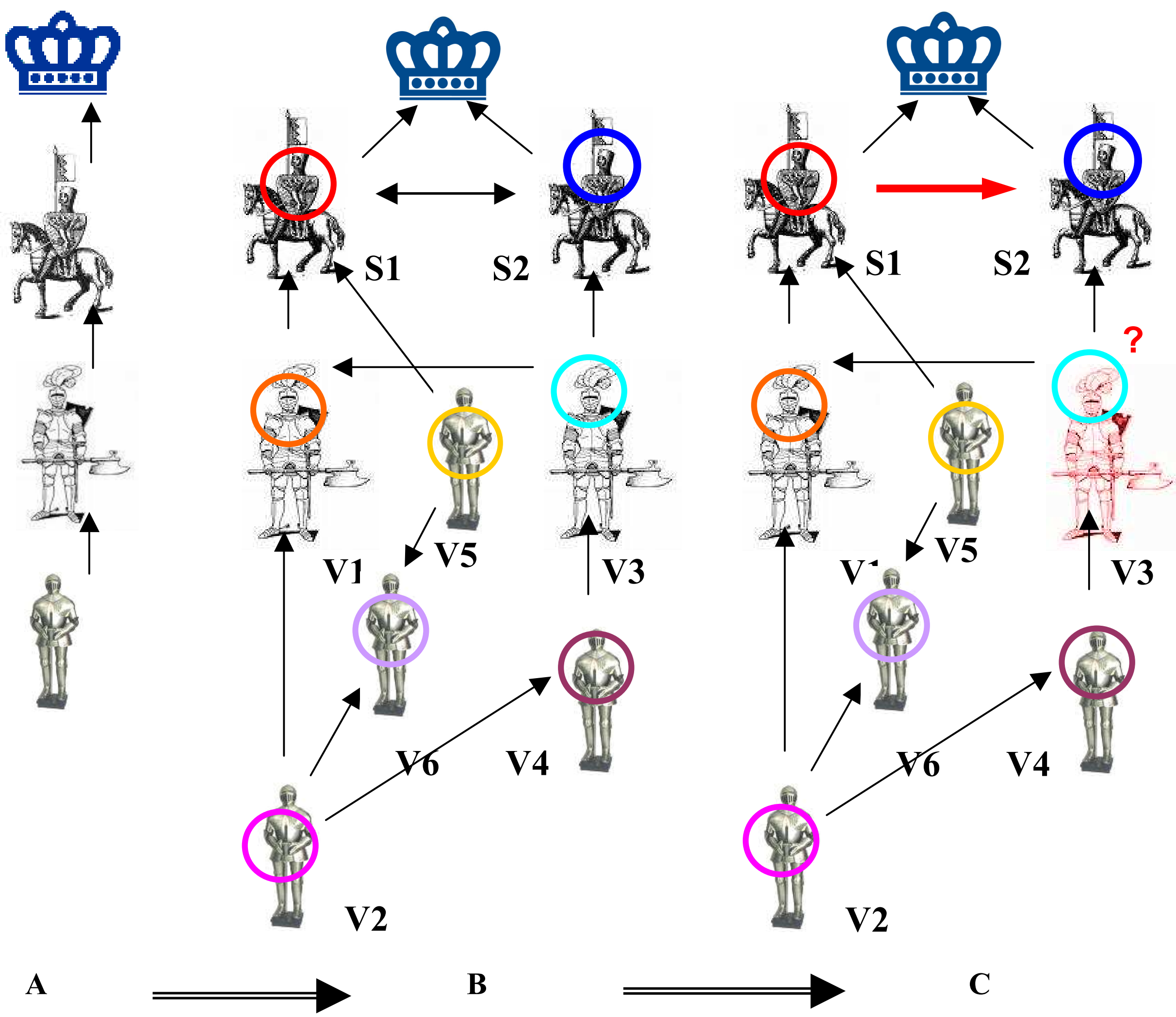
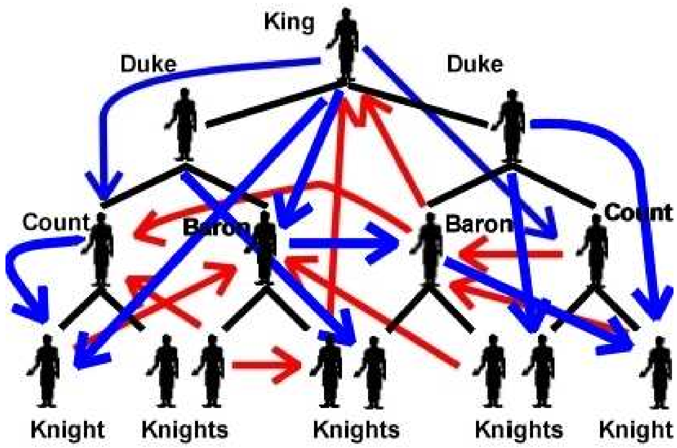


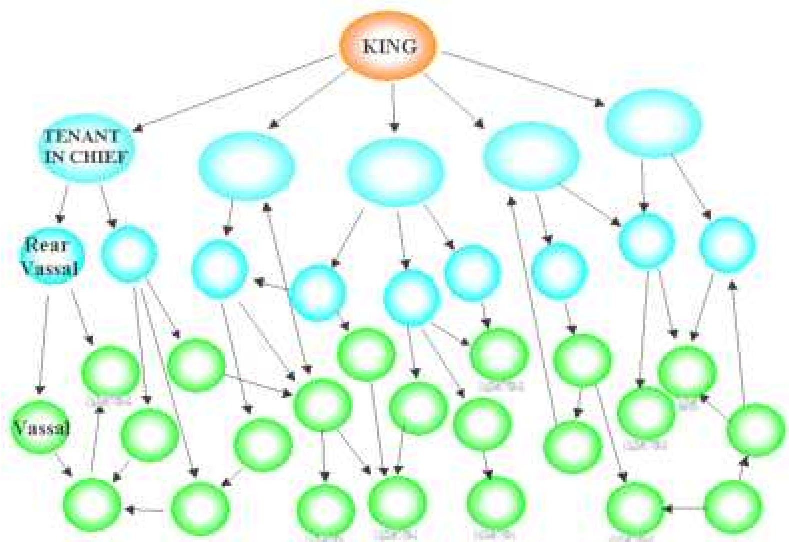
Figure 3.10.1. **Suserains (S1 and S2) and vassals (V1 to V6) under the same crown. A to B: development of complexity. B to C: Dilemma of V3, see text. Simple arrows show rendered services.** Along Steward C. Easton. *The Western Heritage.*

Exystems pose a dilemma: either they are beyond natural science because of their irreproducible singularities or natural science should be expanded to include singular exystems.

"For a human being nothing comes naturally." Philip Pullman, "The Subtle Knife."



A



B

Figure 3.10.2. Complexity of subinfeudation.
Along sources: A: [University of Calgary]
B : [William C. Schuerman].
Black lines in **A** show the non-existing regular pyramidal hierarchy.
Grey rectangles in **B** mark tenants without subtenants.

The friction comes not from the properties of things, but from the terminology. Within the exystem of knowledge it creates tension and stress, typical of the transition state, that has to be somehow resolved. This is the way knowledge evolves. I believe that this tension was the subconscious driving force of philosophy and the initial stimulus for systems theory itself.

> Ludwig von Bertalanffy's approach to systems theory was considered a retreat from "Cartesian-Galilean paradigm of science." Yet the Santa Fe Institute of Complexity's direction consistently clings to that paradigm by the grip of mathematical models.

If the irregularity, tension, and stress of the transition state determine the likelihood of the transformation, how can we compare, if not measure, the instability in exystems?

In this Chapter, I illustrate the significance of structure for evaluating stability with an example from *The Western Heritage* by Steward C. Easton (Holt, Rinehart and Winston, NY 1966, p. 197). **Figure 3.10.1** is a modified form of his original graphs.

Originally, the feudal relations were a simple vertical hierarchy, **Figure 3.10.1A**. The king was the formal owner of all land which he distributed to his vassals in exchange for their on-call services. With time, however, the feudal system became a complicated system of bonds between the king, his suzerains, and the lower rank vassals because the tenants could subdivide and lend their land to other tenants regardless of their power status. **Figure 3.10.2** illustrates the resulting complexity of **subinfeudation** network with modified graphs from two other sources (Source 1; Source 2).

The landlord could also shift toward the subtenants his obligations to the king, which often left the king out in the cold. The right of the tenant to leave part of his land to his heir and off the lord's control was an opportunity for a subterfuge of which the king suffered most. The lord had his own means to control the land of the tenet's heir, for example, by subletting it until the infant's maturity, and so the network of feudal relations was growing more and more complicated and stressed.

In 1290 King Edward I (1239 –1307) issued the *Quia Emptores* Statute ("Because the buyers…") which ended the previous practice of subinfeudation, as the short Statute goes, "which thing indeed seemed very hard and extreme to the magnates and other lords." From now on, the tenant had to accept all obligations of the lender toward his top lord "and shall straightway be charged with as much service as pertains or ought to pertain to that lord for that parcel."

Historians consider *Quia Emptores* and the limitation on the contractual exchange of land tenure for services to be the reason for the ultimate demise of feudalism in England. Taxation and direct bilateral monetary exchange, i.e., the power and market relations came instead of land tenure.

My presentation of the historical background is entirely second-hand and amateurish. See the sources: Stephen E. Sachs, *Subinfeudation and Subterfuge: The Role of Quia Emptores in English Feudalism* and entry on *Quia Emptores* in Wikipedia.

> Stephen E. Sachs' other publications are very wide in scope and, to a chemist's eye, contain sharp analysis, as well as high level pattern synthesis. See, for example, the truly refreshing The New World Order.

Regardless of details, the historical transition, in my opinion, illustrates three remarkable aspects of exystems.

First, the stabilities of transition states can be compared simply by counting the stress points, i.e. mutually interfering bonds. [**Note**: same applies to the cognitive dissonance in social psychology]. The emergence of the stress points is illustrated by **Figure 3.10.1C** , constructed along Steward Easton, whom I quote:

> **Puzzle**: What happens when Suzerain 2 decides he will cease performing feudal services for Suzerain l. and what will Vassal 3 do when called out by his respective suzerains?
>
> The answer to the puzzle is that, if a vassal were anxious to do the right thing, he would give his personal service to one lord while allowing his own vassals to perform the remainder of his service. But clearly this would not hold good **if he were called out by two lords at the same time** who happened to he at war with one another. (Steward C. Easton, *The Western Heritage* , p198)

"If he were called out by two lords at the same time" [**Note**: sounds as a bright metaphor for cognitive dissonance] is the stress point in the transition state which would most probably change the configuration in **Figure 3.10.1B**. As the author notes, such situations were the reasons for constant feudal wars.

The "complexity feud" seems to be the pattern of complex societies. Here are not so remote examples.

That any elimination of a possible stress point advances us toward a tactical or strategic goal is a commonplace. Yet the history of the Iraq War illustrates how stupid humans could be when inebriated by power—even more so than by beer. The planners overlooked the major stress point between the Shia and the Sunni **liberated** from the power of dictator, but not restrained by any other power, such as native army. The **systemic** , i.e., pattern nature of this stress is the same double allegiance which caused the feudal strife in Medieval England. The testimony of General Ricardo Sanchez, whether believable or not, can be referred to:

> "And you know, what I describe in the book [*Wiser in Battle*] is that I'm fighting two different wars. I'm fighting the actual war on the ground and I'm also fighting the war back in the United States, where the administration is attempting to get reelected." General Ricardo Sanchez, Interview with John Roberts, CNN, May 5, 2008.

The stress of double allegiance is pervasive in the all-comprising Economy of America. The high ranking general has to choose between the President's political goals and his own military prudence and common sense. The doctor is under the pressure of pharmaceutical companies and HMOs, let alone time. The scientist has to choose between career, grants, and public good. All the more, the scientist has to choose between his own scientific interests and grants. The presidential candidate has to choose between the truth and the success of the campaign. The congressman, *nolens volens*, marches with the beat of the party.

The morally wrong choice (morals is also part of Economy) cannot be easily characterized as corruption and America does not belong to corrupt countries. It is the complexity of the social web of big power, big money, and big service (work) that unavoidably creates the stress points with big consequences.

> That was the essence of the last millennium of European history: another high-level pattern.

Corruption explodes when the simplicity of tyranny suddenly ends, as in Russia and China. India, in contrast, has been steadily progressing; see Transparency International. The modern contractual relationship between the employee and employer, which goes beyond monetary compensation for work and defines allegiance, is, in my opinion, the feudal pattern. This is, however, a topic as complicated as **Figure 3.10.2B**. See Essay 5. On Medieval America

From what I know about the traditional culture of China, the average Chinese has always been torn between allegiance to the family and allegiance to the state power. If the Medieval complexity is a universal pattern, then we can expect a transformation of the society stressed by double allegiance and a simplification of social relations toward individualism. The authoritarian power structure in China, with all its thousands of years of experience, will, probably, weaken. But what is going to happen if China suffocates in the vacuum of matter and energy resources?

Individualism, contrary to popular American mythology, is incompatible with complete freedom. It needs the strong state power to enforce the institution of property and contractual obligations. As the least protected unit of society, the individual prefers a single lord as the least evil but wants to be as far from him as possible. In the Middle Ages it was called scutage: buying out of military service to the Crown, today done by taxes. What poorer people can achieve by organizing into a political body or an army, the rich achieve through concentration of personal wealth, forming a Money-Europe of a kind.

What the Medieval English history says on the subject is that simplification leads to sharp class stratification. England escaped from that stable state by global expansion and overseas colonization. Next, it was carried over the collapse of colonialism by economic globalization. I am no leftist, but colonization and globalization share the same pattern of geographic spread.

> Do they share more than pattern? What is the efficient cause of capitalist revolution that brought about democracy, individualism, and human rights? The consumer power of masses. You can rule the slaves with a whip, but you need to empower and enrich the consumers, the dung beetles, the dissipators of the social thermodynamics. You need to make them feel like little emperors, little Neros who burn their little Romes every day, so

> that Economy can build new ones overnight. What for? So that you would feel like big Neros. I can't believe I am saying that. You don't believe, either.

To summarize, any contradictory neighborhood of a generator in a configuration is a stress point. Without even measuring the instability incremented of the stress point we know that adding another stress point can only increase instability. How do we know that? From the chemistry of our interpersonal relations.

Second, the transition from subinfeudation to *Quia Emptores* is a transformation under a very general and ominous patter of the behavior of the exystem with growing complexity in the condition of limited sources of energy. Does this pattern presage a modern oncoming change of configuration?

In the feudal exystem, land was the only source of energy for humans and their horses, and especially for the horses, and especially in the insular England. The land tenants multiplied and the parcels divided.

> Land, with its wind and solar farming, may return to domination in the post-carbon economy. In the post-oil economy, land is the source of recyclable carbon, unlike coal. There are already signs (2008).

The growing complexity of feudal relations reminds me of the current economy. When money, power, and service are exchanged in the web of public and private companies between individuals and businesses, then competition, cooperation, and outsourcing are norm. Most people, however, are in the bottom position, similar to that of the medieval "freeholder" or "tenant in demesne," with a thick layer of "rear vassals" and suzerains above. The "terminal" tenants did not have subtenants, lived on land, and worked with their hands. The radical difference from feudalism is the modern institution of property in the absence of a king, but patterns are not about differences, only configurations are.

> I wonder if somebody has already plotted the network of such relations at least for one hundred of large companies and hundred of major holders, with all the unidirectional bonds of profit and controlling power. It would probably look like a very big **Figure 3.10.2A**, only without the black lines of non-existing hierarchy (but who knows).

This Chapter, as most of the rest, poses more questions than it answers. It contains its own stress points. Nevertheless, I insist that the study of exystems is all about asking the right questions because the right answers may be wrong next day, while the questions remain. And so I allow myself to be carried away even farther by my freedom of questioning.

Thus, I completely reject the metaphor of the flat world (Thomas Friedman) as the final result of globalization. It is as wrong as if taken literally. I believe that globalization is simply the global exploitation of inequality, without any Marxist connotations of "exploitation." Globalization still rises the "exploited" from poverty. As soon as inequality starts to flatten, the economic competition over the catastrophically falling resources can only turn the world **political landscape** into Himalayas and Grand Canyons. There are already high level people, well versed in history, who are concerned about the growing inequality in America.

Figure 3.10.3 illustrates this my hypothesis without much verbalization. The **hypothesis** can also be reformulated as follows.

When the energy supply to an exystem falls, inequality rises and hierarchy sharpens. And *vice versa*. Since large exystems have fractal sub-structure, this applies to their subsystems. Thus, the growing income inequality in America and the accompanying Republican revolutionary zeal in politics are results of the closure of the same open frontier of energy, land, matter, and human resources which created the unique American spirit and material civilization.

My other hypothetical assumption is that the growth of complexity translates into the loss of thermodynamic efficiency of the exystem, especially, of economy. This seems pretty obvious, but still needs some proof. The efficiency means the ratio of useful work to the total input of energy. Probably, we should not wonder why the developed economies of the leaning to Socialism Europe are so efficient, although we do not have any idea for how long.

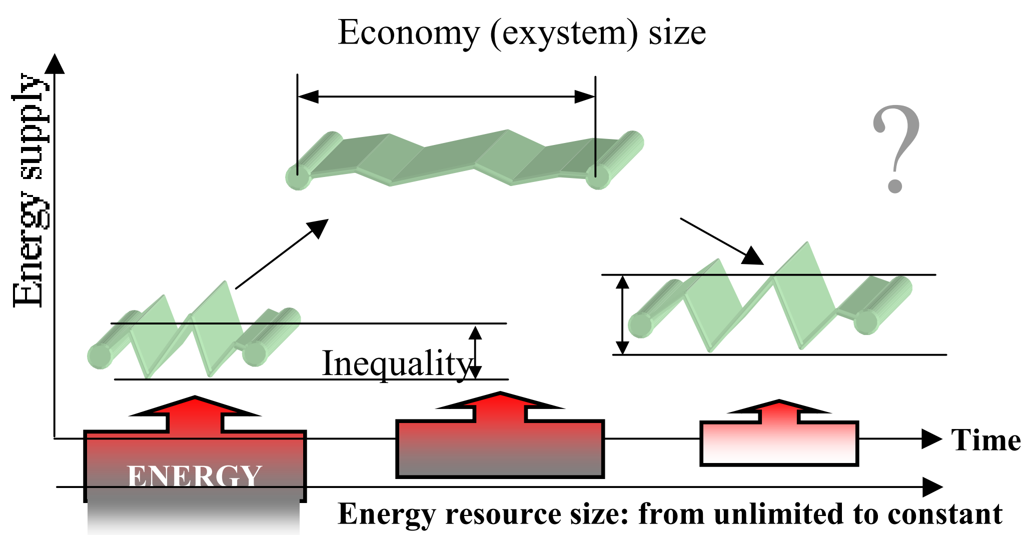


Figure 3.10.3. **Dream of a flat world. Hypothetical correlation between energy supply, exystem size, and inequality .**

NOTE: The subject of **economic efficiency**, especially, Pareto efficiency and Pareto improvement, is controversial: is it really efficiency? The controversy always arises when moral issues are involved. There is no controversy, however, over the enormous waste and inefficiency of the Iraq War. There is no controversy over thermal efficiency, either:

> **Fuel efficiency**, in its basic sense, is the same as thermal efficiency, meaning the efficiency of a process that converts chemical potential energy contained in a carrier fuel into kinetic energy or work. Overall fuel efficiency may vary per device, which in turn may vary per application… (Wikipedia).

If you buy the promise of flat world, ***CAVEAT EMPTOR***!

Third, the comparison of feudalism with capitalism shows, in an invisible light, at least to a chemist, what has been happening with the largest exystem on Earth, which started as the system of single cell organisms. The multi-cellular organisms with their organs and tissues and, later, with nervous system, mind, intellect, industry, and art, were not necessary for the survival of single-cell organisms. Microorganisms, whether with a nucleus or not, flourish in modern biosphere. The complex organisms had grown up **on the cells** in the same pattern as industry, art, and ideology have been growing **on human organisms** and as the cells themselves **on the culture medium** in Petri dishes. Following the Metasystem Transition Theory (MSTT) of *Principia Cybernetica*:

> When a number of systems become integrated so that a new level of control emerges, we say that a *metasystem* has formed. We refer to this process as a *metasystem transition*. (The Cybernetic Manifesto)

> We make a strong analogy between societies and neural, multicellular organisms. The body of a society is the bodies of all people plus the things made by them. Its "physiology" is the culture of society (*ibid*.).

The metaphysical and prophetic part of the *Cybernetic Manifesto*—the formation of a superbeing—is more controversial, but still sober:

> Since the integration we speak about can only be free, only a part of mankind -- probably a small part - should be expected to integrate. The rest will continue to exist in the form of "human plankton" (*ibid.*).

Oh, but this is awful! I want to be human plankton, not a cell in the Leviathan! I have already been a cell in the Soviet Leviathan! I have even been a cell inside a cell there. I am a proud (still) human plankton swimming with the Leviathan of the heartless American economy. I am less enthusiastic to rub shoulders with the human plankton of the Russian or Chinese economy, however. I profess the faith of the One, not of the Infinite.

The above hysterics are only a chemist's view of the world. You do not need to buy it: it is free. What is free is worthless, isn't it?

3.11. HATS AND ROOFS, LIZARDS AND DINOSAURS

The transformation of the Medieval European society returns me to the already expressed hypothesis. It is most probably not new, but I keep looking to new approaches to the problem.

Depending on the energy input, **Figure 3.11.1** , the general exystemic pattern changes **reversibly** between the squashed landscape of scattered small tribes and the sharpness of a wide-brimmed witch hat in modern economy. The hypothesis behind this questionable **Figure** has plenty of stress points and I will use it only as a seed for more discussion. See also **Chapter 57. Temperature and complexity** in The New and the Different.

I see in the series of hats a visual metaphor for two extreme cases of structure: the layered vertical hierarchy of a quasi-organism and the flat horizontal spread of independent smaller units. This distinction is very general. The two orientations, ↑ and ⟶ , result in different stabilities of a system if the properties of environment differ along a selected direction. The simplest example of such environment is gravity: a stick left in vertical position will fall on the ground and remain in the stable horizontal position.

Figure 3.11.1. **A metaphor of dependence of social structure on energy availability; greatly vulgarized.**
Why hats? Because of the shape pattern.

The two patterns of **orientation** are very general and can stand for sets of ordered values as different as distribution of wealth and structure of social control. The corresponding two-dimensional ideograms, “strip mall” and “skyscraper,” or “matador” and “witch” hats, or “flat” and “tall,” are straightforward, **Figures 3.11.2** and **3.11.3**. They also stand for two cases of probability distribution (red curves) : flat and sharp. This is not too much of a stretch since probability distributions of exystems are in practice measured and represented as histograms (sequences of slices through ordered data), **Figure 3.11.4**. Histogram is, therefore, structured.

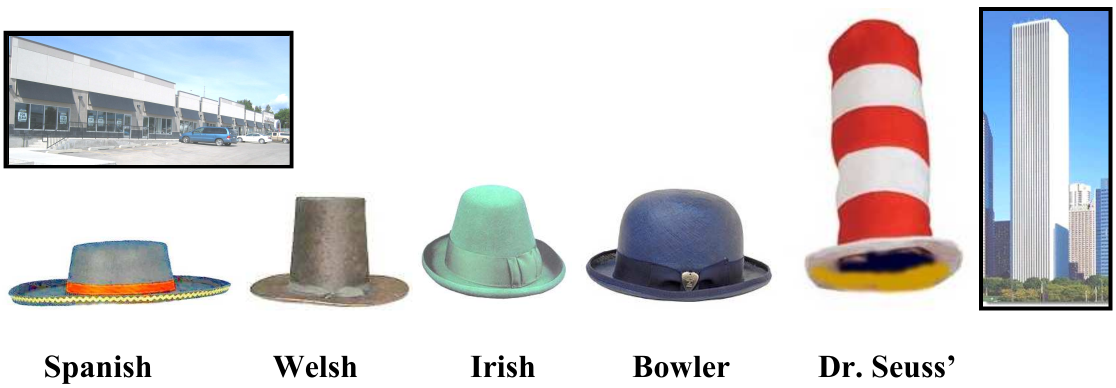


Figure 3.11.2. **Two extreme patterns of orientation: flat and tall hats and buildings.**

Figure 3.11.2 illustrates the generality of the pattern of **orientation**, as well as, at least in case of buildings, the price of freedom to grow tall and against gravity.

I remind that exystem by definition needs an incessant supply of energy not only for function and growth but also for the lowest mode of existence. Even a decaying exystem, like the late Roman Empire, needs energy .It can be, for example, hibernation or sleep mode, like in most modern appliances. They are not exystems. Or are they a kind of primitive viral micro-exystems?

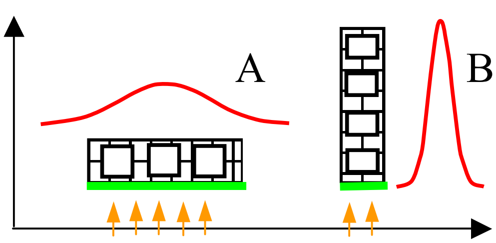


Figure 3.11.3 . **Patterns of orientation**. **A: flat, B: tall.**

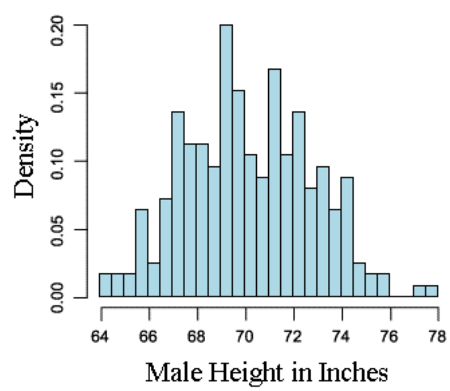


Figure 3.11.4. **Histogram. The sum of all densities equals 1.**

The length of the green line in **Figure 3.11.3** marks the **footprint** and symbolizes the maximal available rate of energy intake, adjusted for efficiency of conversion into useful (i.e., intended) work. The footprint is the third dimension of the **Figure**, which is relevant for comparison, competition, and evolution of exystems. Notably, the footprint, or, better to say, interface, is itself two-dimensional. It characterizes not only the **maximal** available power, but also the range of its consumption between the sleep mode and full throttle. Obviously, by introducing more variables, we are losing generality and simplicity and are shifting from pattern chemistry to hard academic sciences, where we are neither needed nor welcome.

The question I am trying to answer is: what is the **minimum of important things** we can say about an exystem? To find the minimal complexity, we need to codify the **degrees of freedom** of exystems.

There is a reason why the analogy with buildings is to the point: the taller building needs more energy for elevators, water pumping, and maintenance. In pattern terms, it contains more negative bonds. It takes effort to climb the stairs of a building or the career ladder. The tall system consists of subsystems increasingly removed from direct use of energy for work and instead involved in interactions and regulations. Business enterprise is a typical example, but since modern economy includes all ways of energy consumption, modern art and politics are as good. Tall food chains grow on the backs of artists and even election candidates.

There is yet another dimension for buildings: the price of the footprint unit, i.e., land, which is high in downtown, lower in suburbs, and reflects the intensity of competition in flat systems. In tall systems, it is the rewards of the position in the hierarchy.

The size of the exystem, represented by the area of the rectangle or another symbolic figure, is the next dimension. The footprint, vertical complexity (height), flow of energy and its price, size of the system, and the price of height are the main degrees of freedom of the exystem, to which we can add but a few, without a risk to lose the systemic view.

What do the hats represent? I would say that their extremes characterize the extravagancy of the lifestyle: bullfight or witchcraft. Bourgeois headwear is in the middle. Same with architecture.

Trying to stay at systemic level, I am going to compare two really big exystems: old flat Soviet Russia of proletarian equality and modern America of growing inequality and economic witchcraft. Since the old Russia is gone, I will review some of its properties around 1970, as I remember them.

The old Soviet Russian economy covered over 70% of the twentieth century timeline. It looked like the flat wide-brimmed Spanish hats on the left of **Figure 3.11.1** and **3.11.2.**

The inequality of income in Soviet Russia was very low, with a plateau in a few big cities and the brims of poverty in provinces and countryside. The local newspapers were full of advertisements for low skill labor. There was a high demand for Ph.D., advertised *pro forma* only in local newspapers. There was a reason for that. *Propiska*, the residency

> permit in the obligatory internal passport followed the pattern of the old Russian serfdom: it tied each Soviet city resident to the place of residency. The city of residence could be changed only through a direct exchange of the dwellings (rarely owned) or by a special decision of high rank authorities. The peasants (independent farmers did not exist) were deprived passports until 1974, which could be considered the year of the final abolition of serfdom in Russia. The residency permit had been officially abandoned only in 1991-1995, although it was resurrected later under the name "registration", like for a parolee or sex offender, but in Russia applied to any foreigner or law-abiding citizen. Russia remains a police state and most of its now independent components are even more so.
>
> I do not have the data, but I do not remember any deficit of energy in Russia. Electricity was produced almost entirely from coal. Cities were conveniently heated by hot water from the power stations. With the developed railroads and city transport—the private one was negligent—the demand for oil was easily satisfied and gasoline was dirt cheap.

The Soviet social structure, on the contrary, might seem like the witch hat. A handful of non-elected political bosses (the Politburo), like a collective king of a small principality, defined all aspects of Soviet life. This comparison is flawed, however, because the Soviet society had no private property—neither real estate, nor business. The lower bosses were part of more than one complicated hierarchies, see History as Points and Lines, *Chapter 24, The Fall of the Soviet Empire*. The concentration of power at the top was close to absolute and, as any concentration of energy, could lead to instability. The fate of Nikita Khrushchev illustrates the metastability of authoritarian political pattern.

> Metastability in physics and chemistry means that the system is in a stable state, but is separated from a much more stable state by a low transition barrier. For example, explosives need only a slight push to release their destructive energy. In social systems, however, the stability of the final state is not known, all the more, there is nothing final. A physically accurate comparison with a full glass on the table edge is more appropriate.

Russia was a giant **single household**, a unique and unprecedented phenomenon in history. From the pattern angle, we cannot even take it as a template: it is more like an aberration. As a *de facto* configuration, however, it can be as good a starting point as any other, from which other configurations can be generated by transformations. Moreover, having once emerged and developed, the Soviet dinosaur injected its memes (information "genes") into the global pool where they have survived as the alligator of Castro's Cuba.

A big private family-owned company is the closest configuration to the Communist Russia, provided it is the only one in town. The "family" (*Politburo*) was a tight closed circle of mutually dependent people, a kind of a secret cabinet, reporting to nobody. The difference is that any modern business had to compete and cooperate with other businesses, but for a long time Russia, presiding over its satellites, was alone. So was Mao's China, only without slavish satellites. When both had opened to the West their major natural resources—fuel and labor—both entered a sweeping transformation. The pattern of family management, if not ownership, however, seems to have deep roots in Russian mentality. Yet the inequality jumped up and the Russian canotier started to morph into a sombrero and a witch hat.

The patterns of social structure and income may look like two different things. Are they? What is the relation between them? At this point I do not know, but let us explore the ethereal pattern spaces, all the more, we do not need any $3.73 (May 14, 2008) gasoline for that: coffee will do (preferably from the shores of Indian Ocean).

Although not a template, either, the American economy is the opposite of the former Russian one. The social structure is flat and distributed. Political power is not concentrated in one or dozen hands. This pattern corresponds to an unlimited access to energy resources and labor. The wealth distribution, however, hides some amazing witchcraft still debated by economists. I could demystify it, following Robert Reich, as the consequence of cutthroat competition, now on global scale, but I prefer the image of Maxwell's demon working at the wealth pump (see Chapter 3.3). The image, however, needs some further discussion.

I do not have data of income distribution within companies, but it is my personal impression that the major unit of American economy, the company, is a kind of private household by the pattern of management, if not of property. Unlike the Soviet system, the income contrasts here can be extremely high. The difference does not seem overwhelming if we look deeper into the structure of the Russian super-household. While the contrasts of income were negligent by Western measures, the population was split into two classes: the top class of "nomenklatura," well captured by Wikipedia, which I quote:

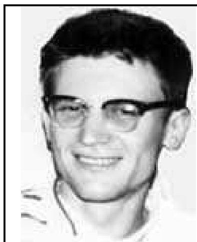
> The **nomenklatura** were a small, elite subset of the general population in the Soviet Union who held various key administrative positions in all spheres of the Soviet Union: government, industry, agriculture, education, etc. The nomenklatura had more authority and claimed higher privileges of the same kind as the ruling class which Communist doctrine denounced in the Capitalist West.

Ruling class is a diffuse and controversial concept, but it is, in a sense, always self-made, if not at present, then in the past generations. Nomenklatura was a non-hereditary top part of local and central ruling hierarchy, dispersed all over the country. It was given by the Party some special upkeeps, allotments, and amenities, shabby by American standards, but impossible to buy for any money. Nomenklatura lived in a different world where money did not matter and which could be compared with the perks and amenities that Google offers its geeks or, better, the top executive officers and owners of big American companies give to themselves.

I believe that the desire of the cream of nomenklatura to achieve Western standards for themselves was among main driving forces of the collapse of Communism. The essence of the collapse was a transition to the capitalist monetary stimulus instead of the feudal land-for-service contract.

In this Chapter I am walking on thin ice over the lake of cold facts underneath, into which I am afraid to fall. Yet I believe the ice is firm enough to support the thesis that the feudal system and the capitalist system are not so much different patterns (they are, but on a smaller pattern scale) as different configurations of the same umbrella pattern of economy. Depending on circumstances, the configurations (which themselves are different patterns of lower level) can be deformed and transformed into each other through stressed transition states.

Can the American exystemic orientation undergo involution into the Soviet one and back—not exactly, of course, but to configurations similar to the extreme cases?



Andrei Amalrik

Before screaming "No-o-o," remember that in 1984 and earlier practically nobody in Russia and America (with the striking exception of Andrei Amalrik, 1938-1980, who did not live long enough to see it) anticipated the coming collapse of Communism. In the punishment cell of the labor camp, it was easier for me to imagine my deliverance from Russia than the events of 1991, which I watched from America. Amalrik's predictions in their totality are a great illustration to pattern thinking: while it is difficult to predict exact dates and configurations, patterns are predictable. For example, he thought that a **disastrous defeat** in the war with China would be the immediate impetus to the collapse of the Soviet Union. Instead, it was the war in Afghanistan. The pattern was right, but "China" could be prophetic, too.

Figure 3.11.5 represents the network of highly abstract hypothetical transformations of exystemic "shape."

The patterns can be:

disconnected (**5 , 10, 12**),
vary from flat ("Spanish", **8, 11**) to
pyramidal ("witch," **2, 6**),
vary from low (**8, 9**) to high (**1, 6**),
solid (**2, 4**) or fragmented (**3, 7, 9**).

The reversible transformations include:

split (**4→10**, **9→12**),
stratification (**4→1**) ,
redistribution (**7→9**) ,
fragmentation (**2→3, 8→9**), etc.

The very chemical appearance of **Figure 3.11.5** can be seen in comparison with an actual network of chemical reactions in a very simplified notation, **Figure 3.11.6**.

The comparison of two pictures illustrates the generality of pattern chemistry. Chemistry is the study of combinatorial objects regardless of their nature, provided they can be characterized by stability. While evaluating stability of complex systems and the relative rates of their transformations, all we need is to represent stability as the sum of well defined increments in any order. In molecular chemistry, we compound lists of increments into stable and transition states, mostly tied to elements of structure, but as soon as the list has been compiled, the sum **does not depend on the order** of the addends. Chemistry is only a way to define addends along configurations. The latter can be quite trivial in finances.

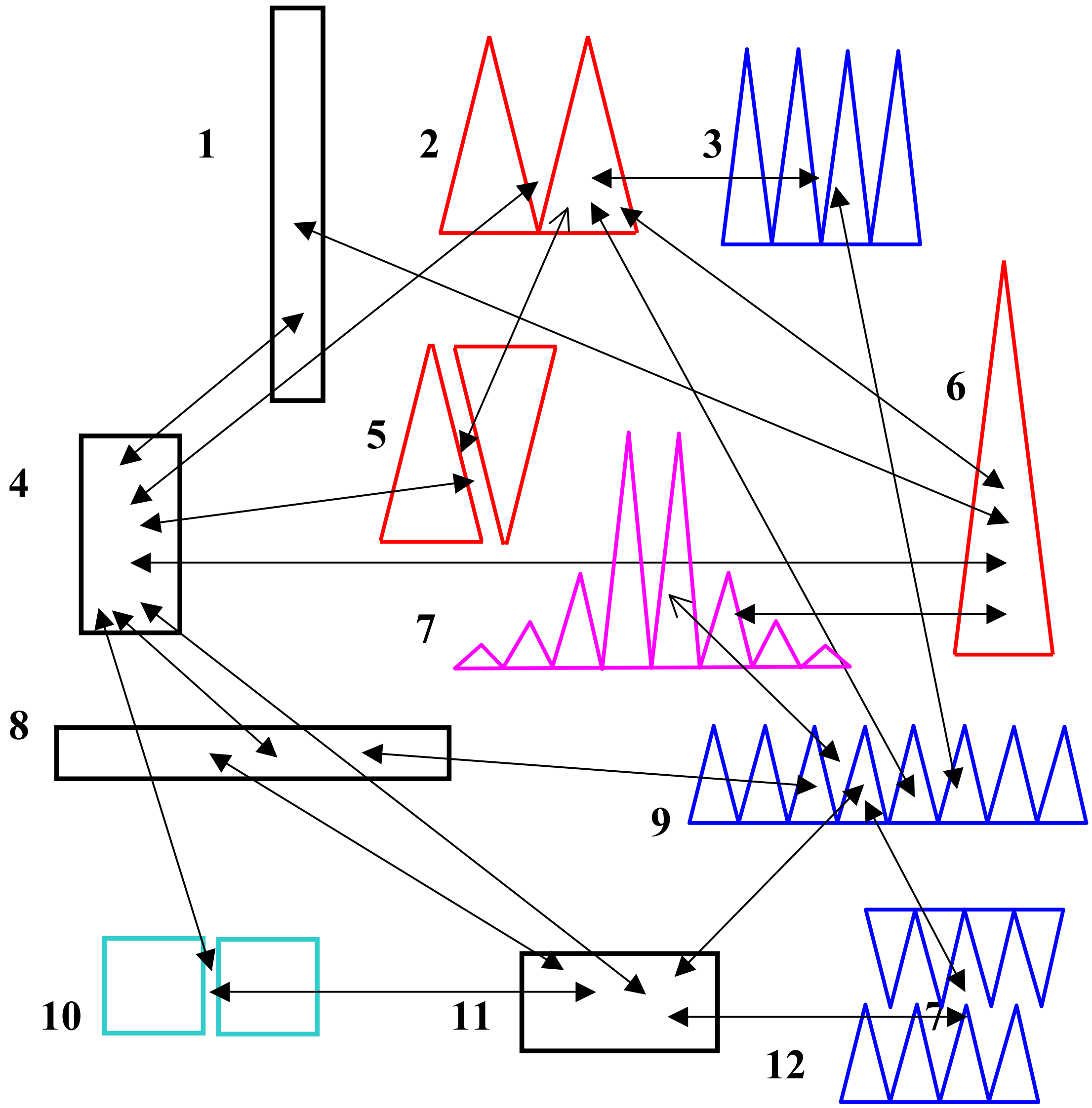


Figure 3.11.5. **Hypothetical patterns of transformations of exystems at the constant size represented by area.**

In molecular chemistry we attribute increments of stability to atoms and bonds. When we analyze the behavior of a group of basketball teams, the slices of a height histogram like in **Figure 3.11.4** could be, probably, taken to account as increments, together with other individual properties of players, like age distribution. The histogram of income distribution might provide increments for evaluating the behavior of society, all evaluations, of course, being comparative.

Therefore, if we accept the **hypothesis** of reversibility of pattern change, know all **relevant** degrees of freedom of an exystem as a pattern, and if we can interpret their effect on stability, we may engage in constructive discussion of comparative behavior of any two configurations. We should be prepared to find in the end that the change is reversible **in principle**, as all molecular chemical reactions, **but not in practice**, as in bacterial cell or evolution of society. The question is so intriguing that it needs a separate treatment. What is important, the treatment is going to be chemical in spirit.

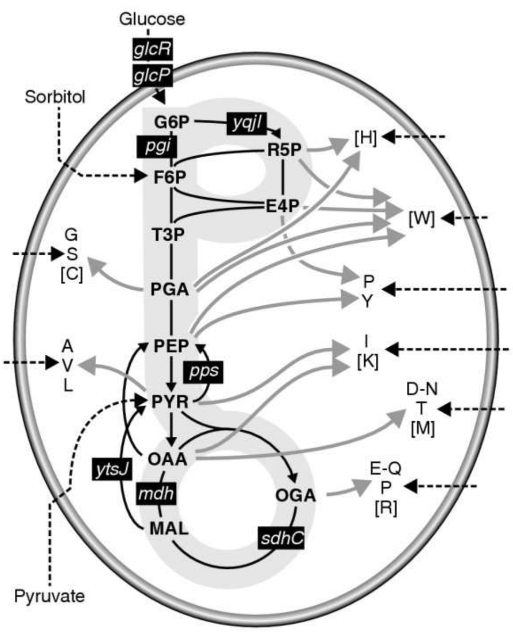


Figure 3.11.6. **Example of a biochemical reaction network, see box on the right. Although the arrows are single, all chemical reactions are in principle reversible.**

Simplified biochemical reaction network of *Bacillus subtilis* central carbon metabolism. Gray arrows outline the biosynthesis of precursor amino acids that are indicated by their one-letter code. Amino acids in square brackets were not detected. Black dashed arrows illustrate the uptake of substrates. Black boxes highlight pathways or reactions that are affected in the mutants used. G6P, glucose 6-phosphate; F6P, fructose 6-phosphate; T3P, triose phosphate; PGA, phosphoglycerate; PEP, phosphoenolpyruvate; PYR, pyruvate; OAA, oxaloacetic acid; MAL, malic acid; OGA, 2-oxoglutarate.

Zamboni and Sauer *Genome Biology* 2004 , 5:R99 ; doi:10.1186/gb-2004-5-12-r99; Web source.

The “thought experiments” with patterns and configurations in this **Chapter** do not bring us closer to definite conclusions, but the game of hats will be continued.

The ongoing discussion about the problem of the commons—the limited resource in public use—is directly related to the subject of this **Chapter**. See Digital Library of the Commons and International Journal of the Commons and I will have to come back to it.

3.12. CIVILIZATIONS IN HOT SEAT

This **Chapter** continues mental experiments with most abstract configurations of exystems, started in **Chapter 3.11**. As this entire text, it is not a "theory" in academic sense, but a preliminary exploratory attempt to complement the current scientific movement toward a unified world view—initiated mostly by mathematicians, physicists, and biologists—with fundamental chemical ideas.

Figure 3.12.1 illustrates an attempt to explore the minimalist pattern of exystem by reducing the number of the relevant degrees of freedom. Insofar as the approach is chemical, thermodynamic aspects of the system should be connected to the structural ones.

The taken to account degrees of freedom (**Chapter 3.11**) are:

1. Source of energy; source of matter is presumed constant.
2. Footprint: Intake (consumption) of energy from the source.
3. Loss of energy through dissipation (heat); marked in the **Figure** also as "exhaust."
4. Size of the system.
5. Height of the system, i.e. the complexity of a hierarchic structure.
6. Orientation. Flat systems ("strip mall") have a large footprint and low height. In tall systems ("skyscraper") this relation is reversed.

Why do we need orientation instead of **ratio** of height and footprint? Because we do not have an absolute measure of height, i.e., complexity, which is necessary for a ratio. On the contrary, the ratio of the loss to footprint, which characterizes efficiency of the system, or footprint to source, which characterizes the constraint of competition, can be in principle estimated because energy and work are quantities measurable in the same units.

Pattern chemistry is not interested in any absolute values, but only in their comparison for different configurations. Do they increase or decrease? Which configuration has more (or less) of a certain degree of freedom? Is the system growing in size or shrinking? How is it changing its orientation? Therefore, the word "change of " preceding each degree of freedom should be kept in mind: change of footprint, change of height, etc.

In **Figure 3.12.1**, configuration **A** is shown side by side with two possible directions of evolution.

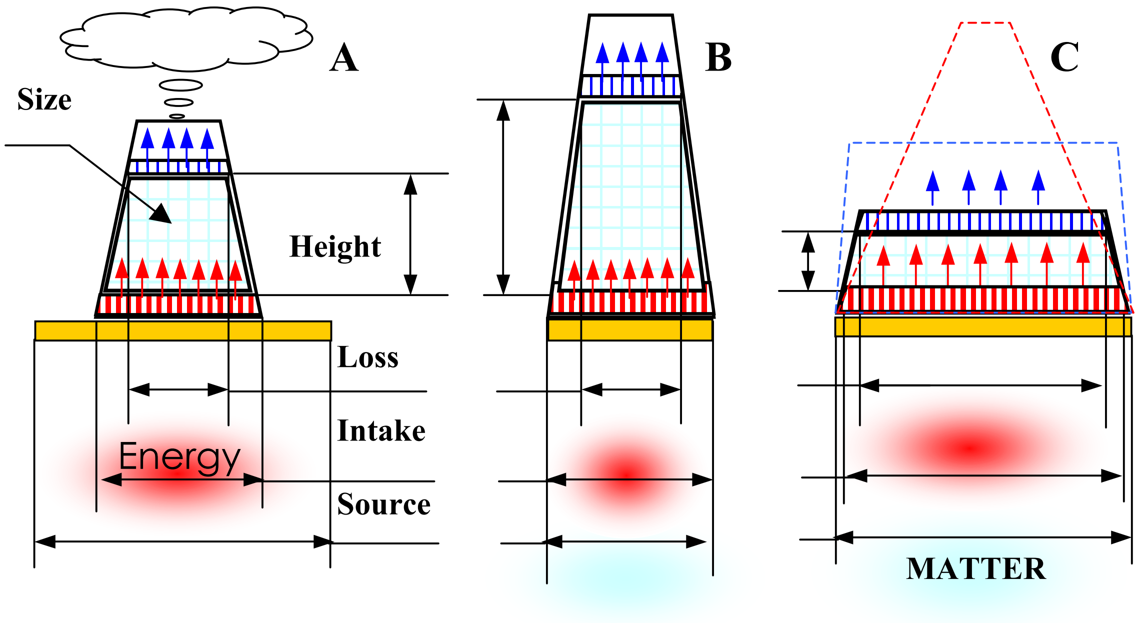


Figure 3.12.1. **Minimal exystemic degrees of freedom**
A: Steady state on unlimited energy resource. B: Growth on limited energy footprint. C: Alternatives of flat or tall growth.

1. Configuration B. What happens if the source of energy shrinks?

The system can grow up, increasing its internal complexity by developing subsystems, only insofar as the systems does not lose stability, which can be achieved by the increase of efficiency, otherwise called productivity. It loses stability if the source becomes smaller than the footprint. The size of the system **B** is approximately twice the size of configuration **A**.

2. **Configuration C.** The system loses height and orientation by spreading its footprint over the unchanged source.

These are only two of many possible situations, selected to illustrate the method of reasoning. Other situations can be constructed from variations of the above degrees of freedom.
Of course, the **source of energy** is the "less free" degree of freedom, but it can also be manipulated, which is today the essence of the entire problem of energy. One way to cope with it is to shrink the size of the exystem or some of its components, as well as to renovate the whole pattern of **economy** which today is, in my opinion, synonymous with civilization.

History records multiple examples of large scale shrinkage of the human component of economy, all of them but one—population control in China—sinister, although the

Chinese example is controversial enough. The shrinkage of Technos is another alternative, unthinkable today, but probably not the day after tomorrow. Exystems always search for stability and adaptation cannot be either decreed or denounced. The natural slowdown of the population growth is an example.

Regarding America and Russia, my reluctant prediction is that America will develop a more vertical structure with the shrinkage of the source. Reluctant, because apparently it has already been happening, as the Bush years testify with the overseas wars, internal cold civil war, consolidation of central power, and religious zeal. The same will probably happen to China. Russia, on the contrary, finds itself sitting on a huge source of energy, much exceeding its footprint. Theoretically (again, reluctantly: I do not like theories in human matters), Russia could relax its verticality and change orientation to a flatter one. It is difficult to change the vertical national mentality, however, and some local independence can be achieved by bribing off the centers of power. It seems that it is already happening.

Unfortunately, the mineral fuel is not only burning with increasing speed, but the fire also threatens to get self-extinguished by the exhaust. With the increasing world competition for the source, the only alternative to shrinkage is to grow tall and use the height for military reconnaissance and exploits. But it is difficult to fight large scale patterns: the war works as the scissors of evolution.

Since humans do not yet drink mineral oil, land becomes an increasingly important source of energy. Most of human history has been nothing but the conquest for land.

I believe we can check my predictions (quite trivial, though: historians know all about this stuff) against the past.

At the very beginning of American history, the colonies found themselves on a vast source of energy: enormous land flooded with sunlight. As result, the flat American democracy, which was actually a new civilization, took shape and began spreading its footprint. Why did Lenin's Russia started with its tall pyramid? Because when the Russian Civil War and foreign intervention began the Soviet Russia found itself on a tiny footprint of the post-WWI devastation and even smaller source of energy. It was cut off the Ukrainian wheat, coal, and the petrol of the Caucasus.

Figure 3.12.2 presents the approximate borders of the territory of the Russian Empire (1913) under the Bolshevik control in 1918. In **Figure 3.12.3**, this area is shown in detail.

It took 70 years for the flattening—and fattening—of Russia to begin. Like in France after the French Revolution, when history took a bumpy road through a sequence of swings between the republic and monarchy, Russian history has been a series of swings between freeze and thaw, with just two short glimpses of democracy through the authoritarian clouds.

As for the American history, if I am not mistaken, the globalization, which took off in the post-WWII years, means a contraction of the source for the second or third time since

1973, this time with new India and China. The oil crisis of 1973 resulted in a spike of American verticality, now forgotten.

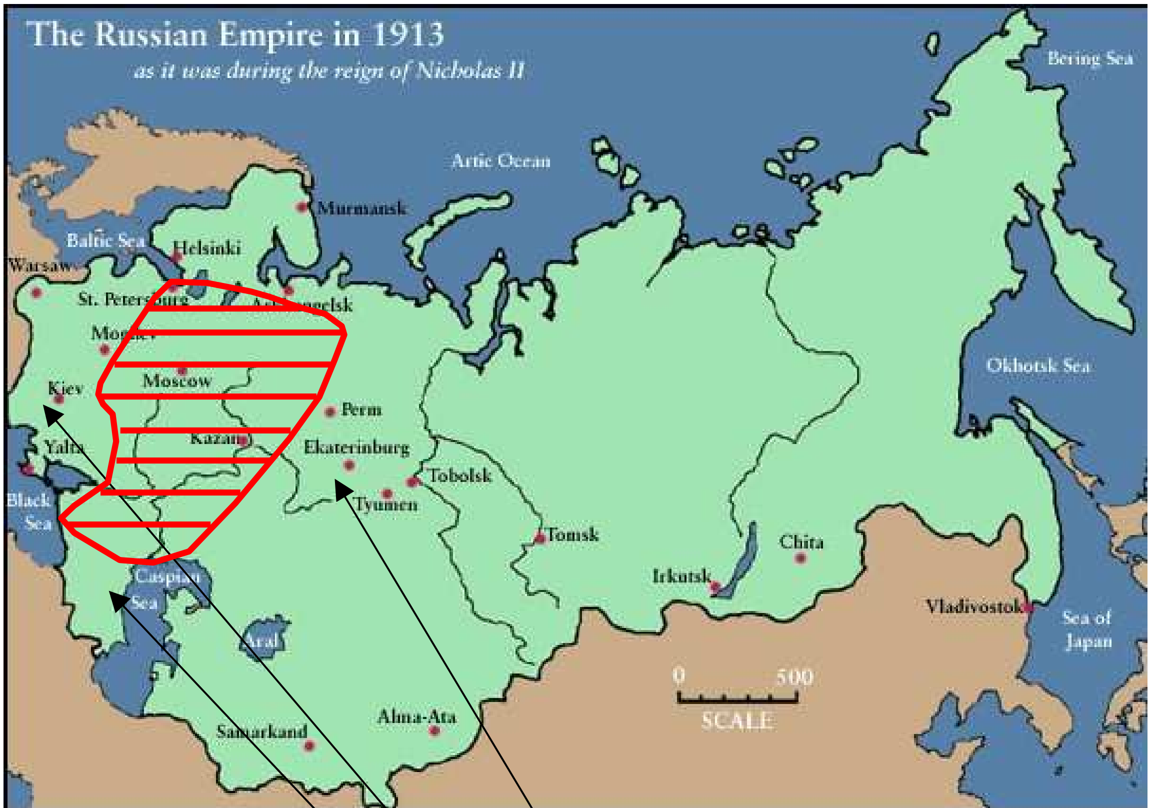


Figure 3.12.2. **The approximate area of Russia under Bolshevik control in November, 1918. Resources: ●oil, ●bread, ●minerals and timber.**

The curious thing is that the **loss** (dissipation is a better term) has its own footprint, part of which is, of course, carbon dioxide and heat, but what is the rest? The exports! They have their counterpart of the **source**, which we can call the **sink**. Competition not only tightens the source, it clogs the sink. Now the minimalist exystem is complete.

It all has been the most common and trivial part of "hard" physics, economics, and history, not to mention common sense. What is the value of pattern chemistry? I believe, it consists of three increments: (1) The unified view of the world, which is always good for education, and (2) the stable view of the world which is good for making important decisions. (3) The third increment is the matter of personal preferences: it is the joy and fun of the mental game.

I believe that the most difficult problem on the way toward a unified world view is establishing a link between thermodynamics and complexity. The two views of the world are strikingly different: planets, electrons, atoms, molecules, machines, and movement in space is seen from one angle and molecules, organisms, humans, civilizations, and evolution from the other. There is only one common object on both sides of the divide:

molecules. They served an evolutionary bridge from one to the other. But why? Because the are capable of growing enormous but easily reproducible complexity of biopolymers, simple and complex at the same time.

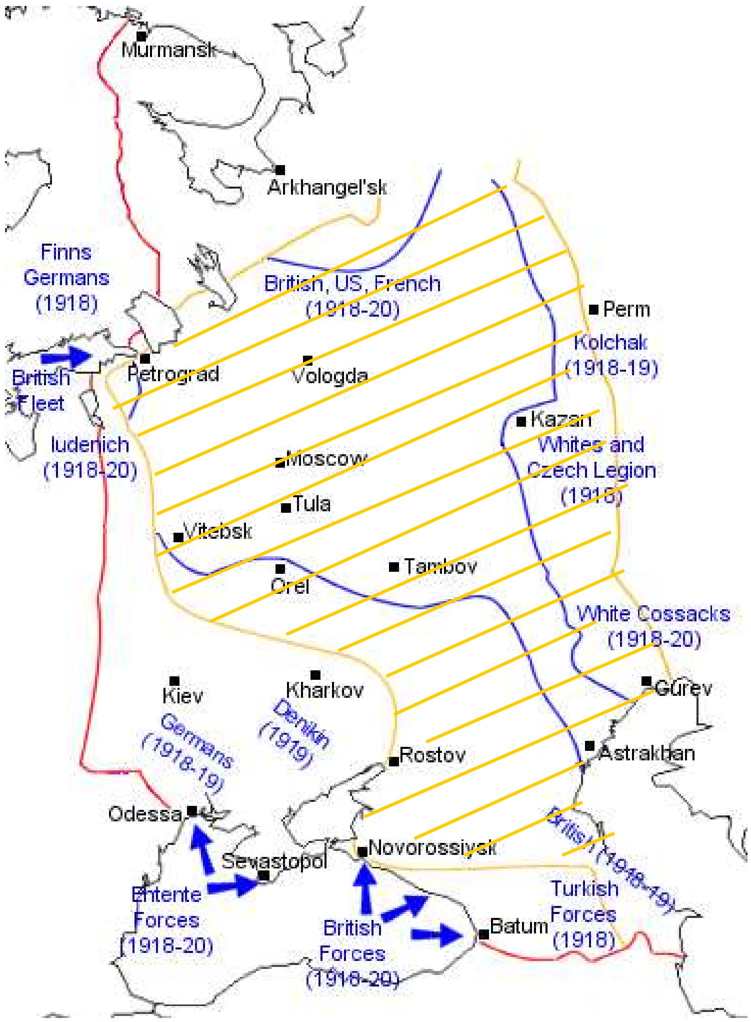


Figure 3.12. 3. **The part of Russia under Bolshevik control, November 1918 (**[Source]**)**
Bolshevik control, November 1918 Maximum advances of 'White' forces Frontiers, 1921 European theatre of the Russian Civil War

This Chapter implies that the tightening of the energy supply of an exystem (which is a change in **thermodynamic** condition) may result in the change of its structural **complexity** in a rather straightforward way, increasing the number of negative bonds. This is a very controversial statement unless we can, in the spirit of chemistry, trace the mechanism of the process or, in the spirit of physics, prove it by equations and calculations. But what about economics, the true science of everything?

I begin to think that economics without thermodynamics—with money but not energy, with gain and loss, but not stability, with growth but not decay—is the thing of the now ending Golden Age of unlimited resources, to which not animals, nor humans, nor machines, but the global exystem must **adapt**. The economics of conquest is always wrong, while the history of conquest is always right.

As for chemistry, at this point I am unable to present the mechanism of the energy-induced change of complexity. In a very general form, the increase of the vertical complexity of the system seems to lead to the increased stability because the new "organs," biological or social, increase the thermodynamic efficiency of the system and allow it to survive on a smaller source. This explains, at least to myself, why biological evolution has been generating more and more complex organisms and why simpler organisms successfully coexist with complex ones: complexification and simplification are in a quasi-equilibrium. Simple creatures feed on sunlight and reproduce in a jiffy, while some humans never grow up. Tall social structures, like China, gain in stability by reducing chaos, while flat social structures, like America, gain in stability by flexibility and **adaptation**. Yet the stone crumbles, while water flows around stone.

The factor that I have not yet taken to account in differentiating between tall and flat systems is temperature: cold systems are solid and brittle, warm systems are flexible and pliable. This pretty obvious distinction was the starting point of my realization that social systems had their own chemistry. It happened around 1978, in one of the coldest social systems of all, which the rest of the world saw rock solid not long before it crumbled. The approximate generalization is that the tall system cannot be stable unless it spends part of energy on its own refrigeration. America used to spend more energy on refrigerating its beer than on freezing the structure of power, but not everybody was happy. The idea of the Republican Revolution as the single party mandate for a foreseeable future, if not, ideally, forever, was shockingly both Soviet and Fascist in its pattern, which is more than just totalitarian. I must add that the idea of a fixed hegemony of any country seems to me equally repugnant.

In natural sciences great new ideas used to conclude a long period of observations and discoveries. In humanities new ideas usually herald a coming historical transformation.

I see a direct confirmation of the process of verticalization in America in the fact of the growing income inequality. This may not mean much in itself because numbers fluctuate. I see, however, an indirect confirmation of a coming historical breaking point in the ideas like "What we need in politics today is not more democracy but less." (Fareed Zakaria, *The Future of Freedom: Illiberal Democracy at Home and Abroad*, W.W.Norton, New York, 2003, p.248). I translate it, following the quoted book, as **more order and less chaos**. In this physical-chemical language, the phrase means exactly verticalization: the increase of energy spending on maintaining lower social temperature and/or larger network of negative bonds. Right before my eyes, "THE END OF HISTORY" on the banners of political philosophy has changed to "THE POST-AMERICAN WORLD." Taking them literally, there is no contradiction in the slogans whatsoever. As soon as the footprint has matched resources, the world history changes direction from expansion to adaptation. In the language of chemistry, kinetic control changes—slowly and probably painfully—to thermodynamic control. This is, however, a topic to be considered separately and Fareed Zakaria's books (and evolution of his views) could be the source for a case study.

The main contradiction and the major stress of the future is to reconcile "more order and less chaos" with the inherently chaotic markets from which the wealth and, as many think, freedom itself come. If my conclusions about the consequences of the shrinking energy source, or, more generally, the end of any open frontier of any kind are correct, the markets will become part of a global household, with "more order and less chaos," too.

> I believe that the Kyoto Protocol is the first reliable evidence of the changing attitude to the market and realization that there are things that could not be bought and sold. The old market illusions and new compromises are reflected in the idea of carbon emission trade.
>
> The stark realism is reflected in the trendy predictions of war for water, food, and energy. The good-natured optimism points to the reduction of birth rate as a solution. By choice or by murder? The world views according to Milton Friedman, Club of Rome, and Thomas Friedman cannot be reconciled.
>
> To me, who still remembers the taste of the real chicken of my childhood, the current state of the American food market (read Michael Pollan) is an ominous illustration of future alternatives. I even remember the healthy variety of American publishing houses only twenty years ago. I also remember the literally, not figuratively, empty shelves of the Soviet stores, the meat department without meat, and the cheese department without cheese—empty for years.
>
> **Exit question**: I have compared two exystems out of many. What is the meaning of competition for the single global exystem with no competitors?
>
> Humans compete with Technos

3.13. THE CHEMISTRY OF FREEDOM

The previous **Chapter** postulates a relation between energy and complexity, but leaves unanswered the question how the flat structure turns into the tall one and why.

The relation between energy consumption and stability of an exystem might also have a bearing on the problem of freedom, democracy, and order, as well as the relation between complexity and stability. This is a Gordian knot that must be undone, not cut. Indeed, are there any pattern democracy and liberty?

I am not up to the task yet, but I will try to loosen it a little.

The only thing both political and market gurus can sell is the vision of the future, soon to be forgotten and replaced by a new vision. Still, I have acquired a taste for almost forgotten books on political matters, published more than five years ago because they offer a window into the way intelligent people perceive the future which turns into the past incredibly fast.

I used to see democracy as a component of freedom until my view was somewhat shaken by Fareed Zakaria's *The Future of Freedom: Illiberal Democracy at Home and Abroad*, W.W. Norton, N.Y., 2003. As usual, I borrow only the formulation of the problem from the source, abstaining from any criticism. Whatever I think about the problem, I only want to look into its chemical aspect.

If democracy is freedom to elect leaders in the one-voter-one-vote manner, is the election of the corporate board of directors in one-share-one-vote manner democratic? And if not, is the influence of money for embellishing or defacing the image of a candidate in American elections democratic? Is equality a basic freedom? The problem looks hopelessly confusing, at least off the chemical bench.

To remind the method of pattern chemistry, we start with an intuitively but not necessarily "true" and usually simple configuration of an exystem: a template. Next, we begin to **move** it through the configuration space in order to find the most realistic representation of the exystem. The movement consists of elementary stages of locking, rearrangement, and unlocking bonds, as well as changing degrees of freedom. Complexity may increase or decrease as result of our mental experiments.

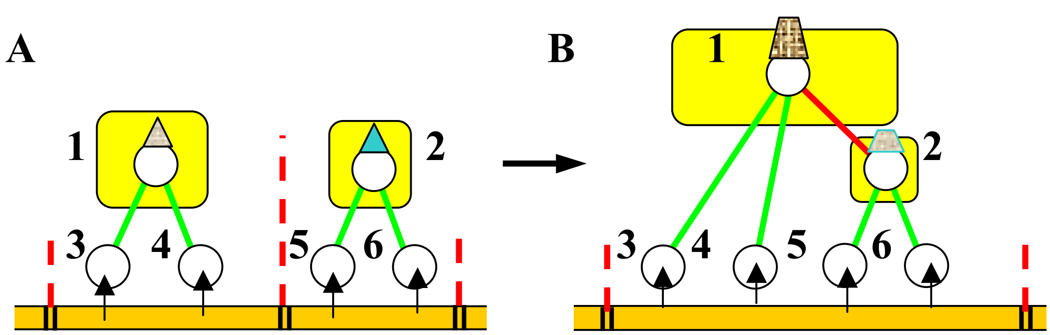


Figure 3.13.1. **Emergence of vertical complexity**.

Symbols:

Positive bond **Negative bond** **Contract bond** **Land** **Wealth** **Border**

Figures 3.13.1 to **3.13.3** are entirely speculative examples. They do not claim any academic validity. Dealing with them can be compared with the work of a molecular chemist who is about to start a new project and is playing with structures on paper regardless of whether they are existing substances or not. The first sketches of an artist or a writer starting a new work fall into the same category. They are **evolutionary experiments** that can be rejected or developed later.

In **Figure 3.13.1A**, six **individuals** constitute flat system of two units, each held together by **positive bonds**, for example, family ties. The source of energy is **land** with its plants and animals. The territories of the units have a marked **border**. This arrangement is not necessarily human and could be exemplified by two neighboring packs of animals if not for an important feature that the animals lack. The two leaders, **1** and **2**, have an additional source of energy denoted as **wealth**, which can be shared with members of the group. Bonds between individuals can also be **negative** .

Wealth is as good a source of energy as land, and it can be land. The difference is that land is the ultimate source of wealth and it is "real," not movable. Wealth can be anything: physical strength, size of the army, food, gold, tools—anything used to maintain negative bonds, for example, to defend borders. Property makes land a form of wealth. When land is sold, nothing immediately happens to it while the property right changes hands.

The underlined terms above are just labels for the generators and bonds of abstract configurations, as well as sources of energy. The natural anthropomorphic interpretation is only one of many possible. Therefore, my comments to the **Figures** are as little academic social science as generalized chemistry is molecular chemistry.

> Nothing can substitute for hard science as the source of knowledge of how things are. Alas, in the case of singular exystems the things never **are**, they are **becoming**.
>
> The distinction between being and becoming comes from Heraclitus, Henri Bergson and Ilya Prigogine.
>
> As it common in science, simplistic configurations taken as starting points (hypotheses) can be transformed into experimental realistic interpretations, but this is not my task. Pattern chemistry performs the opposite process. If the result is not a hypothesis, then what is it? All we can hope to achieve with pattern view of the world is to supplement our limited hard knowledge of the known with limited, but still hard understanding of the yet unknown.

The purpose of the **Figures** in this **Chapter** is to show how the enormous complexity of modern society can arise from a few degrees of freedom. I use this term to denote not just elements of the structure—generators and bonds—but also the thermodynamic parameters and circumstances of interaction. One important point is the evolutionary **origin of wealth**.

The abstract chemical wealth is an evolutionary adaptation to the uncertainty of environment. It is a surplus of storable energy used to keep the exystem well above metabolic cost. The second important point is that wealth is as good a source of energy as land with its plants, animals, and sunlight. It is the same as to say that land is wealth, but more of an eye opener, as far as origin is concerned. In technical terms, wealth is in the same pattern category as car battery. The physical interpretation of wealth is the energy of meta-stable states. Compare with Erich Beinhocker's views (**Chapter 3.2**).

In **Figure 3.13.1B**, individual **1** establishes a negative domination bond with **2**. This configuration can be stabilized only by some additional source of energy in the form of wealth.

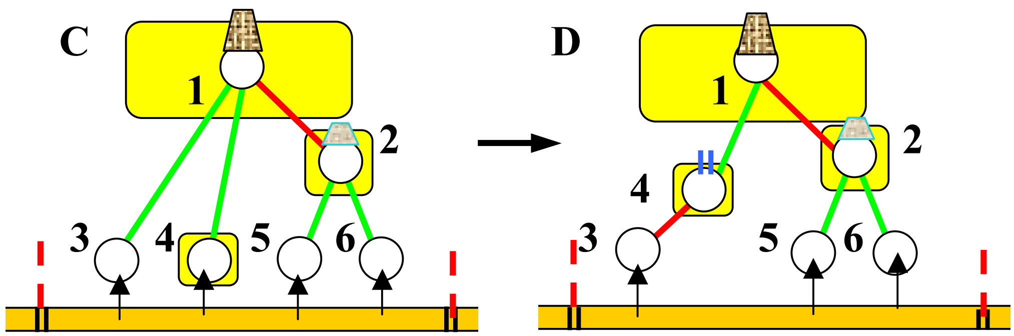


Figure 3.13.2. **Separation from land**

Individual **4** in **Figure 3.13.2 C** accumulates some wealth and undergoes elevation in rank In **Figure D** , individual **4** becomes an intermediary between **3** and **1**, which can make bond **3—4** negative, although not necessarily.

The **contract** bond in **Figures 3.13 E** and **F** is a positive bond by mutual intent. It can become negative when the contract deteriorates into domination. It can be even exchanged for goods. The contract bond works for packages of energy and matter, but not as a permanent source.

Individual **5** does not accumulate wealth, stays off land, is supported by the wealth of **4** , and establishes contract bond with **2**. We can imagine, for example, that **4** shares wealth with **5** because of family or debt obligations. The contract provides a one-time amount of wealth, which is the major difference between the permanent ownership and contract. Wealth, therefore, is a kind of quasi-land. Unless it is the natural land, which is part of nature, wealth can be completely exhausted and nullified. Today, however, the same can be done with land.

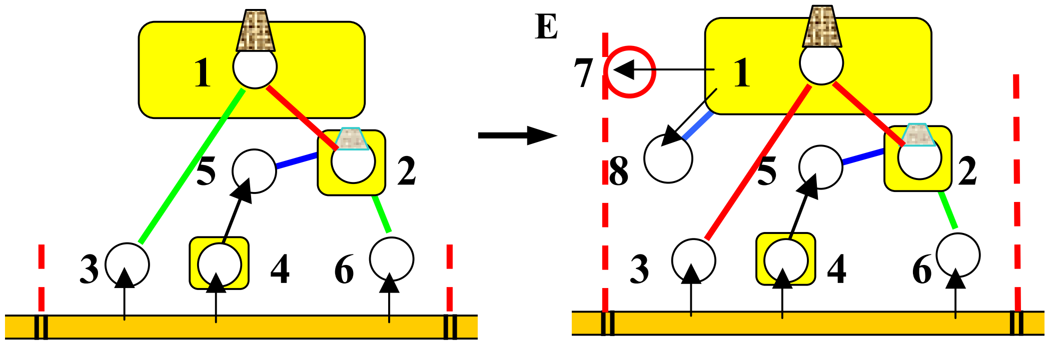


Figure 3.13.3. **Development of contract bonds and state functions**

In **Figure F**, the wealthy leader **1** adds to his staff a permanent border keeper and defender **7** and individual 8 who performs contract jobs but needs a permanent support. Energy can be transferred along all red and green bonds, but the black arrows, which indicate the direction of the flow, are not shown to avoid clutter.

What is freedom in an entangled and complicated economic exystem, always hungry for energy at all levels, with the mess of positive and negative bonds? Reading Fareed Zakaria, I had a feeling that I would not learn what freedom was for the following reason: every really fundamental notion cannot be given a non-circular definition.

Freedom in chemistry seems out of place. All the more, because it is not fundamental there, we could look for its non-circular interpretation. For a test, it seems natural to measure **freedom** with the number of degrees of **freedom**; the latter usually interpreted as choice. This understanding of freedom (of which democracy is a component, not anything separate) inadvertently leads to the conclusion that the problem of America is not too much democracy, as Fareed Zakaria thought, but too little of it in the antagonistic, entrenched, and ossified **two-**(only 2!)-party system. **Figure 3.13.1** then becomes a technical design for the Republican Revolution. But why Republican? Because the Republicans have much less degrees of ideological freedom and can concentrate power per degree. The Democrats have too many degrees of freedom, as a true party of liberty should have, and, therefore, less power per degree. Power here means financial resource single goal, see Essay 53, Power: Hidden Stick, Shared Carrot . This looks like a viable idea, but the logical circle closes immediately with “freedom is degrees of freedom.”

Let us test another approach: freedom is chemical **lability.** It is, roughly, the ease of transformation, which increases when the transition barrier decreases. High lability does not mean that the transition will go in the desired direction. If all transition barriers in the system go down, which happens when temperature increases, the system becomes more chaotic. What social, economic, and political—i.e., exystemic—freedom implies is the ability of a generator to increase its lability locally, in the desired direction, and without disturbing a larger area of the system. In molecular chemistry it is known as catalysis, i.e., selective decreasing of transition barrier in one desired direction. In other words, the individual has to use a pair of **exystemic pattern hands**, his own, owned, or hired. In order to do that and to navigate through the transition state **full of uncertainty** (i.e., unstable), a guaranteed supply of energy in the firm of expendable wealth is as necessary as a tank of gasoline on the road. An individual is as free, therefore, as he is above the metabolic cost. Or, as free as his pockets are full of money. This is a very old and trivial idea.

> *Money payment as the form most congruent with personal freedom* is the title of a sub-heading in the long chapter *Individual Freedom* in Georg Simmel's unique *The Philosophy of Money*,1907 (2004, Routledge,p.285; see **Essay 55, The Chemistry of Money**).

The coin to buy the gasoline for the hayride of freedom, however, has two sides. The other side buys the heat of the revolutionary chaos and permissive culture, as well as the cold of the slavery and obscurantism. Georg Simmel traced the evolution of society from slavery to freedom and liberation by monetary exchange and gasoline on the eve of Ford Model T, when the opposite process of enslavement and solitary confinement of nations by brute primitive force was not yet known. And so, we come back to the main problem of this text: will the freedom machine reverse its gears if the supply of energy by global civilization comes to steady state? And forget freedom, which is just the distance between the desire and attainment what is going to happen in any way?

The elections of 2008 have been a unique chemical experiment with freedom, half-completed by the time of writing this **Chapter**, to which I will have to return later.

As for desire…

3.14. THE SIMPLE CHEMISTRY OF FEAR AND DESIRE

Chemistry does not know what benefits and harms are, unless there is a certain wish. It knows only the difference between the fluctuating peace of the stable state and the turmoil of the transition state. Neither one can be praised on any objective terms. Johann Wolfgang Goethe was able to capture the great human paradox in his *Faust*: the hero enjoys the excitement of the transition state so much that he wants to make it forever stable.

Beware when you make a wish. Norbert Wiener, one of the last great carriers of the Western tradition, recollects another Goethe's fable, *The Sorcerer's Apprentice,* (and other similar tales) in his discussion of the dangers of "non-human devices of great power and great ability to carry through a policy" (*Cybernetics*, MIT Press, 1965, p.176). Taking to account the dangers of **human** devices of "great power and great ability to carry through a policy," recorded in the history of the previous century and fuming from the live open flesh of the current one, I see it as another sign of divergence between humans and things.

That the names of Goethe and Norbert Wiener are not on standby in modern culture is an example of re-memorization (**dilution**, in chemical terms), the loss of the past. The humans who lose their past lose their human nature. But the computers that remember **their** past lose their technological nature.

Google, Thursday, June 19, 2008

Results **1** - **10** of about **25,000,000** for **"hannah montana"** omg!
Results **1** - **10** of about **27,800,000** for **"Miley Cyrus"** omg!
Results **1** - **10** of about **23,500,000** for **Goethe** (include places and institutions)
Results **1** - **10** of about **2,970,000** for **"johann wolfgang von goethe"**
Results **1** - **10** of about **222,000** for **"norbert wiener"**

I believe that the glass of culture is half full, not half empty. It is what we cannot forget that matters most, not what we remember. The question is, what do we remember: a pattern or a template?

By mere accident, I ran into the following example of the shrinkage of the past in American culture. Earlier, I mentioned Fareed Zakaria's book *The Future of Freedom* (2003).

The main idea of that book is presented in the following quotation, but **not** from Fareed Zakaria:

> Indeed, leadership becomes followership as those who are competing for the suffrage of the masses succumb to the temptation of identifying themselves publicly with whatever the masses, in their ignorance and excitement, may be clamoring for, rather than seeking by persuasion to enlist their support for such measures as may be necessary for the security and well-being of the society.*
>
> > * This is the theme of Thucydides' history, in which he attributes the downfall of Athens to the decline in the quality of leadership associated with mass democracy.

The source of both the quotation and the footnote: Louis J. Halle. *Out of Chaos*. Houghton Mifflin Company, Boston, 1977, p. 635.

I could not find Louis J. Halle's (1910-1998) biography on the Web, although he was author of at least 17 books by 1977.

At least two other books refer to Thucydides as the "hindsight prophet" of the flaws of democracy, both published almost simultaneously with Fareed Zakaria's book:

1. The Peloponnesian War by Donald Kagan (2004), Viking Adult; 1st Edition / ARC edition (2003). This book follows Thucydides and only hints on the parallels with America.

2. What's Wrong with Democracy? From Athenian Practice to American Worship, by Loren J. Samons II , University of California Press (2004).

We remember Thucydides as a pattern template: a hall through which configurations in an endless procession walk toward the exit into the fog of oblivion.

The procession becomes more numerous in times like the present ones, when the ancient pattern seems to match the reality of the American e-democracy (**e** stands for both electrons and economy) struggling, failing, and rising under attacks from outside and inside. There must be a driving force for that.

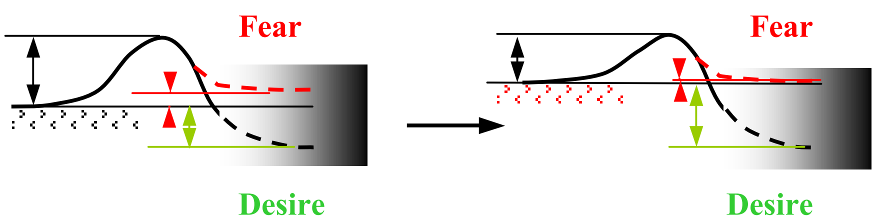


Figure 3.14.1. **The chemistry of desire and fear. Instability of the initial state alleviates fear and increases desire of change.**

The new books on the subject intensely multiply when the rising instability of the initial state of all-comprising economy makes the transition barriers to both their conception and publication relatively lower, **Figure 3.14.1** .

The final state for exystems is always imaginary. If it higher than the initial state, we call it fear and if it is lower, we call it desire. This applies to any action on both individual and historical scale.

A tentative and partial answer to the question of the previous Chapter—what is going to happen?—is that we will certainly adapt to the new situation by modifying our desires and fears.

> [This is a good moment to touch upon the area of science which is most similar in spirit to **molecular** chemistry: social psychology].

3.15. CATALYSIS AND HANDS, PATTERN AND TEMPLATE

This Chapter illustrates the extended discussion in The Visible Hands: *Homo Faber* and the Chemistry of History and The Rusty Bolts of Complexity: Ideograms for Evolving Complex Systems.

I found a unique illustration of some central concepts of Pattern Theory in Philip Pullman's *His Dark Materials* , a rich, courageous, innovative, and imaginative work of human mind. In the third book, *The Amber Spyglass*, a race of handless beings called Mulefa (plural of Zalif) have four legs arranged in a diamond pattern (front, two side, and back) and a trunk. They can use the trunks as a pair of hands only if a pair of Mulefa coordinate their actions.

The way the Mulefa perform work fits the pattern "hands," which covers a much wider variety of configurations. The pattern applies to a process in which objects X and Y (**A** and **B**) either form a bond or lose it. The process is facilitated by the third object Z (**Hands**), which forms temporary bonds with X and Y in the transition state between bonded and unbonded states of comparable stability. In addition to this verbal description, the stable states are presented in a pictorial manner in **Figure 3.15.1**.

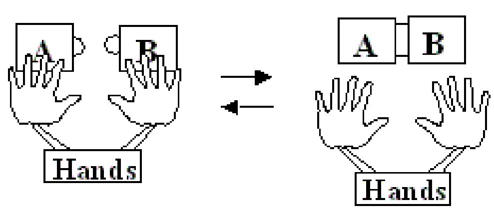


Figure 3.15.1. **Pictorial presentation of stable states in pattern "hands."**

As a chemist, I would prefer "catalysis' to "hands" as the name of the pattern, although I do not insist. I will use them intermittently. The transition state in the process behind catalysis is shown in **Figure 3.15.2** (**Figure 2** in The Visible Hands). Its symbolism is both very abstract and very chemical. There could be variations in the transition state, so that the temporary bonds would form in either of three possible sequences: one simultaneous, two consecutive ones.

The catalytic pattern lies behind the most common processes in exystems. Moreover, it is the only mechanism for any event that cannot happen on its own, except for the movement toward equilibrium and entropic decay. No life is possible without catalysis and no economy without human hands—I mean, human economy. The Mulefa, too, have an economy of their own, but nothing to be envious of.

The pattern covers real, actual, possible, as well as imaginary fantastic situations; some of them shown in **Figure 3.15.2** , where only the Mulefa needs a commentary.

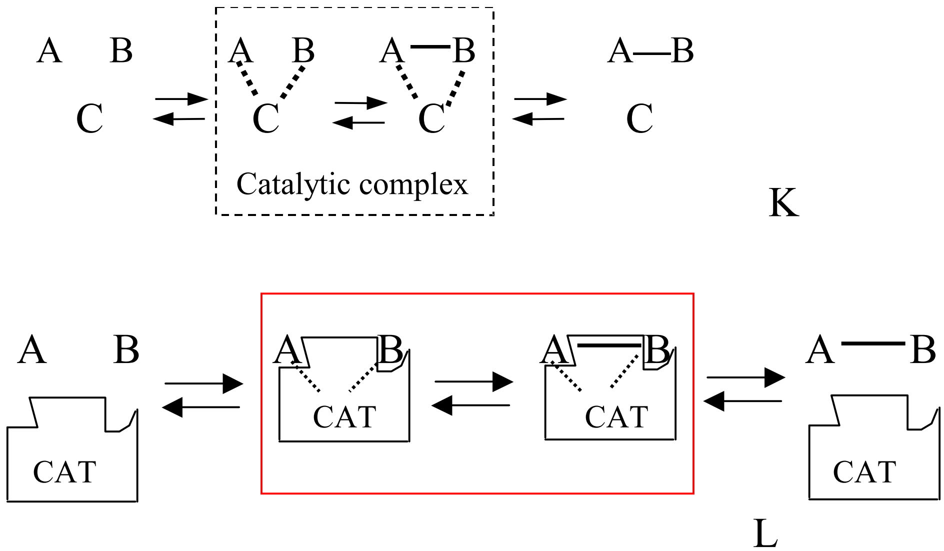


Figure 3.15.2. **Catalysis in less (K) and more (L) detailed versions.**

The universality of catalysis as the most basic mechanism of exystems may be an extra argument for the reconfiguring economics as the science of everything on human scale (if $62,000,000,000 of Warren Buffet can fit human scale; remarkably, wealth of this size limits the freedom of the owner as much as the size of a supertanker limits the freedom of the captain). The new science of our cosmic household (Greek oikonomia: "one who manages a household") may include thermodynamics and pattern chemistry, but it will remain dismal science until it includes neology: the semi-soft science of the exystemic future.

Figure 3.15.3 presents several configurations (more exactly, images, in terms of PT) under the catalytic pattern, for which I retain ideogram "hands" (**A**). **Figures 3.15.1** and **3.5.2** look already more as configurations (i.e., combinations of generators and bonds) than images.

One remarkable aspect of catalysis is completely overlooked in molecular chemistry and physics: the act of catalysis is an **event with a beginning and an end**. This is the same as to say that catalysis, as well as any manual action, is a creative act (even as undoing and cutting). My favorite example is that Galileo and his hand letting go of feathers and stones from the top of the Tower of Pisa never show up in physical laws of movements. We can observe a creative act only when we see both its beginning and end. If the act of catalysis is not ended and the goal is not fixed, the labile exystem forgets the creative act. The cartoon in **Figure 3.15.4** illustrates it in a witty way. This intricate philosophic subject, however, should be left open-ended here.

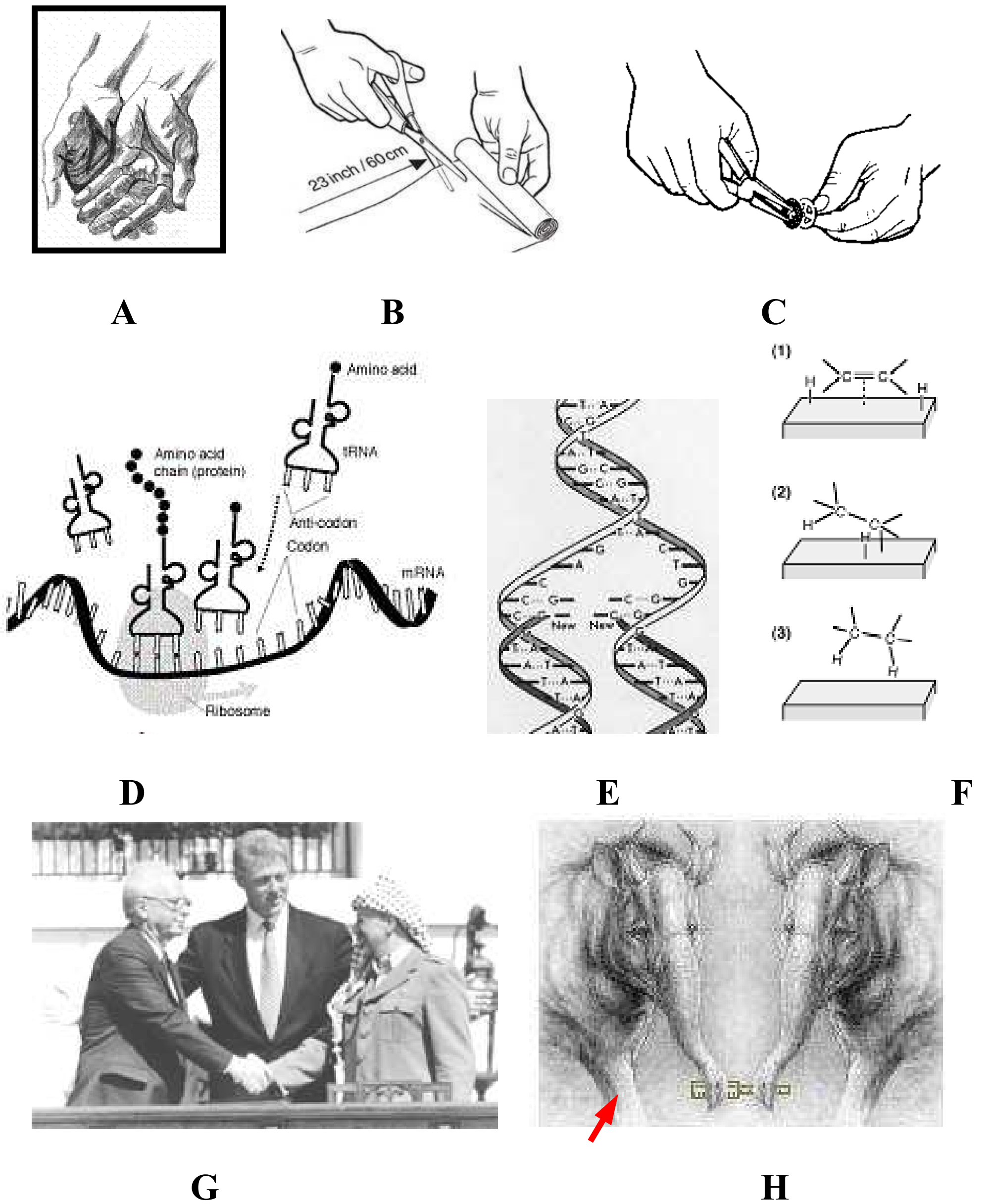


Figure 3.15.3. **Catalytic pattern. Ideogram (A, hands**, may belong to different people**) and images of configurations: B, cutting; C, joining; D, protein synthesis, E, DNA duplication; F , heterogeneous catalysis; G, mediation; H, Mulefa (**the single front leg is visible**).** I have modified the Mulefa picture by Amy Thompson. The red arrow points to the **single** front leg.

Figure 3.15.4. **Catalytic act with a beginning but not an end: Rabin, Clinton, Arafat, 1993.** Author: Reid Sifen (source).

3.16. READING ISAAC NEWTON: CALCULUS WITHOUT NUMBERS

This chapter is more meditative than essential: I want to illustrate the trans-disciplinary nature of pattern chemistry—an offshoot of Pattern Theory—by wide sweeps through time, place, and subject. I am using this as an opportunity to revisit the museum vaults of human understanding and look at the main chemical ideas not from the humming and blinking electronic present, but from the candle-lit distant past.

I do not know any area of knowledge closer to chemistry—as well as the center of the human scale—than interpersonal relations, a source of everyday joy and torment and a subject of literary fiction, social psychology, and piles of self-help stuff. The idea that individual humans are atom-like entities and there is a kind of chemistry between social atoms and molecules is very natural, but whether it is more than a metaphor remains uncertain. Anyway, human chemistry has been on the marketplace of ideas for quite a while. For the history of the subject, see Libb Thims' Human Chemistry and Human Thermodynamics.

> The main reason why I abstain from referring to Libb Thims' flamboyant venture other than as to a commendable review of literature is that he, apparently, uses the term chemistry too literally in the sense of molecular chemistry, while I am interested in pattern chemistry. I can only note that the very idea of human thermodynamics as a separate subject looks to me completely sound. Thus, the concept of metabolic cost (see Chapter 3.6) is part of it. Obviously, human interaction is a component of global economy.

The human chemistry is even richer and more general than the molecular one because of the powerful role of negative bonds in human matters.

The academic literature on the subject is big, diverse, dispersed, and often rather dreamy. I will use in this Chapter only my original sources and observations.

Goethe's novel "*Die Wahlverwandtschaften*," or "*Elective Affinities*" (I would translate the title also as *Fatal Attractions*) has not yet ceased to stimulate literary afterthought. Moreover, it imprinted such pioneering thinkers as Max Weber, Ilya Prigogine, and, probably, every reader with the interest in the intimate mechanisms of human interaction. The article in Wikipedia gives all essential points and references.

The last 8 or 9 pages of Chapter IV in the novel contain a remarkable description of the interaction between two **mail**-female couples **A**—B and **C**—D that may lead to the exchange of partners: **A**—B + **C**—D → **A**—D + **C**—B. The mentioned chapter is full of references to chemistry and the entire novel describes an actual human experiment in exchange. If not for that, the transformation itself would be just a trivial combination of love triangles. Each love triangle transformation, of course, is a pattern counterpart of the molecular chemical substitution. Goethe was the first to look at human matters in that way. Goethe's chemistry, however, is strikingly "chemical."

In the following famous excerpt, which I underline and comment in brackets, Goethe gives not only a great description of abstract positive chemical bond and the transformation itself, but also a **description of the fuzzy unstable transition state**.

> Suppose an **A** connected so closely with a **B**, that all sorts of means, even violence, have been made use of to separate them, without effect [**bond**]. Then suppose a **C** in exactly the same position with respect to **D**. Bring the two pairs into contact; A will fling himself on **D**, **C** on without its being possible to say which had first left its first connection [**transition state**] , or made the first move towards the second. Now then, interposed Edward, till we see all this with our eyes, we will look upon the formula as an analogy, out of which we can devise a lesson for immediate use. You stand for **A**, Charlotte, and I am your **B**; really and truly I cling to you, I depend on you, and follow you, just as **B** does with **A**. **C** is obviously the Captain, who at present is in some degree withdrawing me from you [**transition state**]. So now it is only just that if you are not to be left to solitude, a D should be found for you, and that is unquestionably the amiable little lady, Ottilie. You will not hesitate any longer to send and fetch her [**final state**].
> (*Goethe's Elective Affinities*, D.W.Niles, Boston, 1872, Chapter IV, p.44)

Goethe's novel was published in 1809. In her introduction to the cited American translation, Victoria Woodhill wrote:

> It is very true that ideas of social freedom and of inevitable law governing the action of human affections are rapidly spreading in the world, at this day, and that I may have done something to aid their growth. Perhaps my name may *not*, therefore, be inappropriately associated with this reproduction of the work of the greatest Genius of Germany, the first who promulgated the thought that there is a chemistry of the mind, and that "Elective Affinities" are as powerful and legitimate in the realm of human sentiment as in the realm of matter. (p.*iii*).

Two hundred years after Goethe, a mathematical model of the chemistry of the mind is an evolving project in Ulf Grenander's "Patterns of Thought." See *Publications of Pattern Theory Group*, Department of Applied Mathematics, Brown University.

What was the state of chemistry right before 1809? The most advanced book on chemistry was *A New System of Chemical Philosophy*, Part 1, by John Dalton (1808), who, regardless of some understandable errors, formulated the deepest foundation of modern chemistry: atomic theory. The theory stated what is trivial today: a limited assortment of atoms combines into molecules of chemical compounds according to atomic affinities and the properties of the compounds depend on the ratio of atoms in molecules. Chemical transformation is a rearrangement of atoms. So is global economy. Sometimes overlooked regarding Dalton's work is the **attribution of a number** to each type of atoms, namely, atomic weight. Molecular weight is a sum of atomic weights of all constituting atoms.

The second conceptual block of chemistry—the idea that properties of molecules depend on the **order** of connection between the atoms—was added around 1860. The focus of attention in molecular chemistry shifted from stiff unyielding atoms to flexible labile bonds between them. Chemical bonds were **attributed numbers**: measures of their stability, alias, **bond energies** from which probabilities of bonds directly followed. Energies are (roughly) **additive** over bonds.

> There is a logarithmic relation between energies and probabilities in closed systems: a small change of energy leads to large shifts in probabilities. The quantum-chemical paradigm is not the same as molecular-chemical: it operates with distribution of electrons in molecular orbitals, not just two-atomic bonds.

Around 1920, physics explained the nature of the chemical bond and derived it from the nature of atoms.

The third block—the concept of transition state—had to wait for another fifty years, but it is still is not fully associated with singular numbers.

> In this chapter I intentionally use a slacker than usual language in order to keep in scope a very diverse assembly of subject matter spanning over 300 years.

The central idea of "Patterns of Thought" is the **attribution of a number** to a thought: its "weight" (probability) among all possible combinations of a set of atomic generators (atoms of thought), although this number is neither constant, nor additive over the "atoms." From the point of view of a chemist (see also this) the pattern mind is a very large flask with input and output, in which atoms of thought participate in many combinations and recombinations, only a small part of which reaches the level of consciousness—the foam on the surface. Those conscious thoughts are the "weightiest" at the moment i.e., selected at random as most probable and, occasionally, as quite improbable. Bright new and revolutionary ideas belong to the improbable category. This leads us immediately to an understanding of the chemistry of language, which will be considered separately.

The place of John Dalton in history of chemistry has been firmly established and marked by the unit of molecular mass Da, i.e., Dalton. Some molecular masses are: natural hydrogen H_2 2.016 Da, oxygen O_2 32.00, carbon C exactly 12, and water H_2O 18.015.

Goethe not only had read Newton but also argued with him about the nature of light. I believe it is completely improbable that Goethe's source of chemical knowledge was John Dalton. It was certainly Newton, whose long *Query 31* at the end of his *Opticks* (it starts on Page 350) fascinates historians of science as much as *Elective Affinities* fascinates historians of literature.

The idea that atoms have affinity (mutual attraction) to each other which keeps them together does not belong to Newton, although he was probably the first to clearly see them as physical objects:

> **Newton**: "And therefore, that Nature may be lasting, the Changes of corporeal Things are to be placed only in the various Separations and new Associations and Motions of these permanent Particles; compound Bodies being apt to break, not in the midst of solid Particles, but where those Particles are laid together, and only touch in a few Points." *Opticks*, 1721,

What in my eyes makes **Newton a founding father of pattern chemistry** is the way he attempts to quantify them. He does it without numbers.

Newton has no means to measure the affinity: the means will become available two hundred years later and only due to the development of a non-Newtonian mechanics of micro-objects. Instead, he arranges the chemical phenomena in partially ordered sets, which I frivolously call the calculus of MORE and LESS.

Figure 3.16.1 shows two fragments reproduced from Newton's *Opticks* of 1721.

[363]

pand themſelves, and get as far aſunder as the quantity of Water in which they float, will allow? And does not this Endeavour imply that they have a repulſive Force by which they fly from one another, or at leaſt, that they attract the Water more ſtrongly than they do one another? For as all things aſcend in Water which are leſs attracted than Water, by the gravitating Power of the Earth; ſo all the Particles of Salt which float in Water, and are leſs attracted than Water by any one Particle of Salt, muſt recede from that Particle, and give way to the more attracted Water.

[356]

diſſolves the Metal and lets go the Mercury, does not this argue that the acid Particles of the *Aqua fortis* are attracted more ſtrongly by the *Lapis Calaminaris* than by Iron, and more ſtrongly by Iron than by Copper, and more ſtrongly by Copper than by Silver, and more ſtrongly by Iron, Copper, Tin and Lead, than by Mercury? And is it not for the ſame reaſon that Iron requires more *Aqua fortis* to diſſolve it than Copper, and Copper more than the other Metals; and that of all Metals, Iron is diſſolved moſt eaſily, and is moſt apt to ruſt; and next after Iron, Copper?

Figure 3.16.1. **Newton's chemistry in the calculus of MORE and LESS.**
Source: Newton, *Opticks, 1721*.

Newton:

"…and more strongly by Iron than by Copper, and more strongly by Copper than by Silver, and more strongly by Iron, Copper, Tin, and Lead, than by Mercury?"

Table 3.16 is the modern version of the lineup of metals known to Newton.

Table 3.16 The electrochemical series			
equilibrium	**E° (volts)**	**equilibrium**	**E° (volts)**
Zinc $Zn^{2+} + 2e^- \rightleftarrows Zn(s)$	**- 0.76**	**Copper** $Cu^{2+} + 2e^- \rightleftarrows Cu(s)$	**+ 0.34**
Iron $Fe^{2+} + 2e^- \rightleftarrows Fe(s)$	**- 0.44**	**Mercury** $Hg_2^{2+} + 2e^- \rightleftarrows 2Hg(l)$	**+ 0.80**
Tin $Sn^{2+} + 2e^- \rightleftarrows Sn(s)$	**- 0.13**	**Silver** $Ag^+ + e^- \rightleftarrows Ag(s)$	**+ 0.80**
Lead $Pb^{2+} + 2e^- \rightleftarrows Pb(s)$	**- 0.13**	**Platinum** $Pt^{2+} + 2e^- \rightleftarrows Pt(s)$	**+ 1.188**
Hydrogen (zero) $\mathbf{2H^+ + 2e^- \rightleftarrows H_2(g)}$	**0**	**Gold** $Au^+ + e^- \rightleftarrows Au(s)$	**+ 1.83**

A **number assigned to each metal** determines the position of the metal in the series and, therefore, its behavior, which Newton observed. This number is not absolute, but relative. It is the chemical potential of the metal in its water solution measured on the scale with hydrogen as zero. What "chemical potential" means is of no interest to us: it is the assignment of a number that matters. But what matters even more is that the number itself is not necessary for the prediction of the behavior of metals in solutions of other metals. It is the order that matters. In a more florid language, the metals in the electrochemical series are **"weighed"** against the standard of hydrogen. Those "lighter" (**LESS** positive) than hydrogen, dissolve in diluted acid, while those "heavier" (**MORE** positive) do not.

In the wide sweep that I had promised, we jumped from the chemistry of human behavior to the chemistry of metals. Now let us jump back.

Here is what Goethe writes on the subject, expressing here the spirit of **modern** chemistry, but following, as I believe, Newton:

> **Goethe**: "It is just the most complicated cases which are the most interesting. In these you come first to see the degrees of the affinities, to watch them as their **power of attraction is weaker or stronger, nearer or more remote.** Affinities only begin really to interest when they bring about separations." *Elective Affinities* (1872), p. 40.

Let us jump even farther back in time; see **Figure 3.16.2**.

Figure 3.16.2. **Fragment of the *Papyrus of Ani*, Egyptian *Book of the Dead.* Anubis, the god of the dead, weighs the heart of the deceased against the Shu Feather (right pan) to determine his fate. Thoth , the god of equilibrium, is on the right.**

I see in this picture the same **pattern** as "weighing" (i.e., comparing) metals against hydrogen. The "hydrogen standard" here is the feather from the headdress of Ma'at who personifies justice and law.

I highly recommend the reader to look at the about forty "negative confessions" that defined the behavior of the virtuous Egyptian with pure heart. The checkup list is much stricter than the ten Judeo-Christian commandments. For example:

Ma'at with Shu feather

- Not have I raged except with a cause.
- Not have I made to weep.
- Not have I done harm unto animals.
- Not have I been an eavesdropper.
- Not have I made the order for killing for me.
- Not have I done harm to mankind.
- I have not added to the weight of the balance.
- Not have I diminished from the weight of the balance.
- Not have I carried off the milk from the mouth of the babe.
- Not have I multiplied my words upon words

> The detailed "declarations of purity" and "negative confessions" look like an embryonic form of the Talmudic prescriptions, not yet codified. In my view, the detailed Buddhist commandments are much more abstract and pattern-like. The wisdom of Confucius is mostly in pattern templates.

We can easily imagine an ethical system in which the virtues and transgressions are arranged in a "virtue series" **similar** (a term of Pattern Theory!) to electrochemical series, with or without numbers. In any case, the position in the series is also a number.

Sins in Abrahamic religions are ordered by severity. Thus, Islam lists 70 sins by severity, some of them echoing the negative confessions of Ancient Egypt:

52. Overbearing conduct toward the wife, the servant, the weak, and animals
60 Arguing and disputing violently
61. Withholding excess water
62. Giving short weight or measure

The indulgencies sold by the Catholic Church in the sixteenth century had a price for each kind of sin, thereby attaching a number to each and ordering on the half-scale of severity. Example: " robbing a church and perjury - 9 Ducats, murder - 8 Ducats."

Talmudic tradition (200CE – 500 CE) orders acts of charity (Tzedakah) in eight ascending levels, in which a **combinatorial structure** is discernible. The components of the Tzedakah giving are: willingness, impetus, relation to the recipient, and lasting effect.

1. Giving begrudgingly
2. Giving less that you should, but giving it cheerfully.
3. Giving after being asked

4. Giving before being asked
5. Giving when you do not know the recipient's identity, but the recipient knows your identity
6. Giving when you know the recipient's identity, but the recipient doesn't know your identity
7. Giving when neither party knows the other's identity
8. Enabling the recipient to become self-reliant

It seems that the subtle, but firmly equilibrated along the Middle Road ethics of Confucius (551 BC - 479 BC) was, at least in fragments, based on ordering human behavior on both sides of the border between good and evil. For more detail, see **Essay 13. On Numbers**. I will present here three excerpts from the original source with my comments and emphasis:

> CHAPTER XVI. The Master said, 'Where the solid qualities are in excess of accomplishments, we have rusticity; where the accomplishments are in excess of the solid qualities, we have the manners of a clerk. When the accomplishments and solid qualities are equally blended **[additivity]** , we then have the man of virtue.'
>
> CHAPTER XVIII. The Master said, 'They who know the truth are not equal **[LESS]** to those who love it, and they who love it are not equal **[LESS]** to those who delight in it.'
>
> CHAPTER XIX. The Master said, 'To those whose talents are **above** mediocrity, the highest subjects may be announced. To those who are **below** mediocrity, the highest subjects may not be announced.'

Analects of Confucius, Book 6. Sources: 1 , 2 or 3.

What Confucius seems to do in his teachings is to order human matters not as full lists, but as minimal topological neighborhoods with one or two neighbors: predecessors or successors in line. I believe this is the most ancient and primeval way of representing order of complex systems in terms of their simplest but meaningful fragments. This is exactly the way chemistry made its first steps toward representing enormous complexity. **Note that the fragments are not atoms, they are generators of Pattern Theory: atoms with bonds,** or, to put it differently, Lego pieces.

> The order of Confucian and some other ethics is partial. The fragments do not line up but still present some consistency. Here are two fragments from Buddhist *Dhammapada*:
>
>> 103. If one man conquer in battle a thousand times thousand men, and if another conquer himself, he is the greatest of conquerors.

> 111. And he who lives a hundred years, ignorant and unrestrained, a life of one day is better if a man is wise and reflecting.
> (Dhammapada, Chapter VIII; different translations)

Without going into the subject of **topology**, this is how the sequence of natural numbers 1, 2, 3, 4, 5 can be represented and reconstructed from the lists of its neighborhoods: {1,2}, {2,3,4}, {4,5} or {1,2,3}, {2,3,4}, {3,4,5}. The word TOPOLOGY can be reversibly split into neighborhoods TOP, OPO, POL, OLO, LOG, OGY. There is no way we can reassemble it as TOLOPOGY even though the set of neighborhoods is as incomplete as TOP, OPO, OLO, OGY. This property of linear sequences is used for DNA sequencing, which is a reconstruction of the very long "word" from a set of its fragments. This brings us into the area of **language;** see **Chapter 3.17**

The set of fragments {123}, {323}, {353}, {356} is ambiguous. It allows for two sequences, 123235356 and 12353236, but only because of its incompleteness. The fragment {232} would make it unequivocal. Nevertheless, ambiguities are possible even for complete sets of fragments, but longer sequences. The ambiguity may be eliminated if we have fragments of varying length. Chemistry avoids ambiguity because it **enumerates all atoms** in a molecule, even of the same element, and regards them as **different**, but problems are still possible.

Finally, I refer to **Essay 8. On Buridan's Ass** for another example of using the balance scale, this time for the inner workings of the heart. The subject is known as cognitive dissonance (Leon Festinger, 1957). There is abundance of literature about it on the Web. See also **Chapter 21, Ideas and Actions** in **History as Points and Lines** (second source).

When we are weighing all pros and contras in order to make a difficult decision, we sometimes "add to the weight of the balance" or "diminish from it" and **deceive ourselves** to bring the scale in the equilibrium and to decrease the stress caused by contradicting arguments. The typical examples are the smoker's dilemma and, on a loftier level, Hamlet's dilemma. Today it is, probably, most common as an overeater's dilemma. That was Festinger's theory in a nutshell. After fifty years it still captivates psychologists who have suggested quite a few modifications, all based on unobservable states of mind.

My position is that the chemist cannot know for sure what people **think**. People can believe absolutely absurd things, wish harm to others and themselves, and all our interpretations are guesswork based on our own presumably rational experience. "People deceive themselves" sounds meaningless to me.

Between the initial and final states of the action lies the transition state of stress and confusion and Goethe's *Elective Affinities* is as good an illustration as *Hamlet*. There is a transition barrier toward a personal decision whether to smoke, eat a sweet buttery cake, vote for a controversial candidate, make a dubious investment, buy a useless expensive gadget, and marry a capricious sweetheart. The more tilted is

the bookkeeping balance of our positive and negative entries into the balance sheet the higher—or lower—is the barrier. Advertisers, operators of political machines, and preachers of hate —but also national leaders, reformers, and champions of humanity—are born chemists: they consciously and scientifically synthesize the outcome of millions of events, resulting in few large social shifts.

I hope I have managed to add a bit of weight to the idea that chemical view of the world—as part of the pattern paradigm—is capable of representing the world as a panoramic whole without impenetrable borders between mind and matter. Pattern

thinking may perhaps contribute not so much to knowledge as to understanding how it all is connected in our common household and what kind of economics without numbers can guide us in managing our future. This brings us again to the subject of the future; see **Chapter 4.4**.

3.17. THE CHEMISTRY OF LANGUAGE

Speech, writing, and thought can be represented as configurations of Pattern Theory. Bonds between different words have different strength measured by the probability of their side by side occurrence. This probability depends on the subject, style, and type of language.

Language consists of a large, but limited, number of atomic and molecular entities (sounds, phonemes, morphemes, syllables, words, phrases) and their stable blocks. The elements of language combine into an enormous number of meaningful linear combinations (and a much larger number of meaningless ones, with the speech of politicians somewhere in between).

There is a strong parallel between atoms and words. Linguist Mark S. Baker in his book *The Atoms of Language* (2001) drew a consistent analogy between linguistics and chemistry. Spoken and written languages, however, generate only linear sequences. They have structure similar to linear molecules such as proteins and nucleic acids.

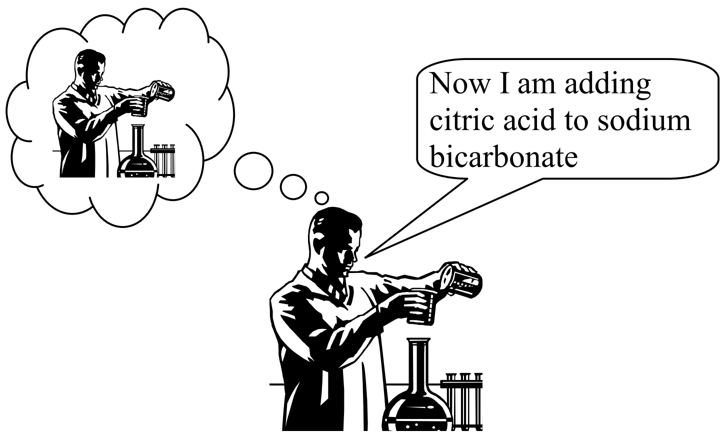


Figure 3.17.1. Language is observable, but what is thought?

The relation between thought and language is a dark area. Speech and writing are believed to be generated by thought. Thought is unobservable (**Figure 3.17.1**), but there are good reasons to believe that it also consists of atomic entities and their blocks, although the structures of thought may not be linear. Thoughts are communicated and exchanged in the form of language. We can have vague and fragmentary thoughts that escape verbalization but are a raw material for it.

Patterns of Thought by Ulf Grenander is a cardinal and constructive investigation of the nature of the mind as the place where both thought and language are generated. I would express its main idea as the perception and mathematical description of thought as a cloud of probability, from which the rain of speech falls.

Chemistry has a special relation with language. For example, DNA is a language with a four letter alphabet and three letter long words. It translates into a long sequence of approximately twenty words of the language of proteins. The meaning of the latter is the shape and function of proteins in the context of the living organism. Chemistry also capable of speaking in the **language of chemical nomenclature** which has a unique word for every possible molecular structure, although this is not always practical.

I have been interested in languages since my youth and I have a limited familiarity with the structure of very different languages, although I speak only two. This is why chemistry of language takes a large part of complexity :

> TIKKI TIKKI TEMBO and the Chemistry of Protolanguage (2004) , Abstract
> Pattern Theory and "Poverty of Stimulus" Argument in Linguistics (2004), Abstract
> The Three Little Pigs : Chemistry of language acquisition (2005) , Abstract
> Salt: The Incremental Chemistry of Language Acquisition (2005) , Abstract
> Salt 2: Incremental Extraction of Grammar by Simplistic Rules (2005)
> The Chemistry of Semantics (2005)

I address in this **Chapter** only one chemical aspect of language: transformation of thought into speech. My initial thesis is: to compare language and chemistry we have to view them as natural phenomena within a larger picture. I start with the statement that thought is not linear, while speech is. Whatever thought is, it must be **linearized** in the process of verbalization, which I consider as a natural chemical (generalized-chemical) process with initial, transition, and final states, as well as kinetics and thermodynamics.

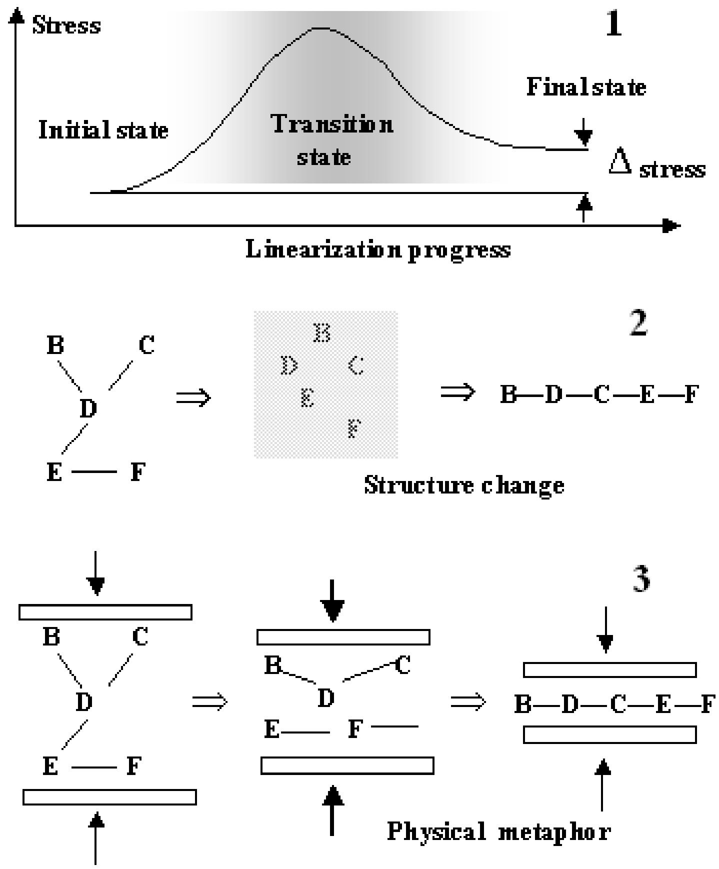


Figure 3.17. 2 Linearization of the source into the output string

Figure 3.17.2 from Chapter 11 in *TIKKI TIKKI TEMBO* illustrates the process of linearization (see also **Chapter 2.8**, Linearization) , which is shown there in three aspects:

1. Transition over the stress barrier from the initial to the final state;
2. The structure of the initial and final states with fuzzy intermediate state;
3. A physical metaphor of the process as a mechanical squashing.

As I said, the area of thought is dark—or probably too much illuminated. Semantics, the study of meaning, is the branch of science closest to the subject of thought. Not surprisingly, it is as far from consensus as philosophy. **Figure 3.17.3** shows the difference between the non-linear thought and linear speech, but I can only be vague in my symbolism.

The phrase in English Ken gives money to Ann is strictly linear. The thought behind it is anything but. There are explicit connections between subject, verb, direct, and indirect objects shown by red lines in part **A** of the **Figure**. It remains uncertain where to put preposition to, but it has no relation to Ken and money. It is probably justified to consider it a part of the verb give-to.

When we think about real characters and real money in real circumstances, we certainly ***have in mind*** that Ken and Anna are somehow connected, even if temporarily and even if they do not meet face to face. Moreover, there is a bond of ownership or control between Ken and money, which enables him to give. He gives to Anna and to nobody else; therefore he ***has her in mind.*** The additional implicit bonds are shown by blue lines in part **B**. Finally, Anna in the act of receiving is already related to the money.

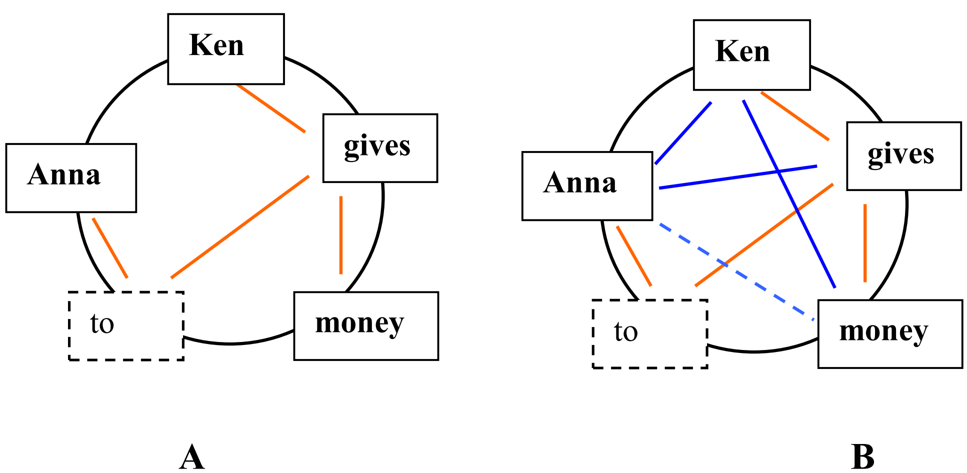


Figure 3.17.3. **Bonds between ideas make thought non-linear. A: minimal structure, B: additional bonds between the ideas *in the mind.***

This is what I mean by saying that thought is **typically** non-linear. Simple thoughts can be linear or even isolated ideas: "Fire!" "This dog bites." The simplest thought is just two connected ideas.

The situation is quite different with the Russian language, in which there is no fixed word order. Ken gives money to Anna can be expressed in Russian by any out of 24 possible permutation of four words (to is rendered by ending e in Anne):

> **Ken dayet dengy Anne,** dayet Ken dengy Anne, Anne Ken dengy dayet, dengy Ken dayet Anne, Anne dayet dengy Ken, etc.

> What language requires more energy to speak, English or Russian? This is a possible question for the chemistry of language. According to my observations, Russian is "heavier," but more nuanced than English. To sort out hundreds of Russian suffixes, endings, and phonetic alternations in order to linearize the thought is more cumbersome than to use mostly naked roots and a ready template of word order. The trade-off is the abundance of Russian expressivity, from crude to tender, which is hardly translatable. In other words, English is an **easier** language than Russian: the transition barrier between thought and speech is lower in English. The fixed word order is a powerful **catalyst**. The difference becomes more significant for unprepared discourse on complicated non-everyday matters. This is one reason why English is the world *lingua franca*. Most other major languages (not the Chinese, however) are more exuberant, the Italian included.

For further details of chemical treatment of language I wish to refer to my publications on language, quoted above. There are a lot of curious ideas and observations, including a description of the most primitive, but still understandable language which I call Nean. It is interesting that English alleviates expressing most complicated ideas by cutting short the length of the phrase.

The concept of Nean as the simplest language for expressing thoughts is speech consisting of pairs of words corresponding to pairs of connected bonds in the thought. For details and computer simulation, see *TIKKI TIKKI TEMBO* .

Language is the very center of the human scale. Unlike molecular chemistry, linguistics can be quite understandable by a lay reader, unless intentionally obscured.

Section 4. WORLD VIEW

4.1. WHAT IS? READING FRANCIS HEYLIGHEN

As I value publications it for the questions it brings up, not for answers, Francis Heylighen's Foundations and Methodology for an Evolutionary World View: a review of the Principia Cybernetica Project rises a fine selection of them.

Francis Heylighen gives a framework for a world view, in the spirit of **Principia Cybernetica,** as a series of questions and answers leading myself to an additional unexpected question: **What is my own world view?**

I am not sure I have the right to extensively quote Heylighen's paper, but it is completely accessible on the Web. The questions and answers start on Page 14.

I will answer all Heylighen's world view questions, selectively quoting some of his answers, whether they coincide with my own or not. I am taking the liberty of removing references from them. The first question is **What is?**

What is? A sequence of events. If no events, then no being. We cannot notice what does not change. Next question: what changes? From the point of view of a pattern chemist, generators (atomic entities in Pattern Theory of Ulf Grenander) and bonds between them.

Heylighen:

> This question defines the domain of ontology. We believe that the fundamental stuff of being, the essence of the universe, consists of elementary processes or actions, rather than matter, energy or ideas. Complex organizations, such as atoms, molecules, space and time, living beings, minds and societies emerge out of these actions through the process of evolution. [Therefore, I agree]

Why is there something rather than nothing? There is no such thing as nothing. Suppose there is nothing. If we ask about it, then we are in the same system with nothing, and there is no nothing. [No denial, I was inspired by the Talmud].

Heylighen:

> The universe arose spontaneously, through self-organizing evolution, based on the self-evident principles of variation and natural selection. Any possible variation

> (for example a "quantum fluctuation of the vacuum") would be sufficient to set the self-organizing process in motion, thus generating a complex universe with its diverse components and structures. [I disagree. Nothing can happen absolutely spontaneously: a change comes from a change. This disagreement is of no importance because we know little, if anything, about the beginning of evolution].

Why is the world the way it is?

The question would make sense if we could compare it with a different world which is not the way this world is. Ours is the only world we know.

Where does it all come from?

Suppose, we have an answer. Then we can ask again: and where did **that** come from?

Where do we come from? We have evolved.

Heylighen:

> Humans evolved out of animals that had the capacity to learn associations from the environment, by additionally acquiring the capacity to think, that is, autonomously control these associations. Human thought is rooted in the emergence of symbolic language. [Therefore, I agree].

Who are we? We are mammals, primates, humans, part of biosphere, part of noösphere, component of economy (econosphere), etc.

Heylighen:

> As far as we know, humans occupy the provisionally most advanced level in the hierarchy of metasystems. Our capacity for thought distinguishes us from the animals by giving us uniquely human characteristics, such as self-consciousness, imagination, planning, play, sense of humor, and esthetic feelings.

Where are we going to?

We do not know the future. A possible alternative is: the more available energy, the more complex is our economy. The less available energy, the simple and closer to hierarchy it is. **In pattern terms** it is possible that history is reversible.

What is the purpose of it all?

The purpose of human existence is to survive as individuals and as the species (William Faulkner: "I believe that man will not merely endure: he will prevail)." To survive means to adapt (acquire stability) to new states of the global system. Adaptation may have its price, for example, an evolutionary split into two systemic species. Adaptation may lead to loss of some features and acquisition of others.

Is there a God?

This is a matter of belief. The problem is that when somebody says he believes in God, why should we believe him? [The double belief reminds me of the two-step predonning in **Chapter 3.9**]. My personal answer is: I do not know, but it does not matter. I have a set of personal guiding principles borrowed mostly from Judeo-Christian heritage, a little bit from Buddhism, and some from my grandmother. I sometimes violate them, regretfully, but I do not believe in any existence, reward, or punishment after death.

What is good and what is evil? Good is what somebody feels or believes is good for him or her. We tend to remain in a good state. Bad is what somebody feels or believes is bad for him. We tend to escape a bad state. **Bad** creates stress and stimulates transition to another state. Therefore, good is always good, but bad is also good, in a sense. It is good to be alive, free, and happy. **Bad** is the spring in the clockwork of evolutionary time.

What is knowledge? I answer with the question: Is there anti-knowledge? Un-knowledge? We may not know something, but can we "non-know" or "un-know" anything? **Practical** knowledge is what catalyzes (speeds up, makes easy) our transition to another state set as a goal. Without knowledge we can act at random or follow our animal instincts. **General** knowledge is the map or picture of the world around, whether we use it or not.

Heylighen:

> This question defines the domain of epistemology. Knowledge is the existence in a cybernetic system of a model, which allows that system to make predictions, that is, to anticipate processes in its environment. Thus, the system gets control over its environment. Such a model is a personal construction, not an objective reflection of outside reality.

What is truth? A statement is true unless proven false. It is false when it contradicts other statements considered true. Hypothesis is a mix of both.

Heylighen:

> There are no absolute truths. The truth of a theory is merely its power to produce predictions that are confirmed by observations. However, different theories can produce similar predictions without one of them being right and the other wrong. "True" knowledge is the one that best survives the natural selection for predictive power . [I agree].

What is consciousness? A perception of environment or self as a sequence of events. The function of consciousness is to linearize (line up, order) our sensations, perceptions, and thoughts. This is why we can describe them in the linear language. Consciousness is the neurophysiological sensation of Leibniz time (which is a sequence of events, not seconds or years).

Do we have a free will? Do we have "unfree" will? We cannot ask about things that do not have opposites or alternatives. This is a fundamental principle of chemistry: we can only compare.

How should we act? We should act according to our beliefs and goals, with the minimal contradiction between them.

How can we be happy? By being healthy, occasionally satisfied, and in harmony with our beliefs.

> **Heylighen:**
> People are happy when they are "in control", that is, feel competent to satisfy needs and reach goals. Happiness is most common in societies which provide sufficient wealth, health care, education, personal freedom and equality. Happy people tend to be self-confident, open to experience and have good personal relations. Promoting these social and personal values should increase our overall quality of life. [Watching movies about tribal life, I always take notice of how naturally happy the people are].

Why cannot we live forever? Again, do we know anything that lasts forever? Not even the universe, they say.

What is the meaning of life? What is meaning? OK, life, liberty, and pursuit of happiness.

> **Heylighen:**
> This question in a sense summarizes all previous questions. It is usually understood as: "What are the highest values, the Supreme Goals which I should try to achieve?" We stress that every human being must freely set those goals for himself or herself. The supreme goal which we choose derives logically from our cybernetic world view: to make a constructive contribution to the evolution of humanity, in order to maximize our long-term chances of survival (immortality). In essence, the meaning of life is to increase evolutionary fitness.

Heylighen's last answer raises further questions, which is exactly what I expect from answers. What are values? Do I need to love all humanity without exception? How do I know the way to increase fitness if what it means to be fit becomes clear only after my (or my species') death? Fitness manifests in competition with another species. What species are competing with humanity? Should I care about abstract humanity more than about my family and my social tribe?

I have tried to answer the questions of the previous paragraph, as well as many others of this Chapter, in my Essays, for example, Essay 21. On Ethics and especially Essay 24. On Myself. See also `Essays Part 1`, `2`, and `3`.

The concept of fitness has been plagued by allegations of tautology since Charles Darwin. As a chemist, for whom the kinetic (i.e., based on competition) view of the world and the underlying concept of transition state are central, I can say that fitness is measured by stability. The stability of species in exystems never lasts, which is exactly the essence of evolution. The system itself lasts for as long as there is sufficient energy and stable environment. There is an optimal interval of generalized temperature for complexity. Are we more fit than our main competitor Technos, whom we create, who eats our food, takes our land, ruins our genes, steals our time, and enslaves us?

My rhetoric should not be taken too seriously. Imagery, like a chemical formula or **Figure 4.1.1** , however, is an intrinsic feature of chemical view of the world.

Evolution is endless hopscotch from one (not for long) stable state to another. I hope we, humans, are young enough to still enjoy it and not just endure.

Figure 4.1.1. **Evolution as hopscotch: from one not-for-long-stable state to another.** Source of hopscotch mat

4.2. CHEMISTRY IN THE WORLD VIEW

The world view cannot be chemical, biological, physical, or anything narrowly specified. It can be compared with the spectrum of white light, in which the colors mix. The following is a preliminary attempt to describe pattern chemistry as the chemical range of the world view spectrum. It does not go far into the topics of thermodynamics, which belong to the physical view of the world, but without no world view is possible. The subjects of information, its transcription, translation, and expression are also left out. The aspect of kinetics overlaps strongly with physics. What is specifically chemical can be associated with structure and the possibility to use it for comparing stabilities of complex objects.

The purpose of pattern chemistry is to contribute to formulating a non-ideological world view centered around human matters.

This view should exclude political, philosophical, religious, and ethical approaches, a consensus on which in diverse communities is hardly possible.

The view should also exclude "hard" scientific content, on which consensus is typical. The evolutionary novelty, however, has the effect of "as if" constantly changing laws of nature. More important, "hard" science softens up to the melting point when applied to human matters. Then it becomes a sellable brand of snake oil.

The apparent inconsistence of the above purpose is that human matters consist of politics, ethics, religion and other areas which the intended world view is supposed to exclude. The solution of this contradiction is that they can be objects, but not means of investigation.

On the other hand, science can be the source of method, but not the technical subject matter. Science of singular events seems to be contradiction in term. We could not predict the future of the Sun if it were the only star in the universe. This brings us to another inconsistence: if we exclude scientific subject matter (such as chemistry, physics, biology, etc.), what remains?

The answer is: mathematics. More specifically, I believe that a branch of Pattern Theory can be adapted for the specific purpose of the representation of exystems. I call this hypothetical version of PT **pattern chemistry** or, within this text, simply chemistry.

Chemistry should not—and cannot—be considered a typical scientific theory in the sense the term theory is used in "hard" natural sciences of the twentieth century. It would not deal with explicit laws of nature and multiple repeating or reproducible events that demonstrably obey those laws. Such events are already covered by natural sciences, including some "hard" enough areas of evolutionary biology and modern social science, for example, genetic reconstruction of human migration and social psychology of small groups.

The subject matter niche of chemistry is the study of exystems: evolving complex systems that run through their unique and irreversible histories, which is the same as to say "live their lives." Unlike a molecular chemical system, but more like life on Earth or global economy, an exystem is represented not by its states and processes, but by its entire history. In the language of molecular chemistry, the metaphor of exystem is a large chemical flask containing each molecule in a single copy.

Chemistry represents complex systems as configurations of points and lines: stable atomic objects (generators of PT) connected by bonds (bond couples of PT) in certain order. Sets of disconnected points without order are also included. Pattern is a class of configurations which can be transformed one into another by a set of rules (similarity transformation of PT). Pattern itself can be a configuration. A change of a configuration is an event in the history of the exystem. A selected typical configuration (template in PT), together with the rules of transformation, represents the pattern. Patterns are mental constructs: they are not directly observable. Configurations are representations of observable images.

Stability of a configuration is determined by increments if its generators and bonds. This is the main contribution of chemistry to understanding exystems.

A comparison with PT would not discover much originality in my chemistry because PT as a mathematical discipline is a generalized chemistry—from the point of view of a chemist. That was my surprising personal discovery around 1980.

What distinguishes PT from the bulk of mathematics is the **openness of its axiomatic foundation**. In classical mathematics, a change of axiomatic foundation means a change of the mathematical system. PT is opened to novelty, so that new generators, bonds, rules, and templates can be included in its configuration space by the scientist who observes the perpetually surprising world and tries to understand what is not yet understood.

> It is very difficult to explain to a non-chemist how chemistry works with complexity and novelty. This is why molecular chemistry looks forbiddingly descriptive and disorganized to intelligent students, however they may be obsessed with the chemistry of their intimate relations. After all, a theory cannot consist of a registry of particularities. It could be also difficult to explain what is so different about PT and why a treatise on PT is as voluminous as a textbook of chemistry.

However sacrilegious it may sound to a mathematician, the mathematical system of PT includes the senses and mind of a mathematician in the state of a constant quest for **understanding the world**. For example, the choice of the template is entirely human, so that, paradoxically, the system of axioms is in the constant flux. Indeed, what is a typical potato? People can disagree. I call the visual image of the template **ideogram**, but other people may not accept the flow chart of matter and energy in a cow as an ideogram of economy. What is important, it does not matter for as long as they cannot dispute it. Templates or ideograms do not need to be consensual! To study birds, flying machines, or UFO, one can starts with either helicopter or chicken, even though the chicken does not fly.

If the above foundations are accepted, the essence of chemistry looks simple.
World is a sequence of events, each with beginning and end. There are concurrent events on different time scale. Events may consist of smaller events.

An event in a system runs from a stable **initial state** through unstable **transition state** to a stable **final state**. Since there is a variety of all three kinds of states, all of them combinatorial configurations, the transformation through the **least unstable** transition state is most likely. On a short time scale, the transitions can be somewhat reversible. Examples: US laws, decisions of the US Supreme Court, situation one battlefield, state of human rights. This applies also to individual human life ("reversal of fortune") and the performance of a business (**Apple Inc.** is an example). There is always a scale threshold for irreversibility: smaller events can be reversible, larger ones cannot.

I am very skeptical about the possibility of measuring the absolute stability of any exystem, although this may change in the future. What we can do is to compare the alternatives of the transition and final states, reject the obviously unstable ones and compare the few remaining stable ones. This is what any responsible statesman and business leader would do without any theory, philosophy, and chemistry **if there is still time to do that**. This is what had not been done either before the invasion of Iraq or afterwards. It is easy to blame or exonerate, but it is difficult to "compare the alternatives" under fire. Therefore, with government as economic enterprise, choose smart, energetic, non-ideological CEO.

The stability of a state is **roughly additive** over its structural increments. While the measure of absolute stability is unreachable, the change of stability is comparable with another alternative change of stability by evaluating the most **significant increments of change** in both cases. PT not just analyses the structure: it contributes a value to each component, which gives it a thermodynamic dimension. PT is a brand of accounting, like molecular chemistry, engineering, business, finances, and even politics.

It is completely natural for a final state to be less stable than the initial one. What distinguishes the stable state is the wall of instability that surrounds it. In this sense, the eight years of George Bush presidency were depressingly stable. They may seem unstable as compared with the eight years of Bill Clinton, whose presidency entered its own transition state during impeachment attempt, but rolled back to the initial state. How little in history is reversible, if anything at all, illustrates the dramatic success of the Republican Revolution—as much as its demise, not yet an accomplished fact in April 2008. The current (2008) election campaign is an extremely unstable and irregular state with its three off-mainstream candidates that promise to change the notion of mainstream.

All the above is, in my opinion, the minimal platform for pattern chemistry. Probably, this is also the way we make up our mind in complex situations: by simplifying it and reducing to minimum alternatives compared by stability and regularity.

It is not up to me to predict whether any kind of edifice can be built on this platform and whether a consensus is possible. A significant part of it has already been built by systems theory. Is there any sense at all in the entire venture?

I believe that pattern thinking, liberated from interdisciplinary enclosures and focused on the anatomy of event, rather than substance, form, matter, energy, and information, may be able to expand the dimply lit area between the present and the impenetrably dark future of the largest exystem we all inhabit.

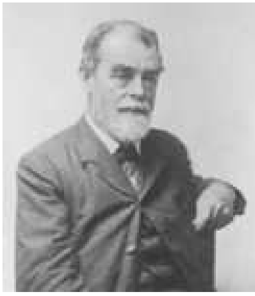
4.3. HUMANS AND THINGS

On numerous occasions in complexity and simplicity I expressed the idea that humans and man-made Things (capitalized as a kind of nation) are two diverging taxonomic units in the evolution of life on planet Earth. As such, they cannot avoid competition for space, energy, matter, and probably control.

The first unequivocal confirmation came this year when the competition of humans and machines for corn had become a media topic. From the point of view of biochemistry, most of the corn is just fuel for the living cells. The current (2008) mineral **oil and food crisis** is the manifestation of the competition between humans and Things for energy. It will take some time before the public realizes that the **surface area** in square kilometers or miles is the ultimate measure of the renewable energy resource. This will mean the end of the First Industrial Revolution, driven by coal and oil, and return to the fight for territory which has been the defining drive of history for as long as we remember. Wind farming, solar energy farming, tidal and wave farming, in addition to plants-for-energy farming—the land makes its comeback to history to wake us up from the sweet dreams of globalization without the borders of space and time. An embittered pessimist could say that Africa and Middle East are better models of the future than the visions of the flat world and humans are destined to retreat to the place and time of their origin.

On the origins of the parallel between humans and Things, see my Essay 6: On the Yahoos, or Apologia of Samuel Butler (2001) , from which I take the following quotation:

> Who will be man's successor? To which the answer is: We are ourselves creating our own successors. Man will become to the machine what the horse and the dog are to man; the



conclusion being that machines are, or are becoming, animate.

← Samuel Butler (1835-1902) in a letter to the New Zealand newspaper *Press*, entitled *Darwin among the Machines*.

Samuel Butler's warning about domination has been repeated by Werner Heisenberg, Norbert Wiener, Langdon Winner, and others. Here I summarize my observations in support of the evolutionary divergence between two global sub-exystems: Humans and Things, or Ethnos (Human Race) and Technos.

Similarity is the core pattern idea. In order to see the divergence we need to find similarities: the differences are too obvious.

The Things have no remembered past, but the latest trend of the new generation of humans (except the historians) is to consider human history and literature before the twenty-first century—probably, even before yesterday—irrelevant, while the latest trend in computer technology is to remember the history of the individual man-made system. Microsof Windows' **Restore Point** utility is an example.

I formulate the trend of "de-memorization," basing on my personal observations during the last twenty years. Taking the fifty years of my life in both Soviet Russian and American worlds, I clearly see a major historical change: the culture of my generation included all known human history for at least one simple reason: selected, extracted and processed, it could fit into human memory. Moreover, the ethical heritage of the Greeks and Romans, together with Judeo-Christian ethical traditions, was kept alive by education even in the Communist Russia. No wonder, because the past human history was about victory and defeat, not hell and paradise in afterlife.

After the advent of TV, the torrents of ephemeral visual noise have been washing away the inherited national habit of educated people to rely on historical experience. When you open a newspaper, your vision serves as a filter, selecting relevance and rejecting the noise. When you watch TV or moving computer display, where the content is arranged not just in space, but also in time, you have no power of selection. Nothing can be done with that and it is irreversible. The decline of reading desiccates the human imagination born at the bonfire thousands years ago as myths and fairy tales.

I do not know if the old habits are still alive in Europe and elsewhere. It seems that they are. I do not even know if the previous history is indeed relevant in global economy and whether news by the minute is all that matters. The gist of common sense—"buy low, sell high"—is oriented toward the quickly moving borderline between this hour and the next, and what happened even a week ago is completely irrelevant. Besides, since the great last victory of the West in 1945, the national memories of almost all major players, except, probably, those few defeated, have been littered with defeats.

In my view, the loss of the past with its powerful cultural template is typically “thingish.” Our washing machine does not remember what was loaded yesterday: it is completely taken over by the controlling sequence of external events.

The computer, however, moves in the opposite direction: toward “memorization,” remembering the past. Not only it remembers every bit we shove up its memory, but it also remembers the sequence of its rich internal states hidden from our view. Some examples—Microsoft’s Restore Point and Wikipedia’s editing history—are discussed in a different context in: Jonathan Zittran, *The Future of the Internet—And How to Stop It*. Yale University Press, 2008, p.154.

Am I speaking about divergence or convergence? By divergence I mean the formation of an independent taxonomic unit; by convergence I mean the acquisition of the equal status of the new unit with the parent one within a larger unit, and by independence I mean competition. In biology, convergence applies to characteristics of **unrelated** species. Convergence seems a fictitious notion in evolution of exystems. Are unrelated Russia, China, India, Europe, and America converging in modern economy? The origin of the USA was certainly an evolutionary divergence. This question, however, needs a closer investigation.

> [**EDITING REMARK**. Competition is a tough subject. You are independent if you can freely compete, but as soon as you enter a competition, you lose your independence in an instant: competitors dictate most of your moves.]

In addition to the “re-memorization,” (1) other signs and trends of “animation” of Things and “mechanization” of Humans are:

(2) Life on call, on standby, wired, never isolated, even at 3 A.M., as in Hillary Clinton’s notorious ad, controlled by the global system round the clock.

(3) Universal storable and operable digital code of all blueprints, schedules, information, data, design, and internal structure.

(4) Competition for matter, energy, space, and time.

(5) A unified economy for all human and technological matters, with money as currency. Initially tied to gold, money could be tied to energy or even land in the future.

(6) Hybridization of human body with machines, artificial organs, organism repair, spare parts, surgery, and maintenance. An information appliance becomes as naturalized as eyeglasses.

(7) Codification of choices in menus, “thingish” restrictions on degree of freedom of change. Narrow specialization of knowledge and function. Some natural breaks on innovation are also discussed in Jonathan Zittran’s book, p. 83.

(8) Political representation of not only humans and Things, but also plants, animals, culture, religion, and nature, including atmosphere and the bowels of the earth. The interests of technology and humans do not always coincide and their lobbies represent both sides. Compare with "Do Artifacts Have Politics?" by Langdon Winner. "Voluntary Human Extinction." represents the planet Earth as plaintiff against humans.

(9) A subtle change may be noticed only by my generation who remembers the old *Scientific American*. It was available in major Soviet libraries. The new generation as a whole does not know how the things are made, how they work, and why. It simply uses them. There is always somebody to fix or improve them. The Things do not question their use either. Both cede philosophy to the system, even the philosophers themselves. Nevertheless, a category of mostly young humans (who came in place of former readers of *Scientific American* and *Popular Mechanics*) has formed a centaur-like hybrid with the computer.

I would not trust this my observation because most of my life was spent far away from America (but not outside its sphere of influence). Here is, however, an indigenous observation: a comment of **L. F. Smith,** an Amazon.com customer.

> The striking thing is the difference between what was considered appropriate and realistic entertainment for kids then and what is now. For example, today a kid who wants to build a model train layout has an enormous range of often enormously expensive equipment from which to choose. Then, a kid would literally build the train layout; that is, he would wind the motor, machine the track, etc.
>
> I have mixed feelings about whether that was a better day for kids, but it sure was a different day, and this book is a look back to it.
>
> (Source)

The book mentioned in the comment is *The Boy Mechanic: 200 Classic Things to Build* (Hearst, N.Y., 2006) based on *The Boy Mechanic* published, probably, in the 1900's and available on Project Gutenberg. ← The centaur is from that book (p. 214).

Economy produces, concentrates, and dissipates material wealth on a scale incomparably larger than the biological needs of humans, which from the exystemic point of view is the best evidence of the divergence of Things. For comparison, handmade fire, knife, arrow, footwear, clothes, walking cane, drugs were extension of human body, necessary for survival, and fully controlled by humans. The phenomenon of a billionaire CEO actively working on further increasing the production and profits of his company has only one explanation: he is the benefactor of Things, not humans. His function is to keep the company—or just himself—running well above the green line in **Figure 3.6.2**. He has no such obligations to the staff and employees.

I itemize the exystemic split between human and their creations without intent to fuel the Luddist antagonism between the two sub-exystems in the exystem of economy. Humans benefit from the production of Things, as they benefit from the fertility of the soil and the power of sunlight, but only if they have their share.

A troubling question is: will technology always benefit from the fertility of humans? There is another troubling question: will humans always benefit from the fertility of technology? And what is **benefit**, anyway? Pattern chemistry does not know what benefit is in advance.

4.4. HUMANS AND HUMANS

The problem I have selected from the vast title topic is the possible human consequences of the limits on consumption of energy.

The problem is related to two ongoing discussions:

1. The problem of **the commons**, i.e., public resources, such as pastures, forests, oceans, atmosphere, and even public knowledge and the Internet, was emphasized in the article Tragedy of the Commons by Garrett Hardin . →

2. The problem of the **limits to growth** was formulated by The Club of Rome. →

I find the argumentation and style of Garrett Hardin's article, as well as his personality, powerful. Hardin was lucky to escape the fate of Giordano Bruno and Galileo.

Both **Hardin** and **The Club of Rome** start with the same self-evident, but still controversial in the faith-intoxicated and wealth-intoxicated subcultures of America observation that Planet Earth is finite. Garrett Hardin Society offers a collection of his articles and essays. Some articles can be accessed here.

For my own views on growth, see **Essay 54. Growth and Anti-growth** , from which I reproduce here Figure 8 as **Figure 4.4.1** .

It is not accidental that both intellectual movements originated in the same year of 1968, as if presaging the mysterious "70" (see **Chapter 3.7**).

I believe now, close to the end of this text, that "1970" was the beginning of **total economy.** I use this term not in the trivial "sum total" sense, but with the meaning of comprehensive global economy, all-comprising not only geographically (horizontally), but also vertically, i.e., leaving practically no human activity outside a certain market system where money is the equivalent of energy. I would call total economy **totalitarian**, but the term is taken by political science.

Figure 4.4.1. **Untitled**

Science and religion, too, are embedded into total economy, where they can secretly embrace or give a wink to art and politics.

Chemistry deals with events. What happened to the world around 1970 will be fully understood only when the current trend ends. Nevertheless, having repeatedly advertised chemistry as the science of time in charge of the question "when," I feel compelled at least to take a peek into the future. Something else is happening in 2008, forty years after 1968, which might foretell how the "70" will end: the final proof of the finite size of Planet Earth is coming.

Commons is what a community jointly owns, uses, abuses, and often exhausts and destroys. Privatization, therefore, is one way to save the resource, while coercive power based on trust (Leviathan) is another.

The commons I am interested in is the global energy resources that sustain our physical lives entangled in the metabolism of the economy. What is going to happen with us when the use of fossil fuel ceases to grow for whatever reasons, be it exhaustion or global warming or both?

Fossil fuel has been the driving force of global development since the Industrial Revolution. Before that, land under the sun, complemented by water and wind mills, was the only source of energy. Life of all human communities, from tribes to empires, was punctuated by wars and conquests for land and its fruit. The surface of the earth offered energy mostly in the form of food, forage, and fuel, as well as in the form of plunder, tribute, and slave labor. The ultimate source of food and fuel was the sun and, therefore, the land capable of supporting vegetation and wild animals was the two-dimensional measure of all renewable (if properly managed) energy resource.

> After the beginning of the Industrial Revolution, a war could be waged for mineral fuel, too, and the Iraq War seems to be the most recent example.

Der Lebensraum, i.e., living space (habitat, land) in German was the main goal of Nazi Germany. WWII, the last old-fashioned big war for land, looks to me even after decades of European peace as the first war of the coming era of energy starvation afflicting both humans and their machines.

In America, the owner of land owns the resources underneath. Mineral resource is by no means commons because it is either private or nationalized Legally, there is nothing to discuss regarding oil and coal as commons, except for the side effects such as pollution, erosion, and defacing of the land **under ownership**. The troubling question is what can happen to **real traditional commons**, such as sun, water, and atmosphere as sources of energy. They, it turns out, are fatefully placed on the solid or liquid surface of Planet Earth! It means that energy can be farmed and farming is tied to ownership of land and sea, i.e., ultimately, land.

> In the former Soviet Union, where land had been declared common property and no private property on land existed, it was *de facto* fully owned by the government: a pure case of leviathanization.
>
> I was unable to get a clear picture of the land ownership in modern Russia, but the principle that the government is in full control of everything seems to stand. **Expropriation** beats **privatization** in the Russian power card games. As they say in Russia, "not every word is written in the line," i.e., you may guess what is written between the lines of the law.
>
> I would speculate, together with some Russian observers, that the recent aggressive behavior of Russia toward Georgia and, potentially, to the Ukraine, is caused by the desire to recapture the sunlight in the pure form. Abkhazia in Georgia and Crimea in Ukraine were absolutely the most scenic and sunny resorts in all Soviet Russia. Stalin's summer residence was in picturesque exotic Abkhazia. The warm sea and the bright sunlight there always directly converted in untaxed income for the population.

Since the exhaustion or at least decline of fossil fuel, as well as because of the supposedly harmful consequences of its burning (nuclear energy faces the same problem of waste disposal), humankind seems to have no alternative to the return to wind, water, and sunlight converted into vegetation or electricity.

America has been enjoying the resources of natural energy, labor, and arable land for such a long time and with such extraordinary results that the effect of open frontier still seems endless.

The economic growth has become the main goal, measure, and obsession of most nations. The stability of the Western society, a historically recent phenomenon, is the result of the growth: life is perceived as good when it is not getting worse. I would translate it as: "Life is good when you are well above the metabolic cost; life is great when you farm money not from the land and minerals, but from the money made by others." I suspect that the unlimited concentration of capital in America, epitomized by big hedge funds, grandiose banks, and great beasts of manufacturing, contributed to growth and prosperity, although not everybody would agree.

Around 1980, American economists began to think about the growing income inequality, its origin, significance, and consequences.

From the chemical perspective, wealth is a form of energy and concentration of wealth decreases stability. The ammunition depot is potentially much more dangerous than the same ammunition scattered over large area. On the other hand, the concentrated wealth is much more productive than the dispersed one (see Essay 53. Power: Hidden Stick,

Shared Carrot). This is a universal principle of nature simply because we link energy to instability by definition, but it does not say when the instability is going to explode.

The last big war for *Lebensraum* ended in 1945 and most people on earth think about it as an episode of distant foreign history. Sixty years in world history, however, is just a fleeting moment and contemporaries and survivors of the war, myself included, are still alive. Optimism and hope is a deep natural instinct of younger generations. Pessimism is not at all the ingrained instinct of the older ones. Americans are naturally optimistic and revolutions today look like extinct dinosaurs of history. Survivors, all the more, are optimistic, too.

← **Antoine-Laurent de Lavoisier**, the father of modern chemistry and prominent tax collector, lost his head in 1794, at the age of 50. I have to skip here the parallel between the pre-guillotine tax farmers of *Ancien Régime* in France and modern hedge fund managers, but it is worth thinking about.

As long as the growing inequality is psychologically accepted by the majority of population—which lasts for as long as the situation of the masses does not deteriorate sharply—the explosive human instinct of expropriation is asleep. When it wakes up, the *Communist Manifesto* will be on hand in hundreds of millions of copies in all languages. To burn all the copies would require a democratically elected demagogue. To put the copies to action would require a leader of a coup. Both roles could be combined in one person.

How is the current state going to change when national economic growth stops or slows down? This may happen not just because of the depletion of energy resources or limits on its production, but also because of the emergence of big competitors, especially with the authoritarian concentration of power, as in China and Russia. While the word "competitor" associates in our minds with production, I mean competitors in the consumption of energy and raw materials.

I foresee only one general consequence: the land for **food and electricity farming** becomes the main currency of wealth. As soon as this happens, the **Ferris wheel of pattern history** will complete a full turn and begin another. My ticket was for one happy ride only.

5. CONCLUSION: PERSONAL NOTES

Generalized chemistry in this text focuses on human scale. The rest is the subject of hard sciences. The only possible position for the center of the human scale is myself. I am human. Humankind is the only thing on earth we are both inside and outside of.

There are at least three chemical aspects of being human.

The first aspect and the most remarkable property of humans is the **stability** of their/our/my human nature. While the whole globe has been radically transformed since the time of the pharaohs, we recognize ourselves in the testimonies of Ancient Egyptians (**Chapter 3.16**) as in a mirror. "We," of course, is a trick: only I of all people know myself from the inside. Yet it turns out that some other people can see me through, if not completely, than to a large extent. Moreover, I expect them to see my hidden nature. I try to disguise some of my intentions and make some others conspicuous, as other people do, too. It is the totality of human testimonies that convinces me of the overwhelming similarity of all people.

This is the second aspect of chemistry in human matters: personality is a **configuration** . I would compare its representation with a bookkeeping ledger from birth to death and sometimes through afterlife. The entries are universal human qualities with attached weights, positive or negative.

The weights are not numeric, but symbolic. Although we cannot attribute numbers to the weights of courage, honesty, attachment to family, etc., we can in many cases compare two people with the calculus of MORE and LESS, as in **Chapter 3.16.** This can never be done in an exact, reliable, and universally accepted way, however.

I am constantly bumping into humans who see and understand the world differently of myself. It is part of my own individual human nature to resist and dislike people who, not even knowing about my existence, want me to understand the world as they do. Moreover, they may not care about my thoughts, but they push me toward behavior synchronized with the behavior of the crowd. They want me to **lie** in the name of **false truth—**an impossible, unstable, and painful configuration!

The third aspect of my human chemistry is that my compliance with the pressure **stabilizes** my life in the environment, but creates **high stress** in my mind. Non-conformists of all kinds know this quandary very well. The conflict between the periphery and the core of human crowd runs through the entire human history. As a

former Soviet subject, I experienced the despotism of the totalitarian system and its aggressive ideology in a very direct way.
In America, the land of political freedom and tolerance, the aggressive religious right is my major concern, although it in no way threatens me personally: I live in one of the bluest states of America. I know, however, that every large exystem grows from a small and simple one. The very idea that I may become somebody's concern makes me feel very uneasy. I am troubled by American anti-intellectualism, distrust of elites, and the habit of using "liberal" as a four-letter word—even though I've got my own bone to pick with liberals.

The contradiction between constitutional separation of church and state and *de facto* collusion of religion and politics is the major symptom of dangerous American schizophrenia. It subtracts rationality from the chemical balance of American mind. It has happened because religious institutions had become part of **total economy**: anybody can open a church for any taste as easily as a hot dog stand, but with the advantages of tax-free income and absence of USDA inspections.

That was the beginning of the chain of thoughts that lead me to the question: what is the possible direction of the evolution of **non-personal** relations between people? I tried to answer that in **Chapter 4.4** in entirely hypothetical way.

The future comes either sooner or later than we expect; only by pure accident it is on time. If we know exactly when it comes, however, it is not future: it is current routine. What is important, most of the future is predictable, especially as pattern. This fascinating combination of power and poverty of our imagination is a consequence of our understanding the world: the most fundamental notions—time, energy, change, order—are simply names of what cannot be defined through even more fundamental ideas. We do not know what they are, we may not even care, but we can understand **how they are connected** with each other. This is an essential part of the chemical view of the world.

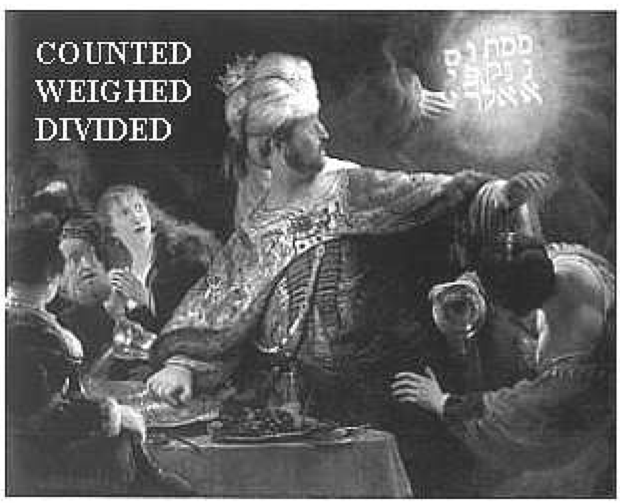
Am I optimist or pessimist? I believe in adaptation, therefore, I am both.

INTRODUCTION TO PATTERN CHEMISTRY

PART TWO: OBSERVATIONS

THE DIARY OF A FERRIS WHEEL RIDER

(IN SEARCH OF ECONOCHEMISTRY)



The Diary of a Ferris Wheel Rider is a record of my observations on the large-scale current developments such as the financial crisis, Election 2008, and other major world events. It plays the role of an experimental complement to the basic ideas of Pattern Chemistry in **Part 1**. The experiment, of course, is conducted by the forces of nature without my participation. My role is to interpret the events from chemical point of view and test the principles.

The word chemistry here, as in Part 1, means pattern chemistry, not the molecular one, unless specifically indicated.

ATTENTION: Chapter and Figure numbers refer to Part 1. Figure numbers in Part 2 start with letter A.

I emphasize again, that I have no professional ambitions whatsoever, have no background in economics or history, suggest no solutions, make no recommendations, promise no practical guidance, use no formulas and equations, and remain a chemist who looks at the world as if it consisted of points and lines subject to most general laws of nature. I am interested in the dancing skeletons of things.

My main source of ideas is Pattern Theory of Ulf Grenander, to which I add very general concepts of chemistry and physics concerning the intimate mechanisms of transformations, as well as very general evolutionary ideas. The main difference of my approach from other attempts to construct a large-scale picture of the world is that I am focused on simplicity instead of complexity. I believe that large and complex human systems—history, economy, environment, society, culture, politics, science, technology, art, ideology—start as simple systems that evolve by simple steps. If so, they can be represented by simple human means. Thus, pictures introduce small children to frogs and elephants before they could see them live and recognize as familiar animals.

September 18, 2008

In Part 1 I speculated on the following possible trends:

1. The possible exhaustion of the sources of fossil energy which have been fueling the Industrial Revolution and globalization will lead to the transformation of democracy into a more vertically stratified authoritarian structure (hopefully, not forever).

2. Man-made things will compete with humans for both food and fuel as if they were separate species, which they actually are.

3. As a consequence of using land for electricity farming, as well as for food production, land will become (again) the main currency of wealth. As soon as this happens, **the Ferris wheel of pattern history** will complete a full turn and start another. I mean here the return to competition for land, which had been the main content of world history before the Industrial Revolution emerged. After that, industry started using coal instead of land and propping itself with steel instead of wood.

I never expected to see some of my conjectures confirmed so soon: within less than a year.

Speaking of the devil, here he is in trinity:

1. Political gurus complain (not too seriously) about "too much democracy" (Farid Zakaria) and would not mind America to become the authoritarian "China for a day" (Thomas Friedman).

2. Automobiles and humans compete for corn, boosting food prices.

3. Land grabs for energy generation are becoming the buzz of the day (The Southwest desert's real estate boom. From California to Arizona, demand for sites for solar power projects has ignited a land grab. By Todd Woody, senior editor of Fortune Magazine, Last Updated: July 11, 2008: 4:38 AM EDT) .

In this DIARY I will try to comment on selected current events from the point of view of pattern chemistry, not economics or politics.

September 22, 2008

OK, here you have it: if not China for a day than a Soviet "Socialist" Russia or at least Socialist France for nobody knows how long:

The transformation of the USA into the USSRA (United Socialist State Republic of America) continues at full speed with the nationalization of AIG . Nouriel Roubini | Sep 17, 2008. The title will do.

How We Became the United States of France

> "This is the state of our great republic: We've nationalized the financial system, taking control from Wall Street bankers we no longer trust, etc… "
> By Bill Saporito Sunday, Sep. 21, 2008

The above titles insinuate that the free market capitalism, which is, supposedly, a **flat** system, begins morphing into a more centralized and controlled **tall** system (**Chapter 3.11 of Part 1**).

September 23, 2008

Why is it possible? As I suggested in **Chapters 3.11** and **3.12**, a flat system of largely independent, interacting, and mostly normally (bell-shape) distributed subsystems turns into a centralized, vertically stratified tall system when the access to energy resource becomes limited. I had neither explanation nor mechanism for this hypothetic principle.

The current events reveal more chemical subtleties and the chemical mechanism of verticalization is becoming visible. The process, at least in America, goes through an intermediate stage of Pareto type inequality (see **Figures 3.3.1** , **3.3.2, A1 ,** and **A2**), which I attribute to the intermediate "hype" systems.

The color lines in **Figure A1** symbolize two extreme modes of wealth distribution. In the blue ("natural" or non-market) systems, most wealth is of middle size. In the red ("hype" or market) systems, a few people **and companies** (Leviatanized super-people) control enormous wealth, which is potentially a source of both power and instability. If "bell shape" is an accepted nickname for normal or Gaussian distribution, there is no such for the Pareto or power law distribution. This is why I put photographs in the background.

The skateboard **ramp** metaphorically reflects some properties of the distribution: the greater the height, the fewer skaters can reach it from the ground level. The difficulty of ascent rises in a non-linear (exponential) manner.

If we imagine that the space under the ramp is made of pure gold, the ramp will represent the power law distribution much closer. Every vertical slice of the ramp will correspond to the wealth in possession of a constant fraction of population.

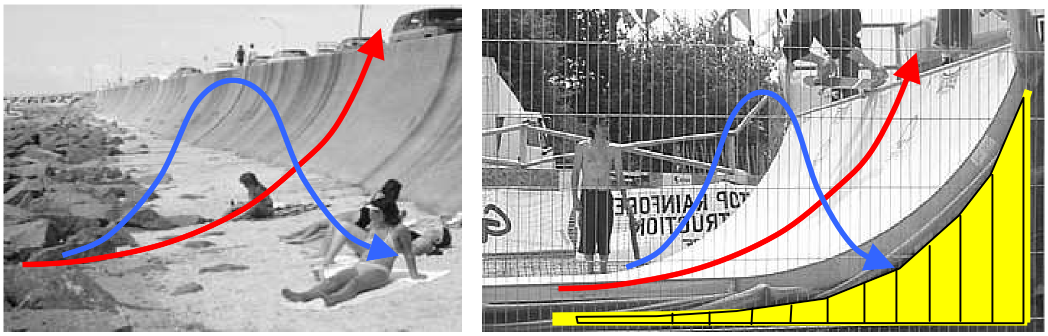


Figure A1. **Galveston seawall and skateboard ramp.**

In a "tall" system, the power and independence of all subsystems is limited by a centralized government, not by the free interactions, as in "flat" systems. The classification of social systems, therefore, is two-dimensional: by size and by concentration of wealth and power. These two dimensions play fundmental role in the intimate mechanisms of chemical processes.

Figure A2 shows the hype system as collection of a large number of small subsystems and sharply decreasing number of larger one, with some giants towering above the skies.

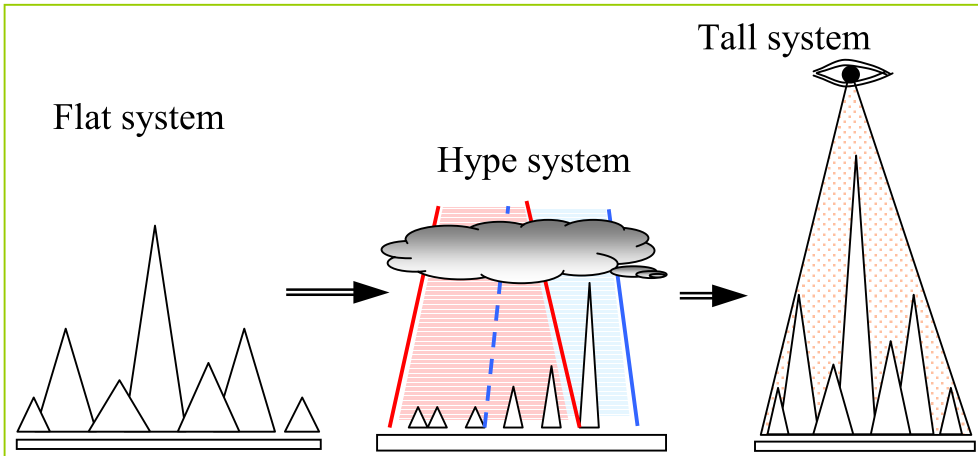


Figure A2. **Verticalization, 2008**
The hype system has a few very large subsystems and many small ones.

Whether the hype system is a transition state or a stable intermediate state depends on the time scale of consideration. To me it looks like an intermediate state because it is commensurable with human life span. On the scale of not economy, but politics, however, the domination of a few powerful competing groups looks like a transition state. The two American political parties and the Cold Civil War between them cannot last forever. Politics today, however, is as much a part of economy (and *vice versa*) as anything else.

There must be another intermediate stage on the way toward the complete takeover by the government, exemplified by the system of former Communist Russia. Putin's Russia is far from that, but the story of Mikhail Khodorkovsky , the richest Russian tycoon expropriated and imprisoned by Putin, points to the pattern mechanism of the ultimate verticalization: **two bears (bulls) of comparable size cannot share a den (pen)**. As soon as a corporation grows to the size comparable with the size of a branch of government, both become dependent on each other.

"Despite not being persons, corporations are recognized by the law to have rights and responsibilities like actual people" (Wikipedia). Despite not being corporations, powerful individuals have a management staff and act on the scale of actual corporations. Traditionally, a corporation has been a kind of artificial individual. Today any powerful (i.e., in control of large wealth) individual is an artificial corporation, even if it is non-profit. Government is a corporation. Megachurch is a corporation. Public Radio is a corporation. The homogenous interwoven society in which no individual is free solidifies and becomes brittle. The image of the Earth's crust and its awesome tectonics comes to mind. The calls to **re-liquefy** the frozen financial system are exactly chemical.

A peculiar thing about government in a democratic country, praised as a benefit of democracy, is that the leader does not pay any material price for the failure and the transfer of power is always peaceful. The corporate leader, unlike a rank and file individual, is well above the metabolic rate (**Figure 3.6.2**). This puts everybody at the top on an equal footing with a CEO of a "hype" company. The descending former leader slides to a slightly lower (sometimes higher) level of wealth with lots of opportunities to increase it. Rewards are shared by few, risks by many. This is quite natural and not a cause for grumbling. The nation has the leaders that it deserves.

The goal of growth/victory at any price increases the concentration of wealth/power , which leads to instability. The presidents/CEOs take risks because they do not pay for it in any dramatic way. [**EDITING REMARK**. As if Lehman Brothers, AIG, and others heroes of 2008 were not enough, the Intel-AMD affair provides a new evidence that the pattern of risk has a very diverse and colorful family of configurations. The configuration of Bernie Madoff, however, is a rarity. Robert Reich in *Supercapitalism* has been proved right again].

> I was greatly impressed by a moment in Charlie Rose's interview with Hank Greenberg, the founder and former CEO of the now infamous American International Group (AIG). He said (at 6:35 min) that his personal interest in the company before the collapse was $2.5 billion. After the crash it became, as he said, **"virtually worthless:" about $100 million**. Whether you are a CEO or the US President, if your wealth/power scale is in billions and trillions and $100 million is considered worthless, whether the money is yours or not, you belong to a different biological species than *homo sapiens*.

Sara Palin sees Russia through her fancy glasses, others may see Paris through theirs, but I see the end of the open frontier through mine. America's adaptation to the new situation is a problem and I see no reason why America cannot solve it, except for the American self-destructing elections that put barriers much higher that Galveston seawall on the way of talented, educated, and intelligent presidential candidates.

In 2008, it seems that the centralization of administrative power has been an ongoing long term process. Strictly by gut feeling, if George Bush's presidency was labeled imperial, the McCain presidency, in case it materializes, will have good chances to be called dictatorial. If he died in office, the svengalization of his Trilby would continue by some shadow regent.

September 24, 2008

In **Chapter 4.4** I mentioned the French Revolution, Antoine Lavoisier, the tax farmers of the *Ancien Régime*, modern hedge funds, and the guillotine. I found it all "worth thinking about."

***Lupus in fabula*, all the same.**

The current financial crisis reminds me of the French Revolution (1789–1799): the mob revolts, corporate heads (rather, their wax effigies) are falling into the guillotine baskets and more money pumps, including hedge funds, are marked for tribunal. But the Bourbon restoration will come in due time, and so will its next demise, in due turn of events. I do not feel any righteous anger, however, because catastrophes are natural events in open non-linear systems.

One of the main causes of the financial crisis, it now becomes clear, is treating the future as reality governed by mathematical equations. It means acceptance of complex, arcane, convoluted, and entangled reasons that could never be proved or disproved other than in the same future that they address and predict. Pattern chemistry is less categorical, more modest, and much simpler. I do not think that human matters can be governed by anything but simple reason: otherwise humans would never evolve. See Simple Reasons.

History—political or financial—is driven by natural, military, economic, and financial earthquakes which catapult society over the transition barrier.

I first noticed the signs of a systemic trouble in America when the troops in Iraq were dying because of the lack of protective armor for the vehicles and human bodies. Somehow the famous American dynamism and creativity did not work. Looking back at that time, I think that both business and government should share the blame.

If there are only two possible large scale patterns, the society swings between them like a pendulum. I believe that the current events strengthen the archetypal significance of flat and tall structures. They also strengthen my belief that concentration of energy in the form of wealth or power (which today are mutually convertible) is a source of instability.

The American idea has been limits on power and no limits on personal wealth. The unlimited open frontier was American reality until recently. The convertibility (very much electronically enhanced) of wealth and power as forms of energy combined with the limits on the natural sources of energy, from which both wealth and power ensue, is a new factor to which America has to adapt.

Regarding adaptation,

To be or not to be, that is the question;
Whether 'tis nobler in the mind to suffer
The slings and arrows of outrageous fortune,
Or to take arms against a sea of troubles,
And by opposing, end them.

Shakespeare, the intellectual troublemaker, excluded adaptation from the options of a noble **individual**, but we all are **incorporated**, powerful or not.

October 7, 2008

A Primer on Econochemistry

Suze Orman, the respectable TV money guru for the masses, advises the audience to change their financial habits and not to keep charging on credit cards, while diligently paying the minimum. In short: live within your means, at least during a world wide crisis.

If the public followed her advice, which is the axiom of human prudence, as old as the first civilizations, the economy would probably go into depression. That would be bad for everybody, even for some rich. If the public did not, the country would go bankrupt, which would be bad for the economy (as it is now) and even for some rich. Cutting on consumption was seen as one of the causes of the Great Depression, although it was certainly a consequence. The past emanates a terrifyingly up-to-date pattern:

> "The traditional explanation [of Great Depression – *Y.T.*] is a combination of high consumer **debt**, **ill-regulated markets** that permitted **malfeasance by banks and investors**, cutbacks in foreign trade [today: **enormous trade deficit** – *Y.T.*] , and growing **wealth inequality**, all interacting to create a downward economic spiral of reduced spending and production." (Wikipedia) .

If something is as bad or good as its opposite, it cannot be either bad or good: it is natural.

Suze Orman's timelessly prudent advice for the masses reminds of the most basic principle of nature: conservation of matter and energy. The advice for the rich is different: high risk promises high reward. With $10 million of personal wealth, the same Orman said "I have a million dollars in the stock market because if I lose a million dollars, I don't personally care." The factor of metabolic cost could not be explained better.

From chemical point of view, there is no contradiction: molecular chemical transformation runs because a small part of molecules has enough energy to jump over the transition barrier. Molecules aside, only a small part of human population has enough imprudent energy to take risk and either win or lose on the way to the next level of satisfaction. Human history has been driven by the risk takers whose achievements were preserved by the risk dodgers. Both could fail, but only the risk takers could win big (**Chapter 3.6**). Suze Orman speaks the language of the hidden chemistry of money-making: one-way street of irreversibility.

The principle of conservation means that, at least on a human scale, away from galaxies and subatomic particles, neither energy, nor matter can be produced from nothing. Since matter is always conserved, whether we care about that or not, it is the handling of energy that we can manage, and money is a form of energy (**Chapter 1.6**). Unlike matter, energy can be lost, but with a receipt, and, unlike energy, money can be lost without a trace. The throwaway heat of our bodies, computers, and machines, dissipated in the atmosphere or the ocean, cannot be recovered as work. In principle, a small part of it can be recovered in cold environment. As for matter, it can be at different levels of utility for humans, but this is a different topic. There is plenty of gold in the ocean water, for example.

In order to change matter, we need energy. For an econochemist, economy is separation, rearrangement, transport, and recombination of atoms by dissipating part of usable energy (Gibbs energy) into heat. With energy, unlike matter, we have a significant set of choices. Like money, energy can have variable value, producing more or less change (work), depending on conditions.

What can we do with energy? We can use it for:

(1) destruction and disorder,
(2) work: construction of order along a design and making the design itself,
(3) increasing temperature (i.e., level of chaos) and intensity of work, and
(4) decreasing temperature (i.e., level of chaos) and slowing work down.

We need cold to produce energy from heat. Otherwise we would produce it from nothing. On could see in it a pattern: we need the poor to make wealth for the rich. Ultimately, all renewable energy on earth is produced by solar radiation or, like tidal energy, by the inertia of the solar system and difference between solid and fluid bodies in it. The miraculous property of sunlight, orderly packaged into quanta, is that it carries energy ready to produce both chaotic heat and work suitable for the growth of vegetation. Solar radiation is selectively driving some molecular chemical reactions without effecting most others. Compare with electricity which would spin a motor but not a glass bottle on the floor. Yet both can be melted down in a furnace.

The above part of the emerging **primer on econochemistry** money is **borrowed from physics.**

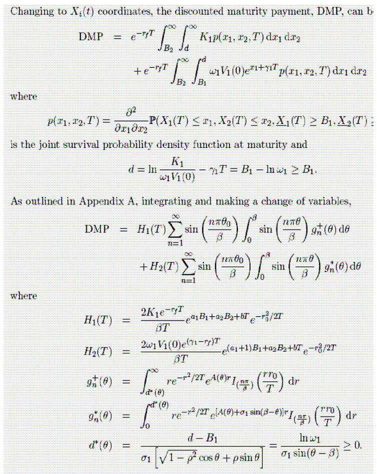
The rest of the primer is inspired by generalized chemistry.

First, a particular transformation rarely runs alone: all possible transformations run concurrently. Nevertheless, if their final states are incompatible, only one wins. If they are compatible, the fastest has better chances to come first. The transformation through a more stable (less stressed) transition state has better chances to be the fastest. All the more so if they use the **same initial** state because the fastest process “steals” the initial state from the slower one. If Obama gains, McCain loses, and vice versa. Presidential races in America are an excellent example of chemistry, especially, starting with the primaries, before it gets really nasty.

Second, growth has been the obsession of modern economy. What is growth?

Growth in chemistry is replication: a system uses energy, matter, information, and machinery to make a copy of a subsystem from its components. Examples: pair of shoes, automobile, business contract, bank account, dinner from a restaurant menu, a novel by Nora Roberts. Those are copies (with variations over a stable core) that can be produced in small or large numbers. They constitute economy.

The United States of America, the State of Rhode Island and Providence Plantations, US Government, European Union, Political Parties, US Public Radio, etc., do not exist in copies. Neither do economies, the largest systems built by humans. Neither does global economy. Even the *Freedom of the Seas*, the largest passenger ship ever built, is intended to be replicated. It represents a class of such copies—Royal Caribbean’s Freedom Class—and from this perspective is no different than a pair of snickers. There is only one USA in the world, however.



Changing to $X_i(t)$ coordinates, the discounted maturity payment, DMP, can b

$$\begin{aligned}\text{DMP} &= e^{-r_f T}\int_{B_2}^{\infty}\int_{d}^{\infty} K_1 p(x_1,x_2,T)\,\mathrm{d}x_1\,\mathrm{d}x_2\\ &\quad + e^{-r_f T}\int_{B_2}^{\infty}\int_{B_1}^{d} \omega_1 V_1(0) e^{x_1+\gamma_1 T} p(x_1,x_2,T)\,\mathrm{d}x_1\,\mathrm{d}x_2\end{aligned}$$

where

$$p(x_1,x_2,T) = \frac{\partial^2}{\partial x_1 \partial x_2}\mathbb{P}(X_1(T)\le x_1, X_2(T)\le x_2, \underline{X}_1(T)\ge B_1, \underline{X}_2(T) \text{:}$$

is the joint survival probability density function at maturity and

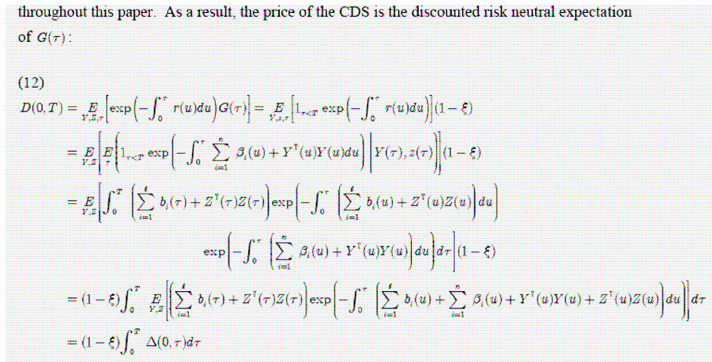
$$d = \ln\frac{K_1}{\omega_1 V_1(0)} - \gamma_1 T = B_1 - \ln\omega_1 \ge B_1.$$

As outlined in Appendix A, integrating and making a change of variables,

$$\begin{aligned}\text{DMP} &= H_1(T)\sum_{n=1}^{\infty}\sin\left(\frac{n\pi\theta_0}{\beta}\right)\int_0^{\beta}\sin\left(\frac{n\pi\theta}{\beta}\right) g_n^{+}(\theta)\,\mathrm{d}\theta\\ &\quad + H_2(T)\sum_{n=1}^{\infty}\sin\left(\frac{n\pi\theta_0}{\beta}\right)\int_0^{\beta}\sin\left(\frac{n\pi\theta}{\beta}\right) g_n^{*}(\theta)\,\mathrm{d}\theta\end{aligned}$$

where

$$\begin{aligned}H_1(T) &= \frac{2K_1 e^{-r_f T}}{\beta T} e^{a_1 B_1 + a_2 B_2 + bT} e^{-r_0^2/2T}\\ H_2(T) &= \frac{2\omega_1 V_1(0) e^{(\gamma_1 - r_f)T}}{\beta T} e^{(a_1+1)B_1 + a_2 B_2 + bT} e^{-r_0^2/2T}\\ g_n^{+}(\theta) &= \int_{d^*(\theta)}^{\infty} r e^{-r^2/2T} e^{A(\theta) r} I_{(\frac{n\pi}{\beta})}\left(\frac{r r_0}{T}\right)\mathrm{d}r\\ g_n^{*}(\theta) &= \int_0^{d^*(\theta)} r e^{-r^2/2T} e^{[A(\theta)+\sigma_1\sin(\beta-\theta)]r} I_{(\frac{n\pi}{\beta})}\left(\frac{r r_0}{T}\right)\mathrm{d}r\\ d^*(\theta) &= \frac{d - B_1}{\sigma_1\left[\sqrt{1-\rho^2}\cos\theta + \rho\sin\theta\right]} = \frac{\ln\omega_1}{\sigma_1\sin(\theta-\beta)} \ge 0.\end{aligned}$$



throughout this paper. As a result, the price of the CDS is the discounted risk neutral expectation of $G(\tau)$:

(12)

$$\begin{aligned}D(0,T) &= \underset{Y,Z,\tau}{E}\left[\exp\left(-\int_0^{\tau} r(u)du\right)G(\tau)\right] = \underset{Y,Z,\tau}{E}\left[1_{\tau<T}\exp\left(-\int_0^{\tau} r(u)du\right)\right](1-\xi)\\ &= \underset{Y,Z}{E}\left[\underset{\tau}{E}\left(1_{\tau<T}\exp\left(-\int_0^{\tau}\sum_{i=1}^{n}\beta_i(u) + Y^{T}(u)Y(u)du\right)\middle| Y(\tau), z(\tau)\right)\right](1-\xi)\\ &= \underset{Y,Z}{E}\left[\int_0^{T}\left(\sum_{i=1}^{\ell} b_i(\tau) + Z^{T}(\tau)Z(\tau)\right)\exp\left(-\int_0^{\tau}\left(\sum_{i=1}^{\ell} b_i(u) + Z^{T}(u)Z(u)\right)du\right)\right.\\ &\qquad\left.\exp\left(-\int_0^{\tau}\left(\sum_{i=1}^{n}\beta_i(u) + Y^{T}(u)Y(u)\right)du\right)d\tau\right](1-\xi)\\ &= (1-\xi)\int_0^{T}\underset{Y,Z}{E}\left[\left(\sum_{i=1}^{\ell} b_i(\tau) + Z^{T}(\tau)Z(\tau)\right)\exp\left(-\int_0^{\tau}\left(\sum_{i=1}^{\ell} b_i(u) + \sum_{i=1}^{n}\beta_i(u) + Y^{T}(u)Y(u) + Z^{T}(u)Z(u)\right)du\right)\right]d\tau\\ &= (1-\xi)\int_0^{T}\Delta(0,\tau)d\tau\end{aligned}$$

A **B**

Figure A3. **Clippings from papers on credit default swaps (CDS).**

A: An Explicit, Multi-Factor Credit Default Swap Pricing Model with Correlated Factors, Ren-Raw Chen, Xiaolin Cheng, Frank J. Fabozzi , and Bo Liu , April 25, 2005;

B: Modelling Bonds & Credit Default Swaps using a Structural Model with Contagion, Helen Haworth, Christoph Reisinger, and William Shaw, June 2006

Pattern chemistry treats unique singular systems on the same basis as a pair of snickers or a molecule of aspirin. How exactly? It cannot be reduced to a short list of statements or mathematical equations. This is what makes the chemical view of the world different from the physical one, although, of course, there is only one scientific view of the world and the border between physics and chemistry is as porous as the southern borders of Arizona and New Mexico.

It is for money, not for glory, that the mathematicians and physicists rushed into economics under the banner of econophysics. It has been already noted in the media that the mathematical equations spelled doom for credit default swaps and similar financial chimeras. Some excerpts from two at random picked papers on mathematical finance are shown in **Figure A3.** Not only man-made things compete with humans: ideas do too.

The main reason for the limits of hard sciences in case of exystems has been discussed throughout **Part 1**: it is the phenomenon of **novelty**.

> "Because of the very nature of mathematics and logic, novelty has no place in the traditional axiomatic systems of reasoning." (**Chapter 2.1 ; see also Chapter 3.4**)

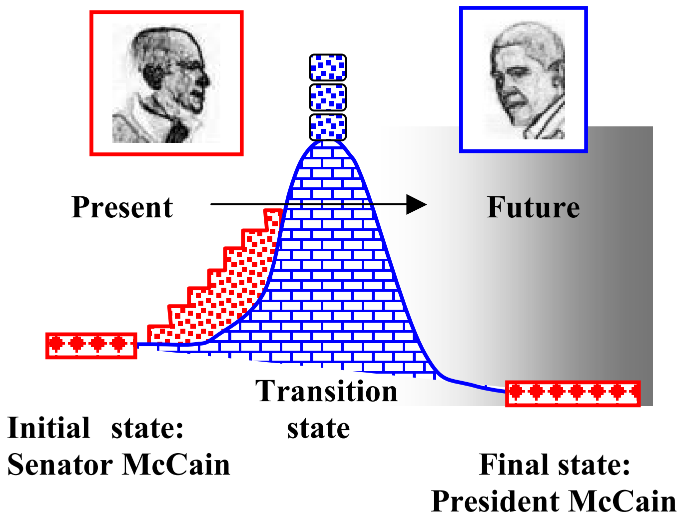


Figure A4. **Transition state for John McCain , his tactics , and tactics of Barack Obama .**

Pattern chemistry is best presented as traditional chemistry: a very short set of principles and unlimited compendium of graphic illustrations and examples. Pattern chemistry gives us not a hard knowledge, but an understanding of what we do not know. It encourages experimentation.

For example, the current economic disaster has contributed to the rise of the transition barrier toward presidency for John McCain and the decrease of the barrier for Barack Obama. From the outset, the very difference of the origins and even the names of the two candidates have been working for them in opposite directions. In order to make the barrier more accessible, John McCain is now building a dirt ramp to the wall of Obama's resilient fortress. His opponent, naturally, responds in kind by putting sacks of dirt on top of the wall, **Figure A4** . This military device is as old as the Roman Empire (see **Figure A5**).

Figure A5. **The siege ramp built by the Romans at the Jewish fortress of Masada.**
Source. See another photo.

The main reason I take the Election-2008 Campaign as an example for econochemistry is that every move of the candidates, dirt or not, is paid by money. The modern American elections are part of economy, and even more so with every new cycle. We can substitute two companies or two industries for the two political parties. The difference is, however, that business competition is not an exclusion game. The business competitors can stay in the game indefinitely long because they have **potentially** indefinite time. This is why modern economy treats the future as if it were yesterday. The Great Crisis of 2008, as dramatic as the Great Election of 2008, is all about the chemistry of the future, based on debt, leverage, fraud, disinformation, and gamble. The details of this chemistry, however, exceed the limits of a primer.

The core idea of pattern chemistry is that the relative stabilities of the initial, transition, and final state of a transformation play the decisive role in the outcome. Although we do not know the final states in advance, the combinatorial ability of chemistry provides us with some basic alternatives.

It is the balance sheet of the increments and components of stability (or stress) that bridges chemistry with economy. Economy, like love, has its chemistry. No wonder: economy is love of money and money is power. But fortunately we are still able to love glory.

This is the end of the primer. For more, see **Part 1**, complexity, and simplicity.

October 9, 2008

A psychological reward of econochemistry as part of pattern chemistry is that it contributes to personal peace of mind and saves from excessive and unhealthy anger. This is where science contrasts with ideology. I agree with Philip Pullman, the author of "*His Dark Materials*" who regards human history as the struggle not between good and evil, but with knowledge and ignorance.

History moves ahead by longer periods of stability interrupted by shorter calamities and catastrophes after which the relaxed system is never the same.

Intriguingly, this is the pattern of movement known as Levy walk or Levy flight and observed in birds, mammals, and even humans: long stretches of steady movement alternating with clusters of short steps or immobility, see **Figure A6**. Levy walk is typical for animals in search of food or fun. It was studied on monkeys, jackals, albatrosses, and humans. Brownian movement is typical for small particles of dead matter in fluids. Bacteria are only shaken by it.

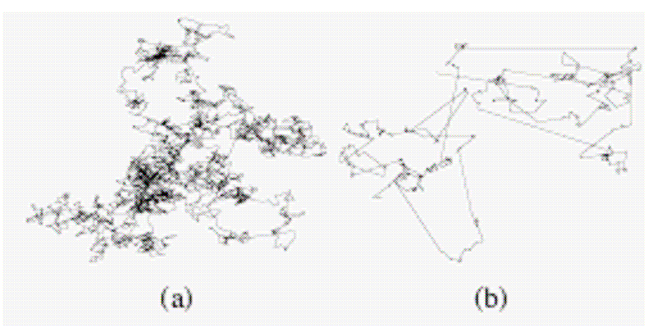


Figure A6. **Brownian movement (a) and Levy walk (b). (source)**

Of course, large scale economic fraud and crime should be punished as a form of financial terrorism, i.e., acts of destruction with massive consequences, but can we punish the nature? Persian king Xerxes whipped the sea for destroying his bridge across the Hellespont, but, as an example of adaptation, he managed to restore the bridge at his second attempt.

> The punctuated by spasmodic fits behavior of evolving complex systems is completely natural. It is described by common-sense equations of **chemical** kinetics for systems with growth on a limited resource (Manfred Eigen, 1971). In other words, along very general chemical principles of behavior, lack of food, energy, money, land, political representation, market demand, etc., combined with the inherent drive for growth, is guaranteed to generate the pattern of steady states alternated by periods of turbulence and uncertainty followed by a systemic change. This subject, however, is too technical for this diary (see ***The New and the Different***, pp. 39, 377, and 430). All I can say is that the "common-sense equations" are nothing but **records of debit and credit**. They are a far cry from equations in **Figure A3** and this is the only reason why I present them. Here they are for ***i*** competing replicating species, identical in appearance, numbered from 1 to ***i*** , credit with plus, debit with minus:
>
> $$dx_i/dt = A_i Q_i x_i \;-\; D_i x_i \;+\; S_{(k'i)} w_{ik} x_k$$
>
> They are written in usual mathematical notation, which is nothing but pattern, and could be also written as a table with the header and ***i*** lines. The Eigen's equations were intended for very artificial chemical systems with replication and not for economy. Nevertheless, their rough similarity to economic reality and basic accounting can be seen from the following foot-loose interpretation:
>
> **1.** There is a system of many economic units growing and competing for the same pool of resources.
>
> **2.** The larger the size, the faster the unit grows
>
>> Then he that had received the five talents went and traded with the same, and made them other five talents. And likewise he that had received two, he also gained other two (Matthew 25:16,17)
>
> **3.** Growth rate of any economic unit at any moment = current size – volume of waste **returned to resources** + volume of exchange with other units.
>
> Obviously, the Eigen's chemistry displays in a system with full material recycling and unlimited energy resource. It is far from current economic reality, but not too far. It is the economy of a spaceship exchanging with other spaceships on the way. Some of the ships are doomed because of errors of production and excessive waste. Others grow and spread before they, too, disappear. Today the comparison of the Earth with a spaceship is trivial. Actually, it is exactly true, only without a chance to trade with other ships and without a common limited resource. Global economy, however, has it all.

Simon Schama is quoted by BBC:

> "But one aspect of American ideology has to be revised, he says - the belief in limitless natural resources as underpinning America's growth."

The renewable energy (sunlight, wing, tides) is a peculiar resource: limitless in time, but limited in space. This is good enough. I am more troubled by our resources of knowledge and ingenuity, but even more so by the ideology of growth. How about happiness? Nothing puts breaks on growth as much as happiness and prudence. Although I am wholeheartedly with Steve Jobs ("Stay hungry. Stay foolish") , happiness and growth can be reconciled in spaceship Earth because they never stay together for long. That was the main result of Manfred Eigen's model of evolution: growth wanders from species to species. As for happiness, it is, probably, the moment of the realization of the desired final state when it appears from the fog of the future and solidifies as the present.

They new historical factors are: exhaustion of planetary resources, development of powerful competing economies of Europe and, potentially but not definitely, of BRIC (Brazil, Russia. India, China), catastrophic debilitating growth of complexity, and resurgence of irrationality, some of it suicidal. The old and yet unchanged factor is the human nature, although it is already under scientific assault.

With the dispassionate attitude to natural history, can we expect the recovery of the world economy and the next period of American prosperity? My answer is yes, but at the price of some systemic change, which may turn out more bonus than expense.

The change I discussed in Introduction to Pattern Chemistry was: verticalization. The public sound and fury over the bailout of financial institutions is the clearest manifestation of the painful paradigm change from the unbridled, insatiable, and aggressive capitalism ("it is the economy, stupid!"), which had made America prosperous, powerful, and great, to "it is the government, stupid!"

Yet there is no reason to panic whatsoever. We have no power over the players on free market, but we have power over the government. It is a dramatic difference that can, ideally, compensate for the obvious flaws of the government.

The only thing we have to fear is the fear of people who are brighter than ourselves.

October 15, 2008

Mr. Bubble and Dr. Doom

Here is another illustration of the basics of pattern chemistry from the econochemistry angle. It is about people who are brighter than ourselves.

As it is common in human matters, the current crisis has projected a whole spectrum of opinions in every aspect involved. The striking exception is the perception of the historical scale of the crisis: nobody has ever seen anything like that. Nevertheless, a few people explicitly predicted it and among them Robert Shiller and, especially, Nouriel Roubini stand out. [**EDITING REMARK**. In fact, a lot of people had publicly articulated the danger of the financialization and its reckless trends.]

This is what **The New York Times** wrote about them.

To my surprise I could not find any draconian ban on quotation without permission at the newspaper site. "Surprise," because I cannot understand why people would limit the spread of their own ideas.

On Robert J. Shiller:

Be Warned: Mr. Bubble's Worried Again , By DAVID LEONHARDT Published: August 21, 2005, http://www.nytimes.com/2005/08/21/business/yourmoney/21real.html

> Today, nine years after his lunch with Mr. Greenspan and five years after the markets finally did crash, Mr. Shiller is sounding the same warning for real estate that he did for stocks. In speeches, in television and radio interviews and in a second edition of his prophetic 2000 book, "Irrational Exuberance," he is arguing that the housing craze is another bubble destined to end badly, just as every other real-estate boom on record has.

On Nouriel Roubini:

http://www.nytimes.com/2008/08/17/magazine/17pessimist-t.html?_r=1&ref=magazine&oref=slogin

> *Dr. Doom* **,** By STEPHEN MIHM
> Published: August 15, 2008,
> http://www.nytimes.com/2008/08/17/magazine/17pessimist-t.html?_r=1&ref=magazine&oref=slogin
>
> **On Sept. 7, 2006**, Nouriel Roubini, an economics professor at New York University, stood before an audience of economists at the International Monetary Fund and announced that a crisis was brewing. In the coming months and years, he warned, the United States was likely to face a once-in-a-lifetime housing bust, an oil shock, sharply declining consumer confidence and, ultimately, a deep recession. He laid out a bleak

> sequence of events: homeowners defaulting on mortgages, trillions of dollars of mortgage-backed securities unraveling worldwide and the global financial system shuddering to a halt. These developments, he went on, could cripple or destroy hedge funds, investment banks and other major financial institutions like Fannie Mae and Freddie Mac.

This is especially interesting:

> Roubini's work was distinguished not only by his conclusions but also by his approach. By making extensive use of transnational comparisons and historical analogies, he was employing a subjective, non-technical framework, the sort embraced by popular economists like the Times Op-Ed columnist Paul Krugman and Joseph Stiglitz in order to reach a nonacademic audience.
>
> NY Times, 08/15/08
>
> (http://www.nytimes.com/2008/08/17/magazine/17pessimist-t.html?_r=2&pagewanted=2&ref=magazine&oref=slogin)

This is exactly what pattern chemistry means: patterns. While nobody has ever seen anything like 2008 in economical as well as political history, patterns have been seen and the components of the past pattern could be recombined into new ones. High level pattern, like "crises always happen" does not say anything specific enough, but the substitution of current and more specific generators, configurations, and blocks for very general nodes of the framework opens way to outlining future alternatives and their odds—never with certainty. Prediction is abstract expressionism with patterns on the palette.

October 24 - 30, 2008

ECONOCHEMISTRY OF INFORMATION

> **APOSTLES: What's the buzz? Tell me what's a–happening**
>
> (Repeat 8 times). *Jesus Christ Superstar*
>
> **"I still do not understand exactly how it happened,"** said Greenspan.

Alan Greenspan has made me come back to the question posed in **Chapter 3.7 What happened in 1970?** of **Part 1.**

I denote by "1970" the plus-minus five years period around the year of 1970. It was the year of the release of the famous album by Andrew Lloyd Weber and Tim Rice. It was the time of many new and far-forward-looking scientific ideas, consolidation of modern chemistry, launch of UNIX, rise of integrated circuits, C language, floppy disks, final strides toward modern computing and Internet. It was the beginning of a new trend in

American and world economy. The turning point around 1970 is clearly visible from the plots of economic **data**. Money started losing value after "1970." Why?

Was it because of the last stab to the gold standard (Richard Nixon, 1971)? Or because of the sharp increase in complexity of all aspects of life (see Joseph Tainter, *The Collapse of Complex Societies,* 1990)? Or because of the explosion of the minimally addressing basic human needs Technos (see **Figure A7**, which can be an ideogram for the growth of social complexity, too)?

Figure A7. **The price of complexity**. **The simplehuman® Brushed Nickel Sensor Soap Dispenser on the right has a sensor and "even indicates when hands are clean." Not yet voice activated. Batteries not included.**

There must be a single root cause.

This was part of my answer in **Chapter 3.7**:

Why is the "1970" such a special point? The explosive growth of Technos was caused by the **digitalization** of its blueprints. This event is comparable with the development of the universal **genetic code** by living organisms. From the pattern-chemical perspective, a code is a code, whether genetic or digital or verbal.

In other words, "1970" was the beginning of the Information Revolution, which is the emergence of the universal code for entire economy—not just science and technology, but also management, finance, law, communication, art, ideology, religion, power politics, body parts, human genome, and, ultimately, human identity. It was the advent of information: a vitally important property which could be snatched in an instant without even your noticing the expropriation. It is like you buy a 100% real diamond and at some moment it turns into glass inside your safe. Economists write about the death of distance (Francis Cairncross), we witness the progressing cancer of newspapers and privacy, but the specter of the death of private property (yes, as history proves, it is mortal, too) can be seen only through the pattern-tinted glasses. The vaults are dying, too.

> Just to let my Election-08 steam out: We, proud individualistic Americans are becoming disposable cogs in the humming and growling and gulping mineral fuel Global Economy. We have no influence over the laws of nature, whether physical or human. We cannot influence ignorant, superstitious, intolerant, dishonest, greedy, gullible people among us because we have the sacred right to be ignorant, greedy, and stupid. And yet our individualism degenerates into anarchy and we snarl back at the government, although **government is the only part of the machine we still can influence**. We can control our sometimes self-destructive personal habits much less than our powerful government. [**EDITING REMARK**. The battle against the state continues in 2009. Has anybody called the militant libertarians **anarchists**. Can I be the first? No, there is plenty on the Web. Another alternative to

government comes to mind: stateless guerillas and terrorists, IRA, ETA, Hamas, Hezbollah, Taliban, with a state of their own in mind. No, I do not want to be the first.]. Now I feel better.

To give an alternative definition of economy, it is the sum of anything you can buy, sell, fake, steal, and screw up.

I believe that the digitalization was the deepest reason for the growth of complexity, dematerialization of money, formation of the financial food chain that concentrated wealth, devaluation of geographical distance, dizzying acceleration of technological evolution, and, most importantly, production of enormous numbers of useless things. As digitalization is a natural process, it cannot be either good or bad. It is here, and all you can do is to adapt.

I would give an alternative definition of technological evolution, too: generation of an increasing amount and diversity of waste comprising matter, energy, and information.

Intuitively, I suspect that the essence of "1970" was the advent of massive **information market**. My intuition is guided by the concept of money as energy (**Chapters 1.6 , 2.5,** and also Essay 55, The Chemistry of Money and Essay 56, From One, Many).

Energy, unlike matter, can be **irreversibly** wasted. Apparently, this is what is happening with money in 2008. Money (better to say: wealth) can disappear over a trading day. It can be made in an instant, true, but it is always **alive**: it can fall ill, escape, die, or bring a litter of golden piglets. And you have to feed and take care of it every day.

This guidance may be insufficient because information is definitely not energy. What is it, then, from the point of neither computer science, nor economics, but chemistry?

From the chemical point of view, information is generalized **catalysis**: **it selectively speeds up creation of order**. The words in bold are treacherous if not used with restrain.

"Order" means a particular order, not abstract order. Order for a chemist is configurations and patterns, as individual as human faces. "Selectively" means that particular information accelerates only one among many **competing** processes of creating order. "Creation" is nothing but change from one state to another and, therefore, is meaningless if used other than as a shortcut. "Competition" may mean that a process accelerates only at the expense of others ("zero sum game," "cake cutting"). This is not always the case, however.

Molecular chemical reactions are exactly "zero sum." Whether economy, wealth, income, etc. are "zero sum" has been a subject of centuries long debates. Whether the cake should be re-cut has been the subject of political wars, among them World War II, World Cold War, and the American Cold Civil War with Election 2008 as its current blue-bloody and red-bloody episodes.

While the closed systems are always "zero-sum" regarding matter, the open (not insulated) systems, extracting matter and energy from the environment like piglets from the sow, are not. No exystem "zero sum," although neither energy nor matter can be destroyed or created. Both can be degraded or upgraded, however, depending on the entropy change in the process.

Therefore, that the capitalist takes something from the worker is a non-chemical statement. Chemically speaking, the capitalist **acquires wealth faster** than the worker. It is the government that takes something from everybody. The government either returns it, optimally, as public good (better to say, social stability; chemistry is ignorant of good and evil), or wastes it. I can easily imagine a taxation system targeting not income but waste and degradation. We can tax not what we earn, but what we lose (and, probably, we should). [**EDITING REMARK**. Tax on emissions if the first configuration of the coming adaptive pattern].

The current crisis, overlapping with the dramatic election, leads me to a question which I have never asked yet: what is the **econochemistry of information**? I never thought about it until this year. I am not even sure it is a question within the scope of econochemistry or pattern chemistry. I am starting the discourse not knowing where it will lead. It seems that the business of information is the most dematerialized and de-energized industry, comparable, probably, to palm reading. I am trying to understand it.

For decades, the definition and meaning of information has been a subject of debates.

The absence of consensus usually means that the matter of discussion is fundamental and cannot be reduced to more fundamental notions. Let us learn about information from the horse's mouth. The concise (206 words), and non-technical description of information in *Principia Cybernetica* completely satisfies me. Here is an excerpt:

> ": the equivalent of or the capacity of something to perform organizational work, the difference between two forms of organization or between two states of uncertainty before and after a message has been received."

All I need for chemistry is "**difference between two states …before and after**." I mean, of course, the initial and the final states of a change.

Information changes the difference between two states as compared to the difference between the two states in the absence of information. We get a business letter and it immediately, right before our eyes, changes from information into data. It cannot change anything else again, except when it surfaces at a trial years later. Contrary to the meaning of the term ("that which forms within"), "in-formation" lives its short life on the interface between within and without.

We use the word "information" in two different meanings. One is the meaning of cybernetics (dynamic act of transfer and processing) and the other is identical with code, template, document, technology, procedure, know-how, etc. (object), which is information only when it works as information.

Therefore, information makes sense not in the initial state/final state pair. It requires a **quartet** of states, i.e., two such pairs to be in play: the pair without information and the pair with information.

1. ☹ → ☺
2. ☹ + information → ☺ + data

It looks like there is no difference between the happy final states in **event 1** and **event 2**. There is, if the happy face in **event 1** appears, **probably**, next weekend or , as in **event 2**, **immediately**. Now, the data could **potentially** be used to make somebody else happy or bitterly envious, working as information. We need two events with the same initial and final states to notice information.

I am coming to realization that not the easiest but the best way to understand pattern chemistry is molecular chemistry. Instead of beating about the bush, let us dip into the bitter brew.

Example of catalysis: chemical interaction between nitrogen and hydrogen combining into ammonia:

$$N_2 + H_2 \leftrightarrows 2\ NH_3$$

Nitrogen and hydrogen do not react at normal conditions. The synthesis of ammonia, known as Haber-Bosch process, was made possible by German chemists Fritz Haber and Carl Bosch, Nobel Laureates of 1918 and 1938, respectively. The trick was to use a catalyst, for example, iron filings, at high pressure and increased temperature. The catalyst does its job but remains itself unchanged. This can be compared only with the act of magic: whatever happens in the presence of the magician cannot happen without him, but he remains unaffected and cool and can repeat his trick next time.

The catalyst does not change any property of the chemical reaction except its speed. But it is not supposed to work for a competing reaction.

The quartet of states in the case of ammonia is shown in **Figure A8-A** (CAT = catalyst):

Metaphorically speaking (i.e., in pattern language), the catalyst guides the reaction along a much easier way. It can be compared with a person in the street giving directions to a lost driver or, literally, the local **guide** in a mountainous region. This ideogram, which for a chemist is rather accurate even in technical molecular details, amplifies the information aspect of catalysis—or the catalytic aspect of information, whatever you prefer. We need also have in mind that the guide is supposed to deal only with those who hired him.

A

	Initial state	**Final state**
Without catalyst (very slow)	$N_2 + H_2$	NH_3
With catalyst (very fast)	$N_2 + H_2$ + CAT	NH_3 + CAT

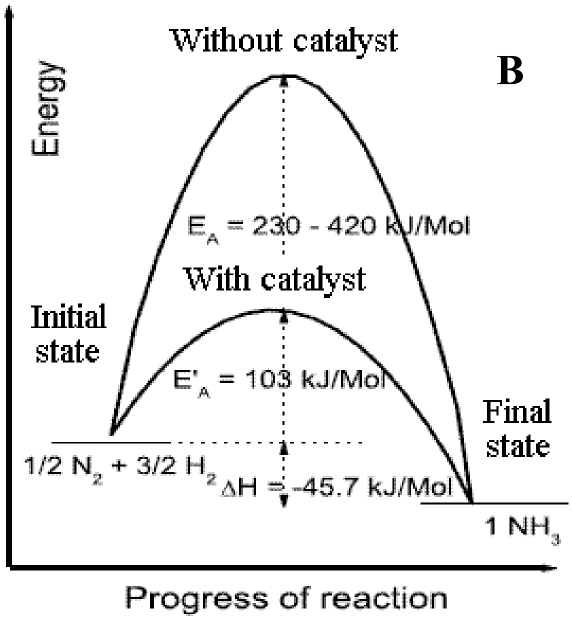


Figure A8. **Catalytic quartet (A) and thermodynamics (B) for synthesis of ammonia.** Diagram **B** uses source. Although the final state is more stable than the initial one, the reaction is "painfully slow" without the catalyst.

The catalyst can be compared with the → stepping stones across a stream: it offers a single fastest path among many possible others, like finding a bridge or ferry or just getting wet.

More about catalysis: **Chapter 3.15**.

Diagram **B** in **Figure A8** looks technical to non-chemists, but an economist or businessmen can see that it is all about numbers on a balance sheet of a venture. Symbol **E** denotes energy, the measure of instability. I recommend the accessible analysis of the process on Chemistry References ("In Chemistry We Trust") site as an example of a business problem with contradicting economic factors (temperature, pressure, conversion, yield, speed) solved by finding an optimum with the help of a catalyst. Looking at the witty banner of the cited web page, a non-chemist should be encouraged rather than intimidated by chemistry:

> **NOTE:** The devotees of hydrogen fuel technology will notice in Haber-Bosch process that hydrogen for the large scale industrial production of ammonia is made from mineral **fuel**: methane. The byproduct is, of course, carbon dioxide.

At this point it could already be clear to the reader (as it is clear to myself, if only because I am not an economist) that the bank loan is nothing but the catalyst for a financial transaction. It offers a quick passage toward the final state of ownership or profitable deal. The problem is, however, that the final state is imaginary and it is in the future. The typical new owner of the home does not own the dwelling: he or she is in a protracted transition state toward a **probable** final state. It may end up in the initial state.

The transition state of molecular reaction is so short that it is rarely possible to observe it. The transition state of human financial transactions can be commensurable with the human lifespan. This is where econophysics and mathematics in general can potentially be misleading: a systemic or global change in economic conditions is tantamount to a sudden change of the laws of nature for a physicist or the set of axioms for a mathematician.

The singular systems do not have copies and are not suitable for statistics. This is the very essence of history. Assuming that the laws of nature and axioms for the system do not change, statistics is natural and informative.

> Does it mean that the current crisis is a direct consequence of the little researched **economics of science**? Does it mean that the physicists and mathematicians looking for better salary have killed the goose laying golden eggs for them? Does it mean that the crisis is a direct consequence of the unbearable complexity of being? Wouldn't it better to elect physicists (like Angela Merkel in Germany) to Congress? I must clarify that I in no sense blame the mathematicians and physicists: in this world they possess supreme intellectual power.

Molecules do not know what either imagination or future are. Both have meaning only in human matters, for example, when a scientist plans a completely new chemical experiment, which may or may not succeed, fail, or bring a big surprise. Economy, which is part human, part technical, is inherently surprising, although surprise, by definition, does not happen every day. Every business transaction by its very nature is experimental. It is only because of the massive numbers of such transactions that enterprises and institutions can function. This is, probably, one of the reasons for the obsession with growth. Any economic catastrophe, therefore, can be considered as massive number of failed experiments. Wherever there are massive numbers, econophysics is legitimate as *post factum* analysis and, probably, as modeling alternative futures. Numbers beget numbers.

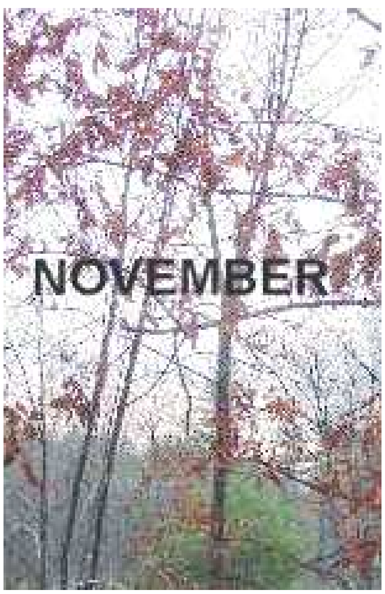
In order to understand why a massive failure is possible in the large community of mostly reasonable humans, their reason amplified with gadgets, diplomas, and hired geniuses, we need to come back to the starting point of pattern chemistry: the notion of exystem.

National or global economy exists in a single copy and it does not make massive statistical ensembles. Neither does individual life. Exystems move in time by irreversible steps. This is why statistics in time, which could be valid for molecular and technological systems, has a limited medium-term predictive power, similar to weather forecasting. Non-linear properties of exystems (i.e., large consequences of small causes) complicate forecasting even more. We can predict anything but the timing of the unexpected.

What we can use for prediction is trend: the difference between today and yesterday. The main assumption is that no trend can last indefinitely, which has not been disproved yet.

I am still far from understanding the econochemistry of information, but some groundwork has been done.

Economics is not dismal science. It is an admirable attempt to escape the oppressive triviality of common sense.



November 5, 2008

ECONOCHEMISTRY OF INFORMATION (II)

TRANSITION STATE IN MODERN HISTORY: PREAMBLE FOR AN ECONOCHEMICAL CASE STUDY

On September 11, 2001, the terrorist attack on USA abruptly—within a few hours—changed the course of history. Only *post factum*, gradually, the transition state from peace to war, from stability to turmoil, and from surplus to deficit has been tracked and reconstructed, with few gaps still remaining in the dark area of decision making .

The terrorists spent a relatively small amount of money not on weapons, but on communication and transportation.

> The 9/11 attacks cost somewhere between $400,000 and $500,000 to execute. The operatives spent more than $270,000 in the United States. Additional expenses included travel to obtain passports and visas, travel to the United States, expenses incurred by the plot leader and facilitators outside the United States, and expenses incurred by the people selected to be hijackers who ultimately did not participate.
>
> **Source: The 9/11 Commission Report**

The attack caused enormous loss of life, war expenses, and physical damage in the USA, Iraq and Afghanistan.

One of the consequences of 9/11 was the re-election of George W. Bush in 2004.

By 2008 the USA was destabilized by the ongoing hot wars, the Cold Civil War, and a financial crisis of uncommon proportions.

On November 4, 2008, the course of American history was changed again with election of Barak Obama. I see it as one of the consequences of 9/11, but I have no data to prove it. The chemical proof is called **mechanism**: continuous chain of events connected by cause and effect bonds.

This time we cannot foresee all the consequences of the event, but, unlike 9/11, we have a full record of the prolonged transition state. It is partially tracked in **Figure A9**.

The campaign has devoured over five billion dollars

> The 2008 campaign was the costliest in history, with a record-shattering $5.3 billion in spending by candidates, political parties and interest groups on the congressional and presidential races. **Source:** Politico

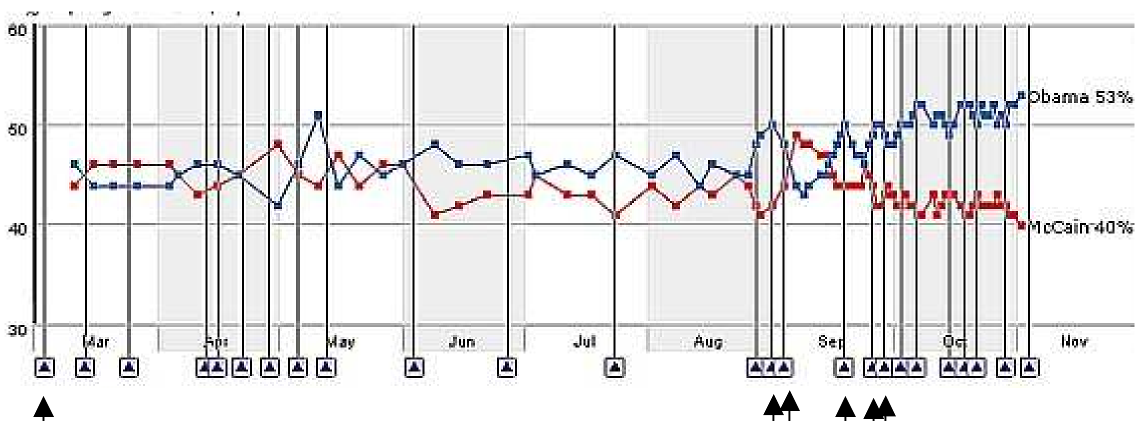
This is much more than the terrorist attack and much less than the American bill for the war.

> The cost of Iraq war is over half trillion dollars and going up every day.

The campaign money was spent mostly on **information.** None of it was spent on weapons and ammunition. No damage was incurred. Where did it go? What has been left of it? What has happened to the money?

This is the background for an econochemical analysis in obvious terms of matter, energy, money, and information. The chemical aspect of the analysis should involve the structure of change in the above terms. This task is not for me. All I want is to illustrate the concept of transition state in history.

Because of the **singularity** of history and in spite of participation of millions of people, statistical equations are not applicable. Yet the structure of change can be detailed in a bookkeeping ledger in terms of debit and credit. This is typical chemistry.



March 4, 2008 **September 1, 4, 19, 26, 29, 2008**

Figure A9. Gallup polls illustrate the historical transition state in Election, 2008. Source: BBC election polltracker . Events of September: 1-4: Republican Convention; 19: peak of financial crisis; 26: first presidential debate; 29: the House votes for bail-out.

What is clearly seen from the poll tracker is the kinetics of the competition of three concurrent and, therefore, competing chemical processes of the winner-takes-all kind. Each process involves the same pool of human "molecules" each of them in one of three configurations: elephant, donkey, or amoeba (i.e., undecided). The chemical transformation comprises three concurrent processes (**Figure A10**).

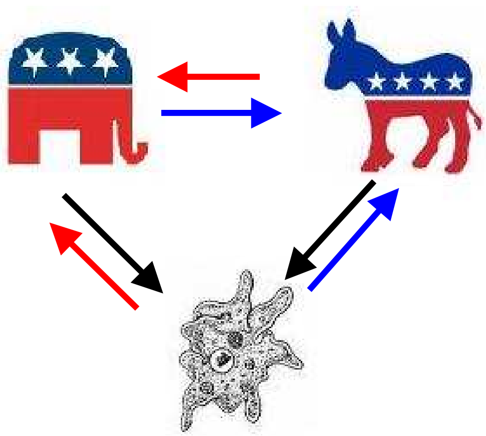


Figure A10. **Reversible switches between Republican, Democratic, and undecided voters.**

The reversible processes are: (1) candidate switch and (2,3) switches between decision and indecision. The "concentration" of the amoebas can be calculated by subtracting the sum of elephants and donkeys from 100.

Figure A10, however, should not be trusted. There could be an alternative chemistry: the partisan voters may convert into each other not directly, but only through a stage of indecision. Or, as a third alternative, there could be a separate stable configuration of principal non-voting, with a transition state of indecision between the three. This chemistry belongs to social psychology and not econochemistry.

Figure A9 magnifies the micro-stages of the overall process and records the external events. Since the number of human "molecules" is large, some statistics is applicable.

This looks like a partial list of increments in the configuration of the election outcome (i.e., list of generators with their weights):

> According to exit polls, Obama crushed McCain among women voters (56 percent to 43 percent); voters under 30 (66 percent to 32 percent); African-American voters (95 percent to 4 percent); Latino voters (66 percent to 32 percent); first-time voters (68 percent to 31 percent); and voters making less than $100,000 a year (55 percent to 43 percent).
> Source: Obama's election redraws America's electoral divide

In Election 2008, the subtle distribution of voting pattern depending on socio-economic conditions was expertly revealed through the exit polls. But the daily changes of distribution of voting intent, as **Figure A9** shows, are driven mostly by the incoming bits of information, whether true or false.

The overall chemistry of the transition state is complex, but it still is chemistry: the effect is determined by the accounting ledger of stabilizing and destabilizing increments in the configuration of the system. The change in external conditions (such as rapidly worsening economy) and the bomb raids of information and disinformation prevent the system from coming to equilibrium.

The election system, not surprisingly, has exactly the same chemistry as the personal relations of love and hate, in which instincts play a significant role. It is the same—more cerebral, though—as the chemistry of difficult decision making, for which *Hamlet* stands as the template.

Charles Darwin, considering possible marriage to Emma Wedgwood, made some pencil notes on two scraps of paper divided into two columns, the beginning of which I reproduce here:

Work finished	*Work finished*
If *not* marry TRAVEL ? Europe—Yes ? America ? ? ? ? If I travel it must be exclusively geological — United States — Mexico. Depend upon health and vigour and how far I become zoological. If I don't travel—Work at transmission of Species—microscope	If marry—means limited—Feel duty to work for money. London life, nothing but Society, no country, no tours, no large Zoolog: collect., no books. — Cambridge Professorship, either Geolog: or Zoolog:—comply with all above requisites —I couldn't systematize zoologically so well.

Source: **The Complete Works of Charles Darwin Online.**

The second, more intimate note was entitled "This is the Question."

MARRY	Not MARRY
Children—(if it please God)—constant companion, (friend in	No children, (no second life) no one to care for one in old age.—

This chemistry, however, is far from my economic interests. I want to know how information and energy in the form of money are linked, not what exactly kind of effect they produce in particular systems. I still have a very vague understanding of the subject.

← Speaking of Darwin, here is a wonderful poster, the original source of which I was unable to track. It was, probably, Center for Inquiry.

November 8, 2008

ECONOCHEMISTRY OF INFORMATION, III

"1970:" DIGITALIZATION OF FINANCES

The mystery of "1970" has been keeping me in uneasy suspense because I could not find a direct confirmation of my hypothesis that "1970" was the beginning of digitalization of economy, similar to the development of genetic code. It looks like I have found it today.

Between 1968 and 1973, the stifling bottleneck of communication and paperwork at the New York Stock Exchange has been outsourced to electronic devices.

I use or quote here **Depository Trust & Clearing Corporation** in Wikipedia .

In **1968**, the **Central Certificate Service** (CCS) was established at the **New York Stock Exchange**.

> The CCS transferred securities electronically, eliminating their physical handling for settlement purposes, and kept track of the total number of shares held by NYSE members. This relieved brokerage firms of the work of inspecting, counting, and storing certificates.

In **1970** the CCS service was extended to the **American Stock Exchange**.

The goal of the transformation was seen as the way to "certificateless society." With hindsight, this awkward expression is nothing but recognition of the separation of information not only from its carrier, but also from its human handler. What about certainty? Certitude?

In **1972,** the **Securities Industry Automation Corporation** (SIAC) was established to provide data processing services to the NYSE.

Next,

> Established in 1973, **The Depository Trust Company** (DTC) was created to alleviate the rising volumes of paperwork and the lack of security that developed after rapid growth in the volume of transactions in the U.S. securities industry in the late 1960s.

Dematerialization of money in "1970" (why not to call it **demoneyzation** or, straight, demonization? demonetization is the official term) was the most fateful step toward the Second Great Depression of 2008. (OK, this is just an uneducated guess).

One can read about how revolutionary and how painful "demoneyzation" was in *The Go-Go Years: The Drama and Crashing Finale of Wall Street's Bullish 60s* by John Brooks (John Wiley and Sons, 1999), pp. 193-195. The monthly statement from the broker—a typically chemical document—was no "adequate substitute for the embossed stock certificates that he [the American shareholder – Y.T.] kept lovingly in his bank safe-deposit box." Today I do not even print out my brokerage statements.

As Stephen J. Nelson notes in "Crisis In and Out of the Financial Markets," (2008)

> The market effects of the transformation to book-entry have been astounding. Book-entry transfer has reduced clearing costs to a tiny fraction of their 1960's equivalent. The system can handle enormous volumes with almost no errors. (Published in TradersMagazine.com)

The last remaining step was flooding the entire economy with computers of all kinds and sizes. I would compare them with ribosomes and enzymes in living cells, but they did not handle atoms: they played with information and shuffled data. The phantom money life forms exploded. →

Like matter, information can be sold, bought, stolen, jumbled, and misplaced. Unlike matter, information can be true, false, incomplete, lost, and hidden. The lack of both coarse conservative matter and tender reassuring human touch multiplied monsters for which the future, devoid of flesh and light, was the natural habitat.

From the point of view of econochemistry, the crisis of 2008 begins to look like an attempt to create a financial chemistry without the laws of conservation, i.e., *perpetuum* *mobile*, eternal motion of a kind. It smells of moldy medieval cellars and stinky chambers of alchemists.

November 9, 2008

ECONOCHEMISTRY OF INFORMATION, IV

THE WRITING ON THE WALL

I do not think anybody can be blamed personally for the financial crisis. It came as any natural disaster comes, separated by only forty years from its "1970" cause: demoneyzation. It was not demonetization, withdrawal from circulation as form of money, as it happened to gold, because paper cash and checks stay well in use beside some bits in bank computer memory.

Neither blame, nor disaster is in the vocabulary of chemistry, although econochemistry may find a place for them. Unintended consequences, however, are completely legitimate in the context of the generalized chemistry of the future, i.e., the final state.

> Today, although much of the money used by individuals in their everyday transactions is still in the form of notes and coins, its quantity is small in comparison with the intangible money that exists only as entries in bank records. Perhaps coins and banknotes will become as obsolete as cowrie shells. →

> A major change in the nature of money would have significant unintended consequences.
>
> Roy Davies **,** Electronic Money, or E-Money, and Digital Cash

The lack of information ("transparency") and, as result, the lack of the financial balance of intangible money is being currently analyzed and recognized as the main cause of the crisis. I cannot go too far into this alien to me territory. All I can say is that it is ridiculous to expect transparency from any kind of future. On the other hand, a **well regulated future is not future at all: it is as much the present as any commuter train schedule**. No future—no risk—no progress—no fun—no evolution.

"It has been counted and counted, weighed and divided."   Daniel 5: 25

I am interested in the most general chemical picture. The crisis of 2008 gives me a nod that, in accordance with one of the basic principles of chemistry, **concentration of energy means increased instability**. The enormous concentration of money and the feeling of hovering high above any metabolic cost and any baseline of uncertainty (or, by the same token, an urge to regain certainty while falling) gives the super-wealthy green light to take huge risks in exchange for expectation of huge returns. The crisis of 2008 has happened because it has happened for the first time. This is the effect of novelty: it is difficult to understand what is happening for the first time. Nevertheless, there are always people who not just see the writing on the wall, but also understand its Aramaic. See the entry of **October 15, 2008** in this diary (**Mr. Bubble and Dr. Doom**)

Klaus Schwab, the founder of the Davos Forum, apparently understood it even earlier:

> Schwab says the delegates treated him like "Cassandra" whenever he questioned the logic of their wisdom on asset-price bubbles in housing, stocks and other financial instruments.
>
> In his office outside Geneva, about a three-hour drive from Davos and overlooking the French Alps, Schwab says the WEF [World Economic Forum] began issuing warnings in **2003** [!!! - Y.T.] to investment banks, insurance companies and hedge funds about the **systemic risk gnawing at the foundation** of the global economy.
>
> ``But the financial community didn't listen,'' Schwab says. ``They were told that any serious look at the economic fundamentals showed that we were in an **unstable** situation. It was denial, total psychological denial.''   Source: INVESTA, 10/24/2008

It is no accident that Dr. Schwab sounds like **Dr. Chemist**. He holds a Doctorate in Mechanical Engineering from the Swiss Federal Institute of Technology, as well as a Doctorate in Economics. Mechanical Engineering is one of the closest to chemistry fields. It is combinatorial and it pursues stability of structure consisting of blocks joined together by bonds. It firmly relies not only on the laws of conservation of matter and energy, but also on liberal safety margins.

The current concentration of money and hyper-inequality has also grown from the seed of "1970." Two remarkable recent books reveal the curious chemistry of wealth, inequality, and desire:

> Robert **L.** Frank, *Richistan: a Journey through the American Wealth Boom and the Lives of the New Rich*, Crown Publishers, 2007 .
>
> Robert **H.** Frank *Falling Behind: How Rising Inequality Harms the Middle Class* , University of California Press, 2007.

Illustrations on pages 7 to 9 of Robert H. Frank's book seem to confirm that the new economic life form born in the 70s was responsible for launching the wealth pump which inflated the inequality out of proportions.

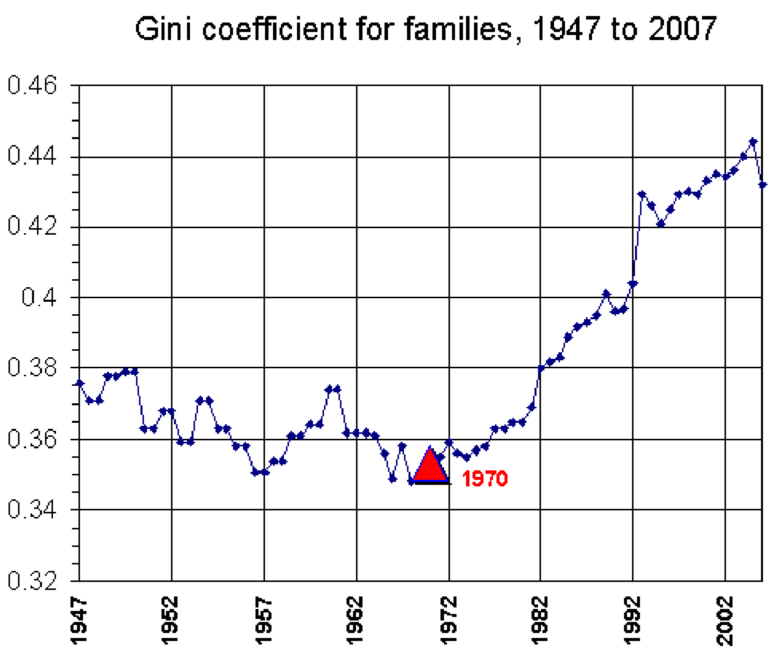


Figure A11. **Income inequality revolution in 1970**
Source: US Census Bureau. Gini coefficient is a measure of inequality.

November 17, 2008

I have found a much more telling representation of the emergence of the wealth pump in 1970, see **Figure A11**, than the diagrams in Robert H. Frank's *Falling Behind.*

Figure A11 casts some light onto "1970" from the income inequality angle (USA data). A giant wealth pump was launched in 1970, or, to darwinize it , a new financial **life form** emerged.

By the way, **LXX** (i.e., **70** in Roman numbers) would be a great notation for the phenomenon of 1970, but it was long ago taken for the Septuagint (*septuaginta* means 70 in Latin), the oldest Greek translation of the Hebrew Bible. I am still tempted to occasionally use **LXX**. This is what info is for: to steal.

November 18, 2008

ECONOCHEMISTRY OF INFORMATION, V

Information: Mind-Matter Chimera

When I had tried to search the Web for the subject of economics of information, I quickly ran into warning signs:

> Information has special characteristics. It is easy to create but **hard to trust**. It is easy to spread but **hard to control**. It influences many decisions. These special characteristics (as compared with other types of goods) **complicate** many standard economic theories. (Wikipedia)

> Several months ago I ventured into the **spooky** economics of information . …Relying again on my naiveté, I thought I'd try another post on the **weird** economics of information. It is almost certain to be **wrong**. Hopefully it will be wrong in an interesting and useful way. Brad Burnham, The Weird Economics of Information

I got all I needed from the horse's mouth: Principia Cybernetica Web

I already referred to *Principia Cybernetica* on the subject of information (see entry of **October 24 - 30, 2008**). Coming back to it, there was no single explanation, but one of several interpretations satisfied me:

> …difference between two forms of organization or between two states of uncertainty before and after a message has been received, …

There is a more tangible aspect of information called data :

> A material unit representing information about a portion of the real world that can be processed by explicit procedures and maintains its characteristics during **repeated** use.

I believe "*real world*" is really something superfluous, especially in modern finances, but that is exactly the point. Real world must obey the laws of conservation, otherwise no accounting is possible, no books could be balanced, and no science would flaunt hardness. What does not belong to either debit or credit has no place in chemistry.

I am more troubled by the "uncertainty before and after." How do we know it unless *post factum*, i.e., **after**? We do not know anything **before** a new event happens. If we do, it is not new.

But let us focus on "*repeated use*." It is the least conspicuous but the most fundamental condition of economics: it should churn out profits many times over and as fast as possible.

Economy is a machine. Machine is supposed to repeat its function. It means that the use does not basically change the machine. So is life, in which enzymes and nucleic acids are supposed repeatedly to do their jobs. Catalysis means repeated function without an observable change of the molecular device. Whether you work for money or food, whether you are a writer of airport bookstand novels, or a doorman, or a fashionable artist, you have to do it again and again because money and food are forms of energy and you are a thermodynamically open system far from equilibrium. "By the sweat of your brow shall you eat bread."

Information is a chimera, a mix of two apparently incompatible species of Everything: mind (message) and matter (data). What happens in a singular act of sending and receiving a message is information. It is an abstract act of selection between two or more alternatives, like in a police lineup. It can be a false identification. What can be used repeatedly is data. It is a thing for purchase, sale, and theft. It can be a source of repeated harm, like a criminal record. It can be a false record.

> To illustrate the difference between mind and matter I recur to molecular chemistry. There are myriads of molecules of water in a droplet. Water behaves as a substance with permanent predictable properties changing in a definite way when conditions change because the myriads of molecules bend, vibrate, move, and collide myriads of times in a fraction of a second in unpredictable and unobservable—chaotic—ways. This is what water means for a physicist. The properties of water are measured and recorded in scientific **data**.
>
> For a chemist, water means the same plus something extra. It is the mental image of water as H—O—H or H_2O , which is not even physically correct because the molecule of water has angular insect-head shape.
>
> 
>
> There is **only one** structure of water for all the myriads of myriads of its molecules. There is only one substance called water. What we see in the formula is a symbol for the abstract mental image of water in a chemist's mind. It works as information only when another mind receives it as a new bit of knowledge. After that, it is only a bit of data in an individual possession. A teacher uses it repeatedly to convey information to students.

The main question in the econochemistry of information is: what information can we have about the future?

The econophysical answer is: we can have some reliable information **on the condition** that the econophysics of the economy remains **the same as in the present.** Then we can evaluate risks and alternatives. In other words, we can rely on extrapolating the past **data** into the future**.** Under this condition the **data can provide information**.

The econochemical answer is: information about the future is received only when the future arrives and is no future anymore. It turns into **data** which are always about the **past**. There are a few very general principles, like verticalization (**Chapters 3.11 and 3.12**), but there is little we need or can do with them in practice. The exception is the principle that no **accelerating** trend is sustainable on human scale.

> The mathematical derivative *dx/dt* of a function $x = f(t)$, by the way, is the measure of acceleration, slowing down, or reversal. The financial derivative is betting on the sign of a mathematical derivative. I suspect that everybody loses in the long run by staying the course in pursuit of stability.

Attention! The specter of **1970** lurks behind derivatives:

> Derivatives have been traded for centuries, with early examples including tulip bulb options in Holland and rice futures in Japan during the 17th century. But futures markets were relatively small until the **1970s** when developments in pricing methodology spurred spectacular growth. The derivatives market has grown 100-fold over the past 30 years, with estimates of the current size of the market at more than $200 trillion, based on the notional value of contracts outstanding. Source: National Bureau of Economic Research. (2005)
>
> Founded in 1920, the National Bureau of Economic Research is a private, nonprofit, nonpartisan research organization dedicated to promoting a greater understanding of how the economy works.

It looks like an ultimate paradox that the strategies of hedging against the risk resulted in the greatest economic crash in almost a century. Was it the "pricing methodology" designed by mathematicians or the computer technology which made modern markets—as well as pricing calculations—possible?

> I have just discovered, to my amazement, weather derivatives! [There are political derivatives, too.]

To summarize:

> The future always comes as information, not as data.
> The data about the future is contradiction in terms.

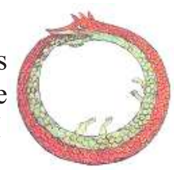
In other words, information—and only information—is always new.

This is pretty obvious and trivial. In practice, we always take risks and gamble with our lives in pursuit of stability. This is the essence of human existence. Physicists and chemists make their living with the religious faith that the laws of nature are constant and universal, although some physicists (Lee Smolin, also) suspect that it may not be so in a very long run .

> **NOTE:** Information is a much more complicated subject. The subtitle of Norbert Wiener's *Cybernetics* is ***Control and Communication** in the Animal and the Machine*. Here I omit both communication and control.

The belief of the "traditional" economics (that of Alan Greenspan's, too) in the dynamics of the marketplace is, essentially, the belief of a physicist in the regularity of fluid dynamics overriding the chaotic movement of individual molecules. It is the belief that Lake Michigan will stay in its banks at least until the next year in spite of the frantic movement of its water molecules.

The advent of computers into economy, the LXX of 1970s, created new conditions and, possibly, a new economic religion, still in the catacombs.



Representation of the market and participation in it in real time gives the picture of the **present**. It is a huge step from the past toward the future, but it is the last possible step. The real time mode reinforces the illusion that the picture captures the future. For trading derivatives, however, such a picture, as far as I can understand without background in economics, is not just absent (there are calls to create it), but hardly possible because it involves risk rating, while rating is influenced by the trading. I am not qualified, however, for judgment in this area.

I would summarize my intuitive impression in the following preliminary way. There is a powerful way to hedge against risk: enforce regulation, constraints, and trend watch. The required chemical change for that is the verticalization in the form of government control and regulation, in the original spirit of cybernetics. The regulation in terms of chemistry means reduction of entropy, i.e., increasing certainty. "Communication and control" is the motto of verticalization. Whether it increases stability is a separate topic. Alas, the hedge against risk means also the hedge against reward. But what do we mean by reward? Certainly it is not an equally spread gain, like brotherly shared booty, but a reward to a few.

Economics of information is spooky and weird, but we would probably feel a firmer soil under our feet if we talked about entropy (or uncertainty), which is the shibboleth for all information talk. Again, from the horse's mouth:

> INFORMATION 1) that which reduces uncertainty. (Claude Shannon);

Since uncertainty is a lack of information and entropy is the measure of uncertainty in chemistry, entropy seems a good probe for measuring equality and, probably, the distribution of risk and reward in society. Obviously, Shannon's statement is circular, but it directly leads us to the most consequential subject of metabolic cost, represented by **Figure 3.6.2** of **Part 1**.

Here I reproduce it again, modified, as **Figure A12.** The fate of an economic entity, according to the **Figure**, depends on two cardinal factors: available resource of energy (wealth) and temperature, which is the intensity (amplitude and frequency) of fluctuations. To put is simply, poverty is brittle (fragile, full of uncertainty), while wealth gives certainty (stability, solidity).

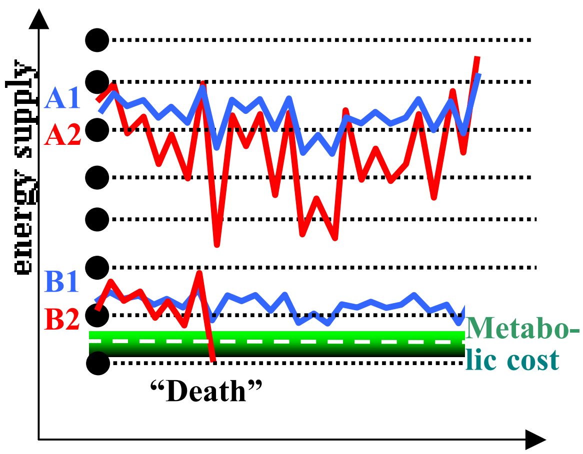


Figure A12 (3.6.2) **Prosperity (A) and poverty (B) at low (blue) and high (red) range of economic fluctuations (temperature).**

I testify that the poverty of the Soviet life felt comfortable while it remained stable. Debt is **future** wealth and therefore not applicable to any Heraclitean system. An essential feature of Soviet life was absence of institutionalized debt, which appeared only late in history and on a small scale.

Measuring inequality is a highly technical and non-consensual topic. See, for example, Götz Kluge, *Entropy, Redundancy, and Inequality Measures* . Reportedly, there are over 50 various measures of inequality, among which the Gini coefficient seems to be generally preferred.

Entropy would be an immediate choice for a chemist because it is an important chemical notion, as well as a conceptual bridge from matter to information. Götz Kluge, however, notes:

> If you do not feel comfortable with how entropy is applied to measure inequality, you are not alone: Many people have difficulties to accept, that inequality is "order" and that equality is "disorder". In the first place, one reason for that is, that using the terms "order" and "disorder" is not the best way to explain entropy.

Entropy can be as confusing as information not just because both are two sides of the same coin, but because it makes no sense without a particular system. Entropy of what? This is the first question. What can be more confusing than the opaque economy as a background for anything, not just entropy?

Figure A13-A presents two imaginary cases of income distribution: equal (blue) and unequal (red). The "population" is divided into five equal quintiles (one-fifths), and the total area of all rectangles is 20 for both red and blue distributions.

Entropy, denoted with **S** in chemistry, can be calculated as follows ("log" = $\log_2$):

S (blue) =
4/20×log(4/20)+4/20×log(4/20)+4/20×log(4/20)+4/20×log(4/20)+4/20×log(4/20)=11.6

S (red)=2/20×log(2/20) + 2.5/20×log(2.5/20) + 3/20×log(3/20) + 4.5/20×log(4.5/20) +

+ 8/20×log(8/20) = 2.13

Figure A13-B presents the change of entropy of household income distribution calculated from quintilized data for 1967-2007 period. I do not have data for previous years, but the entropy has been going down since 1970, compare with **Figure A11.**

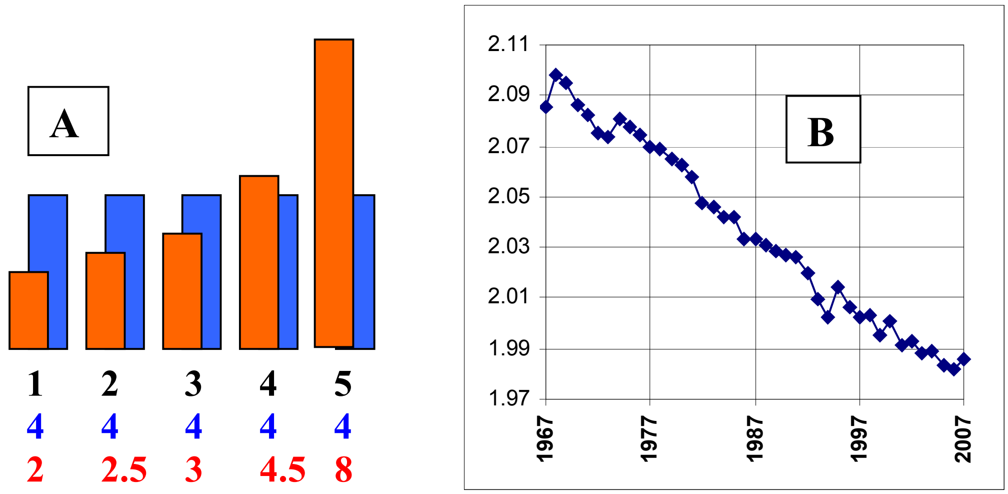


Figure A13. **Entropy of income distribution**
A: Equal and unequal distributions of the same 20 units of total income;
B: Entropy of US household income distribution, 1967-2007 (calculated from source).

Here is my personal (i.e., chemical) interpretation of **Figure A13**.

Consider entropy values **S = 11.6** and **S = 2.13**. Whatever 11,6 means, in order to transform the blue system with equality (**S** = 11,6) into the red system with inequality (**S** = 2.13), all other factors equal, we need energy because the red system with lower entropy is more **organized**. Organization is in my opinion the right word to use instead of order. We also need (important point!) a constant input of energy to keep the red system in its apparently "unnatural" or "unjust" state. Do I need to note that the best economic approximation to the blue system was the idea of communism and among the best existent realization of the idea are the Cuban and North Korean economies?

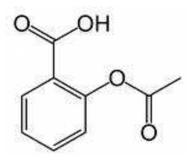
Figure A13-B means that the organization of income in America has been steadily moving toward lower entropy, higher order, and higher instability. This is the essence of the wealth pump that has been chugging along since 1970, consuming huge resources, most of them immediately reinvested into further growth. Let us compare this with the society of equals.

When I think about economic **equality**, I recall the empty shelves of the Soviet stores where I could not buy anything with my very much above average salary. This seems to contradict the previous paragraph, however. The natural resources of the Soviet Russia were enormous. Why was all that energy not used for filling up the stores with goods? If the entropy was high, why there was no ebullient political life?

In order to increase **organization** (our better word for **order**; remember information as "difference between two forms of organization"?), we need information in the form of template, a social design, the genome of economy.

Quoting Götz Kluge again,

> One man's order is another man's disorder, which leads to the second point: Is equality good or bad? Is order good or bad? Is inequality good or bad? Is disorder good or bad?



Organization, structure, design means not order as the opposite of a mess, but a particular kind of order, as devoid of ethics as the formula of ← aspirin.

Fortunately, as a chemist, I can ignore "bad" as well as "good." What I cannot ignore is my duty to find a chemical mechanism of a change: the chain of elementary steps that could not be split into smaller ones. This is a truly detective work, not easy to do even with molecules, so that in many cases, if not in most, the mechanism remains hypothetical. Often it is possible to find the key stage. I am still not up to this task. I can only point to one reason why developed economy can shamefully fail in pursuit of financial security.

The higher the economic unit is positioned on the wealth ladder, the more infrequent it becomes. Super-rich companies and individuals do not form statistical ensembles. The statistical income data avoid the super-rich tail. Thus, the US Census Data which I used for **Figure A13-A** shows only the lower limit of top 5% for the fifth quintile. Such individuals and companies, however, can afford the highest risk, apparently, insured by their own wealth ("Lehman Brothers Cannot Fall"). The principle that **concentration** of energy (wealth, power) means **instability** has never been proven stronger than in case of Soviet Russia and US investment banks. It may provide another proof in China and Putin's Russia.

> [**EDITING REMARK**. Reluctantly, I must acknowledge, that in this sense the wealth and power of America introduces instability into the world. Ironically, the wealthiest part of that world counts on American wealth and power to maintain stability in the world.]

Concentration of wealth, of course, fuels innovation and growth through investment. Only don't ask me whether innovation, growth, or even wealth itself is good or bad.

Safe from the bottom fluctuations at the green line of metabolic cost, large economic entities create their own fluctuations and tsunami waves that radiate through entire economies. One of the reasons is that however large, institutions remain centralized, so that the communication and control center is located in one or, at best, just a few minds.

At this point, I can draw one preliminary and, probably, wrong—or right, but useless—conclusion from this diary. Economics must obey the laws of conservation of matter and energy. In short, it must not contradict econochemistry. If we want economy to be a cash cow, it should look**, weigh, breath, and feel** like one, see **Figure 7** in ESSAY 56. OUT OF ONE, MANY **,** from which I ← reproduce on the left a small fragment. Economics today, however, is in the developmental stage of **econo-alchemistry**, for which the chimera on the right is more appropriate. →

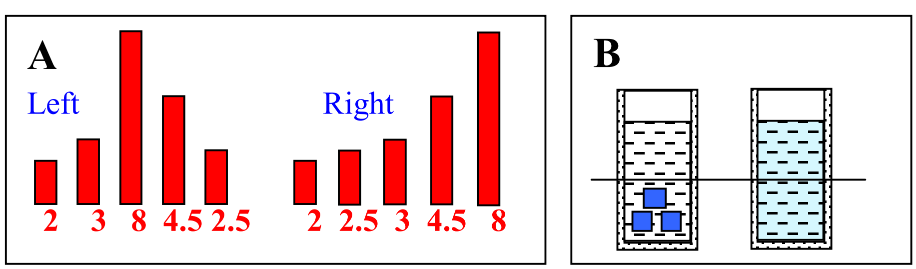
One reason why mathematical economics got so much authority was that it was comprehensible only to mathematical economists. The human scale was lost.

If this conclusion is accepted, information in econochemistry simply dissolves and disappears. Matter and energy stays, together with temperature, which automatically brings entropy. I stand by this idea, however risky to say aloud and surprising to myself it is.

November 21, 2008

MORE ABOUT ENTROPY

In my pursuit of simplicity I want to avoid technicalities. Entropy is a very technical subject, although its evasive idea and even its mathematics are essentially simple. The technicality comes from the necessity to calculate entropy of a real world system. Still, entropy is one of the most fundamental and continually surprising notions. For example, the entropies of two distributions in **Figure A14-A** are exactly equal. This is, probably, the main reason why Gini coefficient is so popular: its calculation is always ordered from bottom to top income.



$S_L = S_R$ $\qquad$ $S_L < S_R$

Figure A14. **Entropy.** A: **Entropies S of the left (L) and right (R) distributions are equal.** B: **Entropy of colored cubes in water (left) is lower than entropy of their solution (right). See Figure A16.**

I cannot imagine econochemistry as the study of balanced (**conservative** is the right word, not for the Republican ears, though) economy without entropy. All the more, I need to show that it is really chemical. **Figure A14-B** is my first illustration.

When sugar (or salt, or alcohol) is brought in contact with water, the distribution of the substance between the top and bottom halves of the liquid is unequal. It becomes equal after the dissolution. Yet in the case of salt the temperature decreases, while in the case of alcohol it increases. The reason for the difference is a subject of molecular chemistry, which I prefer to evade at this point (CLUE: water interacts with alcohol and salt in different ways). What is remarkable, a wide range of examples from economy can illustrate the notion of entropy as effectively as molecules do.

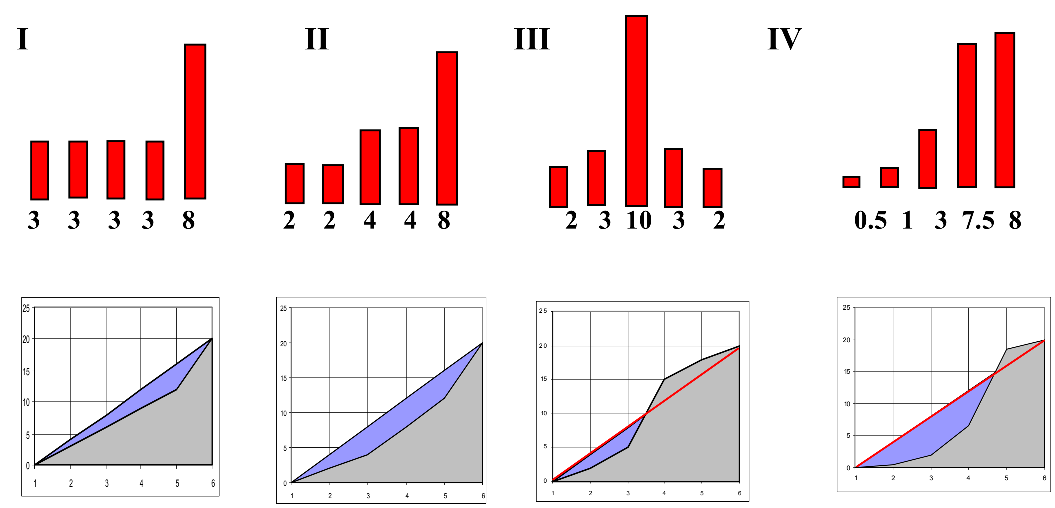
For example, a worker making parts of one kind will spend less energy per part than the worker who makes parts of several kinds. Variety has a lower entropy than uniformity.

> One reason why I am not lingering over thermodynamics—the study of nature in terms of energy, temperature, and concentration—is that the significance of thermodynamics for economics is well known. See for example, Economics Meets Thermodynamics, (2005), Classical thermodynamics and economic general equilibrium theory (Eric Smith, 2005) , and thermoeconomics (wiki). There are plenty of materials, among them the most relevant Nicholas Georgescu-Roegen's *The Entropy Law and the Economic Process*, Universe (1999).
>
> The overall forbidding pessimism of classical thermodynamics is formulated in terms of impossibility, which does not go well with the optimistic underpinning of economy as human activity. Yet chemistry is about creation, and chemical thermodynamics, as my reference to the synthesis of ammonia illustrates (**October 24 - 30, 2008**) , is the way to accomplish the most problematical creative task. As soon as we think about economy on human scale, i.e., looking ahead within the limits of human life, we have no choice but to be optimistic.
>
> Another reason why I am not going to be mulling over thermodynamics too much is that it is chemically blind. The concept of transition state—central in pattern chemistry—comes from thermodynamics and common sense. Thermodynamics, however, cannot say a word about what this transition state may look. This is the task of chemistry.
>
> Final questions:
>
> Any accounting book is a distribution of resources and income. What is the meaning of its entropy? What is the meaning of entropy of the components of wealth or of the price structure, like the price of gasoline? What would it all tell us?

November 23, 2008

MORE ABOUT GINI COEFFICIENT

Literature on various methods of inequality measurement, including Gini and entropic methods is large and technical, but I do not intend to encroach on this area. The following is just a mental experiment in order to ask some question, not to answer them. The question sounds extremely non-chemical: **what is social justice**?



	I	II	III	IV
S	**2.17**	**2.12**	**2**	**1.82**
Gini	**0.17**	**0.23**	**0**	**0.21**

Figure A15. **Entropy (S) and Gini for different quintile distributions. Plots illustrate calculation of Gini.**

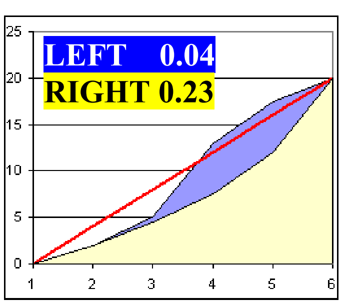


Figure A16. **Gini for Figure A14-A.**

Figure A15 shows four (**I** to **IV**) different imaginary quintile distributions of some asset (wealth) or flow (income). Entropy does not depend on the order of the quintiles, while the cumulative Gini does.

Figure A16 compares cumulative pictures for distributions from **Figure A14-A.** They have the same entropy of 2.13.

I calculated the entropies and Gini coefficients for the distributions in **Figure A15**. I also have an amateurish interpretation of the distributions.

Distribution I reflects a sharp class inequality of a slave-master society.

Distribution II looks like typical for an early bourgeois society with a few classes.

Distribution III is illegitimate, as far as Gini is concerned, because the quintiles (percentiles) are always arranged in an increasing order of the asset. Nevertheless, any distribution can be represented by **cumulative distribution function**, on which Gini measure is based, and a quasi-Gini can be calculated. For example, suppose that the quintiles (percentiles) are ordered by **some other property**, for example, height, **IQ** or political views from one extreme to the other. Unlike an asset, which is extensive, such properties are intensive and not additive. Then **Distribution III** will reward the middle of the crowd. This mode, probably, applies to a closed ultra-conservative society with an elected but not necessarily rewarded leader (an idea for an anti-utopia).

Distribution IV is a kind of an imaginary "anti-Pareto" society with a heavily progressive taxation, so that the more you have, the harder to get more, but only for the rich. It is the opposite for the poor. [Isn't that what is called socialism?] The middle class, therefore, is in the position of owning most of the asset. No wonder, this is the society with the **lowest entropy**: you need a heavily armed hand to crush natural (i.e., animal) human instincts and the power of financial instruments and prevent them from resurrection.

> [**EDITING REMARK**. Only now I see the socialist spirit of the New Testament. On the one hand, you must invest your wealth, material and intellectual. On the other hand, if you rip too much reward, you will have the same problem as the camel pushing through the eye of a needle. Have you read it, good old pious Republicans? **DISCLAIMER**: I am not a socialist. I am not even a Democrat: I am Independent, with capital I]

The right distribution in **Figure A14-A** is the distribution of a typical modern and wealthy society.

I have an impression that Gini reflects inequality only if a highly concentrated wealth is present.

Some questions an econochemist can ask are:

> How stable are the above systems?
> What is their relative consumption of energy?
> What is their ability to grow (economic fecundity)?
> What is their relative competitiveness?
> What are the consequences of growth and decline?
> How would they behave if the resources shrank or expanded?

I do not know how to answer these questions, but they give a lot of food for thought. Note, that they address the large scale properties of the economic exystem as a singular whole. I see their significance in their typically chemical function: they may serve as structural components (generators) for making up a list of **future alternatives** (configurations).

The discredited way to look into the future is extrapolation, however sophisticated the mathematical means are. To construct alternative models of the nearest future and use them as possible final states (intermediate, more accurately) is the chemical way. One of my motivations is a hope to compile a short list of essential degrees of freedom of exystems. This, I believe, could be done much better not by me, but by professionals infected with the very idea of **econochemistry as a program of the apparently impossible task of foreseeing the future novelty.** But why impossible? Science fiction writers do it all the time and even make a living. Moreover, they are often right.

To find a transition state toward the desired final state is a separate task, not always possible.

As for the initial question about social justice, I can give only a personal intuitive answer: a necessary but not sufficient condition of social justice is the social contract providing **payment for a stable metabolic cost**. This answer is just my emotional and ethical choice, which is always personal. One way to do that is to ensure social and economic stability. In a stable society, lower income groups can be stable because of low societal temperature. Shelter for the homeless is a configuration of this pattern.

> It is worth remembering that (1) at least two religions, Judaism and Islam, not just encourage charity, but make it an explicit religious duty and (2) religion is a powerful social refrigerator.

The British Poor Laws had a long history of supporting the poor in exchange for work. As far as I know—and I might be wrong—European-style socialism is the promise of the guaranteed metabolic cost without requiring work. The Soviet-style socialism maintained stability with a heavy hand, but had no socialist relief system. Work was obligatory. The labor camp was a shelter for homeless. American-style capitalism, which does not even have a universal healthcare, according to my expectations, will have no choice but to pump up the muscles of upper extremities (verticalization). How would all those social species compete in the future?

> I have not yet read Global Scenarios to 2025, but I must. The key question I would ask is: Which subsystem of global exystem has better chances to adapt to yet unknown changes? Europe? North America? China? Islam? Democracy? Theocracy? Dictatorship?

I believe questions are much better than answers for evolving systems because answers are always wrong. But they could be right for a while.

November 25, 2008

"SOME TIME IN THE FUTURE…" WHAT DOES IT MEAN?

In my entry of **October 24 - 30, 2008** , I suggested that there could be a single root cause of the turning point at "1970." I believe I can now formulate it in chemical terms: catalysis. Digitalization and information technology, repeating the pattern of genetic mechanism in biological evolution, played the role of a universal catalyst.

The function of catalyst is the competitive acceleration of selected transformations, which leaves all the other possible transformations effectively blocked by the lack of the initial states. Therefore, the steep uphill slope of inflation and inequality, as well as other trends, means simply that the evolution of economy accelerates. This is why we are able to notice the change. In other words, what we see is what had always been happening, only slower.

Does it mean acceleration of time? I illustrated this idea with **Figure 3.7.2**. I wrote: "By doing this, I imitate a slowing of the Leibniz time scale which counts not hours, days, and years, but events. The time ticks after 1970, therefore, are stretched to the right."

This strange idea invites us into the dark ancient halls of philosophy and timeless discussions about the nature of time. Indeed, it would mean a kind of predestination, which is exactly opposite to the concept of incomprehensible future.

Here I throw in the magic word **catalysis**. But what about Leibniz?

Lee Smolin's ***The Life of the Cosmos*** (Oxford University Press, 1997), in which Leibniz takes a place of honor, is a unique, stimulating, and relevant for pattern chemistry guide into the problem, but it is a separate topic. I have just discovered the book. See the end of **Chapter 1.2** of **Part 1**. I hope to return to the subject **some time in the future**.

Preliminary idea is that we notice the acceleration of time against the human scale.

Suddenly, the emphasized words in the previous sentence look bloated with new meaning. They jump into the title of this entry. Voodoo-econochemistry?

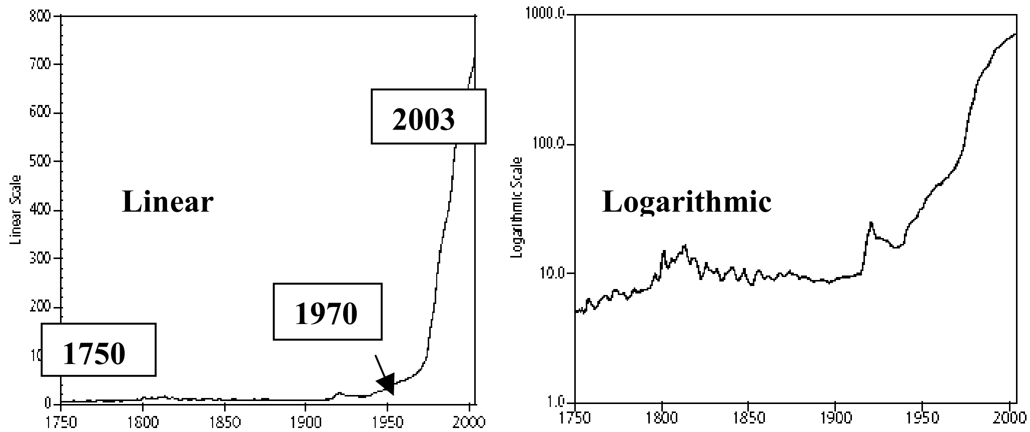


Figure A17-1. **Consumer price index (CPI) of Britain, 1750 to 2003 on linear and logarithmic scale.**
Source: Jim O'Donoghue, Louise Goulding, Grahame Allen. Consumer Price Inflation [in UK] since 1750.

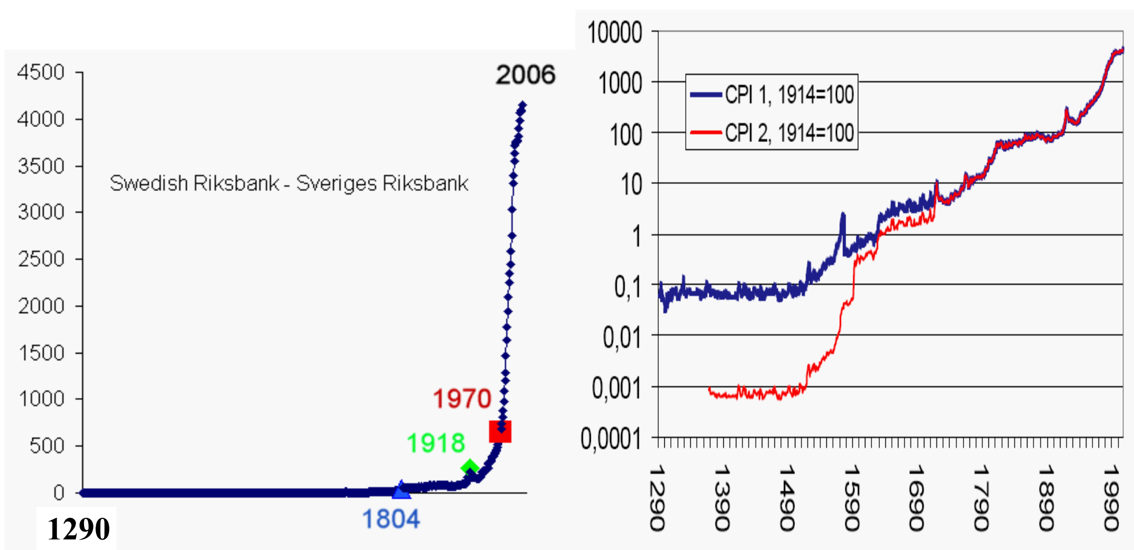


Figure A17-2. **Consumer price index (CPI) of Sweden, 1290 (!) to 2006 on linear and logarithmic scale. The blue curve reflects the face value of a sequence of different debased coins. The high inflation period includes the Northern Seven Year War, 1563-1570. The Great Nordic War (the last war of Sweden) falls on 1715-1719.**
Source: Rodney Edvinsson, Johan Söderberg . *A Consumer Price Index for Sweden 1290-2006.* Paper and Spreadsheet.

Figure A17, in two parts, shows historical inflation graphs for UK (**1750**-2003) and Sweden (**1290**-2006) on linear and logarithmic scale. They record large historical changes—a nation's LXXs and 9/11s—as accurately as annual tree rings and ancient ice samples record the climate change.

The effect of **1970** is stunning. The highest inflation goes, at least in Sweden, hand-in-hand with highest prosperity, which probably changes the very meaning of prosperity. In

America, it seems, the rate of disposal, dissipation, and waste becomes the measure of prosperity. The life cycle of things shortens, the life cycle of humans extends. Time accelerates.

> Along Leibniz, time is the sequence of events. Consequently, if nothing happens, time stands still. Lee Smolin's idea is that time, space, and the laws of nature evolve. I plan to return to his another idea that there is no absolute background and everything is relations.

Some time in the future the inflation curve will flatten out. It will, but when and how? Will it go down, as it happened in history? What would it mean if the giant inflation of post-1970 went down?

December 2, 2008

ECONOCHEMISTRY OF COSMOS?

I have finished Lee Smolin's *The Life of the Cosmos* (1997). Of all books I have read in this genre it is certainly the best written, most captivating, and rich with ideas well beyond physics. It is amazing how much can be conveyed about theoretical physics without equations and practically without visual illustrations.

All the previous books by modern physicists left me empty-handed. I stopped reading them after Brian Greene's *The Elegant Universe* (1999). There was a special reason why I opened Smolin's book (Leibniz!) and I found it was different. I have no illusions, however. I am not a physicist. Although I understand what the author is saying, I do not understand what the author understands because it is so much off the human scale. I have lots of good impressions, but I am anxious to share just one: Lee Smolin's theory of beauty in nature and art (*Chapter 12. The Cosmology of an Interesting Universe*) . In short, the object of beauty is complex on every scale. Beauty is a rich structure, "there is so much to look at." Along this criterion, Smolin's book is beautiful.

Without hesitation I can quote the ugliest and creepiest part of the book:

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> This is the only paragraph of the publication that directly concerns economy. To invert Smolin's definition of beauty, there is so much to loath. Note "or otherwise," which is about both foreseeable and unforeseeable **future**, the jingle of the post-LXX economy. How about reading the book aloud in a public place? What is a possible damage of a 10-line-quotation? What is the punishment? How about freedom of speech? Free dissemination of information? Spreading the word about a good (or bad) publication? Fair use? Be afraid, be very afraid. Of course, I have seen this warning many times, although not all publishers use it, but each time I feel jarred.

Almost all ideas of modern science which I use as building material for **pattern chemistry** can be found in Smolin's book in eloquent, beautiful rendition, which I cannot quote because of the monster above. There are also wonderful paragraphs about evolution, life, and the rarely touched in literature subject of novelty. I would like to say that *The Life of the Cosmos* is about the economy of the cosmos, but the chemist's concept of economy needs (1) a **source** and a **sink** of energy (also beautifully explained by Smolin) and (2) conservation of energy and matter (one of the vaguest aspects of the book). Economy needs accounting. In addition (3), economy displays entirely on a human scale. Nothing is further from the human scale, however, than cosmology and particle physics. Nevertheless, I would like to return someday to a consistent comparison of "Leibniz cosmology" with "Leibniz chemistry." There are many exciting issues. Just one: organic chemist perceives molecules in their transformations regardless of their actual size: only relative sizes may sometimes matter.

The special reason which originally attracted my attention to Lee Smolin's ideas was his attraction to Leibniz' concept of time and space, or, as Smolin inelegantly labels it, **relationalism**. I have already mentioned in **Chapter 1.2** how impressed I was when I first read the correspondence of Leibniz and Clarke at the age of about 25.

It would be interesting to compare Smolin's econophysics of the Universe with my vision of econochemistry. At this point, however, I must regretfully abandon Smolin's book. Inspired by it, I want to repeat some central chemical ideas, this time, in the light of **relationalist** approach. Instead of his very awkward term, I would use something else on hand: **relative**, **comparative**, or just **Leibniz.** It should be noted that to interpret Leibniz today is like to interpret the US Constitution from the standpoint of originalism. To use his **texts** as source of ideas is the right thing. This is why old philosophy does not die: it inspires new ideas by old words, as the sight of a bottle excites the thirsty.

The initial notion of chemistry is event. Again, I mean generalized chemistry. It has the beginning and end as stable states, and a transition state between them. The transition state is also a sequence (mechanism) of known or hypothetical states of different degree of instability.

For me the world divides into events. What does not change is invisible.

It may seem paradoxical, but as a chemist, I definitely refuse to accept Wittgenstein's atomism:

> 1 The world is all that is the case.
> 1.1 The world is the totality of facts, not of things.
> 1.11 The world is determined by the facts, and by their being all the facts.
> ……………….
> 1.2 The world divides into facts.
>
> Wittgenstein, Tractatus

As a chemist, I cannot accept Lee Smolin's (and probably other physicists') belief that everything is interconnected with everything. I believe that events are always local and most of the world, even within the borders of our planet, is completely irrelevant for a particular event. If something is relevant, we have to consider it local on a different scale. For example, our communication with distant extraterrestrials will be local on a nearby cosmic scale. Locality makes the world comprehensible.

I cannot accept Smolin's analogy of the universe with an evolving life-like open system far from equilibrium—which I call exystem. An exystem cannot be either a source or a sink of energy for itself: it needs not just an environment, but two kinds of it: one for the source and one for the sink. What can be external to the Universe?

Time is a relative concept: when the system undergoes an event, time runs. In the absence of events, we cannot say anything about time.

Stability, as well as space and time, is a relative notion. We can only ask—and in some instances answer—which of two states is likely to be more stable. Same applies to energy, work, temperature, and entropy.

We can have some power of prediction by combinatorial construction of various possible alternative states.

The state of the system is a configuration of Pattern Theory. Ideally, the state is represented by a square matrix in which the diagonal gives (rarely exactly) the contributions of generators into the overall value of stability, while the rest of the table gives the bond stabilities. This, however, does not make sense in the Leibniz framework because we have no means to measure absolute values. Instead, we can use two matrices or, rather, a matrix in which only the direction and, if possible, the approximate amplitude of **change** of the entry from initial to final state is indicated. Of course, the sparser the matrix, the more telling. It is never exact or deterministic for exystems.

Did I say **approximate**? If the scale is very coarse, doesn't it lead to a kind of fuzzy discrete "hyper-quantum" structure of all econochemical variables?

Lee Smolin offers a wonderful discussion on an inherent uncertainty of small systems, but I believe that large exystems are also subject to a principle of uncertainty just by the

> reason of their very size. I would call it the George Soros Uncertainty Principle in econochemistry: **we can either act with little knowledge or knew with little acting**.
>
> I was amazed when I saw that theoretical physics—at least the string theory—was not only much farther from consensus that economics, but also accepted the lack of consensus as part of the theory itself.
>
> Reading Smolin's book, I felt myself in a very inhospitable environment not only for ordinary humans, but also for chemists. More than ever I felt convinced that the root cause of the bizarreness of the modern theoretical physics lies in its use of mathematics. The axiom of closure in the deep foundation of mathematics precludes any mathematical treatment of evolution and novelty. Chemistry, with its openness to novelty, as I believe, could be an embryonic mathematics of novelty even for mathematicians. Pattern Theory is a gateway into this kind of mathematics. It even uses human subjectivity for choosing some of its **flexible axioms**.

I end on this note because there is nothing more objectionable to me than a **theory of an exystem**. I believe we cannot **know** economy. We can only **understand** it. We can certainly act. Thus, we can **understand** a lot about physics from popular books. What we cannot do is **learn physics** from them. We cannot act like physicists, either.

Still, we can **learn something about economy** from Lee Smolin's more recent book *The Trouble with Physics: The Rise of String Theory, the Fall of a Science, and What Comes Next* (Houghton Mifflin, 2006). Chapter 16, *How Do You Fight Sociology*? is an excellent illustration of the **verticalization** in a branch of US academic science squeezed by limited resources. Smolin describes not only the emergence of a quasi-corporate structure, but also the typical for authoritarian structures voluntary acceptance of corporate ideology. Unfortunately, he is my only source of knowledge about that.

Life added a couple of unwritten paragraphs to Smolin's Chapter 16. "Sociology" is just a bashful euphemism for economy. As a consequence of the squeeze, a growing number of physicists were spilling over into economics with catastrophic results for their new environment. Human intellect has awesome powers, especially when the cosmic scale clashes with the human one. And world economy fell tumbling down.

> **The terror of cancer is its growth. Why do we worship growth, the cancer of economy? Because it means an opportunity for personal growth, which we enjoy, like life itself, regardless of the ultimate end. Life is growth, even if it ends in decline.**

December 7, 2008

INSURER, INSURE YOURSELF

I keep thinking about the deep chemical causes of the Great Financial Depression of 2008. A simple, even naïve, answer is taking shape in my mind.

The amazing thing about 2008 is that the same financial institutions and instruments that had a distinctive goal of diminishing risk—credit rating, insurance, credit default swaps, hedge funds—fell face down because of their own extravagant risk taking. A person from the street (Main, not Wall) could say that they did it of ignorance or greed, but that would only apply to the extravagance, not to the risk. Risk taking is a necessary aspect of any economic activity, which includes anything to be made: from president to toaster to Broadway show, not to mention money.

How could that happen? The wide spread opinion is that the resistance to regulation at various levels was responsible for the crisis. I have a very atypical for this continent view of the power of regulation: it associates in my mind with the Soviet style socialism. Life without risk is stagnation. There must be a middle road between the law of the jungle and the law of the Politburo or Dear Leader.

I have only one answer to "how could that happen." **The business of risk insurance had no means of insuring itself**. There is no "higher authority" in insurance except the society as a whole, whether you call it taxpayers or government, which is, ideally, the same.

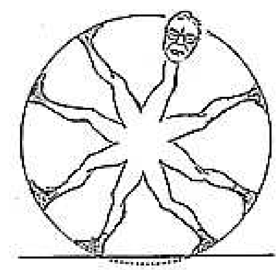
The ability to concentrate resources on a single goal is the essence of power (see Essay 53. Power: Hidden Stick, Shared Carrot). It seems to be the main source of the historical stability of the USA. It is, probably, the source of the subliminal American fear of China and the worship of big numbers.

> Monotheistic religion might have econochemical roots in the instinctive belief that the single High Authority would have more power than a motley crew of squabbling local gods. That would make the inherently risky economy and world trade protected by High Insurance across the forests and deserts.
>
> Ironically, by the end of his term, George W. Bush is presiding over the acts of greatest largess of the Higher Authority on the Hill, but not the one he claimed to report to. Well, how do we know?

My hypothesis of verticalization looks now more chemical than metaphoric: the final tall state is more **stable because it concentrates stabilizing power** as compared with the flat state. What remains to uncover is the step-by-step mechanism. Is it reversible? The further history of the European Union—and even China—may provide an answer. America, potentially, may contribute to our understanding of de-verticalization, too, in some scary ways. Nothing, however, is exactly reversible in history.

Obviously, a rider through history who wants to be self-insured has only two strategies for two extreme types of society: wealth for the extreme flat one and connections to power for the extreme tall. The pattern vehicle for driving is bicycle. It is stable only in movement and only with continuous low amplitude countersteering.

All this is utterly naïve and I cannot stop wondering how trivial the corollaries of econochemistry are, although I know why they look trivial: even the global economy displays on the human scale.



When George Soros, the Werner Heisenberg of finances, contrasts knowledge and action, I am not sure he explicitly remarks on a particular asymmetry of both, typical of modern post-1970 era. I would call it "radial asymmetry," i.e. the contrast between local and global, point and the circle. We can have a lot of global economic knowledge almost in real time, but economic—as well as political—action is always an individual human act. It may take form of disinformation, similar to biological mimicry, but I believe it is not the same as economic information asymmetry. It could be a configuration of a more general pattern comprising both. Still, George Soros' general notion of fallibility of an individual within a system can be interpreted as radial asymmetry.

As for Werner Heisenberg, Lee Smolin in his books runs a great discussion of an observer who is in the **act of knowledge** acquisition about the system. Is there any similarity between the gigantic market and a small quantum system? Of course! It is the smallness of the individual whose range of acts (i.e., pairs of initial and final states) is very small. For example (simplistically): "up or down to next quantum number" has much less uncertainty that "buy or sell." Buy what? From whom? How much? What a headache!

What can chemistry say about all that? Again, the absolute majority of all global information is absolutely irrelevant for any local act.

It is only my amateurish guess that the success of great investors, including George Soros and Warren Buffett, was possible because they had accumulated great—on global scale—wealth power which had no comparable opponents at the time of action. They have to thank Vilfredo Pareto for naturalizing that weird, unnatural, and anti-physical property of economy. The world of super-wealth and super-power is small. It is like a cosmos with a few super-gigantic stars in the rank-and-file stellar crowd.

Finally, I am coming to a chemical definition of risk. Since generalized temperature reflects frequency and amplitude of fluctuations, the individual risk-taking is a component of the social and economic **temperature**. Human fluctuations, interestingly, come from both big conceited wealth and big desperation.

Our greed and stupidity keeps us warm. I never expected to return from my forages in econochemistry with fruits of optimism, but a few sweet apples are in my pockets.

December 10, 2008

GEORGE SOROS: FROM ALCHEMY TO ECONOCHEMISTRY

No fan of Bill O'Reilly, I was struck by his remark on WGBH today :

> "The Rich Guy Syndrome is, **'It's always going to work out, because it always has worked out,** because we have money.' So you get in trouble, you buy your way out." (Bill O'Reilly).

I once heard the highlighted part of the above paragraph from somebody who had freshly joined the club.

This brings me to the question: What is the non-monetary component of total economy (for which I would consider the contraction **totonomy**)?

Obviously, it is human nature. It is remarkably stable, more so than the environment. Not as old as the hills, human nature is more resistant to change than the mountains. I believe that human nature is the only component of economy that has not changed since pre-historical era. This applies to the human universals averaged over the crowd. The **individual** human nature is more like a stream than a hill. Our optimism, pessimism, indifference, and irrationality influence economic decisions. The capacity of a sharp change of beliefs as result of experience is a component of human nature, too. Human nature is inherently hot. It supplies chaos without which economy and adaptation to change would freeze.

The Rich Guy Syndrome epitomizes the belief in a stable world order, and, I suspect, the deep roots of religion. It brings me back to the subjects of optimism and bicycle riding.

I have just finished George Soros, *The New Paradigm for Financial Markets: The Credit Crisis of 2008 and What It Means*, (Public Affairs, 2008). I cannot engage in a chemical analysis which the book deserves, but both optimism and riding through history by correcting mistakes can be found there. "What is imperfect can be improved…"(p. 50).

I really respect George Soros who long ago (1987) had come to econo**chemistry** closer than anybody else in his *The* ***Alchemy*** *of Finance*. Reflexivity—his core idea—does not seem like a good choice of word. Reviewers noted that it was nothing but well known positive feedback. For a chemist, it is the well known **autocatalysis**, also noticed by reviewers. But I think we should accept the term because it asserts a human presence in the picture.

In his earlier book *The Crisis of Global Capitalism [Open Society Endangered]* (Public Affairs, New York, 1998) Soros described remarkable eight stages of the **mechanism** of the boom-bust cycle. The latest book contains real world examples. They look like common market fluctuations until you notice that they span over almost ten years.

George Soros' boom-bust model is a perfect illustration of what chemical transition state is. He also makes a remarkable observation that market dynamics is by its nature historical (i.e., not "natural") process. I cannot resist temptation to quote:

> This is why financial markets are best interpreted as a historical process, and that is why that process cannot be understood without taking into account the role of regulators. (George Soros, "*The New Paradigm*…", p.77)

Reading his earlier 1998 book, I was struck by his capacity of pattern prediction. During the now forgotten global financial crisis of 1998, he predicted that "the global capitalist system will succumb to its defects, if not on this occasion then the next one…" (p.134). He predicted "indigenous political movements" which would "seek to expropriate the multinational corporations and "recapture the 'national' wealth." (*ibid*.). I believe that the Islamic terrorism and Latin-American leftism are two current configurations of this pattern. I even suspect, cynically, that the current anti-Americanism is driven more by the same deep human instinct of expropriation (a.k.a. **envious greed**) than by moral revulsion against George Bush policy. As for the first of the two predictions, it is probably still "next time."

All predictions in human matters are always true, except for the timing. Pattern chemistry, as I hope, will be able to narrow the timing, which is the main reason why we should talk about chemistry at all outside chemical labs.

Here is another example of George Soros overcoming alchemy on the way toward chemistry. Soros sees the role of financial markets in the meltdown of 1998 as "more like a wrecking ball" instead of a supposed stabilizer. Having suggested that the role of financial markets in world history should be reconsidered, Soros continues: "To test this thesis about financial markets, let us take an **inventory of the other ingredients** [beside financial markets] involved and then take a look at what happened " (p.136). I could not describe the gist of econochemistry and pattern chemistry any better. Chemistry is the comparison of "inventories" of stable and transition states, actual and imaginary.

George Soros is much more optimistic in his 2008 book, probably, because he exaggerated the doom and gloom of 1998. To learn from the mistakes of the past is, in his view, the only way to manage the future, as good as it gets.

The New Year and, maybe, a kind of a "new deal" between the American extremes of "invisible hand" and "visible hand" are close. It would be good to end this part of my diary of a Ferris wheel rider on an optimistic note. Will the chemistry of history be benevolent enough for the remaining twenty days? Well, let's see…

> **09:00 am** : **S&P futures vs fair value: -28.90. Nasdaq futures vs fair value: -29.00.** Stock futures continue to indicate early losses for the major indices. (December 12, 2008)

The financial (and political) markets again work like a wrecking ball, with more entertaining (political) sound, but less fury.

December 14, 2008

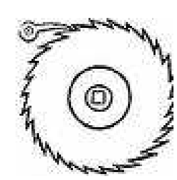
ONCE IN A BLUE MOON

> "once in a blue moon, the risks pile up on one side of the market…"(George Soros).

I wanted to put aside my diary for the Holidays, but I could not drop George Soros' *The Crisis of Global Capitalism* (1998). I can understand why it was so much vilified by the worshippers of the Invisible Hand. They could not forgive the transformation of the beacon of earning into a beacon of warning.

There is a lot to say about it, ten years after the publication, but, first of all, I am not qualified for any professional opinion and, secondly, I am interested only in pattern-chemical point of view. At this point I want to tell about the most surprising for me first section, *The Asian Crisis,* of Chapter 7. Since about 1998, when I for the first time learned some elements of stock market, I have been grappling with a problem which never seemed to trouble anybody else.

I think in terms of natural processes, technical devices, and human nature. I understand how market creates wealth by regular (buy low, sell high) and short selling (take, sell high, buy low, return). I understand that wealth is created every day by human work, physical and mental, which uses energy, dissipates it, and transforms matter in the direction of increased order. What I could not understand was how creating wealth in stock market could be consistent with the laws of conservation. The piston water-pump works because its mechanism is made asymmetric by valves: the piston pushes water through the **outlet** when it moves in one direction, but sucks it trough the **inlet** on the way back. The ideogram for this **mechanism of irreversibility** is ratchet-and-pawl wheel. Any wealth pump must be asymmetrical in this sense. Normal trading works as a typical pump. So does short-selling. But if two work together, how can wealth be pumped up? This looks like a mystery, especially since I believe that wealthy do not steal from the poor, but simply grow wealth faster.



Only while reading George Soros I realized that the asymmetry is created by the fact that, as he puts it,

> …the market makers transfer risk to the market. As a general rule, the market can absorb the risk because different participants move in different directions. **Once in a blue moon**, the risks pile up on one side of the market… (p. 188).

Therefore, the market consisting of two pools of players, **S**[mall] and **B**[ig], pumps wealth from the Pool **S** to Pool **B** because the risk of **B** is dissipated, while the risk of **S** + **B** is concentrated. This sounds absurd, because hedging is a form of insurance against risk. How can that be? The answer is that the risk is concentrated in time, not in space.

I try to illustrate the situation in **Figure A18**, which is only a very crude and probably erroneous attempt. But I must start with some disclaimers.

I must emphasize the big uncertainty around the problem I am trying to resolve for myself. Market is an exystem: evolving, open, non-equilibrium, and non-linear system. It is a deceitfully statistical system. For exystems, there is no consensus on thermodynamics, but there is a consensus on the difficulty of the problem. My personal non-professional opinion is that we should look for non-extensive (intensive) parameters, like generalized temperature, flow, rate, gradient, complexity, **organization**, structure, order, and diversity, instead of the classic extensive entropy and energy, and treat the system chemically, i.e., in terms of MORE and LESS instead of absolute values. We could be satisfied with the detailed mechanisms instead of equations including time. I believe that there is a movement in this unusual direction, but this is still a too technical area for me.

Why is market statistically deceitful? Because a **small** group of big players has immense weight. There is no statistics for anything small, except time series statistics, never accounting for novelty. The swarming of large schools of small fish obscures the presence of great whites in the market. Moreover, the observers may not even notice the presence of a couple of trawlers on the surface, which make no distinction between herring and shark. Concentration of wealth and power is outside the classical physical picture of the world. Market is an ecosystem with human presence—a nightmare for the traditional science driven by its own economics to "publish or perish."

> I have enough arrogance—because I do not yet understand the subject—to quote a remark of Cosma Shalizi on a version of non-extensive entropy (Tsallis entropy):
>
> > "I think the extraordinary success of what is, in the end, a slightly dodgy recipe for generating power-laws illustrates some important aspects, indeed unfortunate weaknesses, in the social and intellectual organization of "the sciences of complexity". But *that* rant will have to wait for my book on *The Genealogy of Complexity*, which, prudently, means waiting until I'm safely tenured," Cosma Shalizi (source).

I would love to see the book with such a promising title, which elegantly formulates what pattern chemistry is about. Now, about **Figure A18**.

Figure A18 is, essentially, a version of **Figure 3.6.2**. It compares the effect of fluctuations on two idealized groups of market players, **Big** and **Small**.

The **wealth pump** concentrates wealth because it accumulates gain faster than loss (buy low sell high). It has been humming since the very emergence of trade in human history.

The pump of a very small size is affordable and works for anybody. The large pump is expensive.

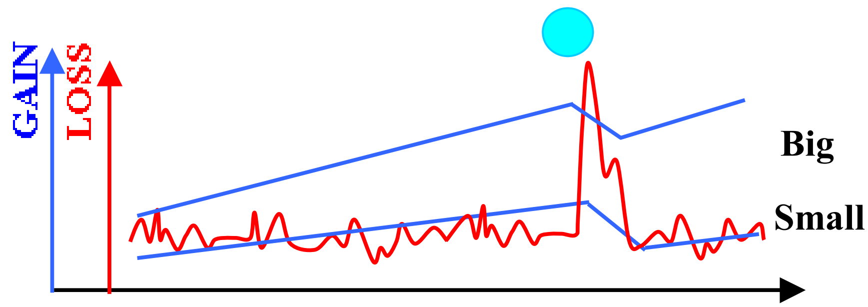


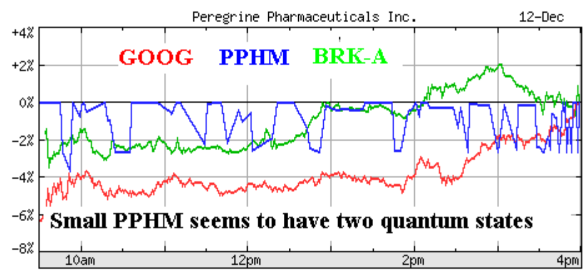
Figure A18. **Once in a blue moon, big bust happens**. **Pumping reward is balanced by pumping risk. Small investors constantly fight fluctuations while Big ones lose big only on rare occasion. GAIN is cumulative.**

The **Big** group comprises all **mostly large** investors who use hedging in one or another form. They are steadily and efficiently accumulating wealth, as the blue line of cumulative GAIN illustrates. The **Bigs** do it because they are big enough to own the more expensive **risk removal pump**, which dumps the risk on the market. The risk comes from the very size of the **Big**, following the main principle of pattern chemistry: concentration of energy increases instability.

> The Big decrease the entropy-like market parameter, which I cannot exactly characterize. Let us say that it is some measure of order (better to say, **organization**) manifested as a deviation from normal distribution or the distance from equilibrium. This parameter, usually mistaken for information (see **October 24 - 30, 2008**), is the crucial white spot on the map of the science of complexity.

In the **Small** group, **mostly** small investors are constantly toiling over order through fluctuations, as everybody is supposed to do under the invisible hand. They lag behind the more self-insured and self-assured big hedgers. The **wealth pump** concentrates wealth because it retrieves **reward** from the bowels of the market. This is impossible without somebody drinking the bitter cup of **risk** dripping from the market skies on rainy days. I do not care much about statistical mechanics of exystems, but I do care about the laws of conservation, without which neither chemistry nor honest finance is possible. Gain and loss, risk and reward must be balanced for any real, not imaginary, system. The spirit of postmodernity, however, is to never balance your accounts.

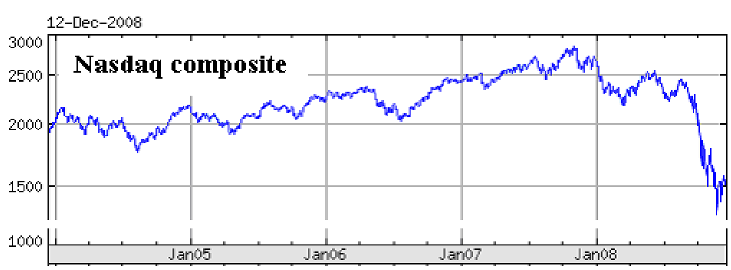
The picture is not complete without the ultimate reason why "**once in a blue moon**, **the risks pile up on one side of the market…**"(George Soros). How can that be if the market consists of millions of players shuffled and reshuffled by the invisible hand?



The answer lies in the chemistry of size (see **Chapter 1.9**). In a small system, any change is the more dramatic the smaller the system. Quantum system is an example, which may explain the uncertainty principle to a lay person. The trading day of a small company → is another example. In a large system, as any chemist could attest, the event is practically always local, and the rest of the system is indifferent to it.

The number of the **Bigs** is small. The number of the **Smalls** is big. A single act of a **Big** is a noticeable market event. A single act of a **Small** is invisible. A few **Bigs** can rock the boat. All **Bigs** can do that even unwillingly because the probability that they all lean to one side is non-negligible. For the millions of **Small** it is impossible without a good reason, for example, somebody yelling, "*Whale off starboard*!" or *"New Dotcom on the horizon."* When a single large system is governed by a single mind, a mind-jerk decision can crack the system, however big.

The red line in **Figure A18** shows LOSS as the timeline of **fluctuations**. There could be, of course periods of consistent gain (negative loss), which are not shown here. The bull periods, with short corrections, are much longer than the bust earthquakes, as market history testifies.



Source: Yahoo!

Long ago, Ilya Prigogine, the founder of all non-equilibrium thermodynamics and science of complexity, called this mechanism "**order through fluctuations**." Examples of simple devices creating order through fluctuations are pedometer and self-winding watch. See also [Yong Pil Rhee, CHAOS AND ORDER THROUGH FLUCTUATIONS IN GLOBAL CAPITALISM IN THE 21ST CENTURY.]

I do not know where to put Warren Buffett, whose *Berkshire Hahtaway* roughly follows Dow in the current crisis, but he, in my opinion, employs an ingenious form of hedging: by not splitting stock, he grows money for those who already have plenty of it and will not need it next week. He closes the door to the irrational plebs—*hoi polloi*—of the Small.

Here is, finally, the overall **tentative** answer to my old question how wealth can be created if one hand of the market seems to be wrestling with the other. This applies to any form of financial risk management. The larger the single individual or corporate wealth, the more risk it generates. The risk is managed by dumping it onto the entire market where it normally dissipates. The system works until the risk management within the small elite club breaks down because of the lack of statistical size. The reckoning comes when "**once in a blue moon**, **the risks pile up on one side of the market…**" because, in the absence of a higher authority, the hedgers and insurers have no ultimate insurance above but the government.

No regulation can prevent the "size catastrophe" of a small system because risk is the very essence of business and growth is its natural instinct. I can imagine, however a zero risk business like, for example, maintenance of the due sunset and sunrise schedule.

A natural way out would be a mutual self-insurance for the pool of 500 largest American companies. Why we do not have it is a political question. Besides, who would like to be in a pool with GM? With politics as one of the most secure (until next elections or a scandal) segment of economy, our society can hardly be called open.

George Soros seems to be half-way to the ultimate reason. Most probably, somebody has figured out the entire mechanism, but I am not aware of that.

The belief in the reason and power of the market today is as irrational as any religious belief. Moreover, it is institutionalized like religion. The worshippers of the invisible hand somehow manage to shove a campaign contribution into the sticky palm.

Since any concentration of both **risk** (obviously) and **reward** (not so obviously for non-chemists) decreases stability, sooner or later, bust (Nassim Taleb's "black swan") happens.

I am not sure there is an alternative to bubble economies other than the visible hand pushing down inequality. This is a different topic, however. George Soros had a word on it, too.

December 16, 2008

FOOTLOOSE ALCHEMY AND OBDURATE CHEMISTRY OF FINANCE

I entitled the **December 7** entry *Insurer, Insure Yourself*. Two days ago I wrote about self-insurance. Speaking of the devil …of insurance. The classical example of self-insurance is what Joseph, son of Jacob, did in Egypt with grain in view of possible famine. Today I read in **The Economist**:

> The Swiss Federal Banking Commission has released details of its beefed-up capital regime, which will help to restrain growth in assets **when times are good**.
> … It [new strategy] will also strengthen capital buffers in anticipation of **periods of stress**. (**The Economist**, *Save yourselves*, Dec. 11th 2008, p.86).

It looks like a conscious remake of the Bible.

> *35:* And let them gather all the food of those **good years** that come, and lay up corn under the hand of Pharaoh, and let them keep food in the cities.
> *36:* And that food shall be for store to the land against the seven **years of famine**, which shall be in the land of Egypt; that the land perish not through the famine.(**Genesis, 41**)

The Economist remarks that it "foreshadows an emerging international orthodoxy."

The Economist foresaw the heresy in **The World in 2008**:

> The ability of American banks to turn their loans, via Wall Street's alchemists, into packages of high-yielding securities and sell them to investors was supposed to have enabled banks to diversify their exposure to credit risk.
> …………..
> The coming year [i.e., 2008] will test how much of that risk has indeed been spread, and how much of the diversification was illusory. Did banks simply replace the risk of lending on their own doorstep with exposures from outside their sphere of expertise?

I still believe that mandatory collective self-insurance for a pool of big companies is better. They will watch each other more closely than ten SECs. Sometimes the government is the problem, regardless of what is means.

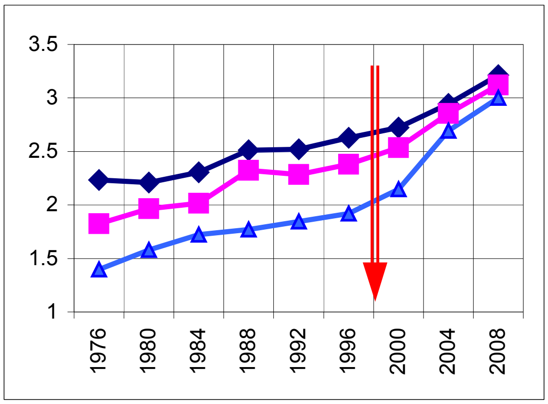
Ironically, George W. Bush practiced collective Bible studies for the White House staff.

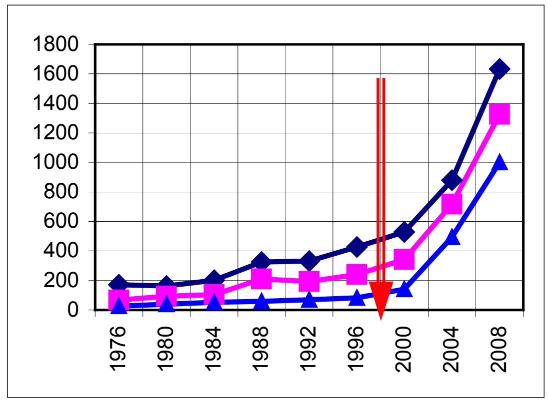
> Typically, 25 to 50 of the 1,700 people who work in the White House complex — department heads, secretaries and mail clerks —attend each session. They meet in the Eisenhower Executive Office Building, an ornate building next to the White House that houses the offices of Vice President Cheney and other officials.

December 19, 2008

MO' MONEY

The mystery of "1970" (see entries of **October 24 - 30, November 8**, **November 17, 2008,** and **Figure A11**) has been one of my major testing grounds for econochemistry. Today I have found another mystery in the area of political econochemistry, see **Figure A19** . I do not know yet what to make of it other than to baptize it **The Mystery of 1998** because this is where it is seen on the logarithmic scale. Is it simply "Mo' Money?" For what? Mo'money for mo' money? Not "*Art Gratia Artis*," I suppose.





Logarithmic Scale **Linear scale**

Figure A19. Total presidential campaign fundraising (**1,** □) total spending (**2,** □), and total cost of the nominees' campaign (**3,** □) , 1976-2008.
Sources for 1 and 2; (**OpenSecrets.org**) source for 3. (**The Economist, 2007**)

HAPPY AND PROSPEROUS 2009!

January 14, 2009

WATER UNDER THE BRIDGE

The financial crisis is in the state of remediation. The predictions are grim. The suggestions are contradictory. The markets are agonizing. Tax cut or stimulus package, public works or home buyer rescue? Bailout or rescue, security or despare?

The vocabulary sounds utterly non-chemical, but what could a chemist say?

I do not know the right answer and nobody does, unless it accidentally will later turn out true. If this is the biggest crisis since the Great Depression, there could not be any **modern** science of Great Economic Crises because so much water has passed under the bridge. I can only say in what direction I would look for the right answer: **concentration**, which is one of the hard core chemical ideas.

The measure of power is **concentration** of resources on a single goal. The goal is a configuration in the future. See Essay 53. Power: Hidden Stick, Shared Carrot . The highest power belongs to the individual, corporation, or government that can designate the largest sum of money for the same single goal.

Note that in pattern chemistry we have only comparative and not absolute measures, except for mere number, like quantity or ratio. For example, $1000 economically means nothing in the long (how long?) run because the unit of measure—dollar—fluctuates. On the contrary, 1000 days, 1000 square miles, $1000 in $100 bills, and 1000 employees do not have context. That days are spent in prison, square miles cover a desert, bills are counterfeit, and employees have been just fired—all that has meaning only in a context.

Closer to economy, the George Bush's checks in the mail (I got one) look to me and many other people like throwing money not even into the wind, but into the fire. For a chemist it is like dyeing → Chicago River green on St Patrick's Day. It feels good and lasts for a day. "Economic rescue package" of this kind sounds like mockery.

Water under the bridge

From the point of view of concentration, more sense would make for the government to support the most potentially productive people, i.e., the successful businesses, entrepreneurs, and the most needy unemployed workers who—sorry for cynicism—would in tandem create a likeness of domestic mini-China ("China for a year"—more than Thomas Friedman is asking for). This, of course, looks like a political chimera in which two warring ideologies are blended into a single being. If , according to Plato, love originated from splitting the primeval genderless human being with four hands and four legs into two similar but different halves, hate and love, most probably, originated from a mindless straightjacket desire to possess. My theory of Platonic hate has been inspired by the Gaza battle of January, 2009.

> **In short, to be effective, the largest sum of money should be given with the smallest number of intentions to the smallest number of people and institutions.**

The effect of concentration is the same in molecular chemistry, war, economy, and politics.

I stop short of anything more concrete. I cannot miss an opportunity, however, to touch upon two derivative issues.

The first is the **chemistry of social justice**. In my view, it is the economic safety net that would prevent people from falling below the metabolic cost and the amplitude of the metabolic line from spikes piercing through all levels of society. If war and genocide remain permanently on the menu of history, if the Great Depression returns after long hibernation, why not the revolutions? The French Revolutions started with empty stomachs. The LA and Oakland riots started with the full ones. I believe it is the obligation of the government to keep the society above the level of large destructive events. They would happen anyway, but more constructive than destructive and not as **concentrated in time**, i.e., explosion-like.

> By the way, all three Abrahamic religions require and practice the safety net. I have looked up Hinduism, Buddhism, and Confucianism and found elaborate philosophy of charity in all three. Buddhism, for example, considers three kinds of charity: goods, teaching, and **courage**.

The second issue is the life cycle of a successful company inadvertently aging with time, losing its edge, and falling into decay, ending with death, quite like a human being. I suspect that concentration of power is the main reason: **growth dilutes** creative and organizing power of the leader. The decline of Microsoft is an illustration. A transition to a very loose conglomerate, a kind of a federation or "business commonwealth" may seem, theoretically, a temporary remedy, but it is inherently unstable because of its looseness. The same applies to geopolitics. The fate of the Soviet Union is an example. The US federal system looks like superb solution because it is based on the distributed, i.e. diluted, but constantly renewed and regenerated power. The danger comes from the interaction with external authoritarian powers, but even after last eight years I believe in the superiority of fluid vitality over inevitable corrosion of iron will …provided a sufficiently large size.

> Finally, about the green Chicago River. One can read on the Web, without reference, that in 1966, because of environmental concerns, the dye fluorescein was substituted by an unknown vegetable dye. Unless proven otherwise, I insist that it is a fable. I finally found a weighty piece of information: "Ironically the dye starts out orange, but then turns green." This is typical of fluorescein.
>
> As for fish toxicity in practically used **concentrations**, it is also fiction. The Web is a modern thing: truth and fiction are mixed here, but can be separated grain by grain. I am not the only one wondering about the mix-up. "A common misconception is that it is a 'vegetable dye' rather than a synthetic." Why do some ophthalmologic clinics call it vegetable die? A probable reason is that a natural fluorescent compound pyoverdin, produced by some monocellular organisms, was originally called "bacterial fluorescein." There could be also another reason : "vegetable dye" sounds reassuring and politically correct. Note that fluorescein works in very small **concentration**. Its effect is a chemically pure idea of national identity.

So much for water under the bridge.

January 15, 2009

A FLIGHT TO SIMPLICITY

My current reading is Richard Bookstaber, *A Demon of Our Own Design: Markets, Hedge Funds, and the Perils of Financial Innovation*, Wiley, 2007. (Preface of October, 2008). The phrase at the end of Preface, "What we need … is a flight to simplicity," makes my heart throb as in expectation of a decisive date.

January 22, 2009

A FLIGHT TO SIMPLICITY, continued

I have finished *A Demon of Our Own Design* by Richard Bookstaber. It seems to me that reviewers do not know what to make of it. Here are my impressions, which should not be mistaken for criticism. I cannot criticize what I have enjoyed.

The book has at least three interlaced but not blended kinds of content:

1. Sparkling reminiscences of institutions, people, and events, written in the best literary traditions. You can actually see the "polished black-and-white Italian marble floor of the foyer" of the Salomon Brothers boardroom, "soon to be deserted" (p. 99) and feel the irony and drama of the recent history of the American finances, in which we all are immersed deeper than ever. That was pure joy.

2. Overview of a sequence of market instruments, techniques, mechanisms, convulsions, and concussions, written in the lingo of the trade and fully accessible only to professionals. Remarkably, even those pages were completely engrossing for me, although I did not understand a half of it.

3. The view of the market as a phenomenon similar to living organisms, social structures, and technological systems. This is the most appealing aspect for a pattern chemist, but, probably, not for an average floor or even desk trader, and not even for any Chairman with a red phone on a brass stand. Anyway, I was reading with delight.

The book is a treasure of deep and stimulating observations and ideas. There is an apparent contradiction, however, between the apprehension in the title, "*A Demon of Our Own Design*," and the ultimate vindication of the demon. On the final pages of the book the demon looks like a new breed of a pet, to the troubling appearance and foul habits of which we should better get used and whom we need to fully embrace, especially after due house training.

I am, probably, mistaken, but I see a logical contradiction in the author's recipe for the house training. On the one hand, the author objects to excessive regulation, but on the other hand, what he recommends, is a rather harsh self-regulation. This is not realistic.

> I want to mention here some other doubts regarding the book. They are very insignificant and few in numbers. I hope to have multiple opportunities to turn to the book for points of support, which are plentiful.
>
> One aspect of markets is only vaguely reflected in author's picture: human greed, of which humans, theoretically, should be as little ashamed as of anything else in human nature. Some humans want to make money and to make more than the neighbors, and to make more tomorrow than today. The desire to excel in the ring, provided being human is the only pass to competition, is the core of American idea, as I see it. It is an expansion of the Greek idea of virtue. What is much less obvious, if being human is the only requirement and we all are in the same boat, somebody must stop the rowdy bunch from rocking the boat.
>
> Richard Bookstaber illustrates one of the main arguments against over-regulation with the stories of major nuclear accidents. Again, he does it so skillfully that you actually see it with your own eyes, even hear, step by step. That does not convince me because both Three Mile Island and Chernobyl incidents illustrate not over-regulation, but poor and insufficient controls. The record of numerous French nuclear plants, although not completely spotless, contrasts with the older unfortunate examples.
>
> The story of Brazilian Jiu-Jitsu is stimulating, but hardly convincing, either. Can you physically harm anybody in the world's litigation paradise? Financially you can beat a competitor or even a bystander in a pulp, let alone mutilate yourself. This is what capitalism is about, isn't it?

"Jiu-jitsu techniques rely heavily on leverage"

To summarize my impressions, apart from greatly enjoying the book, I have found in it a massive support and nutrition for econochemistry. With so much new clarity, I feel that my diary is not far from completion.

Next, I will need to summarize the principles of econochemistry and, probably, return to the larger domain of pattern chemistry. It should probably be formulated in a more serious and professional language. But Richard Bookstaber's book makes me doubt the importance of the appropriate attire, tie, cufflinks, cologne, and all that stuff. Ideas look best young, messy, and naked.

January 24, 2009

A FLIGHT TO SIMPLICITY, continued

Next, I will attempt to digest the material of "*A Demon*" with the chemical stomach. The author is a high-intelligence high-flying investment risk professional with what looks like a sense of personal responsibility for the fatal consequences of best intentions. Since my personal background is worlds away, all I can do for my own purposes is to turn author's answers into questions by a kind of reverse engineering and then try to answer them in my own language, fully prepared to fail.

> There are plenty of other old and new sources on risk in general (for example, Peter L. Bernstein, *Against the Gods: The Remarkable Story of Risk*, Wiley, 1996) and current crisis in particular (Edward Carr, *Greed—and Fear*, a special report on the future of finance, *The Economist*, January 24th, 2009, with references). Since I am not an economist, I can be satisfied with one good source of not answers, but questions. The reason is simple: in human matters there are unlimited numbers of answers to few basic questions. In hard science, the right question is half the answer. I will stick to Richard Bookstaber who has backgrounds in both.

1. Destruction of wealth. In the crash or 1987, in 18 hours, " …wealth equal to several years' worth of gross domestic product (GDP) was wiped away" (p. 13). There is nothing that can be destroyed in molecular chemistry: only the form changes. If one structure is destroyed, another one emerges from the rearranged debris. Without this principle, not only generalized chemistry, but any science is impossible.

QUESTION 1: What does it mean chemically when we say that wealth has been destroyed?

If part of wealth has been destroyed, it did not exist, did it?

> **Short tentative answer**: Wealth is a product of extensive and intensive quantities.

2. "**Number-crunching wave."** The invasion of mathematicians, physicists, and, as it turns out, even a chemical engineer into economics resulted in the current theory of risk management. It all started with the Black-Scholes model for portfolio insurance by hedging.

When I looked up the Black-Scholes without any intent or ability to understand its mathematics I was struck by two things. First, its assumptions are blatantly unrealistic. Second, the time of its publication was 1973. It was the beginning of the Brave New World of total economy, inequality, and a kind of Cambrian Explosion in science.

> See entry of **November 17, 2008** , and **Chapter 3.7. READING ROBERT REICH: WHAT HAPPENED IN 1970?** of **Part 1.**

If nothing in human matters is universally consensual, what is the value of quantitative finance?

QUESTION 2: Why did mathematics fail economy?

Did it? As Bookstaber writes, the risk "should be diminished but it isn't;" "…we seem to be doing the right things but the results go in the other direction" (p.5). Math did not fail economics: Robert C. Merton, and Myron S. Scholes were awarded the Nobel Prize in 1997, just ten years after the giant market crash. Bookstaber clearly indicts the Black-Scholes for the crash of 1987 ("...the portfolio insurance programs continued robotically to spit out sell orders, oblivious to anything but the current market level and the mathematical requirements of the hedge, " p. 25).

> **Short tentative answer**: Mathematics is based on the axiom of closure, i.e., that the subject and assumptions do not change during inference.
>
> **NOTE**: George Soros, with his "reflexivity" version of my above answer, was attacked or ignored exactly because he, in my interpretation, insisted that in human matters there could not be any scientific truth. Then how could you trust any professor of economics?

3. Illiquidity as the source of the crash. This is one of the central ideas of Richard Bookstaber. It seems to me that crash means illiquidity by definition: no buyers and/or no sellers. The market screeches to a halt because everybody is afraid. The pressure in the boiler drops.

> What does it mean to be afraid? To perceive risk as too high. George Soros notes that market participants are driven not by their best interests, but by "their *perception* of their best interests, and the two are not identical" (*The Alchemy of Finance*, Wiley, 2003, p.5). Of course! How can we know what is somebody's best interest until we know how everything turns out in the end? If illiquidity is only a perception, can it be mediated by a spoonful of the **liquid** from the bottle labeled "Courage"?
>
> Richard Bookstaber illustrates the difference between risk and its perception by the principle "innocent until proven guilty" (p. 161, 169): each successful space launch decreases the perception of risk. This is a very general and deep idea applicable to all exystems, including world history. It is also a great illustration of the Soros' reflexivity.

QUESTION 3: If (if!) the crash is (or caused by) the rising tide of risk, what is risk from the point of view of chemistry?

Is risk a conservative property? Is it a structure? How does risk management manage to change it so that it comes as devastating tsunami rather than stormy but navigable sees?

> **Short tentative answer**: Risk is the distribution of economic fluctuations.
> Risk has the same distribution as wealth. It is anti-wealth, so to speak, the financial anti-matter.

4. Risk management. Richard Bookstaber suggests that complexity cannot be managed by complexity and simplification is the way to mediate the fatal combination of complexity and tight coupling, i.e., the inherent lack of time for counteracting the crisis.

QUESTION 4: Is there any alternative to growing complexity?

I believe that complexity is the main threat to stability of economy.

> Economy today is what was called civilization half a century ago. Humans have entered the eon of coexistence with things. I believe that tight coupling is also the universal problem of not just economy but the entire modern way of life: no time to think in the short run, no sense to think in the long run. Computerization, automation, signalization, menus, buttons, and regulations are adaptive responses to the increasing speed of events, which they further increase in an autocatalytic loop.

Technos is a life form which cannot be fully controlled and dominated by humans. It is truly a demon of our own design. Obviously, any life form adapts to risk.

What are the directions of adaptation for both humans and Technos?
How possible is simplification?

> **Two short tentative answers**: 1. Economy can adapt to complexity-created risk by further thingization of humans (watch the *Network* movie, 1976).
> 2. Simplification could be achieved by limiting the size (increasing the number) of larger market participants and **flattening** the system. I doubt it is possible. The larger the player, the more it controls the regulators.
>
> On flat and tall systems, see entry of **September 23, 2008** and **Chapter 3.11, HATS AND ROOFS, LIZARDS AND DINOSAURS** in **Part 1**.
>
> **Answer without a question**: Further exacerbation of wealth inequality and job insecurity will result in social tensions and a full circle turn of the Ferris Wheel of history.

Simplicity now!

January 28, 2009

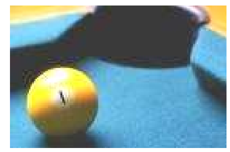
A FLIGHT TO SIMPLICITY, continued

QUESTION 5 "How can we manage a risk we do not know exists?"
(Bookstaber, p. 241)

Richard Bookstaber is very convincing on many points, but I am not sure that coarse rules of behavior he proposes would give anybody a market advantage, unless by chance.

I can't help thinking about what is most painfully familiar: Soviet communism. It was based on the most simplistic system of rules, for example: have a superior to assume responsibility for orders and a subordinate to be responsible for their execution.

By the way, Russian communism had something in common with capitalist markets: gambling on human nature. The Soviet idea was that while you were living in poverty, your children would be living in the **future** workers' paradise. Capitalist markets are also based on the promise: you can get fabulously rich—or just better off—in the **future**. The enterprise of suicidal Islamic terrorism works on the same principle. Compare with **Matthew 6:34** : "Take therefore no thought for the morrow: for the morrow shall take thought for the things of itself. Sufficient unto the day is the evil thereof." While markets bounce back and forth on the promise, marketeers work on the bonus which **irreversibly** drops into the pocket, like the billiard ball. →



Sorry, I have been carried away. That was an improvised example of a very general pattern. Let us take a more concrete example.

War is a market of destruction. Suppose, we have coarse rules of war. Now comes terrorism. Is it a war? Or, if it is—people killed and buildings destroyed on both sides—can we say aloud that this is war? The rules do not say anything. Even **Matthew** 6:34 says more**.** George Bush acted along the coarse rule: hit back.

It is ridiculous to blame George W. Bush for the expression "war on terror" if we can say "war on infectious diseases," "war on crime," or "war on drugs." It is just a metaphor. Moreover, it is ridiculous to blame him for anything but disinformation, if proven so.

For twenty-five years we have been witnessing an utmost confusion in America regarding Islamic terrorism. As result, coarse rules have not given a decisive advantage, while no fine rules have emerged. "Sufficient unto the day is the evil thereof" still stands. No wonder: politics and media are markets with a few long positions and scores of short ones.

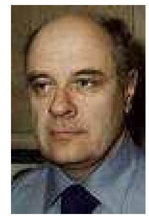
The market advantage can be mere luck, but also a result of either a secret fine technique or just the very nature of economy. With a power law distribution of size (for example, Pareto law), there must be a winner, however temporary. Same in the war on terror: technology matters.

Short tentative answer: The minimal relevant information is the most general **pattern** of behavior. This is one of the basic precepts of pattern chemistry, based in turn on Pattern Theory of Ulf Grenander.

For example, any accelerating growth or decline—any accelerating trend—signals an economic danger. Everybody understands this, but human nature prevents the cockroach-style coarse but healthy reaction of escape. For better or worse, human nature can be **coarsely** described as cockroach with imagination. This creates a gap between best interests and their perception.

How general patterns can be, see The Rusty Bolts of Complexity : Ideograms for Evolving Complex Systems . Note the ideas of **René Thom** (Catastrophe Theory) and related Figure 5. See also Ideogram : A Simpleton in a Complex Family.

← **René Thom** and **Ulf Grenander** →
Founders of most abstract Theories of Everything applicable on human scale.



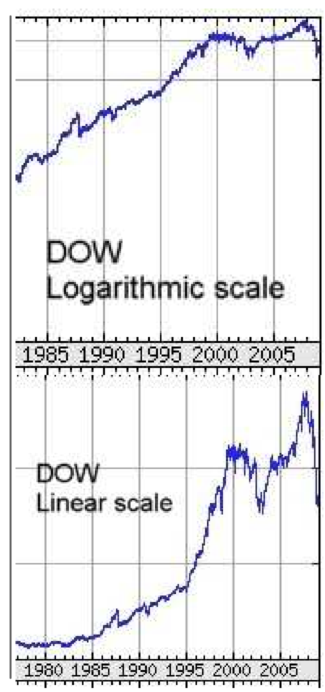
February 6, 2009

THE RISKY CHEMISTRY OF RISK MANAGEMENT

I am interrupting my "FLIGHT TO SIMPLICITY." Still suspended in the air, I am already looking for a spot to land.

The Web does not provide me for the final stretch with sufficient information and I have to use books.

> It is an opportunity to really appreciate the blessing of paper publishing which, although also a part of economy—maybe because of that—still manages to retrieve pearls from the dung heap.



Here is my circle of reading for this segment of the diary:

Finished:

1. Richard Bookstaber, *A Demon of our Own Design, Markets, Hedge Funds, and the Perils of Financial Innovation*, Wiley, 2007.

2. Peter L. Bernstein. *Against the Gods: The Remarkable Story of Risk*, Wiley, 1996.

The two books, both of them entrancing and incisive, complement each other: the first with physical background, the second with mechanisms of human nature. It is absolutely obvious that Peter Bernstein predicted the current crisis in the most unambiguous way, warning that the "entire financial system" can be "at risk" next time after 1987 and 1994. Both years look today like tiny blips. Mysteriously, the enormous crashes of 2000 and 2008 will look like blips in 2200. Or so we predict. But if they will, then is it worth managing risk at all?

> Anxious to test my pattern-chemical wings and full of arrogance, I predict that, contrary to popular expectations, the unstoppable rise of the stock market (even adjusted for inflation) will slow down to fit an S-shaped pattern. I do not know when.

Both books characterize the exterior of the crises as the lack of liquidity, but Bernstein clearly points to a deeper reason: human preference for gambling instead of known in advance loss. He also firmly denies any possibility of predicting unpredictable. The book turned out incredibly rich for my chemical demands.

Nevertheless, although it is time to summarize and answer the questions from A FLIGHT TO SIMPLICITY in a more serious manner, I still need to look into a few sources.

3. Emanuel Derman. *My Life as A Quant*, Wiley, 2004.

The first half of it is one of the most engrossing texts of non-fiction I have ever read. It is simply beautiful as a literary work and as a peek into the innards of academia. The second half is often cursory and bleak. Private life all but disappears.

> I recognize some familiar, in spite of my limited experience in the US, shapes, but I do not see in the book much ado around the word "grant," which is the fuel for most of the academic research business. The author did not need to worry about that: the grants from DOE were taken for granted.
>
> It was also greatly encouraging for me to see that some publishers and authors did not bother to do proofreading, so my numerous errors in online publications may not look that much offensive.

The Financial Modeler's Manifesto , January, 2009, by Emanuel Derman and Paul Wilmott, which starts and ends as a spoof of the Communist Manifesto ("A specter is haunting Markets –" … "nothing to lose but your illusions.") , I believe, summarizes the second half, which I have not yet read, and brings it all up to date.

4. Michael M. Lewis, *Liar's Poker : Rising Through the Wreckage on Wall Street* / Michael Lewis. Penguin Books, 1990.

I was laughing like mad, as never before in my last forty years of life, while reading this book. I have stashed away some quotations to decorate the margins of my econochemistry.

5. *Panic : The Story of Modern Financial Insanity* , edited by Michael M. Lewis. Norton, 2009.

I was most impressed by the Introduction, which reminded me the scenes of tearing down the Berlin Wall, Dzerzhinsky monument in Moscow, and Saddam Hussein statue in Baghdad.

Not yet finished:

6. George Soros. *The Alchemy of Finance Wiley*, 2003. I am already familiar with main ideas.

7. Publications of Constantino Tsallis , a theoretical physicists. He is the author of wide-ranging works on generalized entropy known as Tsallis entropy. I do not expect to fully understand the mathematical texture, but I have noticed some very general ideas possibly meaningful for pattern chemistry. Areas explored by Tsallis cover economics in general, risk aversion in particular, power law, astrophysics, biological evolution, cellular automata, human and computer learning, complexity, etc., which is exciting for anybody seeking generality, if not a science of everything. [Tsallis' papers online].

> In short the entropy of some natural composite systems—in the same category as what I call exystems—does not just sum up the entropies of the subsystems (the property of extensivity), but adds also their intricate interaction. This is why Tsallis entropy is called non-extensive. It is also non-unique: there are an infinite variety of non-extensive entropies.
>
> I doubt relevance of any physical theory for exystems. Nevertheless, I can see a deeper and entirely chemical idea behind this principle: it does not matter how we calculate entropy as long as the order and ranking of systems and their states along their entropies, i.e., **inequalities** in pairs of states, remains approximately the same. By losing the quantitative edge we can gain the longevity of the qualitative one. **In other words, what we call entropy is inequality.**

February 9, 2009

THE RISKY CHEMISTRY OF RISK MANAGEMENT continued

The Financial Modeler's Manifesto points to human nature as an inherent source of the prediction failure: "Whenever we make a model of something involving human beings, we are trying to force the ugly stepsister's foot into Cinderella's pretty glass slipper."

Further, "The truth is that there are no fundamental laws in finance. And even if there were, there is no way to run repeatable experiments to verify them."

I have some doubts about that, in spite of my great admiration for the authors and their manifesto. It may seem as enormous arrogance on my part, but in fact it is not so enormous: I see the world as a chemist and not as a financial engineer, physicist, trader, consumer, investor, retiree, mathematician, economist, and not even as a man from the street, either Main, or Wall.

> Human nature, as I have noted earlier, is incomparably more stable than society, economy, and even climate. It can be studied, but not through artificial requests like to choose between an 80% chance of winning $4,000 or 100% of taking $3,000. The study needs observations of behavior of people who will be guaranteed the reward of $4000, with $3000 on the table, if the wheel of fortune stops the lucky way. The study will be useless without the knowledge of financial status of the participants, as well as of many intimate details of their lives, and if such details are perchance available, it will be useless anyway. The complexity of theory cannot exceed the complexity of facts.
>
> I intuitively believe that human nature is not as complex as it may look. The problem is that humans do not like revealing their **entire** nature too much. Unlike Einstein's god, they are not as subtle as unwillingly devious. In this they are dramatically different from the natural material world—from elementary particles to galaxies as well as from most complicated machines and other human creations. We are still learning something about the human nature of Richard Nixon, although it is today of no relevance.

Without having finished my reading, I believe that I have enough support for the way to answer **Question 3** (**January 24, 2009**) suggested in the entries of **November 21, 2008** (MORE ABOUT ENTROPY) and **November 23, 2008** (MORE ABOUT GINI COEFFICIENT).

Again:

Question 3: What is risk from the point of view of chemistry?

I see risk for a subsystem of economy as the event in which the **negative fluctuation** of resource (energy and/or matter, or just energy, for simplicity) exceeds the metabolic cost—the minimal inflow of resource needed to maintain an exystem. As result, the economic entity, whether an individual, company, or society, cannot survive and is dissipated, absorbed into the economy, or deeply transformed.

> In reality, there can be a potentially harmful disturbance of another kind: high generalized temperature of the environment which prevents dissipation of energy in the form of heat or, more generally, chaos. At high temperature no useful work is effective or even possible. [**EDITING REMARK**. As an example, a large part of money for Pakistan, Iraq, and Afghanistan, if not most of it, has been wasted because of the chaotic, i.e., "hot," atmosphere of events. Same applies to the financial crisis.]

Risk management consists in organizing the interface with environment in such a way that fluctuations are minimally chaotic (i.e., least surprising). Any process of organization needs its own share of resource. Risk management cannot destroy "chemical" wealth because it is a form of energy and is conservative. Why? By definition, anything measurable we deal with cannot be destroyed; it can be only converted. This is why mathematics is possible: 2 + 3 = 5 and not 4.9. In order to understand the world, we need a principle of conservation. This is why, probably, ancient cultures had elaborate burial rituals.

Risk management in financial markets simply **transfers risk to somebody else**, and my respectable sources of financial wisdom, however few in number (for example, Peter L. Bernstein), confirm that. I believe this is done by converting risk into a more ordered form. It requires work and this is why big wheels in financial markets are paid big. They need to dissipate huge sums of money.

I cannot provide any equations. All the more, thermodynamics of **complex** open systems far from equilibrium cannot say anything substantial for the reason of its protracted yet still early infancy. The reason for that lies in the very nature of complex systems: they have particular irregular structures, for which descriptive information cannot be compressed. This incompressibility is typical for all exystems and is clearly visible in chemistry and accounting, as I earlier illustrated on examples.

> Interestingly, complexity of exystems cannot be compressed for the same reasons which, probably, were driving Constantino Tsallis toward generalization of such fundamental and hallowed concept as entropy. Benoit Mandelbrot preceded him with "multifractality." Physics proper, however, in principle cannot deal with incompressible information, which it delegates to the lowbrow kind of physics called chemistry. With more generalization, physics melts in generalities. To continue this train of thought, I would need a long digression and I would rather revisit the topic later.
>
> As a visual illustration, I reproduce here a sample of Pacific Northwest Native art ("Killer Whale" by Carl Stromquist), formula of codeine, Chinese character for "chi" (*qi*, vital energy), and a fragment of a retail receipt, all in **Figure A20**. Each consists of distinct, more or less variable elements and can be completely described only by the **list** of elements and their relative connections. A receipt from a supermarket is the same kind of object. It is symmetric, however, to the transposition of rows and columns. Same is typical of chemical structures written in matrix form. Pictures of the whale and "*qi*" can be deformed. The pictures are configurations of Pattern Theory. Pattern is the full spectrum of "legal" transformations, which needs the "law".

Risk in financial modeling is inherent because of the physical upbringing of most modelers. Why?

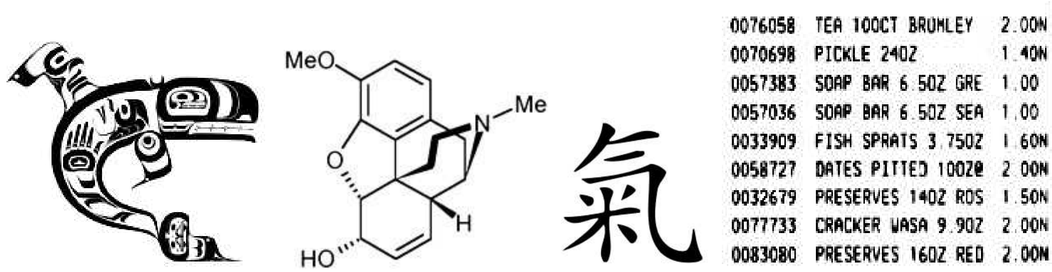


Figure A20. **Incompressible information: Pacific Northwest art, codeine, Chinese character, and a fragment of a receipt.**

QUESTION 2: Why did mathematics fail economy?

My short tentative answer which I gave earlier stands much firmer after the **Manifesto**:

> It should be obvious to anyone with common sense that every financial axiom is wrong, and that finance can never in its wildest dreams be Euclid. (Derman and Wilmott) .

On various occasions I addressed the significance of axiom of closure (the set of terms and axioms for a theory is closed) for the physical picture of the world and its negation for exystems. Still, there is no reason to be nihilistic about fundamental laws of higher generality than the laws of finance. The principle of **conservation** is so general that it looks like a Kantian category. Yet it is not trivial: conservation means that in any event there must be a balanced list of quantities (as well as "material" elements, i.e., generators of Pattern Theory) even if we cannot calculate some of them. In terms of accounting, a deficit calls for recounting. As for repeatable experiments, repeatable experience can serve as a surrogate. Life is an experience, not an experiment.

Conservation? Aha!

QUESTION 1: What does it mean chemically when we say that wealth has been destroyed?

It means that we are wrong. Wealth ("chemical" wealth), or whatever stands behind this term in pattern chemistry, cannot be destroyed. It can be **created**, **dissipated**, and it can **fluctuate**. If it looks like some value was lost, then the value had been inflated. If it looks like wealth has been created, a part of growth may be an illusion, but a part can be real. Wealth is created in the exystem of economy from matter and energy and is dissipated into less organized and more degraded forms of matter and energy.

In chemistry and physics:

$\Delta G = \Delta Q - T^*\Delta S$; where G is energy, Q heat, T temperature, S entropy, and Δ change.

In economy, by metaphor rather than by inference:

$\Delta M = \Delta W - T^*\Delta S$; where M is money, W waste, T generalized temperature, S order/organization, and Δ change.

The parallel is not my invention. The whole way of thinking about economy in terms of **not statistical mechanics** , as econophysics does, **but classical macroscopic thermodynamics** belongs to **Nicholas Georgescu-Roegen** and has deeper roots ("thermoeconomics"). See also. If this is not a household name in economics, it is because you cannot gamble on macroscopic thermodynamics. Unlike statistical mechanics, it does not play roulette, neither French nor Russian, with economy, but demands to balance your books.

I cannot say that Georgescu-Roegen's ideas revealed something **practically** important. Thermodynamics says just a few words, but they are carved on heavy granite blocks good only for a foundation, not for the edifice. All economics needs are those few words, but there are few ears for their infrasound. Georgescu-Roegen is not to blame for that, however.

The major obstacle for macro thermodynamics to lean with all its awesome weight onto economics is the fundamental lack of clarity as far as open systems far of equilibrium are concerned, not to mention exystems. Nowhere have I found anything of substance on this subject (which does not necessarily mean there is nothing). On the contrary, I have learned through Constantino Tsallis that Albert Einstein already in 1910 saw the nature of the obstacle. I reproduce Tsallis' quotation of Einstein with my emphasis:

> In order to calculate W, one needs a ***complete*** **(molecular-mechanical) theory** of the system under consideration. Therefore it is dubious whether the Boltzmann principle has any meaning **without a *complete* molecular mechanical theory or some other theory which describes the elementary processes**. $S = k \ln W + constant$ seems without content, from a phenomenological point of view, without giving in addition such an *Elementartheorie*.

Beyond that second-hand (actually, third-hand for me) quotation, in the original paper, which I looked into, Einstein suggested a way to circumvent the lack of complete picture (what chemists call mechanism) of the process. This could be done by using only the observable parameters of the system, so that the irreversibility of the process "*nur eine scheinbare sei*," "would be so only in appearance," but I am not competent to judge this idea. I can only note that Einstein further makes the stipulation " *Wenn die Nichtumkehrbarkeit der Vorgänge keine prinzipielle ist…*" "When the irreversibility of the process is not in principle important..." For exystem, this is important in principle, but, I am afraid, impossible to circumvent by definition. This leaves to us only the chemical way to deal with exystems: there are initial, transition, and final states, and all we can talk about are **differences** between the parameters of those states and their **imaginary alternatives** (**!**). Why the exclamation mark? Because alternatives never materialize. I hope this is the lasting impression of any reader of Michael Lewis' *The*

Liar's Poker , apart from the extra-long telephone cord to increase the range of the phone hurled as an anti-geek weapon. There is no science closer to economics than chemistry.

We do not need to know what money or wealth is, but we always know what is paid for what and know the difference between MORE and LESS from either receipts or FBI tapes.

Gold is naturally flashy, but what becomes visible in the light of macro thermodynamics is waste. I believe that people and companies should be taxed not by their income, but by their waste. Moreover, they will be. I am saying this three-quarter-seriously, but I intend to come back to this idea 100% seriously. Until then, see movie WALL-E (brilliant for the first 20 minutes). By the way, the movie illustrates one of the central concerns of Georgescu-Roegen.

Sorry, chemistry is numb about information. It knows only catalysis, which is not so difficult to price, unlike the notoriously difficult information, know-how, and human capital, because it results in the measurable increase of productivity. Chemistry measures things in action, not on the shelf.

> Chemistry is pragmatic and prosaic, although, like a beloved wife of many years, quite capable to emanate romantic glow for those who espoused her for better, for worse, for richer, for poorer, in sickness and in health.

Econophysics chants:
Mesdames et messieurs,
faites vos jeux!

Econochemistry growls:
Ladies and gentlemen,
balance your books!

Now we are about ready to tackle **Question 3**.

February 22, 2009

SMALL THINGS : a digression

(1) The monstrous, unreadable, in spite of urgency and importance, 1000+ pages of economic stimulus bill illustrate the econochemical principle that the measure of power is the amount of money designated for a single goal. I refer here to the project, not the final version (also), but there is no big difference, I suppose. It has hundreds, if not thousands, specific goals, for example:

> Watershed Rehabilitation Program; Developing and maintaining a broadband inventory map; Improve, repair and modernize Department of Defense facilities; Lead Hazard Reduction Program; Funding to strengthen the health information technology infrastructure; Plug-in conversion credit, Extension and expansion of qualified zone academy bonds, etc., etc…

The bill contains thousands (I haven't checked exactly how many) numbers of mysterious origin:

> …funding $143,750,000… ;… for the period beginning October 1, 2010, and ending December 31, 2010, $143,750,000…; … $12,501,000 …; Family Housing Operation and maintenance, Air Force, $16,461,000…; … **shall be $1,667 in the case of each half kilowatt** [this is my favorite! it is in the final Act] etc., etc.

Not only that, it contains hundreds of exact numeric limits on some articles of funding. I am very much interested if all those numbers really add up.

This reminds me of the Soviet plans and directives, always full of goals like "improve," "strengthen," and "intensify." I understand the reaction of Republicans.

Although an Obama enthusiast, I am very skeptical that any government bill longer than 50 pages can act as powerful breaks for an economic disaster. But let us see. This is a public experiment in econochemistry.

(2) A curious thing is happening. The gloomiest economic predictions are coming from all sides with the same intensity as the optimistic ones used to come just last year. At the same time, the predominant buzz is that nobody knows what and when is going to happen. Reading Michael Lewis' *Liar's Poker*, as well as the *Panic* anthology, I see that nobody of the market perpetrators ever remembered anything from the past except the size of the last bonus. Meanwhile, I collect predictions as yet another experiment in econochemistry. Here are some:

> Even with credit markets thawing, Fed officials see unemployment persisting at 8 percent or higher through the final three months of 2010 (Bloomberg).
>
> How can they see that? Isn't it like "**shall be $1,667 in the case of each half kilowatt?**"
>
> Instead, the U.S. contraction will be U-shaped: long, deep, and lasting about 24 months (Nouriel Roubini).
>
> MOSCOW -- For a decade, Russian academic Igor Panarin [former KGB analyst] has been predicting the U.S. will fall apart in 2010. (TheWall Street Journal).

Selection of an oracle is like selection of stocks by throwing darts.

(3) Around the mystical year of 1970, the world of American academia began to grow as a fully incorporated branch of economy. Emanuel Derman in *My Life as a Quant* writes:

> By the end of the Vietnam War a deteriorating economy and a **public revulsion with science** in the service of war put a large dent in research funds. During the 1970s and 1980s, many theoretical physicists who had once hoped to devote their lives to fundamental research were forced to become **migratory laborers** if they wanted to remain in academia… (page 4).

Today we read that "***Harvard Narcissists with MBAs Killed Wall Street***" (Kevin Hassett) . The narcissists are those who wanted to be not "doctors or engineers," but investment bankers. The phenomenal success of former migratory laborers attracted to Wall Street "the best and the brightest" (I found no proof that they were either the best or the brightest) who, armed with Harvard MBAs , pushed out "people randomly selected from the population" who used to lead Wall Streets through all perils.

The author of the above catchy anti-intellectualist phrase hints that the Harvard graduates led by "cocky Harvard- trained lawyer, Barack Obama " can ruin whatever "the squinty-eyed president of the United States, George W. Bush (Yale BA, Harvard MBA)" spared.

The migratory laborers would not flock to Wall Street if not for astronomically sounding rewards offered upfront.

What does it tell me? That Wall Street attracted the "narcissists" the same way the Department of Defense projects had attracted them before 1970 (and afterwards) because **market is a war for survival**. What a great example of a pattern! Wall Street believed that if the geeks had invented the nuclear bomb, they could invent a market bomb. And the geeks promised. And they did. And they successfully tested it a few times on the Street. And each time the Wall fell tumbling down. And was rebuilt.

"Revulsion with science" for whatever reasons never ever pays off.

(4) What else happened in "LXX" : "1970" ?

> Until the early **1970**s, exchange rates were legally fixed, the price of oil varied over a narrow range, and the overall price level rose by no more than 3% or 4°o a year. The abrupt appearance of new risks in areas so long considered stable has triggered a search for novel and more effective tools of risk management. (Peter L. Bernstein, Against the Gods: The Remarkable Story of Risk, John Wiley, 1996. p.305)

> In the spring of **1970**, Scholes told Merton about the troubles he and Black were having. The problem appealed to Merton immediately. He soon resolved their dilemma by pointing out that they were on the right track for reasons they

themselves had failed to recognize. The model was soon completed. (*ibid.*, p.312).

End of digression.

February 24, 2009

THE RISKY CHEMISTRY OF RISK MANAGEMENT continued

Back to **Question 3**: **What is risk from the point of view of chemistry?**

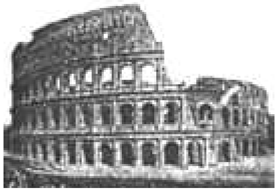
I will summarize here point by point what I have already touched upon throughout this diary, **Part 1**, and Essays 51 to 56. What I see through my small window of reading and observation seems to confirm my preliminary speculations.

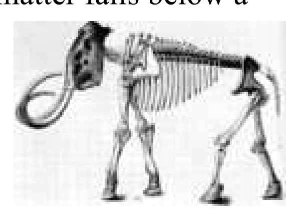
1. Whatever market risk had been, it took a new form and became a problem by "1970". LXX was the breaking point in the evolution of economy. The essence and significance of LXX is not yet completely clear. It could be intuitively characterized as the increase of the generalized temperature known in the markets as volatility. Regarding chaos, if entropy is a measure of the quantity of chaos, temperature is its intensity.

An econochemist would prefer to say, "The **change** of temperature is the measure of the **change** of intensity of the chaos. The **change** of entropy is the measure of the **change** of the quantity of chaos." This sounds ugly but keeps us on the safe side of the fenceless border between chemistry and physics: the side of definitions.

Molecular chemistry has no laws of its own: they all are from physics. In pattern chemistry "law" is what follows from definitions, although I suspect that this also universally true. Pattern chemistry has the right of domestic definitions. The physical terms like energy, temperature, and entropy, have different, although somewhat **similar** meanings here. Thinking in patterns means thinking in whole families of definitions, each being a configuration under a pattern. This of course, is not acceptable for any hard science.

2. Risk is created by volatility. It is no different from all natural risks from fire, water, wind, lightning, automobile, disease, war, etc. The essence of risk is the instability of human condition, which follows from the basic asymmetry of life: too much of a good thing is always good, but too little of the good thing can kill you. The same applies to all exystems: when the input of energy and matter falls below a certain minimum—metabolic cost—the exystem loses long term stability, and dies.





The ruins of ancient civilizations are skeletons of dead exystems. The Roman

Colosseum and a mammoth skeleton are configurations of the same pattern and either of the two pictures can serve as the ideogram. Shakespeare suggested the human scull. I have no objection, but it is politically incorrect to be a pessimist in America. Imagine that it is politically incorrect to be a woman or a man.

3. In the long run the survived exystem adapts to a new condition: it evolves. Thus, the fall of the Roman Empire was the end of neither its population nor European civilization. The end of the mammoth was not the end of the *Elephantidae* family. As for *homo sapiens*, it had adapted to both desert and tundra. As for Wall Street, the Wall fell many times, but the Street has survived.

Survival or adaptation, none is ever guaranteed. Adaptation may end up face against the brick wall in a dark cul-de-sac.

4. We never know how much wealth is in the market or in anybody's hands. We can only measure its changes.

Our thermometer does not measure heat: it measures the change of the volume of the liquid in it. Our bathroom scales measure not our weight, but its day to day changes. It is the units and calibration that make the impression of absolute quantity. →

France, May 2008, gasoline, € per liter. 1€ = $1.55

5. Since the econochemist believes—for the lack of conflicting evidence—that nothing can be destroyed without change into something else, "destruction and creation of wealth" does not make sense. Neither does any "creation," other than as figure of speech. Markets fluctuate and drift in different ways depending on the time scale. They are multifractal: the observed behavior depends on the time scale and does not always repeat itself from scale to scale. Strictly speaking, only multifractal systems with regularity are predictable. We never know, however, how regular an **exystem was** until it is transformed or dead. Compare with Solon/Aristotle: no man should be counted happy until he is dead.

> **NOTE:** As an example, I refer to the chosen at random work *Forecasting Multifractal Volatility* by Laurent Calvet and Adlai Fisher (1999). They write: "We assume that the forecaster knows the true generating process with certainty, but only observes past returns." This statement is the formula of deterministic fatalism, in spite of the probabilistic approach. It is the same as to say "We assume that there is nothing new under the sun." Compare this with what Einstein wrote in 1910 (see **February 9, 2009)**.

There are plenty of market palm readers who try to extrapolate market behavior into the future. In the short run it mostly can be done, but, starting from some range of prediction, it is impossible. The situation here is similar to weather prediction. Weather, as far as I know secondhand, is fractal. As for the climate, I believe it is not.

6. On large enough time scale, any monotonous trend ends. On the human scale, there is no unlimited growth in nature. Moreover, exystems, as all open systems, are irreversible. Much simpler open systems, for example, the liquid flow through a tube, are reversible. By increasing the pressure we reach a critical point, characteristic for each particular liquid, pipe, and pressure, when the smooth laminar flow becomes turbulent and the resistance to the flow sharply increases. Energy is lost on turbulence.

7. The problem with illiquidity? Liquid dynamics is a bone dry but amazingly instructive area of engineering. What would a physicist say? The onset of turbulence can be predicted by the famous **dimensionless (!)** Reynolds number which includes only a ratio of measurable parameters. I remember how I was amazed by that in my college years. Many decades later, market "liquidity" clicks in my mind as liquid "liquidity."

I wonder if anybody has ever tried to find something like the Reynolds number for the markets and economy. It would signal the approach to dangerous turbulent areas of trading where energy ("wealth") turns to thermal waste ("loss"). If not, fluid dynamics geeks, you can try. Wall Street may reward your success before squeezing you dry.

The Reynolds number for a tube is simply the ratio of the throughput of the fluid to viscosity (**V**: fluid velocity; **D**: tube diameter; μ : fluid viscosity; ρ: fluid density):

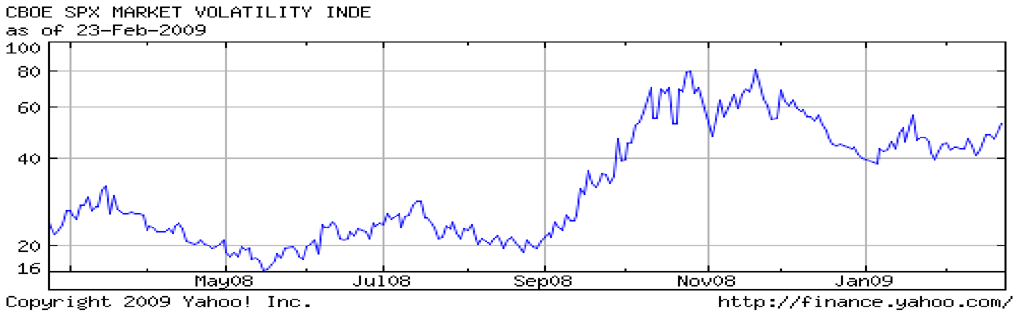
$$\mathrm{Re} = \frac{\rho V D}{\mu}$$

Isn't illiquidity similar to "fluid viscosity?" Anyway, viscosity is the measure of illiquidity or "influidity" in physics.

> Osborn Reynolds (1842 –1912) found his number from experiments guided by theoretical considerations. Later it was shown how it could be inferred from hydrodynamic equations. On history, see: N. Rott, *Note on the History of the Reynolds Number.* There are other critical numbers: Prandtl, Peclet, etc.

A dimensionless criterion of behavior is an impressive pattern. Reynolds number works also in magnetohydrodynamics, as well as in… horse racing.

8. What is the reason that we can always predict what happens to a fluid in a particular system when the flow increases, but cannot predict when the market will go into turbulence? Market turbulence shows in the volatility index VIX. Here is the dramatic chart of the Great Volatility 08/09:



The simplicity of water is the reason. Behavior of water consists only of collisions between molecules and with the hard inner surface of the tube. The molecules have only short-range interactions.

The behavior of investors—and exystems—greatly contrasts with the behavior of molecules. The investors have memory of previous market history, can announce their positions in advance, on a short or long notice, are aware of the behavior of distant players, and have information about the properties of the market as a whole. Depending on strategies and circumstances, they can plan in advance or have no time at all for analyzing the unstoppable—until the bell—flood of information. They form a network of relations which is not fractal either in space or in time and is full of long-distance interactions, quite like the spider web.

The completely "unnatural" phenomenon of private possession of wealth is most important of all: each market "molecule" either carries its own energy source of limited but potentially very large capacity or borrows energy from a "socket in the wall." Some of them also have access to a different kind of treasure: insider information, supposedly even more private than private property. Besides, everybody is under the spell of interest rates set from outside the system. Tsallis entropy (and other versions of entropy) was intended for such systems, although I cannot imagine how it could be **realistically** calculated.

9. One of the definitive principles of pattern chemistry is perception of generalized **energy as measure of instability.** At the same time, the common concept of convertible into work physical energy is reserved for the concept of **resource**. The energy of the sun, food, wind, tide, and mineral fuel is the resource which can be used for both stabilization and destabilization. Every exystem is part of the physical world but its evolving complexity is beyond traditional physical methods based on axiomatically closed mathematics. I vaguely foresee mathematical methods with open axiomatics, tuned up to human matters, but they require a massive chemical shift in thinking. I see Pattern Theory (Ulf Grenander) as a prototype of such methods. Note, that pattern is an open **family** of configurations; addition and deletions of members, even adoptions, are natural for family.

Our world cannot be completely irregular and chaotic, but however sophisticated Einstein's God is, even He does not know all about the future. What follows, the super-heavy market molecules with highly concentrated "wealth" are the source of high instability because of the nature of wealth as energy. Having entered the game with the purpose of increasing wealth, the big players inadvertently increase instability.

Figure A11, Income inequality revolution in 1970 (November 17, 2008) is my major support for my understanding of our bubbly era of champagne and agony. The advent of new means of concentration of wealth and the general acceleration of the flow of energy and matter through the narrowing tubes squeezed by world competition invokes the image of turbulent flow. **Figure A 21** illustrates the situation.

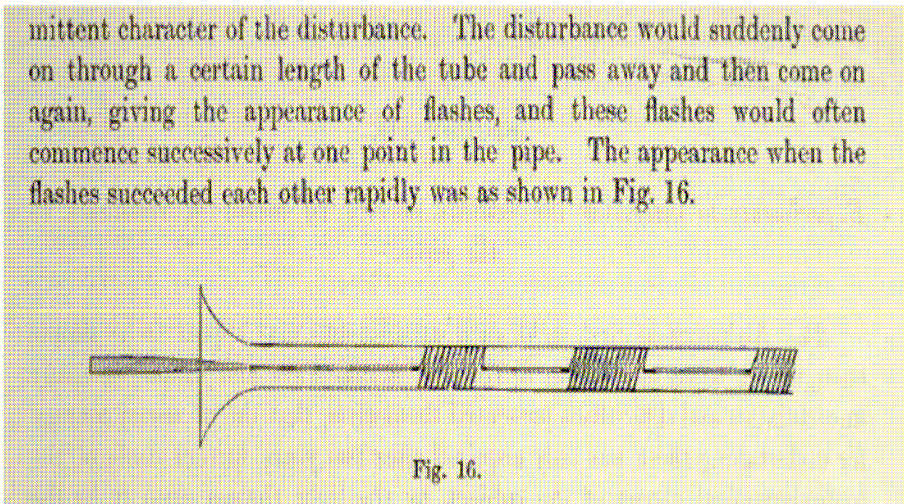
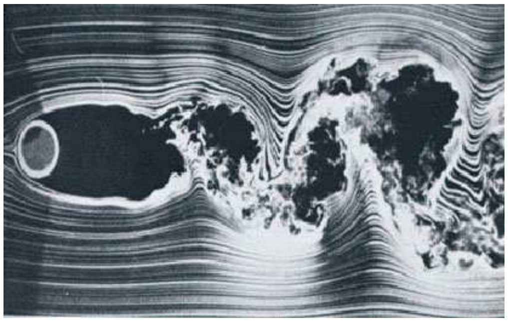

mittent character of the disturbance. The disturbance would suddenly come on through a certain length of the tube and pass away and then come on again, giving the appearance of flashes, and these flashes would often commence successively at one point in the pipe. The appearance when the flashes succeeded each other rapidly was as shown in Fig. 16.

Fig. 16.

Figure A 21. **Illustration from Reynolds' original paper. A dye is injected into the flow left to right. Note the commentary above.**

Compare **Figure A21** with the VIX volatility index chart for the last five years:

10. I am far—but not too far—from seeing a pattern similarity between fluid dynamics and market dynamics. The very use of the world **turbulence** when describing markets suggests that turbulent flow is an ideogram. But I am not satisfied with a distant similarity. I am looking for some kind of mechanism explaining why the MMMs—money making machines—work smoothly for a while but suddenly create a spasmodic market disruption (*crescendo interruptus* , to combine the modern and ancient versions of the same language that gave me the name for my web site). As quants seem to agree, the anti-risk devices repackage risk and unload it on somebody else within the market and even outside, for



Turbulence

example, resulting in unemployment. Since risk is measured in the currency of wealth (= energy, stability), it cannot be either created or destroyed: it can be only converted. How is it done?

11. Here comes a moment of possible confusion and I have to repeat my disambiguation: by chemistry I mean pattern chemistry, which is (today) anything but academic science. It is just a series of separate takes on the problem of understanding exystems.

One of the tenets of pattern chemistry is that there must be a serious reason why exystems are so forbidding for hard science (physics, chemistry, economics, even systems theory). The academic study (to avoid the word **science**) of exystems is in principle controversial, non-consensual, and non-experimental and, therefore, like history and arts, cannot be a subject of traditional hard academic science. Bluntly, the future of a complex evolving system is beyond what is today understood as science. Either the concept of hard science should soften up, expand, and give room for exystems, or the study of exystems should harden into some consensual form. As for experimentation, we should be satisfied with a comparison of past predictions with former future turned into recent past.

The second way, which does not contradict the first one, is the acceptance of patterns instead of configurations and, next, ideograms instead of templates. This is close to thinking in metaphors and analogies. It smells of classical German philosophy, is typically alien to academic science, and is viewed as reserved to teachers and charlatans. New ideas, however, always meet resistance and even the great Black-Scholes paper was rejected by most journals in the field. With hindsight, it was a quite reasonable thing to do.

I anticipate the confusion to come from my use of the word "entropy," although hard scientists could also cringe at my use of the terms **energy**, **stability**, and **temperature** and all economic terms.

To expiate my taking liberties with entropy, I want to point to a precedent in the hardest natural science of all: physics.

Constantino Tsallis ends one of his papers on non-extensive entropy with APPENDIX: "Scene at the restaurant *AU LABYRINTHE DES ENTROPIES.*"

> — Would you have some fresh entropies today, for me and my friends?
> — Absolutely Sir !
> We have them extensive or not, with definite concavity or not, nonnegative defined or otherwise, quantum, classical, relative, cross or mutual, included in several others with a small supplement, composable or not, expansible or not, totally optimized or a little rare, even completely out of equilibrium... single-trajectory-based or ensemble based...

There is much more on the menu of this French restaurant, check it out! The quoted Thsallis' paper is entitled: ENTROPIC NONEXTENSIVITY: A POSSIBLE MEASURE OF COMPLEXITY .

Entropy is a pattern, not a single configuration. I have the right to select my own template.

> [**EDITING REMARK**. The rest of **Part 2** is a record of slow, painful, and tortuous movement toward realizing what can be a pattern-chemical equivalent of the entropy of classical thermodynamics. I am giving here my answer, so that the impatient reader will be spared the trouble of cutting through the cerebral jungles. But then the questions—the true stepping stones of understanding—will be lost. Anyway, the answer is: **pattern order**, measured by **inequality of distribution** of pattern energy, matter, and temperature over the size of the exystem. How can it be that order is more abstract than entropy, which is synonymous with disorder? You can still step into the jungles.
>
> Only while editing **Part 2** I realized that the concept of chemical potential, introduced in 1873 by Josiah Willard Gibbs, one of the deepest chemical thinkers, is a distant molecular-chemical prototype of pattern order. In my interpretation, it is the measure of the increase of instability by imposing a **chemical** change. This deeply rooted in physics subject, however, is beyond my competence].

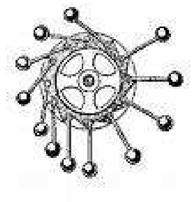
February 26, 2009

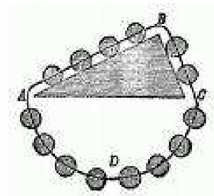
12. In short, my **intuitive** understanding of the nature of market jolts since the invention and spread of market insurance is that the earth trembles because quants are tinkering with its future in the epicenters.

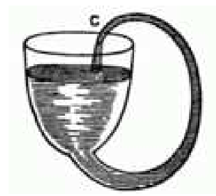
> Quant : "A **quantitative analyst** is a person who works in finance using numerical or quantitative techniques." – Wikipedia.

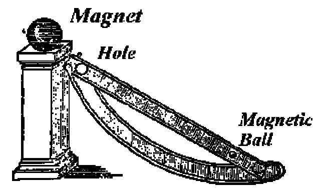
Such techniques are impossible without computers, The repetitive failure of investment insurance is one of numerous consequences of digitalization of economy and marketization of higher education and academia.

From the chemical perspective, I would compare perfect investment insurance with *perpetuum mobile*, perpetual motion. Let us call it perpetual motion machine of e-kind. The "*e*" prefix stands for "economy," or "electronic," or "enrichment"—whichever you like. At least three older kinds of perpetual motion are known. Examples of the 1st kind, the oldest one, are below.

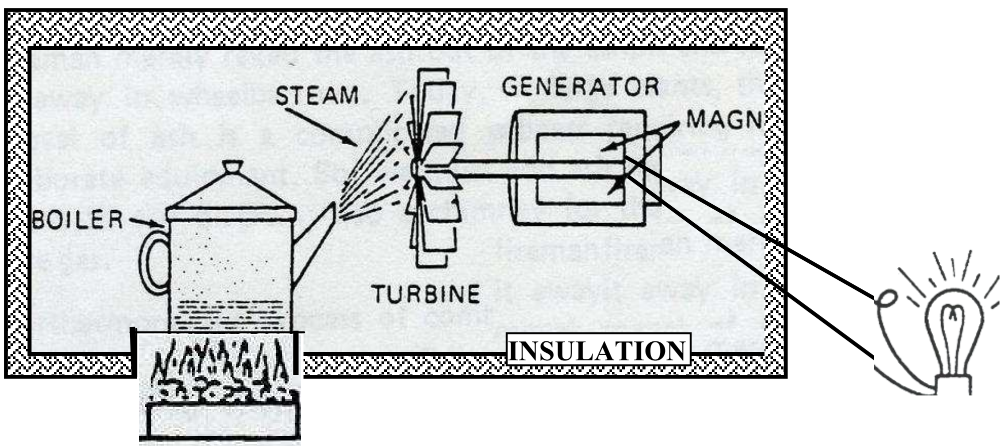








The machine of the 2nd kind is surprisingly difficult to picture. There is no consensus about what it is, either. It is not so much perpetual as nonsensical. The following picture is my version, not necessarily correct. It continuously extracts useful energy from an insulated container with a tank of boiling water inside. The tank is heated from the outside, but the catch is that the machine itself is inside the same container together with the tank and cannot dissipate heat.

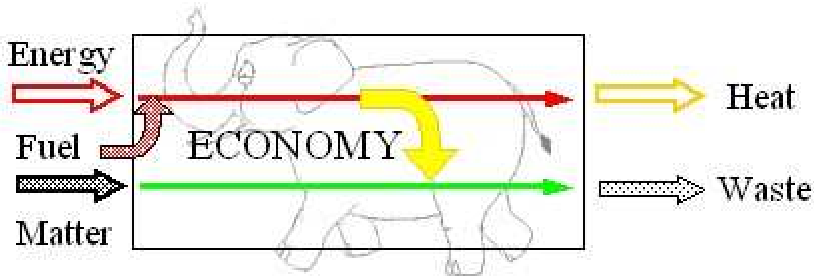


There is also the impossible machine of the 3rd kind: any machine that uses a source of energy and performs work without any loss. This is closer to economy: "loss" already sounds pecuniary.

The perpetual investment of e-kind generates wealth for years without even a single week of loss—OK, a month, damn it. This pipe dream of ultimate greed does not contradict, however, the law of conservation of energy: economy has its due source of energy and matter, as well as the proper receptacle of waste, at least for a while.

I regard the impossibility of the e-kind as the first cornerstone of the econochemical foundation, even though I have no charts to present as evidence: in all honesty, the evidence of impossibility is impossible to procure. The cornerstone is buried so deep that most hands-on economists seem to have forgotten about it.

I reproduce here **Figure 11** from my **Essay 56, From One, Many**.



Note that from the point of view of chemistry, money circulates inside economy and expressions like "injecting money into failing economy" or "economy generates enormous wealth" make no chemical sense. Neither wealth nor value does, for that matter. Money has no value outside economy. It circulates inside economy like ATP inside living organisms. Monetary values and market data are reflections of economy on the wall of the Plato's cave.

> If the market got the value of Bear Stearns so wrong, how can it possibly believe it knows even the approximate value of any Wall Street firm? (Michael Lewis, in *Panic*, p. 342)

The following quotation from the "Perpetual motion" entry in Wikipedia looks into the issue in a very general way. The emphasis is mine. To reinterpret the emphasized words chemically: "so long as the universe does not evolve as an exystem."

> The conservation laws are particularly robust. Noether's theorem states that any conservation law can be derived from a corresponding continuous symmetry. In other words, **so long as the laws of physics (not simply the current understanding of them, but the actual laws, which may still be undiscovered) and the various physical constants remain invariant over time — so long as the laws of the universe are fixed — then the conservation laws *must* be true,** in the sense that they follow from the presupposition using mathematical logic. To put it the other way around: if perpetual motion or "overunity" machines were possible, then most of what we believe to be true about physics, mathematics, or both would have to be false. **However our belief is that mathematics is absolute: its veracity is not dependent on anything that happens in the real world.**

It is the economy, stupid, and economy is not just ticker numbers: it is our real world of nested dolls from atoms to the solar system!

13. It is time for clarifying the meaning of entropy in pattern chemistry. Whatever changes entropy in any part of economy (or any system) changes it overall in the same direction. I declare it, almost seriously, as the principle of relaxed extensivity: increase of entropy of a subsystem cannot decrease the entropy of the system.

> What is "almost seriously?" It is not a joke. It means "with relaxed seriousness."

First, about the consequences of increasing (or decreasing) entropy. In physics and molecular chemistry:

$$\Delta G = \Delta Q - T*\Delta S$$

The change of Gibbs energy **ΔG** equals the change of heat **ΔQ** minus temperature **T** times the change of entropy **ΔS.**

Obviously, this applies only to a closed physical system, which the market is not. I want to drastically relax this equation into a very general qualitative principle of pattern chemistry. For the second cornerstone of pattern chemistry we need something like:

If the exystem maintains its level of stability, temperature and entropy are related inversely, while either of them and thermal waste are related directly.

This is not some kind of law which needed a genius to discover: it is a consequence of definitions of the basic concepts of generalized energy, temperature, entropy, and heat.

> Josiah Willard Gibbs (1839 – 1903), who contributed to the definitions and their understanding, was one of the creators of modern chemistry. He and Svante Arrhenius (1859-1927) in Sweden prepared the theoretical foundation for the much later concept of transition state, which is the third cornerstone of pattern chemistry.

As for entropy, I am going to cook up my own opposite of entropy: "anti-entropy" for which I prefer the plain vanilla term **order**.

I am certain that with few exceptions of minor importance, the very word **entropy** is misleading in economics unless it is just a metaphor. By **order** I mean a whole pattern family of concepts corresponding to what we understand as organization, architecture, mechanism, or any structure emerged either in the process of natural evolution or enforced by human mind, determination, and work. It is the very essence of the birth, life, and death of exystems. Low entropy means high order/organization; high entropy means low order/organization and high chaos. By the way, order has two handy meanings: the ordered state and the order (command, effort) to establish and maintain certain order. The function of management and government is both.

I am interested in the order contained within the system. The term *syntropy* was suggested for that, see **Syntropy: Definition and Use** by *Mario Ludovico*. For more, see the Syntropy journal. It is an interesting topic, but I abstain from digressing at this point. I wish to add only that syntropy/negentropy is understood as both the degree of organization (order) and "the pressure exerted by someone or something to keep inner order (Silvia M. Grinberg), "i.e., order as template and order as control.

Those who are interested in the application of thermodynamics to economy and society can find a relatively limited spectrum of publications on "economic entropy" and "social entropy." This direction of thought is not yet influential. I wish it could change, although

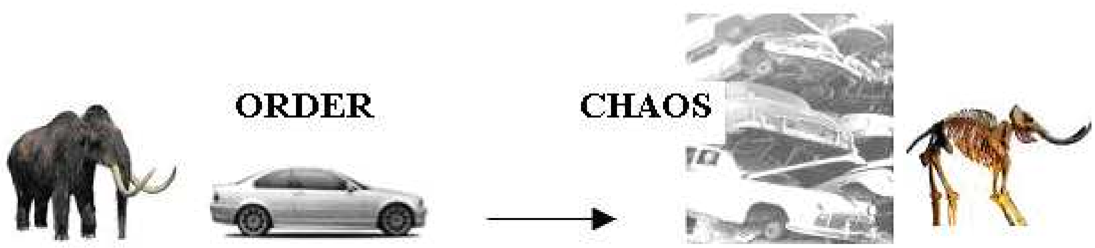
I realize that a kind of Tennessee (or Kansas) clash with Darwin could ensue. (By the way, Darwinism is one of few universally accepted theories about unquestionable, but directly unobservable facts). There is also a factor of economics: while the quant charges an arm and a leg for arcane programs, the "entropist" cannot charge a lot of money for what the client can understand on his own. (Economics is mangy with cynicism and I have caught some germs!)

I see a lot of confusion around the application of classical and statistical thermodynamics to economy, although the confusion could well be only mine. I believe that physical thermodynamics is of very little use for pattern chemistry. See entry of **February 9, 2009** for some of the reasons. Incompressible complexity is incompatible with statistics and, I dare say, with physics itself. As for mathematics, as we know it, I simply do not know. If there is any trace of order and regularity, mathematics will sniff it out.

The equation $\mathbf{\Delta G = \Delta Q - T*\Delta S}$ suggests something important, but what is it? I believe that exystemology needs a high level generalization of thermodynamics, probably, beyond recognition by physicists. For example, this looks like a sample of Medieval scholasticism, but I swear it is meaningful:

The measure of instability consists of two components: measure of chaos and measure of order.

In physics and molecular chemistry chaos and order are two names for the same thing. They relate to different wings of the scale of chaos/order. In economy, however, chaos and order take tangible, diverse, and complicated forms. I reproduce here a part of **Figure 6** from Essay 56: From One, Many as an example, in which neither order nor chaos is complete, though. I accompany it with another juxtaposition where exystemic chaos looks more ordered than order.



14. How can it be that an increase of either order or chaos increases instability? It is because both are different ("complementary" along Mario Ludovico) forms of organization. If it seems confusing, it is. I quote Mario Ludovico to illustrate the confusion:

> In my view, and allowing for the historical origins of the word, the appropriate meaning of "syntropy" is the "degree of internal organization" that characterizes any system of events. This is basically the sense the word was given by Italian mathematician Luigi Fantappiè (1901-1956), who did also coin the word.

> I deem it impossible to grasp the concept of *syntropy* without having assimilated the concept of *entropy*, since – as I'll try to show – not only are the two concepts in a strict mutual connection but *entropy* and *syntropy* are also *complementary* concepts**:** In other words, where it is possible to measure a level of entropy there is a *complementary* level of syntropy.

I gladly accept "system of events" because chemistry is about events, not artifacts. Yet I do not think that entropy and syntropy are two things: they are one: degree of organization, order.

The word "event" is the key to a possible clarification. Event assumes time. Chemistry—as well as human history—emphasizes the distinction between short run and long run. In the long run, organization falls apart and dissipates, while in the short run we need energy to increase what we call either chaos or order, or both. The classical thermodynamics, however, does not know any short run: it stipulates equilibrium as the final state of any isolated system, although no such system can be found within the solar system. The refrigerator and oven, usually found in the kitchen, both require energy and both are open systems.

> **NOTE:** In the quoted paper, Mario Ludovico defines syntropy as difference between the maximal possible entropy characteristic of equilibrium and the current entropy, tacitly assumed in a non-equilibrium state. This implies the distinction between long and short run. See also: Negentropy.

Again, I see thermodynamic parallels in economy, but not direct universal applications. As usual, I recur to illustrations.

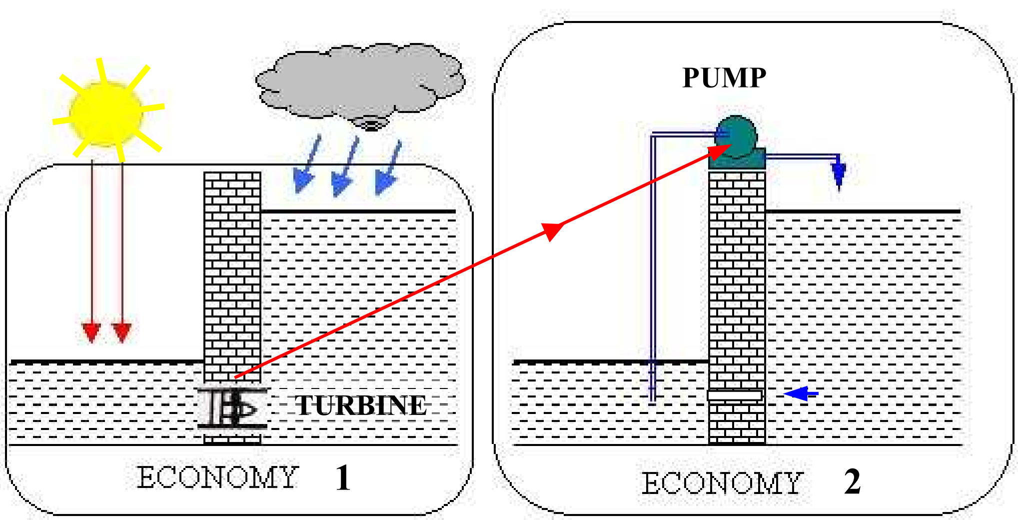


Figure A22. **Use of energy for maintaining instability**

Figure A22 consists of two parts, each depicting a dam maintaining different levels of water on its sides. The left picture is a metaphor of global economy: practically inexhaustible resource of sunlight evaporates water at the warmer side and the vapor condenses at the cooler side. This is how rivers originate and flow.

The left dam with a turbine and generator produces electric energy which is used for maintaining the difference of levels across the right dam with a leak channel close to the bottom. Both dams are artificial man-made structures. However solid, robust, and devoid of motion, both are potentially unstable. They need maintenance, oversight, and protection, especially the turbine, generator, and the pump on top of the second dam.

The meaning of the **Figure A22** is that energy **artificially** produced from a **stable external natural source** on the left is used to maintain the **instability** (a stock of potential energy) of an **artificial** construction on the right. If the supply of electric energy stops in Economy 2, the water on both sides levels out. The micro-economy 2 , therefore, is a part of the macro-economy 1. We can speak about the fractal structure of economy in this sense.

15. How can we deal with the enormous complexity of exystems?

With time, when our civilization completely digitalizes, there is a chance that it will become a giant machine with humans as tiny bolts, nuts, and cogs, as in the dream of Joseph Stalin, which he expressed using the word *vintik*, a small screw.

> I toast to the simple, plain, modest, people: the little screws that keep active our great state mechanism in all branches of science, economy, and the military. (Joseph Stalin, Speech on June 25, 1945)

Until the rebellious human nature drastically changes or is subjugated by obedience pills, this kind of picture looks relatively distant, as the Russians say, “there, over the hill.”

On this side of the hill, digitalization already causes a sharp discord between the relative freedom of computers from the heavy constraints which thermodynamics imposes on humans. For computers there is only short run. For humans life is short and the hard progress of understanding is slow. History, however, is long, which makes it a good laboratory for involuntary experimentation with the categories of long and short, a market of a kind, if you will, where you bet on your life, like in Russian roulette.

Chemistry, all the more, pattern chemistry, appeals to vision and imagination. In order to represent complexity I use diagrams, photos, and ideograms **as a molecular chemist uses chemical formulas**. In this way I stay within the human scale. A few pictures follow.

The same large economy that uses natural sources, creates artificial structures, and maintains social and technological stability, can plunge into chaos and wreck its own robust static creations, not to mention dynamic ones. **Figure A23** illustrates this kind of large scale change. In picture **1,** I attempted to recreate something like the construction site for the Roman Colosseum.

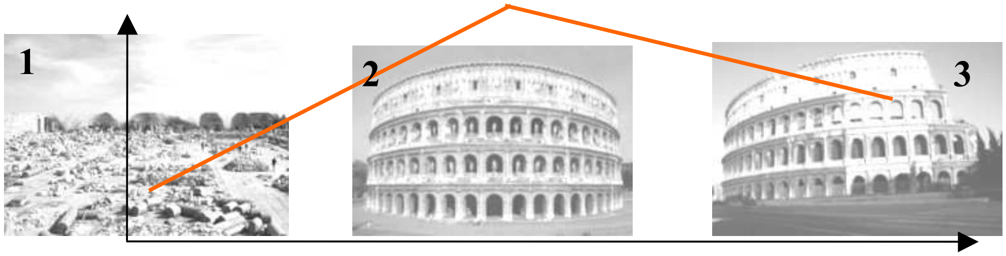


Figure A23. **Creation and loss of order : construction site → completion → decline**

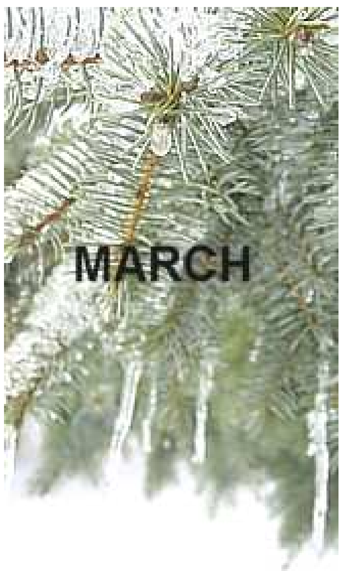
Obviously, a lot of energy—exclusively in the form of food!—was used for building the Colosseum. Same source of energy was also used for partially destroying it at a different historic period. Today energy in the form of food, fuel, and electricity is used to preserve what remains.

Figure A24. **Vandalized foreclosed homes, 2008-2009**

Pictures in **Figure A24**, spread all over the Web, show vandalized foreclosed homes. This is how the component of chaos looks in overall economy. A chemist, thinking in patterns, puts the half-ruined Colosseum and the homes on the photos **in the same pattern basket.** Both order and chaos stay in the global economy because they are the same: the measure of instability/stability. Economic waste can be if not reversed then reconstructed into order if enough energy and will is available.

What has happened to economic maintenance, oversight and protection? This is not quite a rhetorical question. Before coming closer to possible answers, I will pose another question, this time a rhetorical one: If the government is the problem and if the government is cut to the bone, federal taxes nixed, and Rush Limbaugh elected President , what is going to happen to the American economy?

Actually, there is an answer: relapse into feudalism.



March 3, 2009

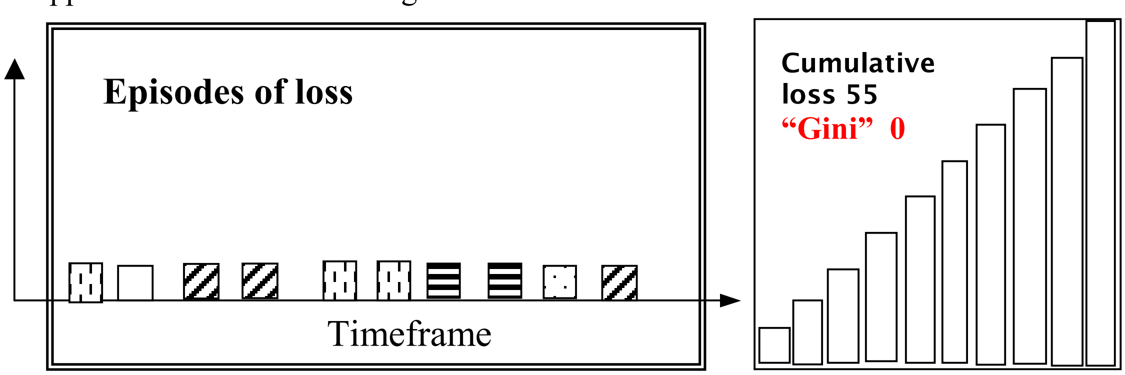
16. The work of a risk manager, as I see it, consists in smoothing the distribution and so reducing the surprise and danger of market loss. It can be done by creating a machine similar to the wealth pump but with the opposite effect of decreasing inequality instead of increasing it. I mean inequality of risk in a **system of events**. This concept of risk management is not limited by market.

The idea was hinted to in the entry of **November 23, 2008** and **Figure A15**: **Entropy (S) and Gini for different quintile distributions**.

Let us consider several events of "wealth loss" within the same **timeframe**. I portray them as rectangles (bars) of the same unit base and a whole number of units height. The loss equals the area of the rectangle. The events ("episodes of loss") occur at different times within a selected fixed interval. The total loss in **Cases 1** to **5** is always 10.

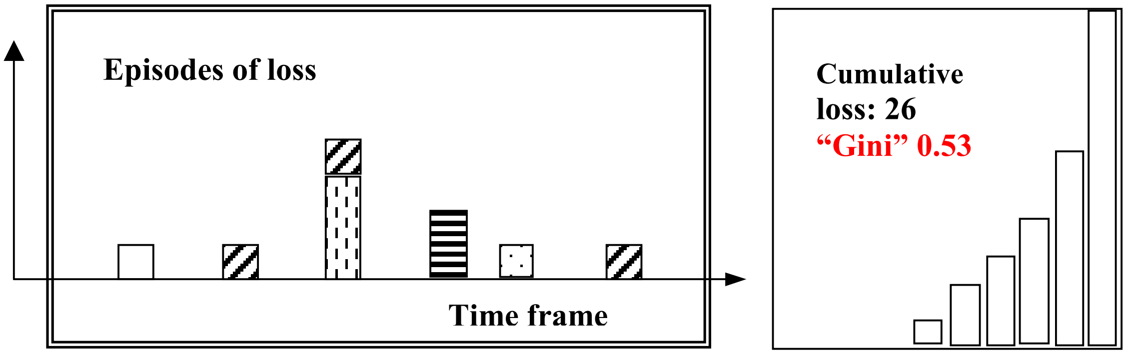
Case 1.

Suppose we have the following distribution of losses

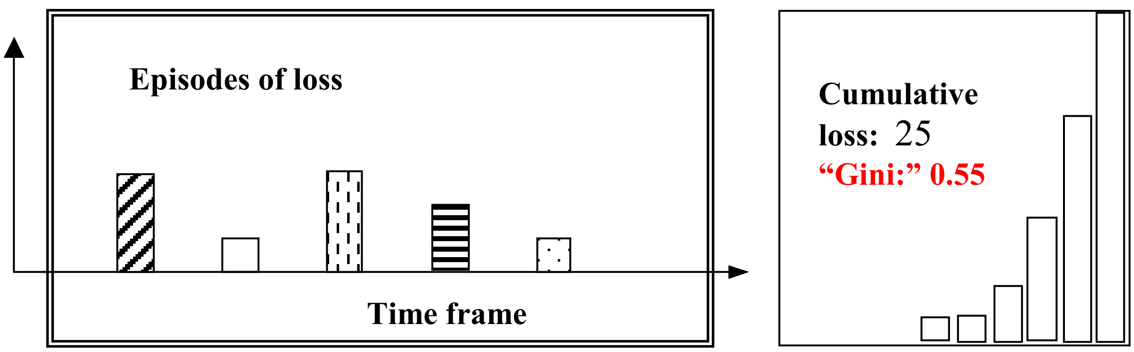


The purpose of the risk management is to prevent high spikes of loss which push the system down to the metabolic cost. **Case 1** is the ideal situation: the unavoidable loss of 10 points is distributed evenly. Each episode is of minimal danger. We are interested in the distribution of events by the size of loss. A cumulative diagram is shown on the right. Its Gini coefficient, which characterizes the inequality of distribution (statistical dispersion), is minimal: 0. I assume, maybe controversially, that the number of episodes is always 10, with some zero losses.

Case 2.



Case 3.



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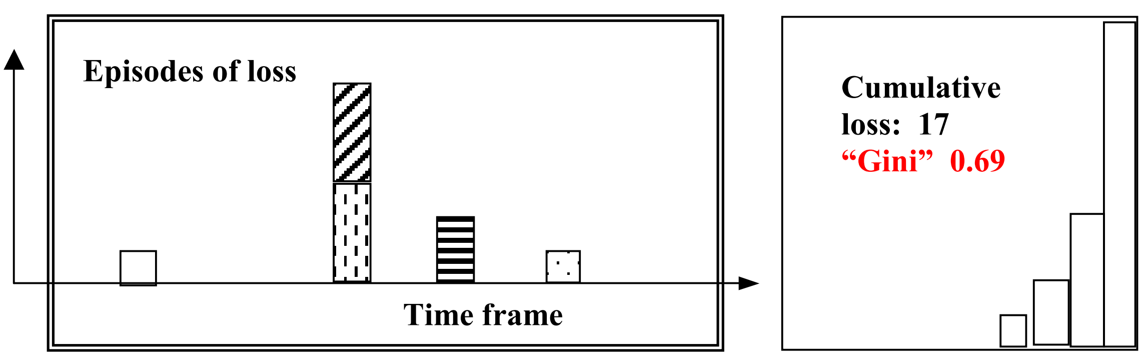

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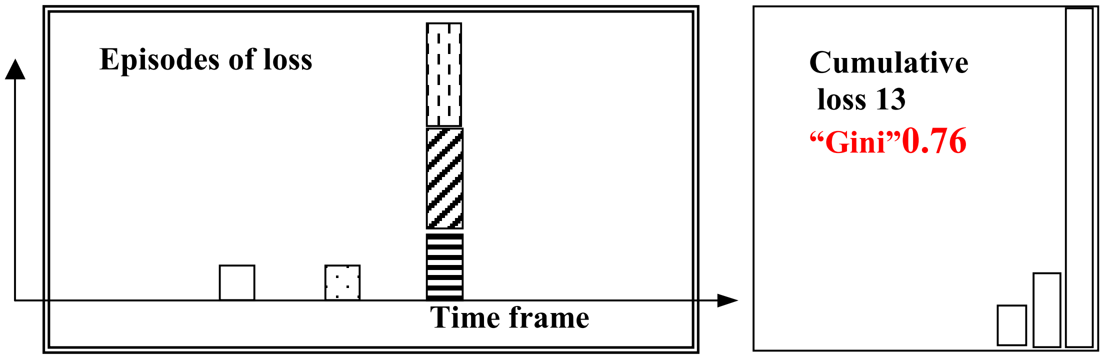


The five cases show that "Gini" of risk distribution more or less corresponds to our intuitive understanding of risk : the higher "Gini," the higher inequality, the higher the biggest single-episode risk.

Risk management should decrease the total amount of risk and fracture risk into small bits within the same amount.

Of course, my model is nothing but a totally imaginary and rather arbitrary manipulation with concepts, but it is the **pattern** of reasoning that I want to outline.

When we decrease risk by manipulating the market or its part, we **perform work** on the segment of market and its distribution of risk. In other words, we enforce an increases order on it. This "negentropic" or "syntropic" kind of order increases the overall instability of the manipulated market sector.

Order is anything that constitutes an **enforced** deviation from the existing spontaneity. To increase chaos, nobody needs to enforce anything. I find the fact that **redistribution** of certain quantity changes the stability of the system highly nontrivial, but this is natural in molecular chemistry.

Obviously, the wealth pump, humming since 1970 and blowing inequality of income out of any **normalcy**, inadvertently destabilizes economy, working in tandem with the portfolio insurance. I suspect that everybody who bought large volumes of mortgage securities added insurance to them, but I have not yet found a confirmation.

> **NOTE:** (1) Catalysis does not enforce either order or chaos, but speeds up the transition to a new state, whether more ordered or more chaotic.
> (2) Both **normal** (Gauss, bell-shape) distribution and equal distribution have the same minimal Gini 0.

In chemistry nothing can be either created out of nothing or destroyed without a trace. In the current crisis of 2008-2009, the government, whether Republican or Democratic, but not yet Theocratic, does the only thing the nature of things dictates**: it pumps more**

money into economy. Of course, as I have mentioned earlier, this expression is senseless: the money is not taken from the sun and wind, but borrowed from another part of global economy. I mean China, which is potentially even less stable than America because of the higher concentration of power.

> **NOTE:** The social consequences of economic decline and unraveling should be a separate topic. As is common in history, demagogues, strongmen, and dictators come with collapsing economy. The Russian default of 1998 brought Putin to power. For ten years it worked for Russian economy.
>
> **"**While large churches have flourished throughout history, early records show that the U.S. had about six large churches in the early part of the 20th century. That number grew to 16 by 1960 and then in the **1970**s, they began to proliferate and draw public attention" (USA Today) . Was it because of growing affluence, or income inequality, or both?

Exystems evolve along very intricate and subtle mechanisms which are not as static as dams and reservoirs but as dynamic as turbines, pipes, generators, motors, and computers. With the fundamental lack of consensus in human matters and in the historical perspective, it is difficult to blame either the arrogant culprits of the current crisis or its clumsy fixers. The problem is, however, that the government, by increasing the already monstrous deficit, gambles on the future of the nation along the same pattern as the sharks of Wall Street. I do not know whether there is any alternative, however.

What can we hope for? As I noted earlier, the human behavior changes near the level of metabolic cost. Simple and deep instincts take over. The same applies to institutions, corporations, and communities. The humans, not computers, are searching for the strategy of survival and tactical means of its realization. The Election 2008 show was breathtaking. The Great Depression 2 promises to be another one. While the sun supplies us with energy and fresh water (**Figure A22**), we can be optimists in the country as big and ingenuous as America. If only we knew in advance how much optimism we would need. Since politics is part of global economy, we need a lot.

17. What is the human biological metabolic cost, anyway?

Anne Applebaum in her extraordinary *Gulag: A History* (Doubleday, 2003) quotes a testimony of Thomas Sgovio, an American victim of the Stalin's slave economy:

> The wicks ["goners"] stood around the tables, waiting for someone to leave some soup or gruel. When that happened, the nearest lunged for the leavings. In the ensuing scramble they often spilled the soup. And then, on hands and knees, they fought and scraped until the last bit of precious food was stuffed into their mouths. (Page 336).

> The "goners," as Sgovio has explained, were not just ill: they were prisoners who had reached a level of starvation so intense that they no longer looked after themselves. This

> deterioration usually progressed in stages, as prisoners stopped washing themselves, stopped controlling their bowels, stopped normal human reactions to insults—until they became, quite literally, insane with hunger. (Page 337)

So much for the health of the broken little screws of the Soviet state mechanism.

Stalin died on March 5, 1953. Today his popularity in Russia is the highest since 1956, although most Russians have never lived under Stalin. This tells something about the power of historic patterns. They offer ready alternatives to unstable societies, as well as to unstable segments of stable ones. In America I see two such patterns: the Civil War and the Great Depression. They have re-emerged as the configurations of the Cold Civil War and the current economic crisis.

March 6, 2009

I come back to two remaining questions.

QUESTION 4: Is there any alternative to growing complexity?

The answer is obvious: simplification, starting with the US Tax Code and requirement to provide an English translation to any Legalise. Realistically we can expect that, when complexity leads to a series of disasters, an opposite trend will emerge. Unless there is a serious shock, the transition state is impassable. This is the third cornerstone of pattern chemistry.

QUESTION 5 "How can we manage a risk we do not know exists?"

The short answer is: by refusing to bet on the future as a whole. This is extremely difficult in the American economy of the virulent promise spread by aggressive advertisement in the culture of pathological optimism. Don't bet your ranch on promise.

(1) By self-insurance. Squirrels and other food-caching animals do it. Hibernating mammals do it with fat in the body. Santino, a chimp in a Swedish zoo, stocked stones to attack the visitors. Joseph, son of Jacob, did it. I did it by buying a house **only after** having first created a safety cash reserve. When both my wife and I had lost jobs, our mortgage payments stayed on schedule. Same applies to the entire society. Only not everybody can have a cash reserve.

(2) By watching the trend. Any fast and sharp growth means a pending crash. OK, but what can you do then?

(3) By keeping the social instability low through relaxing all kinds of inequality and stress.

Now, away from platitudes!

(4) By identifying the historically new large scale trends and arguing about them.

What is the most **potentially** dangerous **new large scale** trend that I clearly see?

The victory of Technos (man-made things) in the competition with humans.

I have called it earlier (**January 24, 2009**) the **thingization of humans**.

We (and they) will adapt. There is no logical argument for characterizing any adaptation as danger. By danger I mean the **suffering of the transition state**. Looking back into the past, adaptation is a blessing …if you are in the present.

The thingization of humans had started with slavery. It continued with wrist watch. It goes on with wireless handheld devices. Where will it go further? To conflict or to convergence? Things are learning to think. We are unlearning to think. There is more about that in my Essays.


David Levy

No time to think. NO TIME TO THINK. There is a growing literature on the subject of thingization. See David Levy's video. After having read selected sources on modern investment, I am firmly convinced that all or most high rank market participants and regulators knew the danger of derivatives and gambling on the future. There were at least three subjective factors in their somnambulism: (1) they hoped to exit the dangerous path in time and (2) they had no time to think and (3) they were personally well off and secure.

> Today, March 6, 2009, Google:
> Results **1** - **10** of about **545,000** for **"no time to think"**.

What is the fourth cornerstone of pattern chemistry?

Concentration of wealth and power increases instability of the system.

I suspect that the crisis of 2008-2009 is partly a consequence of deep political stagnation because of the concentration of power during the George W. Bush years, but it is up to historians to investigate that. Who was able to think had no time; who had eight years of time did not think.

Nevertheless, we should see the good side: an opportunity for change to the better. Yet because of the inherent lack of consensus in human matters, instability is objectively neither good nor bad. Note, however, that sharp inequality goes against basic principles of five major religions, which tell us about what is good and bad.

March 8, 2009

The concept of syntropy (Mario Ludovico) as a difference between maximum entropy and current entropy has been a productive push for me to complete this diary or, at least, to take a recess.

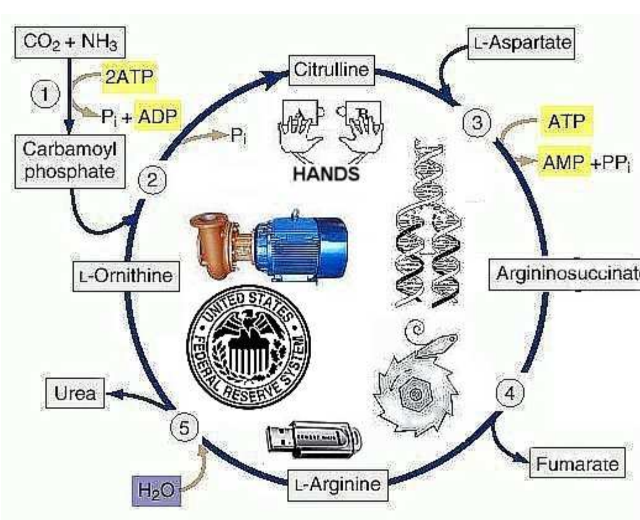
There is a whole menu of entropies. Similar but shorter menus exist for energies and inequality measures. This tells me that no consensus can be expected from direct application of thermodynamics to exystems. Non-equilibrium apart, a deeper reason is the necessity of having a detailed description of each system for defining its entropy.

The initial physical model for defining entropy was ideal gas. It had no ambiguities and complications and Boltzmann-Gibbs “normal” entropy could not be disputed. Gas, all the more, ideal—without memory, viscosity, chunks of goo, and slimy web of connections—cannot be a realistic model for exystems, however. What can be done instead? I believe that as the first approximation of an exystemic thermodynamics we can be satisfied with the simple principle:

In the short run, the increase of instability of an exystem consists of two components: increase of chaos and increase of order.

It is assumed that order in a closed system can never increase in the long run. What can cause the increase of order in a system open to energy but closed to information? I see the only possible answer: evolution, a highly non-physical, even “non-mathematical,” and certainly not creationist process which puts major exystems on track. It starts with Bios, i.e., living organisms, but even pre-biotic Earth could be seen as an exystem with solid landscape and plenty of chaos, as well as the powerful regularity of planetary rotation as a primitive template.

In order for the evolutionary machine to run on the external source of energy, the system needs the right mechanism. The clockwork mechanism (called “movement”) → consists of gears, spring, balance wheel, escapement, etc.



←The mechanism of economy (See **Figure A28**) includes a set of abstract parts, some of the **ideograms**:

resource, sink, metabolic cycle, pump, chemistry (generalized), structure, catalysis, memory, template, reproduction, etc. A full description of evolution in terms of ideograms would be an exciting adventure. Its Technos lingo can already be heard.

Evolution, like market, needs dangerous fluctuations in order to keep adaptation going. They can be of external, as well as of internal nature. From pattern-chemical point of view, exystems run not "on the edge of chaos" but on the edge of the sword: the edge of survival.

What is so chemical about that? Let us take a look at ← what a chemist is doing in the lab. He adds a reagent to a mixture of other reagents—like Galileo dropping a stone from the tower of Pisa—and only then the chemical reaction starts. →

The chemical reaction goes toward the state of equilibrium with the environment, although the chemist almost never waits until the equilibrium is achieved, which could take an indefinitely long time for reversible reactions without a catalyst.

Molecular transformation starts at the moment when the state of a prepared mixture or a pure reagent is sharply disturbed by the either addition of another reagent or irradiation, heating, a tiny speck of a catalyst, etc. Experimental molecular chemistry needs a human hand the same way wrist watch needs a hand to wind up the movement. The self-winding movement can be kept ticking by random or regular movements of the wrist, without using fingers. Similarly, the mechanism of life on Earth could be wound up by regular alternation of day, night, tide, and seasons, as well as earthquakes, fires, volcanic eruptions, and other irregular events. Same—has anybody noticed?—applies to trade, spread of inventions, geographic explorations, growth of the cities, institutions, companies, etc. The media are self-winding, too, forever in search of shocks and tremors convertible in sensations and rumors. Adaptation needs a change to adapt to.

Back to economy. To summarize, exystemic risk is caused by (1) proximity to the metabolic cost, combined with (2) high instability because of forcefully ("artificially") skewed distribution of some extensive parameter and (3) high enough degree of chaos. From this position, the principle of the instability change as the **combination** of changes in chaos and order looks like a very wide exystemic generalization.

I have neither right nor desire to say "sum" instead of "combination." I also prefer to use "order" instead of "syntropy" because I am not certain that both words mean the same and are used exactly the same way. Thus, I am doubtful about the possibility of exact calculation of absolute values in any exystem, which everybody tries to do. One has to deal carefully with human matters. This is ascribed to Einstein: "Not everything that can be counted counts, and not everything that counts can be counted." I found it in "*Enough: True Measure of Money, Business, and Life*" by John C. Bogle (Wiley, 2009), a stimulating book for a Buddhist.

Anyway, I acknowledge the primate of syntropy as a concept in exystemology. This is how it sounds:

> In my view, and allowing for the t historical origins of the word, the appropriate meaning of "syntropy" is the "degree of internal organisation" that characterizes any system of events. This is basically the sense the word was given by Italian mathematician Luigi Fantappiè (1901-1956), who did also coin the word.

It has been advanced by an **architect**: Mario Ludovico. whose ***Syntropy: Definition and Use*** contains many truly pattern-chemical remarks, for example:

> Substantially, with no change in the number and quality of the objects of the set, *order* and *disorder* are only *ways to compare* different combinations of relations between the objects.
>
> ……….
>
> As to any economic system, it is licit to suppose that the *boost to produce*, or the *cause* of the economic sectors' production, i.e., what could in general be referred to as "**the intent**" of the production activities, is in the *expectation* of *benefits***.**
>
> ……….
>
> In simpler words, the *actual transformations* in the system are those that imply changes in the system's *structure***;** as seen, this structure consists of *the set of expectations* (the *intents*) that works as an "engine" in the system. A sequence of convenient changes in the structure of the system is indispensable to the system's survival. In the evolution of any system, there is a series of crucial points, at which either the system changes its structure suitably or incurs its disintegration.

Any chemist working in the area of synthesis is an architect by nature. The analytical chemist does reverse engineering. The physical chemist is expected to say when the structure will be completed or ruined.

It takes time, energy, and template to increase organization and to build a segment of economy, to bring up a child, and to develop a new idea. When such ordered structures emerge not through long evolution but by acts of human will, they are inherently unstable **in the historically short run**. Syntropy is the measure of this instability. We never know, however, what maximum entropy of any complex system is. We can only trace the direction of change.

It is only a **postulate** that when we increase inequality of distribution and reshape it, with great efforts, from normal bell shape into the Pareto inequality, the exystem loses stability. **Figure A25** illustrates this transformation, but does not imply any instability of the cumulative distribution on the right. I believe, however, that it could be substantiated. I also believe that inequality is what distinguishes exystems from all other systems. In Darwin's language, winners are absolutely natural, while equality is not.

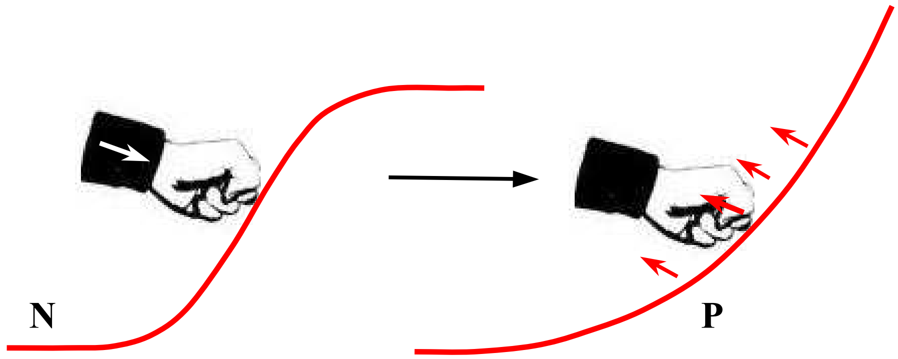


Figure A25. Cumulative distributions. N: normal ; P: Pareto (approximately)

We need to know intimate properties and structure of the system not only for estimating its instability on the way to acme, but also on the way down to demise. The self-inflicted "economic Pearl Harbor" (Warren Buffett) tells us that the architecture of American economy is vulnerable. I doubt, however, that there will be any consensus on the nature of the vulnerability. I see only one principal flaw, if it is a flaw at all: the human-driven economy has not yet adapted to the great digital cataclysm of LXX.

> **NOTE**: How ironic that the civilized American society is capable of behaving in a self-destructive way, crushing its own economy. Or was it the barbaric economy that trampled civilization? Warren Buffett: "the nation is engaged in an *economic war.* " Hasn't it been all along? By the way, war with whom?

March 10, 2009

Concentration of power and concentration of wealth are reciprocating forms of unequal distribution of an economic parameter. They result in the increased component of order in the thermodynamic balance of the exystem and, therefore, in increased overall instability.

The following examples reflect my surprise and enthusiasm caused by the discovery that, contrary to popular and my own expectation, not only chaos, but also **order** increases exystemic instability. It is much less surprising with the hindsight.

Example 1. **Trade and evolution of society**. The stabilizing effect of trade resulted from the double crisscross inequality of distribution of goods and wealth. Trade worked toward leveling out both. War and conquest were alternative ways of redistribution.
If so, has the trade with China a stabilizing effect? No, because manufacturing and consumption are not equalized but polarized. Distribution of world power, however, is equalized or even reversed.

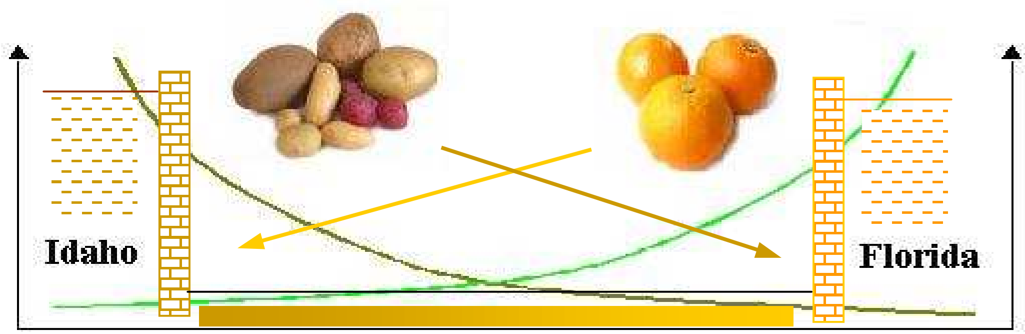


Figure A 26. **Trade reduces the stress of unequal distribution of resources**

Example 2. **Feudalism**. The contract relation between highly concentrated power and dispersed resources was the first step toward consolidation of European empires and, later, limited monarchies and democracies.

Example 3. **Militant empires**. The short-living empires of Napoleon (10 years:1804-1814), Hitler (12 years: 1933-1945), and Stalin (24 years: 1928-1952) were characterized by extreme concentration of power. At some moments of history, all three had found themselves in close proximity to the metabolic cost of their nations.

Example 4. **The Soviet Empire**. 70 years:1917-1987. The stability of the long—on the scale of modernity—existence of the Soviet Russia had a lot to do with the low inequality of income distribution as well as with the low social temperature maintained by political oppression. Political and economic power was completely concentrated in a few hands.

The distribution started to change during the last decade of the Empire's history. This is only my own surmise based on personal observations. I have no sources to confirm it.

A high inequality of income distribution in the shadow economy and the appearance of underground millionaires was one of several factors in the meltdown of Russian communism. The second factor was a realization by the Soviet power elite and their families of the enormous contrast between living standards of Russia and the West.

Example 5. **The separation of powers in America** is, apparently, one of the main sources of American political stability.

Delocalization of energy is a powerful factor of stability in molecular and pattern chemistry. Without concentration and localization, however, nothing can be done.

Back to chemistry—**pattern chemistry**: neither economics, nor econophysics, nor physics, nor molecular chemistry. I see the series of economic instabilities in America as a result of LXX. In 1970 the chemical reaction culminating in the current financial plague was started by dropping the catalyst of digitalization into the flask of American economy. No time to think anymore: the chemical chain reaction runs too fast and out of control. Still, thank God, it is not a nuclear chain reaction. Economy will adapt to computers and enter a quieter period until something else, not foreseen today, will plunk down into the chemical flask, emitting a lot of stink.

Next I am considering to combine **Introduction to Pattern Chemistry** with **The Diary of a Ferris Wheel Rider** and add an overview.

March 11, 2009

Last remark before the recess. I have tabulated 139 spending provisions in **American Recovery and Reinvestment Act of 2009** listed in Wikipedia.

Two examples of provisions:

- $70 billion: Alternative minimum tax: a one year increase in AMT floor to $70,950 for joint filers for 2009.[30]
- $15 billion: Expansion of child tax credit: A $1,000 credit to more families (even those that do not make enough money to pay income taxes).

Figure A 27 shows the cumulative distribution of expenses. Its **Gini** coefficient of inequality is **0.77**, which means a significant but not decisive concentration of expenses in a few allocations and, in my interpretation (Essay 53. Power: Hidden Stick, Shared Carrot), a somewhat ambivalent exercise of power. Although the tax relief takes the lion's share ($288 B of almost $800 B), it is highly delocalized because it spreads over millions of taxpayers of **wide income range** . It may seem from the chemical interpretation of power that tax relief is in general ineffective. On the other hand, it automatically concentrates if applied to a population with sharp inequality of income distribution. Then it works only for a small part of

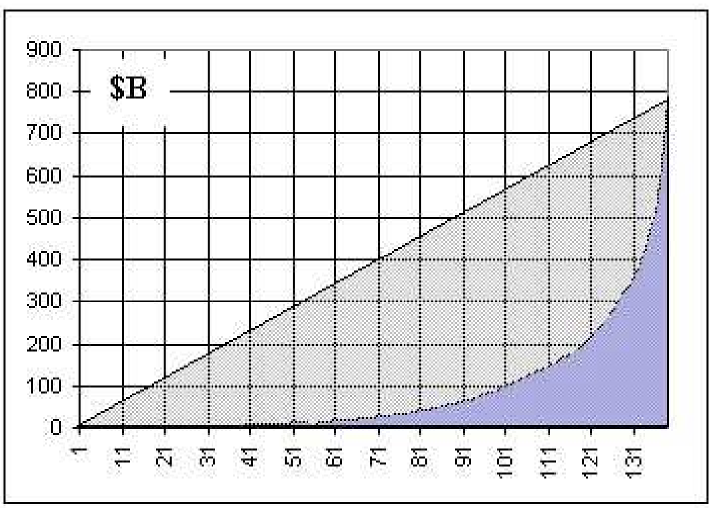


Figure A 27. **Cumulative distribution of expenses in American Recovery and Reinvestment Act of 2009** population: the rich. In other words, in agreement with common sense, for most earners the tax relief is irrelevant.

Is it logical to enrich the rich in order to stop an economic crisis? Yes, if you want to embolden them and make eager to take more investment risk, which was the reason for the crisis in the first place. I really do not know what to think, but I am—irrationally?—on the side of those who suffer. I have a selfish interest in it: mass suffering does not make the victims better people, but brings to power bad people. Why it did not happen in America during the Great Depression 1 (GD1) is a separate question. One possible answer: although radio was already there, no Rush-Limbaugh-like sound was heard.

The role of inequality of wealth distribution in economic destabilization is my current obsession. It turns out that the inequality of wealth distribution was cited as the reason for the GD1. Note the **pump** in the following quotation.

> *As mass production has to be accompanied by mass consumption, mass consumption, in turn, implies a distribution of wealth -- not of existing wealth, but of wealth as it is currently produced -- to provide men with buying power equal to the amount of goods and services offered by the nation's economic machinery.* [Emphasis in original.]
>
> Instead of achieving that kind of distribution, by 1929-30, a giant suction **pump** had drawn into a few hands an increasing portion of currently produced wealth. This served them as capital accumulations. But by taking purchasing power out of the hands of mass consumers, the savers denied to themselves the kind of effective demand for their products that would justify a reinvestment of their capital accumulations in new plants. In consequence, as in a poker game where the chips were concentrated in fewer and fewer hands, the other fellows could stay in the game only by borrowing. When their credit ran out, the game stopped.
>
> Memoirs of Marriner S. Eccles. Quoted from http://en.wikipedia.org/wiki/Great_Depression

March 12, 2009

CAN REGULATIONS INCREASE INSTABILITY?

I wanted to take a recess, but a troubling question woke me up in the middle of the night.

Having learned a lesson of Great Depression 2 (GD2), we demand tougher financial regulations. It means more order. But if order increases instability, how can regulations stabilize economy? Then I recollected the word "structure" which I had listed as a component of economy. I hastily added the Federal Reserve logo to **Figure A 28**, but the doubt persisted: isn't structure a form of order?

I could not ask myself a better question.

As I have illustrated with the pictures of Colosseum, even structures made of stone are not stable. Regulations, criminal and civil law, tribal and national traditions, religious, ethical, and business norms, political platforms, scientific conduct, organization of healthcare, and similar structures are forms of order. They may not require a constant daily supply of energy to prevent them from coming to static equilibrium, but they have their own dynamics and instability. The pump and the water (or wealth) which it pumps uphill have very different instability time scales.

No exystemic order is stable, but the stability varies between the living cell and the celestial order, the most stable of all.

The difference between long and short run permeates history, technology, and chemistry. The solid structural order of the pump is much more stable than the water pressure it maintains. US Securities and Exchange Commission is more like the last model of the pump of the money-making machine, and the next model might be somewhat different.

Therefore, yes, regulation is a form of order and it increases instability, but in comparison with what? In pattern chemistry everything is about MORE and LESS. We can only deal with the last link in the chain of events. New regulations may either increase or decrease instability **as compared to preceding regulations**. Moreover, they can work differently in the short and long run. In pattern-chemical terms, markets are fluid and regulations are solid. Pattern structure is solid but it can melt down. Fluid can freeze. The maintenance of regulations requires less energy than the functioning of markets, technology, transportation, healthcare, and education, but, like the Roman Empire, the law needs to be periodically renovated and defended from assault, as well as destroyed, whatever promises the victor a better reward. And what about the cost of rebuilding the Great Wall on the Street, periodically blown up by domestic financial terrorists? History is a perpetual experiment in adaptation.

George Soros in his **New Introduction** to the new edition of *The Alchemy of Finance* (Wiley, 2003) describes the divide between natural science with "laws of universal validity" in which thinking plays "a purely passive role" and social science with interconnected thinking and reality. What does it mean that thinking and reality are interconnected? Aren't they really fused in natural science? Can we talk about natural and social sciences in the same pattern-chemical terms?

As a pattern chemist, I am compelled to find a way to speak in **common language** about anything in the world, which is, probably, the best definition of pattern chemistry.

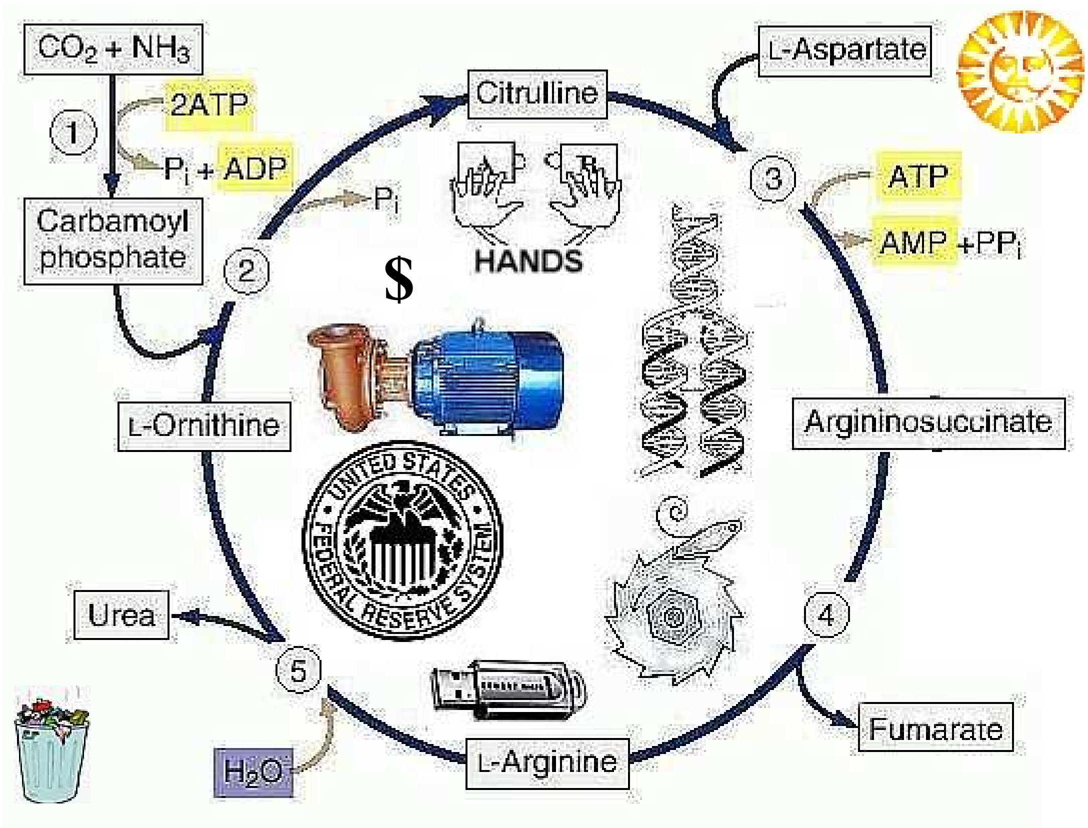


Figure A28. **Mechanism of economy as ideogram.**
Clockwise: hands (catalysis), replication, ratchet (irreversibility), memory, structure, motor and pump, and money, all inside a metabolic cycle. Batteries not included.

I do not see any impenetrable schism between natural and social science. There is only one evolving understanding of the world. The difference is that the current state of natural science is consistent with observations on a very large time scale, at least as long as half human life and usually much longer. Social science is consistent with observations on a much shorter scale, probably not more that half human life and usually much less in our times. The longer the time scale of observation, the less valid our understanding of social phenomena. Regarding natural science, it is the opposite Natural science is valid in the long range, while social science in the short one. “Market science” must have its own rather short and variable—depending on regulations—range. The human scale—the knowledge of “hard core” human nature as part of natural world—takes the intermediate range.

March 19, 2009

FROM ALCHEMY TO CHEMISTRY OF FINANCE

With this entry I am getting off my Ferris Wheel.

I am still reading *The Alchemy of Finance* by George Soros, but it looks like I already have all major components of pattern chemistry, including econochemistry and cliochemistry (chemistry of history) in embryonic form. Next, I am going to re-analyze and summarize everything in a separate file and add it, together with *The Diary of the Ferris Wheel Rider* to the *Introduction to Pattern Chemistry*.

March 22, 2009

I am back! I am under a powerful impression of just finished *The Alchemy of Finance*. Certainly, this is the weightiest item on my bookshelf of economics reading. It has a symphonic sonority with obsessive themes, variations, development, and transposition of great questions, guesses, and deep asides, supported by the *basso ostinato* of "Reflexivity. Reflexivity. Reflexivity." It also reminds me of the unhindered and unconditional intellectual quest, outmoded today, when a thinker of past centuries had to bet not just his livelihood but sometimes his very life on the outcome of the inquiry. Paradoxically, it tells me that the times have not changed much! George Soros, as he notes, is protected by his success (p.373). What if he wasn't? But he is not protected from the indifference to his brave and original mission which will be brushed off by many in search for the recipes of overnight enrichment.

Honestly, I have skipped most of the pages about pecuniary gain and loss, which is the bulk of the book. The author's thoughts about what I call the human scale, however, stay with me and challenge to find my own answers.

The Alchemy is the **best starting point for pattern chemistry** because it poses the main question: what is so different about economy as compared to the rest of nature? If not for the humans in the role of atoms with imagination, we would not need any patterns and could do with equations.

Here are a few singing sparkles from George Soros' bonfire.

1. Social theories should not be "parading in the false feathers of natural science" (p. 9).

2. "…thinking is part of reality people have to think about" (p. 16).

3. “There are as many expectations as there are participants, but there is only one outcome” (p.18). [This is the paradigm of chemical kinetics: a series of alternatives, but only one final state. It cannot be predicted unless all alternatives are compared.]

4. “A badly designed car will not run while social institutions or ideologies can be badly flawed and still persist” (p. 22).

5. “I should like to end with an impassioned plea for reinstating philosophy as the source of all knowledge and wisdom” (p. 44).

6. We cannot “afford to stop asking the eternal questions about the relationship between thinking and reality” (p. 45).

7. “…credit is one of main avenues that permit bias to play a causal role in the course of events” (p. 85).

8. “We now live in a system where we continually go to the brink and then recoil when we see the abyss opening at our feet” (p. 92). [We at the top recoil, but part of society is already at the bottom of the abyss.]

9. “Yet the pursuit of operational success often drives people to try to compete with natural science by making more unconditional predictions” (p. 322). [Promise is what drives science as part of economy. Modern science is never over the counter: it is all the futures market].

10. “Each form of social organization was found wanting in something that could be found only in its opposite: totalitarian society lacked freedom; Open Society lacked stability” (p. 331). [Can America be counted as Open Society if at least half of Americans have a closed mind?]

11. “The sooner we recognize that some kind of regulation is necessary in order to maintain stability, the better our chances of preserving the benefits of a nearly free market system” (p. 331). [Written in 1987, true for today].

12. “ The newly created international lending agency would use oil as its unit of account“ (p. 347 !!!) [What does pattern chemistry say? Energy is the ultimate natural currency.].

13. “Life can be seen as a fertile fallacy” (p. 373).

INTRODUCTION TO PATTERN CHEMISTRY

PART 3 PRINCIPLES

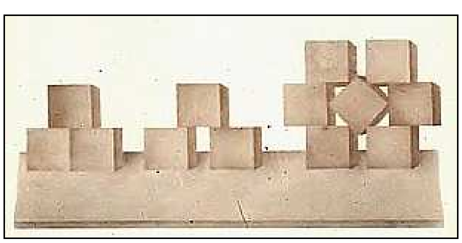
THE STEPPING STONES OF UNDERSTANDING

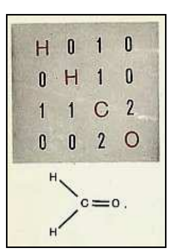
PREFACE TO PART 3

The PATTERN CHEMISTRY project emerged in 1970s from a vague idea of a generalized chemistry. Only recently, in April 2009, I found my original publications in the Russian popular science journal "Chemistry and Life": *On Chemistry and Chemists*, 1978, No.1, p.3, and *On Temperature, Time, and Happiness*, 1979, No.12, p. 116.

> *Chemistry and Life* (Химия и Жизнь; since 1996: *Chemistry and Life—XXI Century*) was an extraordinary and unrivaled undertaking of I. V. Petrianov-Sokolov (Петрянов-Соколов Игорь Васильевич, 1907-1996) and a group of free-thinking enthusiasts, but this is a different story from Nikita Khrushchev era.

For sentimental reasons I reproduce here the work of the professional illustrator of my old essays. I took no part in the upper two drawings. The French words over the human figure with the handless clock instead of the head are **tempérament**, **température**, and **temps**.





The arrangement of cubes relates to the story of Clever Elsa from the folk tales of Brothers Grimm. When Elsa had been sent to the cellar for beer, she noticed there a hanging pickaxe. She began to cry bitterly. She had just imagined that one day she would marry Hans, give birth to a child, send it to the cellar to fetch some beer, and the pickaxe would fall down and kill the child. I cited the story as an example of the combinatorial nature of both molecules and thoughts. I wrote, "Elsa figured out one of possible combinations of "atoms of reality;" herself, her fiancé Hans, cellar, beer, and pickaxe." I emphasized the difference between divergent thinking, which generates a number of outcomes, and convergent thinking, which arrives at a single answer. I believed that creative arts embodied the divergent thinking, while chemistry required both.

I also reproduce the matrix representation of formaldehyde, which I since then often used as an introductory illustration of the "trans-chemical" concept of configuration.

When in 1980 I ran into *Lectures in Pattern Theory* of Ulf Grenander, published by that time in Russian, I realized that somebody saw the world in a similar way and has built a solid mathematical foundation for my fantasies.

Chemistry is the loveliest playfield in the world for kicking the ball of imagination.

Part 3 concludes and summarizes my 30 year long pursuit of illusive goals.

In **Introduction to Pattern Chemistry, Part 1 : FOUNDATIONS**, I assembled various snapshots of the world taken from the position of pattern chemistry. They had been accumulating for quite a while on my website spirospero.net. I saw them only as building blocks for the foundation and not a ground level support for the edifice which was still without a general plan. Having finished **Part 1**, I did not know how many blocks (principles) would be needed above the ground level, what the plan was, and what could be built upon the foundation.

In **Part 2, OBSERVATIONS**, I described my lay impressions of the events in American economy in the form of a **DIARY OF A FERRIS WHEEL RIDER**. The **DIARY** starts on September 18, 2008 and ends on March 22, 2009, even if something extraordinary happens after that.

Part 2 was a kind of testing grounds for a possible more systematic layout of **PRINCIPLES**. The **DIARY** also included my reflections on a small selected library of books on economics and markets. The actual number of books I had been reading was larger, but still only a tiny fraction of all related literature. It is absolutely impossible for anybody to have familiarity with literature on EVERYTHING, which is exactly the subject of pattern chemistry. Moreover, it is unnecessary in times when the torrent of information is roaring in the turbines of Google and rising behind other, more specialized, information dams. Unfortunately, although most of that information evaporates with time, the vapors condense into the information fog in which both information and its seeker can be lost.

In the times of the info-flood I do not aspire to disembark on any firm grounds in **Part 3, PRINCIPLES**. What I want is to divert part of the fluid substance of our days into a separate quiet channel where it could be inspected with some pattern-chemical means. I would like to the emerging picture of the principles to be more coherent, less stirred up by daily winds, more dogmatic, but by no means complete. Here I am taking a quiet walking tour along the stepping stones of understanding.

In **Part 3** I use less illustrations. Figure numbers start with **B** and **Chapter** number, for example, **Figure B2-1.**

As **Part 3** is a partial recapitulation of the previous two, some repetitions will be hard to avoid. Relying on Google and googliputs, I supply only a minimum of Web links and references. Practically everything relevant can be found online, often even one step ahead of the time of relevance.

As before, by chemistry I mean pattern chemistry, while academic chemistry is specified as molecular one. I am not interested here in hard academic sciences of physics, molecular chemistry, biochemistry, physiology, biology, etc. The object in the focus of my interest is **exystem.** I have finally accepted this term for **evolving complex system.** Representative examples of exystems are: global economy, biosphere, society, culture, language, and individual human life. More specifically, I am interested in the world on the human scale, i.e., observable, interactive, and tangible. Chemistry deals with neither atoms nor galaxies. To put it differently, it is the everyday world of the majority of people regardless of specialization. Still, chemistry requires a certain level of education. This level would be lower if the education itself started with general universal and trans-disciplinary principles.

The exystems form a tree-like hierarchy and the largest exystem that I know is global economy. In our time it includes all forms of human activity, some of then previously not directly involved in the global metabolism of money: global politics, party politics, culture, art, ideology, science, technology, education, health, environment, and even, to some extent, language and sex. I have no evidence that human nature itself is under market pressure, but I easily imagine, with the help of sci-fi writers, how it could look in not so distant future unless the world economy changes its course of evolution.

> **HINTS AND GUESSES**: Judging by the present trend, the future humans could look as hybrids of physiology and technology (including molecular chemistry). The share of technology will increase with individual wealth. I can see, incredibly, that even the senior TV anchorettes are looking younger every day.

The incompleteness of our understanding of the world on the human scale is one of the most fundamental principles of understanding the world in general. The exystems are Heraclitean systems (H-systems), as distinct form Aristotelian systems (A-systems): H-systems change while we speak, never come back to any previous state, and thus resist "hard" academic science. The incompleteness of exystems means that our axiomatic knowledge about them—the set of basic statements which do not follow from other statements—changes with time. In other words, **evolving systems evolve** and this is why they are incomplete by definition. Without drawing a parallel with mathematical incompleteness, I believe that there are true statements about exystems that cannot be logically proved, there are false statements that cannot be logically refuted, and there are contradicting statements that cannot be resolved.

A dogmatic listing of "principles" would be a false pretence of academicity. I absolutely deny any intent to build a theory. I am afraid of any use of the term "theory" in connection with exystems. "World view" is a much better term and "understanding" is even better. But if pattern chemistry is not a theory, what do we need it for?

The utilitarian idea of pattern chemistry is that **patterns** may change much slower than momentary **configurations** that fit the pattern. In addition, patterns transcend time, space, and interdisciplinary borders. Following Henri Poincaré, who said that "Mathematics is the art of giving the same name to different things," patterns **are** mathematics. They are, probably, the best surrogate of mathematical formulas and equations that we can have on human scale.

Whether mathematics itself is a chemical, i.e., atomistic and combinatorial, system, only mathematicians can decide. I believe, it is. A typical mathematical expression is a pattern for a family of more specific expressions: $y = Ke^{b}$ stands for $y= 3e^{-2}$, $y= 5e^{2}$, etc. Patterns of grammar are another example.

Since we deal with the inherently incomplete and fluid system of knowledge, sophisticated mathematical means can be applied only if it is well defined for well defined stretches of time and space. While this knowledge is considered **incompressible** by prevailing theory of complexity, Pattern Theory is the way to compress it.

Pattern Theory of Ulf Grenander is an unusual mathematical discipline because it is open to new axiomatic statements and requires continuous human participation. Pattern chemistry is first and foremost a very *particular* way of looking at the world in the atomistic tradition as a *particulate matter*. It is itself a **pattern** of representation of the world and it covers the molecular chemistry as one of its **configurations**.

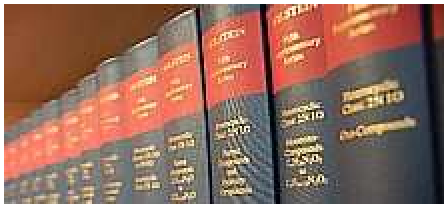
1. FROM CHEMISTRY TO EVERYTHING

A good way to inhale the spirit of chemistry is to open a college textbook of organic chemistry.

An average textbook for beginners consists of a relatively small general part and a much larger—and potentially endless—description of structure and behavior of different classes of molecules. The general part heavily uses results of atomic and molecular physics in order to explain how and why atoms form bonds, how the bonds split and recombine, how it all displays in time, and what factors influence chemical reactions between molecules. The general picture maintains its generality by focusing on atoms and bonds instead of whole molecules as complex structures. The number of known substances is immense and the number of possible but not yet isolated ones even larger. We can draw their structures without ever seeing them in flesh. Chemical formulas are **ideas**, not things.

The special part reminds very much a textbook of botany or zoology. It is about the classification of molecules by structure (classification of architectural styles comes to mind), their behavior and interaction, and often about practical importance of various "chemical animals." Seen from such a distant point, the special part can be also compared to books on world literature, history, and languages. Thus, each chapter of a treatise on economics can be expanded to describe the fine structure of every national economy and it major institutions. Moreover, biographies can be regarded as subdivisions of a giant treatise on human nature, behavior, and considered an abstract counterpart of a paragraph on a particular chemical substance, such as aspirin, in a chemical monograph.

> It is interesting that chemistry was the first science, as far as I know, which attempted to publish a comprehensive and updateable treatise containing the **entire available knowledge and its history** since 1771 (!) in chronological order. It was *Beilsteins Handbuch der Organischen Chemie* , (see also), founded by Friedrich Konrad Beilstein in 1881**.** By 2008 it contained over 10 million chemical structures, 10 million chemical reactions, and 37 million factual entries. By 1998—its last year on paper—it counted 503 volumes. I remember how I first felt intimidated by its beautifully bound mammoth volumes as a freshmen, around 1955, when it was still a far cry from its future explosion in size. When I plunged into



> its pages, my sufficient German language kept me afloat and I could navigate the immense ocean of information. No electronic database can give you the physical sensation of the size of chemistry on human scale, which only *Beilstein* or *Chemical Abstracts* on paper can do. And yet chemists can manage all that complexity because they are guided by the hidden between the covers simplicity.

Chapters about some general problems can be included into the special part when a particular class of molecular structures provides good illustrative material.

In modern hard science, the information selected by the author of a textbook for an entry has its original source in the form of a very detailed journal paper or book by one or many authors, usually, but not always including the author of the textbook. The original sources describe in greatest possible detail the experimental or theoretical work done at a certain time and place, so that anybody in the field can repeat them. The same original sources are supposed to cite references to the works of the predecessors in the field. The scientific knowledge, therefore, forms a dense interlocking web of original and derivative works, as well as reviews and compilations. The web evolves in time and very old data gradually drop from the references—same way as in the World Wide Web.

The writer of fiction presents constructs of imaginary personalities, situations, and events—quite like a chemist—but we know well how much the imaginary constructs can be influenced by previous work of fiction, as well as actual events in the life of the author and other people, with whom the author not necessarily had any contact—quite like science.

I cite Plutarch's *Parallel Lives* as a classical example of a publication in **human chemistry**. It was one of the most influential books in history of Western culture. I still find it a captivating reading. Plutarch uses available to him contemporary sources to present biographies of Greek and Roman historic personalities often separated by time and place.

Plutarch is looking for patterns in human behavior, i.e., general properties of human nature manifesting throughout lands and years. Moreover, he is obviously inclined to parallels not just in human fortunes but also in various spheres of human activity. Here is an example from his biography of the Roman general and consul Gaius Marius (157 BC–86 BC). After a military victory over the northern Barbarian tribe of Cimbri, Marius was recalled to Rome and offered a celebration.

> However, he refused to do so, either because he did not wish to deprive his soldiers and comrades-in-arms of their share on the honor, or with the intention of increasing public confidence at the crisis by showing that he was, as it were, putting all the glory of his first victory into a deposit account with the Fortune of Rome, in hope that, after a second victory, it would be returned to him with interest. (Gaius Marius, in: Plutarch, *Fall of the Roman Republic*, Translated by Rex Warner, Penguin Books, 1958/1988).

The use of the explicit financial terminology for political behavior is a **configuration** of a **pattern** known in literature under different names such as trope, metaphor, allegory, parallel, analogy, comparison, etc. Is the term "political capital" yet another echo of Plutarch?

Alas, although I cannot read the Greek original, it seems that earlier English translators of Plutarch took less liberties with the text. Yet the **pattern** remains clear in all earlier translations.

> … he himself did not think it convenient: whether that he were not willing to deprive his soldiers and officers of their share of the glory, or that, to encourage the people in this juncture, he would leave the honor due to his past victory on trust, as it were, in the hands of the city and its future fortune; deferring it now to receive it afterwards with the greater splendor. (Translation of John Dryden, 1631 –1700)
>
> …but he refused it, either because he did not wish to deprive his soldiers and his companions in arms of the honor that was due to them, or because he wished to give the people confidence in the present emergency by intrusting to the Fortune of the State the glory of his first victory, with the confident hope that she would return it to him ennobled by a second (Translated by Aubrey Stewart & George Long, London, 1899)
>
> But he refused to do so, either because he did not wish to deprive his soldiers and comrades-in-arms of their due honors, or because he would encourage the multitude in view of the present crisis by entrusting the glory of his first success to the fortune of the state, in the hope that it would be returned to him enhanced by a second (Translation of Bernadotte Perrin (1847-1920), Professor of Greek at Yale University).
>
> However, he declined it; whether it was that he was unwilling to deprive his men, who had shared in the danger, of their part of the honor, or that to encourage the people in the present extremity, he chose to intrust the glory of his former achievements with the fortune of Rome, in order to have it restored to him with interest upon his next success. (Translation of John Langhorne and William Langhorne Baltimore 1938)

Note that "restored to him with interest" is rather close to Rex Warner's translation. Probably, it was inspired by the post-1929 business atmosphere of the twentieth century.

I have quoted five translations of the same original Greek text in order to illustrate, in a quirky way, the idea of pattern in Pattern Theory. Pattern is a *paterfamilias*, "father of a family," to use another trope.

Meaning aside, the five fragments are configurations of letters, morphemes, and words which can be converted into each other by transposition of their atomic building blocks. Very few complete words (he, of, the, glory, etc.) are shared by all fragments. I suspect, that some other languages would allow more overlapping. Let us take letters as **generators**, i.e., the basic minimal atomic building blocks combined into strings of text. Let us regard the strings as **configurations**, distinguished by the sets of generators and the order of their arrangements into strings. Then **pattern** will be defined by the set of generators, rules of their bonding into strings, and rules of **similarity** transformation of one configuration into another.

We need very complicated rules of **regularity** in order to preserve the meaning of translations. This is why the automatic translation remains only a partially solved problem—a special part without the general one. But suppose we have an automatic editor which translates from English into English without a loss of meaning. The following problem will arise: what should be the exemplary translation used as the standard of meaning? The selection of such text, called **template** is entirely the matter of human choice, subject to the controversy which always accompanies human matters. As for the configurations, some will be closer to the template than others: they will have **metrics**, quantitative measures, such as distance.

The bonds between adjacent letters also show metrics: some combinations are more probable than others and some, like sxg and iie are utterly improbable, unless in abbreviations. We can say that not only some letters have more mutual affinity than others but words also show selective preferences to joining into meaningful phrases. In other word, some **bonds** between **generators** are more stable (probable) than others.

The terms **generator, bond, regularity, similarity, template, metrics**, and **pattern** are the key concepts of Pattern Theory.

I have used the above rather artificial example in order to avoid repeating the basics of Pattern Theory laid out in Ulf Grenander's original works and numerous expositions on my website, as well as in **Part 1** of this text. As for the analysis and synthesis of the text by frequencies of combinations of its elements, it was one of the very first forays of computer science into linguistics, initiated by Claude Shannon even without using computers.

I hope this illustration illuminates the parallel between pattern chemistry and molecular chemistry: atoms combine into configurations according to rules, some bonds are more stable than others, and some molecules are more regular and "make more sense" (more stable/more probable) than others. Same applies to thoughts and sounds of speech.

There is yet another similarity of principal importance: the stability of a molecular or generalized configuration is **roughly additive** over the stabilities of its parts down to generators and bonds. Since similar configurations form pattern, what could be a template for the pattern of additivity? Clinging to the human scale, I suggest a supermarket receipt, which is additive over the values of purchased items, discounts, and taxes, where applicable. For an economist, it could be the price structure of a product for sale, whether gasoline made of hydrocarbon molecules or credit default swap made of Devil knows what.

One thing distinguishes molecular chemistry from biology and linguistics: atoms and their configurations combine into large molecules in practically unlimited number of ways. To translate it into biology, it would mean all kinds of chimeras between totally different species of plants and animals—and of unlimited size!—as well as linguistic chimeras made of different languages and styles. Exystems spend a lot of energy to preserve their fine pattern structure, which we call **order**, and keep the constraints of regularity in place. The major reason why they do not have a combinatorial freedom is that they are constrained by their history. Much more than any natural laws, history limits what can happen in an exystem because in life, language, economy, etc., **almost** the entire generator space, rules of regularity, and the size come from yesterday. The difference between "almost all" and "all" in exystems is tiny, although the consequences can be large.

Even in the anarchistic molecular chemistry there is a distinction between stable structures and the unstable ones which appear only for fleeting moments when one stable configuration transforms into another through the ephemeral and irregular **transition state**. I consider this the main contribution of molecular chemistry into pattern chemistry and, possibly, future development of Pattern Theory.

An imaginary modern Plutarch could discuss the evolution of human values in the era of democratic capitalism, evoking Plutarch's biography of Alexander the Great who cared "not about luxury but only about virtue and glory," while the modern human value is expressed by a number, normally, of dollars, euro, or other currency. Yet another moralist could object that Alexander's virtue was measured by biographers in extinguished human lives and conquered lands, with no lasting result except enriching the genetic pool of the local population. I emphasize *ad nauseam* that the intrinsic absence of consensus seems to be the main distinction of human matters from molecular ones. The difference is subtler, however: the disagreements in natural sciences are temporary and passing, while in human matters they are chronic. Humans fall not only into distinct subspecies of sex and age, but also in many "hyper-sex" subspecies of character, temperament, disposition, upbringing, and even wealth- and power-dependent quasi-biological features. Sex is a configuration, not a pattern.

The subject of consensus opens to even deeper analysis. It is said that natural sciences are experimental, which ensures the arrival to consensus. But why is experiment possible?

There are properties of nature which seem so self-evident that people forget about them. I want to compare inanimate matter and human matters in this regard, but I am looking for a less awkward terminology. I would prefer to speak about systems and exystems. The typical physical system of many particles possesses the property of ergodicity: it has a definite number of states and it can change from any state to any other, albeit only in theory and through a possibly long sequence of intermediate states. Automobile is an example, theoretically but only up to a point practically. Ideal gas is the best example, imaginary, though. Therefore, physical systems can be experimented with: observed while switched from state to state, assembled, duplicated, and deconstructed. Although none is exactly ergodic, they are at least reproducible.

Exystems are not ergodic in principle. "You cannot step twice into the same river." Moreover, there is yet another deep distinction, invisible in its triviality: physical systems can exist in a number of copies, so that they can be studied **in spite of their irreversibility**. Plants and animals, mangled and dissected in a scientific experiment, killed and discarded, can be taken fresh from the pool of similar—or even genetically identical—organisms. Fallen in battles and accidents soldiers are replaced from the stock in the same uniforms.

> It is appropriate to say here that my compassion to humans and animals is based on the instinctive pattern perception of the world: we all are a family.

Exystems exist in single copies. For a general, the soldier is not an exystem. For the soldier and his or her human environment, another soldier in the same unit is unique.

Therefore, as a rule, we cannot experiment with exystems. We can only push them around and observe their behavior, usually slightly damaged. The situation is completely different in molecular chemistry. The contents of the experimental flask are analyzed and discarded, the flask cleaned, washed, and replenished with reagents for the next experiment.

Let us return to the tour of a textbook of organic chemistry. The special part is a digested selection of a tiny fraction of enormous experimental material accumulated by chemists all over the world mostly in the twentieth century, when powerful physical methods became available in chemistry. The significance of those methods was that, in principle, **nothing could be missed** as far as molecular transformation was concerned. Chemistry before the second half of the twentieth century rarely possessed the 20/20 vision. The reconstruction of what actually happened in a flask when two substances had been mixed, as well as a construction of a desired molecule, drawn on a piece of paper in advance, required the highest level of ingenuity.

The role of experiment in molecular chemistry contrasts with the situation in pattern chemistry. If not experiment, then what? We rely on our successful immersion and active participation in human matters as a weak proof of our understanding. If we adapt, either our understanding was correct or we have been lucky. Yet there is a kind of a surrogate for experiment, too: since exystems are large and complex, we can observe a variety of similar sub-exystems in different conditions and draw conclusions about their properties.

> This is what social science is good at, but why is it good? Because human nature changes very slowly or not at all, so that we cannot see any change from the times of Plutarch. The very subject of evolution of human nature is well established and there are academic courses. Yet I am not aware of any **comparative** study of the evolution of human nature from Antiquity to the twenty-first century, although such studies are known for economics, technology, culture, and language. I suppose, there is something, but what I found was about the **unobservable** pre-history, even if about the evolution of virtue. One can say that the world of Plutarch is also unobservable, moreover, even fictional, but his texts are real. This is a murky but intriguing subject.

The non-reproducibility of exystems precludes their study by the methods of hard science, at least on any large scale of time and space.

The financial crisis of 2008 presents striking material for the study of exystems. The mathematical methods in finance were designed to insure companies from big losses, yet the biggest overall loss in 80 years has indeed happened with still incomprehensible historical consequences. Why did it happen? This question, which I consider central for testing pattern chemistry, was addressed at the end of **Part 2**.

The idea which I am going to advance is that it is only on a sufficiently large **interdisciplinary** pattern scale that we can gain some additional understanding of the behavior of exystems and leave this understanding for future historians to test.

Patterns are commonplace. Everybody is discussing patterns in anything.

Google, Sunday, May 17, 2009: …about **22,500,000** for **stock market** **patterns**.

But if you want to be considered a serious professional, worth your bonus or research grant, you should better stay with patterns in your specific area of discourse.

Pattern chemistry is trans-disciplinary. **DISCLOSURE**: I have no bonus or grant to lose.

2. FROM EVERYTHING TO ECONOMY

I am going to make a step away from a real organic chemistry textbook to an imaginary textbook of pattern chemistry. I see it consisting of two parts: general and special. The latter describes behavior of various structures involving humans, while the former contains general principles.

Alas, I have to discard this design because (1) there are numerous academic sciences studying human behavior in various conditions, including markets and politics, and (2) there is no academic science to borrow the general principles from, although thermodynamics is recognized as a discipline of a universal applicability. The reasons for this autonomy of my prospective area of discourse are:

(1) Exystem is EVOLVING COMPLEX SYSTEM.

(2) Thermodynamics requires a sufficiently detailed description of the system.

(3) Detailed description of a COMPLEX system is hardly possible: system changes while you study it and the description is too long and never complete.

> **NOTE:** Complexity roughly means large size combined with large diversity.

(4) Detailed description of an EVOLVING system cannot be fully extrapolated into the future.

> **NOTE:** It can, but in the least interesting aspects.

Therefore, I have to choose a strategy which departs form the scientific tradition based on description, experiment, repetitive observation, and prediction. There is no way to decide whether this is really science as we know, but there is possibly a way to expand what we mean by science. I do not want to be distracted by regalia, however. I am anxious to plant the seeds of ideas and it is up to others to classify them—or even to notice.

I take economy as the working example of exystem. It is extra-large, diverse, human-driven (is it?), evolving, and in all regards complex. An additional circumstance is that economy is still in some crucial aspects a well-defined system because the government keeps records. Taxation is a blessing of a kind, after all.

I have discussed economy as exystem in **Parts 1** and **2**. Here I will summarize.

Economy had been developing since very long ago, but we still have reliable data to reconstruct its non-stop evolution.

Evolution of economy could not have been predicted and projected into the future, for example, in times of Plutarch. Evolution is visible only with hindsight.

Economy is geometrically limited by the planet Earth and near space, with tendrils reaching, at a great expense, the outer limits of the solar system and even the observable universe.

From a big pattern distance, economy looks like **biochemistry**: it has a source of energy convertible into work, the access to heat dissipation, and it uses this energy to combine, split, and recombine atoms and molecules, as well as other kinds of **generators**. Economy locks and breaks bonds between building blocks of society, technology, culture, production, etc., including humans. For an extraterrestrial observer revisiting the Earth today after ten thousand year long absence, the looming, swarming, panting, roaring, clicking, ticking, or quietly waiting in an ambush population of material things would be the next striking impression after the city lights seen from apart.

Great numbers of people would be seen totally torn from the original source of chemical energy in the form of land. They would be dependant in a mysterious way on the global economy, which had taken over most of natural food production and diluted it with a lot of unnatural one.

The choice of generators in Pattern Theory is axiomatic: we populate the set of generators by selecting those most appropriate for a particular purpose. Moreover, we can always change it, which is important for keeping pace with evolution. We see and sense only what we are designed to see and sense by evolutionary adaptation to our global environment.

An individual human is not the best choice of generator for representing patterns of economy. Family, even consisting of a single person, is better. Family, in principle, is self-sustainable, capable of living off the land, especially as part of community. The vulnerability of all living organisms to abrupt fluctuations of environment is the major factor of Darwinian evolution. From this angle, the global economy, single enterprise, institution, and family economy are configuration of the same pattern. They both have something in common: they need a reliable source of energy and sufficiently cold environment not only for recombination of their atoms, not only for dynamics, but also just for preserving the status quo: for doing nothing. The generators and bonds in open systems, to which exystems belong, need energy for their very existence in approximately the same form. I call this minimal energy **metabolic cost**. It is the cost of exystemic identity, if you wish. From Roman Empire to Soviet Empire, metabolically **insolvent** societies collapsed, spilling the beans of new, smaller identities.

While individual units of economy are mortal, their larger aggregations—extended families, tribes, communities, populations, societies, and civilizations—can exist a long time. Belief of any civilization in immortality, however, finds no support in records of history. On a large pattern scale, nevertheless, very few civilizations, if any, perish without a trace: they split, exchange, and recombine their atomic entities, following the chemistry of historic process.

Econochemistry is just a brash term for the study of pattern behavior of economy as human household in the solar system.

I confess of poking econophysics in the rib. It is important, however, to understand why I do not challenge econophysics. The hard science, like physics or, for that matter, anything complying with mathematics and logic, has a paradoxical similarity to religion in America: whether you believe in God and go to the temple is entirely your own business, but when you mix politics and religion, you step on many toes. The equations of econophysics and mathematical finance can be checked for validity and consistence and I suppose they are correct. It is the faulty **axiomatic** assumptions and conditions of applicability that could be ruinous when mixed with business and politics.

Hard science is reliable in inanimate and living nature because the object of study is not evolving or evolving so slow that it is constant on a defined time scale. If so, the object has an intelligible future. The future is a peculiar object of study: for exystems it does not exist except in our imagination. This is a dramatic contrast with physics, molecular chemistry, and most of biology. It takes an irrational belief—or indifference to outcome—to bet on the future, yet we do it all the time. This is how I understand George Soros' reflexivity. On the contrary, it is reasonable to rely on physics and molecular chemistry, but then the only thing we can **personally** expect with full certainty is our death.

I was greatly impressed by *The Alchemy of Finance* by George Soros. His subsequent books on reflexivity cannot compete with this opus. Within the chemical paradigm, I believe that the essence of his concept of reflexivity translates into chemical language as the inherent opacity of the exystemic future. His statement, "Yet the pursuit of operational success often drives people to try to compete with natural science by making more unconditional predictions" (p. 322), is the exact formulation of the reason for the global economic crisis of 2008. It is also the best starting point for my root **chemical** question: if the future of an exystem or its part cannot be **fully** understood, then **how much** we still can comprehend?

Economics had been—and still is—an alien subject to me when, motivated by the developing crisis, I chose economy as a template for the most abstract exystemic pattern. Soon I saw deep chemical similarities between more familiar exystems and economy. Later I found additional attractions of economy as object of pattern chemistry.

(1) There is only one economy on earth and it can be screwed up by not just our homespun American AIG: "arrogance, incompetence, and greed" (Congressman Paul Hodes), but also by generally recognized and even Nobelized mathematical finance.

(2) In spite of extreme complexity, the overall metabolism of matter and energy in economy is relatively clear.

(3) Modern global economy comprises practically all aspects of human condition and spheres of activity. Modern economics leaves no stone unturned in search for the money burrows.

(4) Economic earthquakes come unexpectedly (although always predicted by somebody); nevertheless, economy bets on the future.

(5) Economy is full of mysteries, while economics is devoid of consensus.

(6) Society suffers economic heart attack, but adapts to it and rehabilitates in time to meet the next one.

The tight monetary embrace of global economy is the striking departure from the earlier stages of history when the wealth could be counted not just in gold and silver but also in the currency of virtue, valor, and glory. This embrace often turns spasmodic and suffocating.

Presidential elections of 2008, the outcome of which was the only political event in America I celebrated in 20 years, was a victory of financial organization over irrationality—the circumstance I do not know whether to celebrate or to mourn because it could work the other way around: money against rationality. Academic science, higher education, art, healthcare, law, and national defense, traditionally the priceless articles of national survival and prestige, are, at least in America, no-frills branches of economy. I do not see any apocalyptic tragedy in total financialization of life. The normal response of an exystem to a threat is adaptation, but unless the threat is really shocking, the exystem will not budge. I believe that the demise of automobile industry in America is shocking. If you read ancient authors, you will notice how much of dramatic change an adaptation involves.

For example, Plutarch writes about Sulla:

> There was nothing grand about Sulla's own domestic background, and when he was a young man he lived in cheap lodgings. He was reproached with this in later years when people thought that he had become more prosperous than he ought to be.

A member of aristocracy said to him:

> "There is certainly something wrong about you, who have become so rich when you father left you nothing at all."

What a strange un-American reproach would it be in our time! All right, we have adapted, but to what? To the astronomic amount of money around, most of it not ours. What we have not adapted to is the ghostly immateriality of modern money: it is neither gold, nor paper; moreover, it is neither today nor tomorrow. We will be naturally transported by the river of time into the future to see how the future looks, if it is still there, but there is no way back into the past. A cartoon in **The New Yorker** advises the losers to invent a time machine, go to the time before the crash and convert all assets to cash. A chemist cannot take this kind of vanishing or mushrooming money seriously, which is yet another principle of pattern chemistry. The modern belief in money has something of a religious faith.

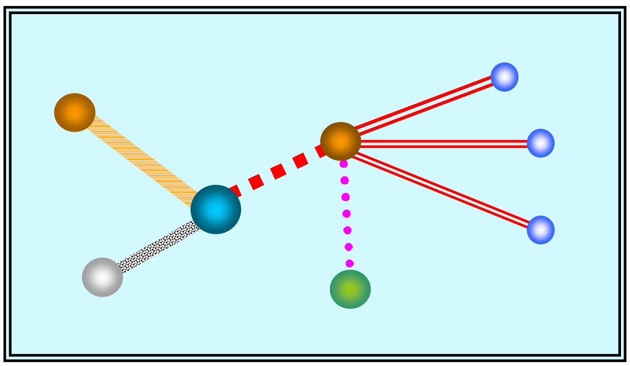
More generally, we have not yet adapted to the information revolution and to the advent of a new threat: competition between humans and technology (which I call Technos): a new kingdom in the taxonomy of life on earth.

My secret hope—just revealed—is that ideas of econochemistry will stimulate interest in economics based on the principle of conservation and (what a sacrilege!) reject the very use of the notion of money and value as something that can bear fruit or rot overnight or even in the nick of time. More specifically, ecological, i.e., “natural” economics (Nicholas Georgescu-Roegen was one of the promoters), in addition to the postmodern one, which has its own legitimate domain, would deal with the currency of energy as it had been dealing with the shining indestructible yellow metal in pre-modern times.

> Moreover, one may imagine Utopian local authorities making contracts in which payment would be no longer in coinage upon the gold basis, but in notes good for so many thousands or millions of units of energy at one or other of the generating stations. H. G. Wells, *A Modern Utopia*, Chapter 3, §2.

3. FROM ENERGY TO INSTABILITY

If molecular chemistry was only about the distribution of bonds between atoms, it would be nothing but a giant art gallery of abstract paintings consisting of labeled points and



← connecting labeled lines. The pictures would differ only in composition but not in the elements. The creative and predictive power of molecular chemistry is that it deals with physical objects possessing mass and energy, more generally, mass-energy. The mass of the molecule is exactly the sum of the atomic masses, while the energy is the sum of energies of its bonds. The difference between atoms and bonds is that there is a fixed list of about 100 atomic masses (not counting isotopes), while the energies of the bonds between a given pair of atoms vary (usually not too much) depending on what kind of bonds and atoms are nearby.

I will not repeat here the general description of the mechanism of chemical transformation from stable initial state to stable final state through unstable transition state. If the transition state were stable, there would not be any reason why it should change into anything like another stable state. All possible configurations would always coexist in an equilibrium.

> **EXAMPLE.** If you wonder why you are not rich, it is because there is a high transition barrier between you and wealth. Some components of what you need to jump over the barrier are: desire, ability, luck, and opportunity to test your luck. Somebody who has **more** of it competes with you. In other words, you are probably too stable to jump over the fence toward the greener grass. You lack "uneasiness." (See **Chapter 7** of **Part 3** on uneasiness).

In molecular chemistry, higher stability means lower energy and lower stability means higher energy. When we leave molecules and turn to exystems, we do not need to abandon the concept of stability. What to do with energy, however, is a tough question.

What role can physical energy play in history? Here are some leading questions.

(1) By 1786, the French Monarchy was insolvent, which was the main source of its instability. Can we use the currency of French *livres*—or any monetary currency—as the surrogate measure of stability?

(2) Food, as you probably know, is the only source of human and animal energy. The **food shortages** in Paris in April 1789 triggered the violent phase of the Revolution. Can we measure the energy of the configuration of France under Louis XVI in Joules or calories?

(3) It was the promise of land—the ultimate source of food—to Russian peasants (80% of population), which pulled Russia into the incredibly violent and cruel revolution in 1917, resulting in the total expropriation of land. If food is the source of energy, how can the lack of food increase the energy of protests?

The above questions are not idle and the answers, I suppose, will not be entirely negative. The USA and the world are right now, in April 2009 in the state of significant instability which can be measured, pretty accurately, in dollars. Some signs of violence on part of well fed, healthy, and fit youth can be seen on the streets of London. Are we on the brink of the world revolution and where can we go from the cursed by the demonstrators capitalism?

> **NOTE**: Can the information revolution, intended to benefit the users, result in the **expropriation** of the users regarding their identity and personal information? There is only one pattern answer: YES. The expropriation is going on, although it is not centralized. In totalitarian states, it was. The cloud computing and outsourcing of data storage of any kind especially troubles me. I am an information counter-revolutionary. Identity must be private property protected by the law and the ownership of anti-IT guns must be included in Second Amendment.

There is certainly an assortment of mechanisms of transformation of food energy into human actions within the economy. These mechanisms, comprising psychology and physiology, are not left unexplored, the experimental methods are available, and it is already clear that any form of human activity or inactivity requires some minimal consumption of energy in calories (metabolic cost). Interestingly, the stimulus to study the cost of human activity or its absence seems to have come from sports, which is an economically very lucrative and sharply competitive business. Even though the winner-takes-all principle makes the stars expensive, they are profitable.

In the Soviet prison camp where I spent some time, the calories were sufficient and the riot that I once witnessed was caused not by hunger, but by alcohol. In modern society, it is not just calories but the overall satisfaction measured in money that determines stability. Sociologists and economists research it on regular basis. This is not the way, however, to give a short answer regarding the energy versus stability problem. My solution of the relationship between energy and stability in pattern chemistry is: let us use **instability as generalization of energy**.

We do not have any non-circular definition of either energy or stability, but we know how to use the concept. There are practically important theories of well defined static, dynamic, and abstract mathematical stability, but for my purpose the intuitive concept of **social and economic** stability suffices. There is no difference, and never was, between the two and it is just the habit to separate them which moves my hand. From now on I use only "economic," i.e., exystemic interpretations of physical terms.

> **NOTE**: Physics is based on the principle of **conservation** of energy and matter, with the emphasis on conservation. Only conservative processes are predictable because they are accountable. If we see concept of conservation as pattern, the mathematical operation of addition is tacitly based on conservation too: no digits can be either pinched or slipped into. Finances are based on the sanctity of addition, while investment is based on the sins of multiplication. Patterns transcend the borders between mind and matter, but it is not quite clear how they do it and why it appears that humans can violate any principle but a physical law.

High economic stability, like physical energy, means that we can expect the economy to return, more or less, to the **pattern** from which it by some reason deviates. Thus, periodic bouts of volatility do not make markets inherently unstable; volatility is a regularity of the pattern. Nevertheless, economy, like any exystem, evolves: not by volatility, but by infrequent but large steps with pattern change.

> I have been greatly intrigued about the "velvet revolution" which happened in the US economy in 1970 ("VXX") and I keep collecting data about the cluster of events, all met with enthusiasm at the time, which, in my firm opinion ultimately resulted in the economic crisis almost 40 years later. My latest addition to the growing collection is the polarization of politics and the emergence of the Cold Civil War by the end of the 60s.

Robert Reich in *Supercapitalism* has his own view of the VXX . I also anticipate another, more violent, economic revolution after which the pattern of growth will take place in the Museum of Evolution Patterns side by side with the dinosaurs. Since I do not believe in the predictability of evolution on the large scale, I would never bet on any of my subjective anticipations, however. All we see in the crystal ball is alternatives, with more alternatives out of focus.

I can envision an economy based on renewable sources, which contradicts no law of nature, as well as the happening slowdown of population growth. Both trends are already taking shape (would that be good for democracy? would democracy be good for us?). Yet as I tried to emphasize in pattern chemistry, the question **what happens sooner** is the typical and most important question of chemical kinetics, molecular or not. It is not "to be or not to be." It is to come first or to lag behind. Becoming, not being, is the question.

Chaos is irreversibly ejected from the economic metabolism: heat, radiation into space, fluids (including exhaust gases), solid waste, and radioactive waste. Theoretically in perfect global economy all material waste can be recycled, but heat and radioactive waste can be lost irretrievably, although for different reasons.

> When I made a suggestion to **tax trash** (waste) instead of income, I was not original with the idea. What I meant, however, was to tax waste literally: every pound of garbage, every month when a building is empty, every day when gadgets are not used, and every dollar of lost money. This is a very crude idea, not yet thoroughly thought over. There is more to it, however, if we look far ahead. In short, it seems an effective way for humans to dominate in the competition between humans and Technos. The competition itself started when the life cycle of man-made Things had become much shorter than the life cycle of humans. As Things had become disposable or short-living (unstable), they took over the basic human needs. I would also tax financial loss by investment banks, which would nip future crises in the bud.
>
> This is may seem like a bizarre idea, but let us accept it for a moment: the whole history of humans and Technos started when human lives became considered worth wasting in offensive wars.

As for order, its pattern template is $T*\Delta S$ of thermodynamics (**T**: temperature, **S**: entropy), although entropy is the most confusing, even senseless, concept if applied to exystems. Like energy, it also needs generalization, which I discussed by the end of **Part 2**. I would speak about stability consisting of two components: chaos and order, although I am not satisfied with the terms. **Created order** is probably the simplest and most abstract measure of instability.

I risk going astray in these matters, but details hardly matter much until the sprouts of econochemistry rise at least half inch above the ground.

As I tried to show, we cannot calculate anything chemically important on the scale of economy, but we can decide whether a certain increment of stability has a positive or negative sign. Organic chemistry still uses such qualitative considerations. In the future (if it is even more dehumanized and digitalized than now) we may be able to do the calculations, as quantum chemistry does for molecular chemistry today. They could be reliable when the effects are significant in size and few in numbers.

Molecular chemistry is a giant tree of knowledge with many branches. Molecular **chemical thermodynamics** and **chemical kinetics** are two of them. They apply thermodynamics, simple assumptions, and some common-sense mathematics to molecular problems such as equilibrium and speed of chemical reactions. If pattern-chemical thermodynamics can be generalized, what about kinetics?

The main question addressed to kinetics is: what comes first, i.e., what is going to happen "tomorrow" (next moment, next day, next year, etc.). The answer is: of all possible outcomes, what can happen faster will, probably, happen indeed. One can object that we need to know all possible alternatives, but we never know all of them in an evolving and complex system open to environment. This is correct, but even molecular chemists deal with incompleteness and uncertainty all the time. Their predictions, although true most of the time, occasionally fail. To run into a wrong prediction is a great bonus to a scientist because it opens the way to a new discovery. As science, which is also an exystem, adapts to failures, so do plants and animals, and so should we.

> **CONFESSIONS.** By my nature, I am a skeptic and a pragmatic pessimist: I expect the worst, but prepare to fight it and overcome the obstacle. I tend to look for worst alternatives. I am mostly suspicious of people in power. With such disposition, I am greatly surprised by my own instinctive attitude to Great Depression 2: I am not at all pessimistic. I am witnessing a big systemic American fiasco, but I see it as the once in a lifetime and certainly first on my memory act of evolutionary adaptation by trial (arrogant, ignorant, and greedy) and error (huge, shameful, but productive). I would probably see it differently if the crisis directly affected me, however. I cannot hold anybody personally responsible because of the inherent incompleteness of exystemology. In democracy we cannot blame even a president like George Bush: only ourselves. Yet Alan Greenspan is the closest candidate for the scapegoat. He was not elected and he put on a lot of airs. The bell tolling for American auto industry troubles me most of all because I do not know whom to blame.

4. FROM ENERGY TO ENTROPY AND BACK

I am turning to a difficult and still controversial—since Boltzman and especially Shannon—subject of entropy. After many decades of discussion in literature the subject has not been exhausted. I am stimulated by its crucial importance for understanding exystems and encouraged by some recent contributions by Constantino Tsallis and Steven (Steve) Pincus. I suspect that its very controversy is the key to comprehending the place of human matters in total human knowledge. My problem is that I am not good at fully understanding the physical and mathematical side of discussion.

I will start with money. At the end of my ride on the "Ferris wheel of history," a startling idea came to mind: we should exclude money from consideration in econochemistry. The idea sounds all the more radical that on many occasions I pointed to the similarity between money, energy, and ATP (adenosine triphosphate) which is a universal currency of energy in all living organisms.

Chemical prediction and explanation are based on the balance of many positive and negative entries when two states are compared. Chemistry is unthinkable and useless without conservative principles embodied by honest and thorough bookkeeping. Same is true for any hard reliable science. Energy stored in ATP is conserved. Money is not conserved in the same sense.

I have two fresh examples: the Bernard Madoff affair and the pension funds tied to stock market. What happened to the billions of dollars that thousands of people entrusted to the fraudster? Is the complete balanced account of the affair possible? Suppose, some money is found in five years. It will not be the same because of inflation. People who live off the pension funds will not be the same. Would you rely on market rebound in five years if you are 80 years old? Money is lost every day, but it is the religious belief in the resilience of the market **on the time scale of human life** which keeps money flowing into the market. Then something happens out of the blue and shakes this belief.

People who discuss the Madoff affair on the Web keep asking the same question "what happened to the money?" Someday the books will be checked against the facts and testimonies, but the believers in the power of accounting might be disappointed. If miracles happen in the world, it is with money. The second lesson of the affair, next after the eggs-in-basket parable, is that no man-made evidence can be fully trusted.

Money belongs not to chemistry but to markets, where the constant and fast dynamic exchange creates an illusion of intrinsic value, and to finance where belief in some chiseled in stone principles of bookkeeping creates an illusion of value conservation.

The only conservative alternative to money in chemistry is physical energy, which is close to the point of view of Adam Smith. Any specific product can be measured in amount of Gibbs energy required to produce it from less ordered resources. It is easier said than done. This amount depends on the generalized temperature and change of entropy. None of them can be measured with any instrument.

The problem of information in economics does not exist for an econochemist. For a chemist, information enters the picture in the role of catalyst, which does **not enter any balance** because it is returned unchanged. The catalyst itself is a material product, for example, a CD with Windows software or just the brain of a computer scientist. I expect that an econochemist venturing to estimate the cost of election of Barack Obama as President could discover interesting variations in energy consumption and dissipation depending on daily happenings and collisions of the campaign. Such evaluations, however, could be meaningful only on a comparative MORE/LESS basis. This is a pristine area (at least I have not seen anybody there). If you asked me what it means to be an accomplished econochemist, I would say it is to feel fully comfortable with information/entropy in economy.

For now, I leave a more detailed econochemical analysis of information and temperature as an exercise for future econochemists, but not myself.

> **HINTS AND GUESSES**: (1) Creation of a new catalyst in a stable storable form stabilizes the exystem of human and animal problem solving. (2) Catalysts, for example, DNA, undergo Darwinian selection; there is consensus at least on that. (4) Temperature is the amplitude and frequency of fluctuations over a unit of time. (5) There is some literature on entropy of event sequences (time series) in various exystems, see Approximate Entropy , (ApEn), suggested by Steven Pincus. In principle, ApEn is applicable to one-time single sequence of some length.
> (6) Strictly speaking, the catalyst at present state is a bundle of selected memories of the previous state. Events in exystems form "anti-Markov" chains in which very little happens at random. (7) Probability always brings controversy to evolution. Darwinism is not in random mutations but in remembering them: social mutations are not always random. (8) God is a creator whose right hand remembers what the left hand has done.

I am looking for simplicity. Temperature and entropy as entries in calculating energy is too much complexity.

As a rough approximation, in spite of all disadvantages of money as compared with ATP, we can use amount of money as a surrogate measure of the ability to perform work in the exystem which is in a **very stable** state. In this sense (and many more) money is energy and energy is power: ability to produce effect in the form of work.

The major ambiguity about energy and economy is the relation between physical energy of all food and fuel and stability. There seems to be a break in logical continuity. A change in energy supply and its dissipation is just one factor, but something is missing because energy can be used for both creation and destruction. Of course, I can say that it is the difference between physical and chemical approaches that is responsible for the breach. Physics leaves structure, non-reducible complexity, and individuality to chemistry. Chemistry needs an exact description of the system for its accounting of the "structured finance" of energy and entropy, which not impossible regarding an exystem, but is today impractical.

If order and energy is all we need for the most general form of stability balance—in differential form, of course—then why not to express order in terms of energy and not entropy and temperature? Unexpectedly, molecular systems and exystems (as well as some physically implementable structures such as webs and lattices) provide a very humble dimension to do that: size. I speak about size instead of space and geometry because size applies also to structures without Euclidean geometry. The size of configuration is the total number of its generators.

There are different scales of size depending on how we group small blocks into larger ones. A crude example is quantiles: quintiles, percentiles, etc., which are used for presentation of statistical distribution of a variable over a large population. Social classes and estates are another example. Note the lack of any objective standard for choosing a quantile or wealth category: it is a matter of convention and convenience, while classes used to be well defined legally.

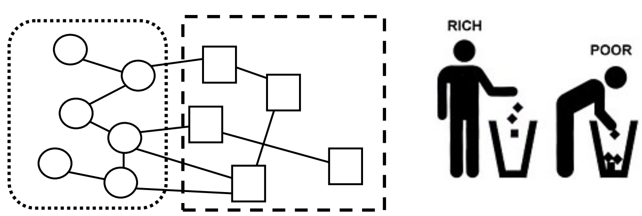


Figure B4-1. The size of the configuration

It sounds trivial that configurations of large size, such as societies, can have only non-uniform distribution of a variable like wealth. What may be less trivial, any measure of the non-uniformity of a real and not idealized system is a member of a whole family of estimates. I was rather surprised to find out that physics had been aware of the problem at least since Einstein. I see this circumstance as a possible definition of the borderline between physical and chemical sciences. Physics needs a full description of the system to calculate entropy, which means that the full description does not depend on time. Chemistry needs a snapshot of the system to compare it to another snapshot, regardless of date and time. My gut feeling is that the divide is created by the term "probability" itself—one of a few controversial topics in mathematics. According to one school of thought, probability is just a more specific variety of a more abstract kind known as frequency or occurrence.

I can only be very amateurish on such subjects, but I can call references to support me. See Frequency probability , Probability and frequency (Tom Loredo) , Frequency , and Frequency interpretation of probability. In other words, I am a staunch frequentist. I believe only my own eyes—a strange thing to say for a chemist who normally never sees face to face molecules he has so much power over.

If you want power but think politics is dirty, go into chemistry.

I think that probability-based measures have the least utility in pattern chemistry of exystems. I have an impression that the growing diversity of methods of measuring order is one of the undercurrents of modern science not yet fully recognized.

I believe that a physicist or mathematician could do a much better job in explaining the available choice of concepts related to measuring order, but I am only a chemist with an ambition to conform understanding to human scale. Most important things should **not be fully** entrusted to specialists—neither money, nor health, nor identity, nor life.

I decide to skip a review of the so-called electron delocalization in molecular chemistry, which inspired the main idea: concentration of money is the source of economic instability. I can only say how it sounds in chemistry: **the less localized** an electron is in molecule and the wider it is spread over more than one atom, **the more stable** the molecule is. The reasons for that are of quantum-mechanical nature. **Stable** , **stabilization**, and **stabilized** are exact words used by molecular chemists. There is no logical or causal connection between electrons and markets: there is only the pattern.

Figure B4-2. **Inequality as pattern**

1: Ice in water; 2: Icebergs in the ocean; 3: UN Human Development Index (2008); 4: Living in São Paulo, Brazil ("thin line between rich and poor")

Using the pattern, but again without a consistent logic, I formulate one of main principles of econochemistry as:

The less "normal" the distribution of a variable (money, energy, resource, temperature, components of culture, etc.) the less stable the exystem.

Inequality can be a misleading term. **"Equality"** in exystems means **normal (Gaussian** is a better term**)** bell-shaped distribution. Equal distribution—same share to everybody—is also unstable. It takes effort to make **all** bolts and huts equal in size. Using *abnormality* or *non-normality* instead could also sound misleading. **Pareto** distribution is the correct term for the kind of inequality which is normal for economy. Gaussian and Pareto distributions (as well as other important distributions) are, in fact, patterns, i.e., families of distributions.

I present some configurations of the pattern of inequality in **Figure B4-2**.

What have been all hedge funds, private equity firms, corporate insurance, and investment banks doing since 1970? They were increasing inequality of income and wealth distribution.

Figure B4-3. **The Water distribution systems**

As I mentioned earlier, the inequality does not involve redistribution of income already in possession. The system of disequality follows the pattern of water distribution in agricultural irrigation. The flow of "water," i.e. energy from economy, is regulated by a system of gates and pumps positioned between production and appropriation.

The gates require much less energy to operate than the pumps. The resulting heavy inequality, leading to the instability of the system, consumes an amazingly small amount of resource—just the food and drinks for the management, traders, and electricity for their computers—but with astonishing global consequences. As for personal consequences, they are not less contrasting. The efficient wealth pumps and gates are expensive to get and install, but they pay off lavishly. I begin to suspect, however, that what I call "wealth pump" is mostly a system of gates, but this is just the same as Maxwell's devil.

The art and purpose of economic regulation is not to enforce a normal (Gaussian) distribution, not to implement communism or socialism, but to insure the stability of economy. The most stable economy is the one which does not change, which is never possible in exystems and not even desirable. What kind of change is then desirable? There is no answer to this question. It is the matter of belief that we need to understand the nature of our world as a whole in order to make our own decisions while we still have some individual influence and control over our lives. Take care of order and the nature will take care of chaos.

I want to emphasize that I do not make any discovery. I simply generalize notions of natural sciences, as befit a pattern chemist. I am trying to present the connection between inequality and instability as a universal and inescapable principle of exystems, not based on other principles, but following from our choice of basic axiomatic notions fully commensurable with our experience on human scale. Inequality and instability is something which we can see with naked eye. I am not a proponent of either equality or stability.

By April, 2009, when I am writing these lines, the role of wealth concentration as the internal cause of the **current** economic seems to be widely recognized. It has been noticed that the excessive risk-taking is the result of wealth concentration, too. It will be most probably forgotten in a few years. Moreover, the story will repeat itself all over because it is exactly the concentration of wealth which is the ultimate goal of people in possession of wealth machinery. Besides, this goal is part of normal human nature. It leads to a vicious cycle: the more wealth concentration the more instability, the more instability the more concentration as insurance against loss in times of instability. Yet "vicious," unlike "cycle," is beyond chemistry. Instability of the exystem is its definitive property and stable exystem is contradiction in terms.

I see the purpose of pattern chemistry not as any eye-opening revelation of previously hidden truth of practical significance, but as a step to a unified and simplified picture of the unbearably complex world. Complexity is the worst enemy of democracy: it makes democracy as inefficient as the air conditioner in the room with wide open windows. Worse, it makes democracy look ridiculous. So does simplicity.

In short, as I repeatedly indicated, pattern chemistry is a way to peek as far as possible into the future of an exystem, which is, unlike molecular systems, opaque by definition.

5. FROM ECONOMY TO RELIGION AND BACK

The American addiction to religion could be a consequence of the complexity of modern science, but there must be a more general—econochemical—reason.

I have quoted the Scriptures in this text often enough to demonstrate my respect for the Bible. The old religious texts, whether Christian, Jewish, Buddhist, or others, for which nobody was paid royalty, are outside economy. Next, I am going to demonstrate my disrespect to mixing religion with politics. This cocktail is produced by a vibrant part of American economy.

Since Alexis de Toqueville, the role of religion in society has been one of the most fascinating aspects of American life for visitors, immigrants, and some natives. I must say that it has been the least comprehensible phenomenon for me.

> **DISCLOSURE.** I was brought up in an atheist society with the full-blown secular religion of Soviet ideology. *Dhammapada* was the very first religious book in my youth and it had a powerful lasting influence. I had read the New Testament at the age of about 25 and was deeply and positively impressed. I read the full Russian Bible at 40 and Jewish Torah at 50. The only reason why I did it so late was the difficulty to get hold of the books. I still turn to the Bible and Torah in English from time to time and value them as great human documents and one of the foundations of my own Western culture. I consider the religion/politics mix the major threat to any culture, however.
>
> My heritage is exclusively Jewish and this is who I am. I see myself as a secular Jewish believer in Judeo-Christian moral patterns. I cannot say whether I am an atheist because I do not know the difference between the believer and non-believer if both follow the same moral patterns. When somebody says he is a believer, I have to believe him, but I never have a proof. This requirement of double belief makes me skeptical regarding the questions of faith. If you believe, you act. And if you act, this is your belief. I am not the one to judge.
>
> I do not judge religion by the criterion of truth. Neither have I anything against personal religious beliefs and habits of any kind or willingly performed rituals. I value the social function of religion in small communities. If I am repelled by the militant American Christian Right, it is not because I came from communist Russia, but because its aggressive intolerance is so much different from the Christianity known to me from the original source—the Gospels—but so much familiar to me from the aggressive intolerance of Russian communism.

Religious politics, from Reformation to Iraq, has been one of the historically most effective ways to cause instability and guarantee years of bloodshed. It is still, paradoxically, the preferred way to enforce stability in an authoritarian society. Religious conflict is about power and domination.

It seems to me that at least two secular religions—communism and extreme libertarianism—are similar in the blindness of faith, renouncement of logic, and political involvement, although they could not be more contrasting in the doctrine, but the doctrines are so nebulous and fragmented that none can be taken seriously.

Kevin Phillips' *American Theocracy: The Peril and Politics of Radical Religion, Oil, and Borrowed Money in the 21st Century* (Viking Penguin, 2006) was on a short notice prophetic. His *Bad Money: Reckless Finance, Failed Politics, and the Global Crisis of American Capitalism* (Viking Penguin, 2008) updates the previous book *post factum*. Although its title sounds like another dark prophesy, the book is optimistic at least on the single count of theocracy.

What I could **not find** in "*American Theocracy*" was the economic mechanism of the current preaching boom in America. This is a difficult and unpleasant topic for me and it looks like for others, too, although there is a noticeable but ineffective literature. Economics of religion is limited to direct description of economic and social aspects, as well as parallels of religious activity with markets.

What makes people prefer religion to other spiritual goods, many of them free? I suggest the chemical analysis of the problem as an exercise for somebody else, not me.

> **HINTS AND GUESSES**: Entertainment, unlike many material goods, does not involve any **damage risk** on part of the consumer. In the language of econochemical patterns, indigenous and intense American religion is (1) mass family **entertainment**. (2) Like **sports**, it (a) offers the performing stars (preachers), suspense of struggle, sweetness of victory, and bitterness of defeat (for example, over Darwin and abortion), as well as (b) **club** identification and networking with not just your star but all his fans. (3) It (a) **promises reward** in the future, which is typical of investment management business but not the investment itself, and (b) feeds on the **post-1970** accumulation of wealth. (5) Religion is not just **tax-free**, which is of minor importance, but free of any kind of **regulation.** (6) Churches **compete** and advertise.
>
> For comparison I quote two papers of Laurence Iannoconne, a leading researcher in economics of religion. Note his view on risk, with which I disagree. Religion is so popular because it is risk-free in the sense that no loss is ever expected. Religion is no lemon.
>
>> However one defines religion and religious goods, it is clear that religious activities **involve a large amount of risk**. The promised rewards may never materialize, the beliefs may prove false, the sacrifices may be for naught. In this respect, religion is the ultimate "credence good"—a fact noted by several authors. Introduction to the Economics of Religion (1998)

> Injury-oriented sacrifice can be modeled as a market phenomenon grounded in exchanges between a relatively small supply of people willing to sacrifice themselves and a relatively large number of "demanders" who benefit from the sacrificers' acts. Contrary to popular perception, it is on account of limited *demand* rather than limited supply that markets for "martyrs" so rarely flourish. Suicidal attacks almost never profit the groups best equipped to recruit, train, and direct the potential martyrs. The Market for Martyrs (2003)

The ultimate religious promise is the arrival to the state of supreme stability and eternal motion without evolution. Within this pattern, Abrahamic religions, Buddhism, and Hinduism are exceptionally close configurations.

I drew the following chart using the numerical data of **Table 3** from American Religious Identification Survey (ARIS) , 2008 . It presents the Lorentz curves and Gini coefficients of inequality for membership in 24 larger denominations in three different years.

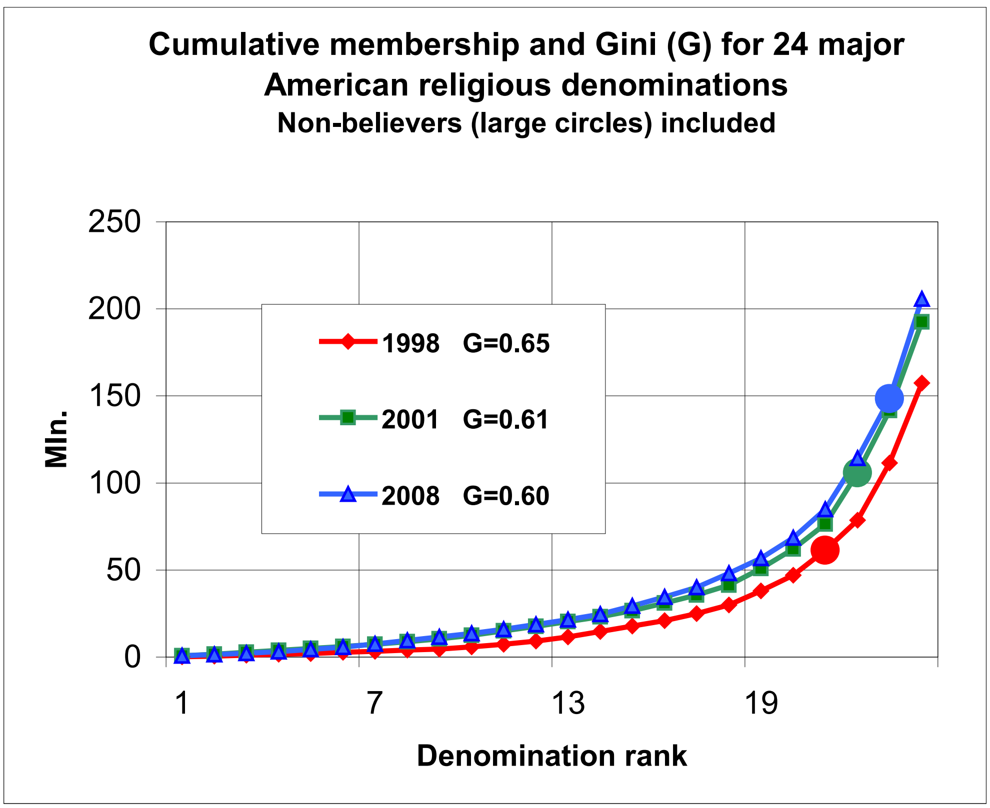


Figure B-5-1. **The market of beliefs.** **Original data are from:** http://b27.cc.trincoll.edu/weblogs/AmericanReligionSurvey-ARIS/reports/ARIS_Report_2008.pdf

The 0.6 Gini corresponds to the "classical" Pareto 80-20 principle: 80% of believers (including non-believers) belong to 20% of denominations. I interpret it as an evidence of a capitalist market of beliefs, which agrees with some professional observations. But what is capitalist market, anyway? I see it as an economy where money buys a money pump. Jesus, according to Matthew, clearly speaks not of wealth but of knowledge, but the pattern stands for both:

> For whosoever hath, to him shall be given, and he shall have more abundance: but whosoever hath not, from him shall be taken away even that he hath. (Matthew, 13:12).

The Gini inequality index for USA income distribution is around 0.46 (2007), which is the highest for advanced economies. Yet the wealth distribution, although more difficult to estimate, is much more unequal (Gini ~ 0.6). Moreover, it starts with small negative and ends with astronomic positive values.

The Gini for belief distribution turns out to be a measure of market freedom: in an ideologically constricted society, the minor denominations would be suppressed and one would overpower all the rest. Looking back at the Soviet Russia, I feel certain that the overwhelming majority of Russians did not care for either Communism or Christianity whatsoever. If asked by strangers, they would never acknowledge that as far as communism was concerned. Moreover, cautious people would never tell the truth even anonymously, as if the secret police had supernatural powers.

> **NOTE**: The influence of changing immigration patterns on religious affiliation is undisputed, but it is not quite clear how it changes the ratio of non-believers and generic Christians.

If religion is on the market, it must be dynamic and adaptive to the consumer tastes. Kevin Phillips' *Bad Money* contains a short overview of the latest "prosperity gospel." "Donate, and God will reward you" echoes with the obsessive DONATE of Barack Obama's Internet campaign (to which I donated) and even the basic call of the market: "Invest, and the market will reward you."

There are other signs of adaptation, for example, vacillation of religious leaders between embracing the protection of environment or fighting it as a false religion, but I do not expect "God wants you to be rich" to vanishing from the menu.

Vilfredo Pareto lived in times late enough to use modern terminology:

> There is a rhythm of sentiment which we can observe in ethics, in religion, and in politics as waves resembling the **business cycle**. (*The Rise and Fall of the Elites: An Application of Theoretical Sociology*, Transaction Publishers, 1991, p.31)

As for much earlier times, I was surprised to find out that the title of what I knew as 95 theses of Martin Luther sounded as a modern PhD thesis or paper on derivatives: **DISPUTATION OF DOCTOR MARTIN LUTHER ON THE POWER AND EFFICACY OF INDULGENCES,** October 31, 1517.

Compare with a paper: **On the Efficiency of the Weather Derivatives Market.**

Compare with the title of the workshop **Derivative Markets in Emerging Markets: Improving Efficiency While Safeguarding Financial Stability**, April 23–24, 2008, Brasilia, Brazil.

Pattern chemistry can be extreme, too.

Wasn't indulgence a kind of insurance against the heat of the hell?

The not-so-secret ingredient of religiopolitical cocktail is called DONATE. A pinch of science would not hurt, as creationism promises. Science, however, may become the primary ingredient of the triple mix.

A new apocalyptic insurance market is emerging right before our eyes: **FIGHTING GLOBAL WARMING.** I believe in science because it always in doubt. I believe that the global warming is real, man-made, and threatening. But the strategy of fighting it has something of the religious faith because, like apocalypse, i.e., the end of the world, global warming has never happened on human memory. We are protected by science from global warming even less than by mathematical finance from market loss.

Let this lame Chapter be a tentative incursion into the area of econochemistry of belief. I will return to global warming in Chapter 8, *From consequences to adaptation*.

6. FROM INSTABILITY TO EVENT

I described the general pattern of chemical event on many occasions. In short, there is a single initial stable state and a set of **possible** final stable states. There is a set of **possible** unstable transition states between them. In general, there is no one-to-one correspondence between stable and transition states. One transition state can produce two or more different final states. Event is the recombination of the initial stable state into the final stable state. Each of three principal states in an event can be a superposition of various configurations.

The entire pattern of **reversible** chemical events is ideogrammatically portrayed in **Figure B6-1**, where the buildings stand for stable states and the walkways for transition states. The ideogram reflects the difference between both: the students spend most **time** confined to the buildings , while the walkways are mostly for **short time** traffic. The forks in the pathways, typical in chemistry (for example, in decision making) are a consequence of systemic complexity.

Figure B6-1. California State Polytechnic University, Pomona , 1965

To streamline the quad ideogram, let the buildings be towers of different height with stairways up to the halls and offices. Instead of the walkways let us imagine skywalks—sharply arched bridges—some of them intersecting (**Figure B6-2B**) . The students and staff—young, middle-aged, and old—have to climb the stairs to get into the buildings and pass the skywalks to get from one building to another without ant mechanical aid. The physically impaired would stay in the only ground level building, others would find the highest bridges impassable, and the young and restless would have no problem at all. A certain distribution of the population over the buildings will finally establish. It will be defined by the campus architecture, as well as by the energy of the occupants. The systemic events—passages from one tower to another—will have different frequencies.

To imitate human history, we need only to eliminate reversibility by letting the people live their normal life, multiply, and revolt against gravity and death by inventing airplanes and medicine, and teach all that on the global campus. Wars, revolutions, market bubbles, and bank crashes will follow.

In molecular chemistry, experiment in a test tube is the simplest and fastest way to find out what happens if we mix two ingredients. The most reliable way to see the future is just to have some patience.

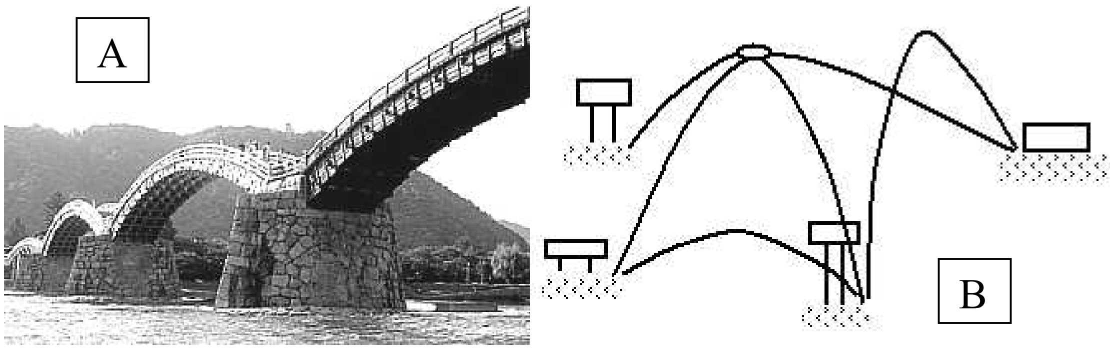


Figure B6-2. **A: Kintaikyo bridge (1673), Japan. B: Imaginary "Exercise Campus" of towers and bridges.**

In general, the more patience and temperance we have, the more the future will be like the present. Yet we do not have patience. We are made mostly of water and we need energy to maintain the shape of our cells, filled with liquid, to move in space, and to keep the neurons flickering. We have inherent **instability** which nudges us to act. At the moment of death we lose most of it and start losing the rest pretty quickly.

The idea that human instability, dissatisfaction, and stress push us to act is very old. Ludwig von Mises borrowed from John Locke the term "uneasiness" together with the entire idea. In pattern chemistry "uneasiness" translates into non-equilibrium. Although disequilibrium is a much better term, it has been taken by economics to signify, as I understand, various deviations from **how the things should be**.

> I use the composition of realistic and make-believe elements to illustrate once again what pattern means. It is not just a shape or a mode of behavior within a selected domain of objects, from tile patterns to spending patterns, but a kind of a mathematical formula highly independent of what its variables are. Yet it is very difficult, even impossible, to formalize the invariance in the traditional symbolic way unless, as in 2D image recognition, the background space is already well tilled for mathematical formalism. Even then, however, the human subjective choice is necessary for the selection of a template. Thus we can talk about the uneasiness of atoms and molecules at increased temperature, as well as uneasiness of exystems. We choose, however, to speak in least understandable terms about most mundane things and this makes science work.

Ludwig von Mises added to (1) “the uneasiness” two more conditions of human action: (2) imagination of a better future and (3) belief that the action will achieve it. We certainly cannot speak in this language about molecules or anything that has no imagination and belief.

In physics, the best counterpart for the state of “uneasiness” is called excited state, i.e., unstable state of increased energy. Physically, the transition state is a passage through a series of excited states. The concept of transition state itself came from physics.

It seems paradoxical that humans increase their activity and dissipation of energy exactly when reason and sensations suggests the opposite: immobility to save energy. My chemical parallel to von Mises’ idea is that (1) the humans act when they are extremely pessimistic about the outcome of inaction and see no better future for themselves. Then animals and humans start exploring, sometimes chaotically, whatever comes into view and to mind. Therefore, (2) they believe that inaction will achieve nothing and is harmful.

Actually, people under severe stress do not need any belief because the danger and hunger release the triggers of powerful instincts which take over reason. This sounds like sophistry, but there are subtle chemical undertones. The stress of danger makes the living “molecule” climb the high and frightening skywalk toward the greener pastures not even in sight. The optimist perceives the transition state as a paved pathway through a rose garden, until experience proves otherwise.

Without too much indulgence into psychology, which has a chemistry of its own, I move straight to my goal: the problem of risk. Obviously, the possession of capital in form of money, young age, or professional experience provides foundation for optimistic expectations and straightens and safeguards the passage—“lowers the transition barrier”— to the stable final state, more or less close to the target. The vitality may stay with the person after the passage, experience increases, and only the capital may drop. The loss, however, can be without significance if wealth is big enough. This is the chemistry of human action, but I feel a great **uneasiness** regarding the dire triviality of my “analysis.”

Maybe this extravagant wording sounds less trivial: **wealth uses energy as catalyst** when it throws itself into the market and recoups the expenses in the end**.** This is the chemical essence of ideal successful investment which is supposed to recover the “catalyst” and generate something extra. Capital is, in chemical language, autocatalytic. The extraordinary difference of exystems from physical systems is that physical energy can be a component of stabilization, as well as destabilization, although energy and instability are configurations of the same conceptual pattern. The mechanism of this astonishing miracle has but one possible explanation: stabilization and destabilization are two products of the exystemic evolution which can be represented only as a record and not as equation. Patterns are the way to compress the detailed record. Darwin, actually, uses the language of patterns because this is what the natural language is. Why cannot we use it in economics?

Money in the role of catalyst (here the alchemy of finance turns into chemistry) may answer a possible question of why rich oil resources stabilize dictatorial regimes. It may also add weight, in a roundabout way, to my distrust of money as a productive concept in the scientific, i.e., based on the laws of conservation, "**realpolitik**" economics.

Is conservation really necessary?

Let us see how econophysicists look at money, craving aside. Next, I quote one of important works in econophysics. I do not comment other than highlighting a few words.

> We **claim** that, in a **closed** economic system, the total amount of money is conserved. Thus the equilibrium probability distribution of money P(m) **should** follow the Boltzmann-Gibbs law $P(m) = Ce^{-m/T}$. Here m is money, and T is an effective temperature equal to the average amount of money per economic agent. The conservation law of money **[5]** reflects their fundamental property that, unlike material wealth, money (more precisely the fiat, "paper" money) is not allowed to be manufactured by regular economic agents, but can only be transferred between agents. (Adrian Drăgulescu and Victor M. Yakovenko, Statistical mechanics of money).
>
> > **[5]** M. Shubik, in The Economy as an **Evolving Complex System** II, edited by W. B. Arthur, S. N. Durlauf, and D. A. Lane (Addison-Wesley, Reading, 1997) p. 263.

Note temperature as the average money per agent. Of course, it means that money is considered a form of energy. But temperature is an intensive value, while energy and conserved money are extensive.

Note also reference [5] to the paper by Martin Shubik entitled *Time and Money*. Its version (1996) is available on the Web and it is well worth reading because it is very sober, i.e., free of chemical "substance abuse," realistic, and very enlightening with regard to mathematical finance, conservation law, disappearance of money, "economic earthquakes," regulation, and other buzzwords of today. No retelling will substitute for author's insightful, chemically clean reasoning, which is only a tiny part of his productivity in the field.

> Dragulescu and Yakovenko's reference to Martin Shubik seems misaddressed because he shows with a clever pattern example that money in real life is not fully conserved. Yet I cannot have any chemical—all the more, any other—arguments against the above quoted paper of Yakovenko group. Its conclusion is completely disarming:
>
> > "We do not claim that the real economy is in equilibrium. (Most of the physical world around us is not in true equilibrium either.) Nevertheless, the concept of statistical equilibrium is a very useful reference point for studying nonequilibrium phenomena."

The strict compliance with the law of conservation is possible only when "time disappears," i.e., economics is in a steady state, all books are balanced, and no events, except the normal dance of fluctuations, happen. This economic nirvana, however, is a purely religious idea.

> When the more cautious attempts have been made to measure phenomena, such as the propensity to consume or the Phillis curve [inflation *versus* unemployment] , however, the grand dynamics [of Marx and Keynes] appear to **melt into a welter of special cases and context dependent incidents.** In contrast, the highly mathematical and apparently precise formulation of general equilibrium **has no dynamics** as it avoids process modeling
>
> Martin Shubik , *Time and Money*.

M. Shubik's ideas guided me in an oblique way to the question about the evolutionary role of economic earthquakes and wealth concentration. With regard to exystems, either is as destructive as it is creative, probably, like any natural force. Today we can hear the question, "does capitalism work?" It works exactly as our planet works: with periodic **natural** disasters.

Chemistry is all about the step-by-step down to earth modeling of the **sequence of events,** i.e., as Leibniz understood time. In molecular chemistry, all possible events happen concurrently, some faster than others. There are two key circumstances. (1) The faster events "rob" the slower ones of the initial configurations, which dramatically reduces the complexity of the resulting final state, and (2) because of chemical equilibrium, the result in the short run commonly changes in the log run. In the short run, the result is determined by the speed of transformation (kinetic control) , while in the long run it determined by the relative stability of alternative final configurations (thermodynamic control). Since experiments with molecules are reproducible, we can acquire rather detailed knowledge about many, if not all, unstable transitional configurations and thus explain, predict, and control the molecular events.

I want to reuse my old example of Clever Elsa from **Preface**. Her thoughts in the cellar could take a different course. She could think about her future son taking the pickaxe and do some great and useful work with it. That would normally suppress the pessimistic alternative. **In the long run**, she would forget all such nonsense and marry Hans. The tale had no happy end, however, because she was too clever to be happy. A new thought paralyzed her mind: "Is it me, or is it not me ?"

In exystems, i.e., human matters, events—from individual acts to econochemical processes, from religion to science, from war to diplomacy, and from politics to creative arts—are reversible only as a rare exception. The transition states are typically either hidden or incompletely recorded. The final states are always short-living and usually excluding alternatives. As for the energy, it cannot be measured in physical units, all the more, the efficiency and mode of use is highly variable. Still, the comparison of resources of energy in form of food, fuel, and cash remains very meaningful in everyday life, individual as well as corporate. Similarly, the balance of voting force in US Senate is of decisive political importance, although, for example, 60:40 corresponds to a large number of voting configurations subjected to usually hidden powerful forces shaping individual votes along party lines.

The chemical view of "eventology," as kinetics can be called, has an important aspect. When we deal with statistical ensembles, even if they do not involve large numbers, the events are driven by **elites**: the agents with highest energy, i.e., most unstable, lead the transformation along the skywalk from one state to the next. Thus, the youngest will be most mobile around the Exercise Campus (**Figure B6-2**), but only in the short run. With time, there is a chance that the distinguished staff will move around in escalators and elevators, leaving behind the students—provided there is enough money and strong coffee.

With molecules, only the most energetic elite is able to overcome the obstacle of transition. The difference from human society is that molecules exchange energy, maintaining the same distribution depending on the temperature. Therefore, as a molecule of high enough energy jumps over the transition barrier, another one takes its place, and so on, until the equilibrium between jumping back and forth establishes. This is possible because of the absence of private property, i.e. a long term tie between the molecule and its energy.

The Russian Revolution of 1917 turned into a holocaust of elites: the rich, the landowners, the powerful, the intelligent, and the ingenious were gone. Immediately, a new—proletarian—elite began to form. It did not, however, possess material wealth and could be the power elite only. This is why Russia had to wait for 70 years until a new business elite began to compete (sometimes, to its peril) and coexist with power elite. Interestingly, because of the absence of private property, the Russian communist power elite was rather fluid. Power in Russia has been always easy to lose, together with freedom and even life, at some dark periods of Russian history. The same happened in Mao's China.

What about democracy? I leave the question to the reader as an exercise.

> **HINTS AND GUESSES**. My guess is that politics in democracy, as any politics, is elitarian. Elite is always (1) a numerical minority, (2) feels "uneasiness," and (3) has access to wealth, whether it possesses it or not. The elites select, process, and wrap up propositions into gaudy packages. Most voters accept or reject the gifts without looking inside: the wrapping is enough. Besides, you need to belong to an elite to see the inside.
>
> We stick to democracy because it works and keeps social instability at an acceptable level, at least most of the time. Democracy is our symbiotic adaptation to industrial capitalism which operates on a limited resource of skilled hands and minds and requires smooth relations between social strata (although I suspect any economic formation requires that, even the totalitarianism). Democracy is so historically young and diverse that we do not know much about its long term properties, especially, remembering Hitler. It seems that a democratic society has, like a typical organism, self-regulating (homeostatic) properties, but exystems take us by surprise when they morph in the long run. As soon as ideology begins

to amass money, it enters political life with the blind destructive power of irrationality. The major historical test for democracy, quite unprecedented, is the ascent of **large** non-democratic or semi-democratic but equally industrious nations against the backdrop of resource depletion. The cardinal question is how democracy will react to the shrinking natural resources. I believe that Vilfredo Pareto's *The Rise and Fall of Elites* and its modern reassessment are highly relevant to the subject.

7. FROM EVENT TO CONSEQUENCES

Molecular chemistry is obsessed with detail: it looks at a chemical reaction as an event which splits into a sequence of smaller events, but not so small that the sight of atoms and their bonds would be lost. Biochemistry deals with the largest known chemical events with biopolymers. This is something that molecular chemistry shares with history and both share with pattern chemistry.

The Battle of Waterloo is an example of a small but definitely exystemic event. The historian presents it as a sequence of smaller events, always remaining at the level of humans, horses, and canons. Even if history veers into physiology or meteorology, it is only because of the contribution of an ailment or a storm to stability and order.

History—global, regional, national, institutional, and individual—is descriptive chemistry. Only it is not yet pattern chemistry. The word "pattern" today is widely used, but it is limited to a particular field of knowledge. A historian stays with people, horses, rockets, and nukes. A pattern chemist would stay with exystems of any kind—with

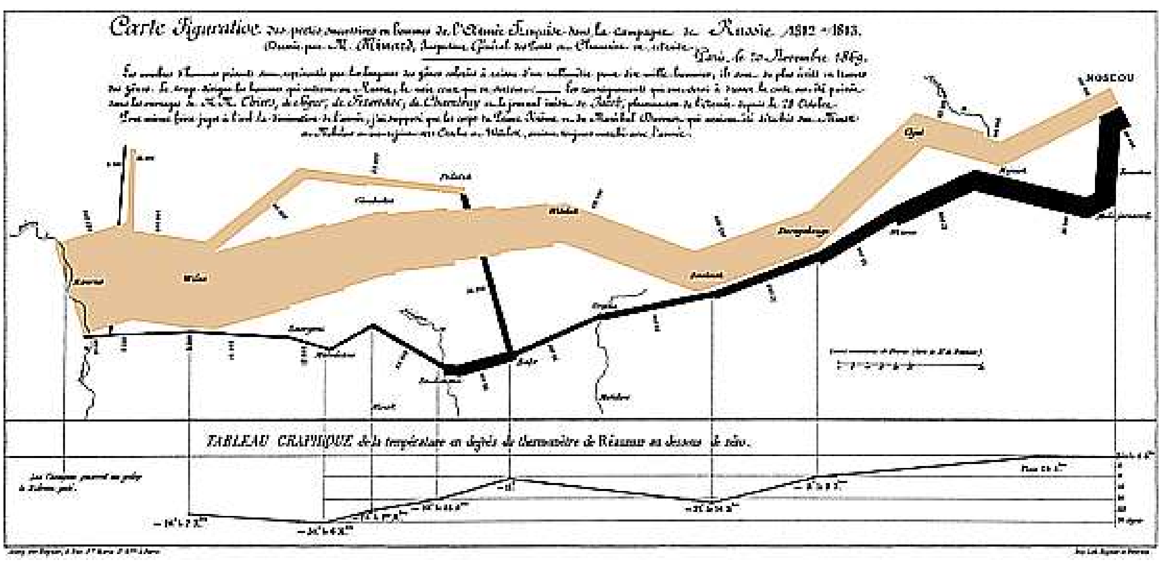


Figure B7. **Charles Minard's graph of Napoleon's losses in the 1812 campaign from Russian border toward Moscow and back. The bottom part shows falling winter temperatures during the retreat; – 37.5 C° (– 35.5 F°) was the lowest.**

EVERYTHING.

I consider Charles Joseph Minard (1781 –1870) one of the first intuitive econochemists. He used graphic representations of historic events, like Napoleon's invasion of Russia and Hannibal's campaign in Europe, and of economic processes, like cotton trade in Europe and British coal exports. He displayed information in space, time, size, and even ambient temperature, as his most famous graph illustrates, **Figure B7**. There is a lot about Minard on the Web, where one can find also spectacular modern graphs of the same nature generated by computers (Lothar Krempel). Yet it seems that Minard remains unrivaled regarding the extent of complexity he managed to render. His graph can be easily enhanced with the addition of dates of arrival and departure at certain points (some are given for the retreat), details of battles, clashes, food supply, diseases, etc. Minard statically represents dynamic configurations. Animation cannot do that.

I believe that a similar graph could be created for the Great Depression, War on Terror, and current global financial crisis—all three against the map of the globe. Through pattern movies we could look into God's mysterious laboratory of pattern chemistry.

There must be a way to describe the consequences of an event in a very abstract and universal language. I suggest **size**, **concentration**, and **growth**. To add temperature as intensive variable would be good, but it follows from the fluctuations of extensive variables. Growth, size, and concentration are related parameters. Concentration is a ratio of two sizes: quantity and volume. At this point I do not clearly see a possibility to use absolute numbers for stability and order, however. Probably, non-dimensional measures of inequality are best candidates. Ideally, pattern chemistry should not use any units of measure except naked numbers.

As soon as I had looked into economy as a chemist, I immediately saw how much exystemic properties depended on the factor of size. Molecular chemists are able to express size, concentration, and growth in non-dimensional numbers of particles and their ratios. Since particles belong to different classes (atoms and molecules), the chemical complexity finds a universal expression in symbols of species and numbers of their populations. This is equally typical for the *realpolitik* economy based on conservation laws. The post-Waterloo balance of power in Europe could be an example of **realpolitik**.

> Probably, I am taking liberties with this German word by using it not in its current meaning: politics based on national interests instead of ideology. What I have in mind is closer to geopolitics, which comes from the fact that the surface of the globe is constant. As an excuse, I remind that all *realpolitik* , for as along as I remember, was about borders and spatial distribution of power. As for the sources of power, land and population are most important extensive values.

As the meltdown and extinction of *la Grande Armée* was the consequence of Napoleon's campaign of 1812, so growth—the opposite of extinction—is the major pattern consequence of modern economy.

Growth is what economy had inherited from its biological roots. Growth is in the very chemical nature of life as replication an as the basis of all exystems built upon it. Bacteria multiply, we do it, wealth does it, and all our things do it. Of course, growth is coupled with decline. We call the growth/decline couple in exystems competition. The overall outcome of competition for economy is still growth, although for the biosphere it is decline. To have a balanced picture, we should remember the glorious buildup of the Grand Army as if its collapse would not happen. Our perception of the past can change in eight years or overnight.

I suggested in **Part 1** that there was a relation between resources and verticalization. As I see the problem at the end of my project, the more regulated and ordered—**tall**—system requires less energy to maintain stability than the more anarchic flat one. This, however, is still an unresolved issue for me and I am not satisfied with my argumentation. The former Soviet system is a confirming example, but it is not enough.

The bone of contention between pro-Obama and anti-Obama camps is best presented in terms of "tall" and "flat" ideologies. In the eyes of the enemies, the opponents are seen as socialists and anarchists, although nobody seems to dare using the "anarchist" label against the core American ideology of individualism.

> **DISCLOSURE**: I am an individualist but not anarchist.

Globally, I see the previous century as a period of political fragmentation fuelled by the growth of global economy and shaken by big wars. Although there is economics of war, war is not economy or, at best, is bad economy. It looks like the fragmentation confirms my—and Thomas Friedman's—thesis and the world becomes, in a sense, flatter. What is the consequence? Competition as a kind of war, although some economists deny the parallel. What is the consequence of competition? Supercapitalism of Robert Reich. What is the consequence of supercapitalism? Government—and political power in general—becomes branch of economy.

I do not want to push any predictions. I believe that the next two decades will give rich material for testing hypotheses of pattern chemistry and we—or whoever still has time and interest—should just wait. For happy people there are good times and bad times to die.

I want to add another hypothesis. There is a particular consequence of the engulfment of human matters by economy: human life goes on the market and is up for trade. War is an economic transaction—exchange of the dead—in currency of human lives, as the statistics of wars illustrates. In a conflict between nations or their alliances, the side which pays lower price for human life has a better "bad economy" of war, whether cold or hot. In a way, this returns us to the old pattern of slavery. We may become slaves of ourselves. I sense a great weight in Zbigniew Brzezinski's warning against hedonism, without necessarily agreeing with the rest. Thus, I do not quite like the negative use of the word "hedonism:" the US Constitution, with its "pursuit of happiness," is hedonistic. But I understand what he means: unrestrained sensual greed.

The crisis of political legitimacy and economic vitality that Western Europe increasingly confronts—but is unable to overcome—is deeply rooted in the pervasive expansion of the state-sponsored social structure that favors paternalism, protectionism, and parochialism. The result is a cultural condition that combines escapist hedonism with spiritual emptiness—a condition that can be exploited by nationalist extremists or dogmatic ideologues.

> This condition, if it becomes rampant, could prove deadly to democracy and the idea of Europe. (Zbigniew Brzezinski, *THE GRAND CHESSBOARD: American Primacy and Its Geostrategic Imperatives,* Basic Books, 1997, p.73*).*

The suicidal terrorism runs as lively business because human life in the terrorist-supplying nations can be bought cheap and sold high. I realize that this opinion is controversial.

> To compare, in Stalin's Russia human life was even cheaper and it could only be consumed on the spot, not sold. Voluntary sacrifice was mandated. The voluntary ultimate sacrifice, however, was glorified, but generally not mandated.

I am talking about consequences of events, but how can I see a **possible** consequence? Same way a chemist sees a possible way to a synthesis of a new desired substance or a detrimental side reaction along the way. Same way a writer directs the character toward a disastrous mistake or a happy end and an inventor sees a not yet built contraption. The mind engineers a configuration from known generators and rules of similarity. Something happens in my mind when I do that. As I suggested in previous e-publications, this something is itself similar to a chemical reaction with mental configurations. Patterns do not carry any proof of origin, whether molecular or neurophysiological. The same way history makes its irreversible moves on the "Grand Chessboard." This is the main idea of Molecules and Thoughts and Ulf Grenander's Patterns of Thought . It is the main assumption of pattern chemistry, which in turn borrows its principles from Pattern Theory.

Any practical person would wonder how the abstract ethereal pattern principles could be applied in the real world. My answer is that for any practical task there is a hard or semi-hard science—the hardness is measured by the degree of consensus—to which one should turn. While Pattern Theory has clear practical applications, the only practical application of pattern chemistry that I see is to set human mind free from the narrow enclosure of specialization. The fertile confinement of specialization has been triumphant in creating modern civilization, science, technology, and global economy, but now, when we have successfully created this global mess of complexity, we need to have a comprehensive but less detailed view from a high altitude. The **pattern**—not just metaphor—of what we should do is the same as for the venture of great geographic discoveries that resulted in the map of the world. This time, however, the metric space is not Euclidean. It is the configuration space: Grenander space. We need a pattern map of the world. A version of such map can be seen in Pattern Theory.

Very old patterns return in refreshed, rejuvenated, and surgically enhanced configurations. For example, the Internet is successfully resurrecting the Medieval phenomenon of the city mob, described, for example, by Victor Hugo in "***Notre-Dame de Paris*.**"

> It [Court of Miracles] was a vast place, irregular and badly paved, like all the squares of Paris at that date. Fires, around which swarmed strange groups, blazed here and there. Every one was going, coming, and shouting. Shrill laughter was to be heard, the wailing of children, the voices of women. The hands and heads of this throng, black against the luminous background, outlined against it a thousand eccentric gestures. At times, upon the ground, where trembled the light of the fires, mingled with large, indefinite shadows, one could behold a dog passing, which resembled a man, a man who resembled a dog. The limits of races and species seemed effaced in this city, as in a pandemonium. Men, women, beasts, age, sex, health, maladies, all seemed to be in common among these people; all went together, they mingled, confounded, superposed; each one there participated in all. (Victor Hugo, *Notre-Dame de Paris*, Translated by Isabel F. Hapgood, Volume I, Book II, Chapter IV, *The Broken Jug*)

Internet is not just a market place when we buy, sell, save, and lose. It is the Medieval city throng where anybody can malign, extol, or denigrate anybody and stir up either hate or adulation. Anybody can steal, fake, and deceive with ease in the dense dematerialized and demoralized e-crowd. Anybody with loud voice can sway the mob. Respectable networks, happy to have free “content,” proudly fill their web pages with the faces and noise of the crowd.

> Not that anything is wrong with that. Nothing is wrong with the circulation of elites, either. Not that anything is wrong with evolution. Seriously.

The pattern of holy war returns in the form of the wars on drugs, terror, abortion, and poverty, as well as Islamic terrorism, ethnic and sectarian genocide, and environmental extremism.

The pattern of a growing, conquering, losing its grip, and collapsing empire returns in the configuration of a financial institution too big to fall and automobile manufacturing company too big to keep.

8. FROM CONSEQUENCES TO ADAPTATION

Finally, the ultimate consequence of all events in exystems is adaptation. Unfortunately, while exystem adapts, i.e., arrives to temporary and relative stability, not all species survive, all the more, not all subspecies.

Humanity has survived all wars, epidemics, acts of God, acts of greed and stupidity, and the onslaught of Things. The shortness of human life alleviates the pain of adaptation. New generations do not inherit old skeletons in the closet. Can humanity survive its own growth which brought the problem of global economic suffocation? Can it adapt to living with the greatest danger of all: enormous concentration of destructive energy in nuclear explosives and ideology of hate? Pattern chemistry could take as an ideogram what Anton Chekhov said about the art of playwriting: "If in Act I you have a gun hanging on the wall, then it must fire in the last act". →

Intuitively, I feel that the problem of counteracting global warming is too big to succeed: it exceeds the human scale. There is a consensus on the phenomenon, but no consensus on the remediation. Billions of dollars will stuff the pockets of those who promise clean coal, carbon dioxide sequestration, and unlimited energy from hydrogen. The tested way of adaptation is the alternative: control population, educate citizens, switch to renewable sources as much and as soon as possible (but not more and not sooner), and adapt to whatever happens afterwards, as we have adapted to the daily danger of driving, after having adapted to life in desert, tundra, and big city.

We can adapt even to the nuclear danger by raising high the transition barrier to nuclear attack and limiting its possible impact. We can do it by lowering the price of life of aggressive enemies and knocking the gun off the wall. We must, however, somewhat lower the price of our own lives, too.

It could be more difficult to adapt to "easiness" of life.

This is what I wrote 30 years ago about happiness in *Chemistry and Life* magazine: "If the temperature of our life equals our temperament [i.e., temperature of the personality], we are happy, we are oblivious of the running time, and we want this state to last forever." I mentioned Goethe's Faust. "Faust's happiness is a state of an intense spiritual equilibrium. A chemist would compare it to the state of chemical equilibrium at high temperature when the direct and reverse reactions run at the same high speed. " The question I put forward in my 1979 essay was about the difference between the happiness of Faust and the happiness of characters in the short story by Nikolai Gogol *The Old-*

World Landowners (Старосветские Помещики). Their happiness looks like a low temperature equilibrium.

This is how the story, the title of which I would translate as *The Countryside Oldtimers*, starts:

> I love the quiet life of the reclusive small landlords of those remote villages which are called in the Ukraine "old time." Like the decrepit but picturesque cottages, they strike you with a motley beauty and a complete contrast with some new and shiny house with the walls not yet rinsed by rain, roof not yet touched by the green moss, and red bricks not yet showing through the chipped plaster of the stairs. I like to descend for a minute into the realm of this incredibly solitary life where not a single wish flies either over the picket fence around a small yard, or over the wattle fence of the orchard full of apple and plum trees, or over the nearby rickety huts hunkering down in the shadow of poplars, elderbushes, and pear trees. Life of their modest owners is so peaceful, so peaceful, that for a moment you forget everything and begin to think that passions, desires, and the unsettling images of evil spirit which are disturbing the world do not even exist and you have seen them only in a vivid and dazzling night dream.

Even this epitome of stability did not last, however. As Gogol notes,

> Along the strange nature of things, negligible causes always gave birth to great events and, on the contrary, great ventures used to end with negligible consequences.

Have a happy adaptation!




9. FROM COMPLEXITY TO SIMPLICITY

The Global Financial Crisis of 2008 has opened the floodgates of morning-after publications. Here are some titles of which I have secondhand information from (1) *The New Yorker*, June 1, 2009 and (2) Charlie Rose Show, May 28, 2009 .

(1)
Gillian Tett "Fool's Gold: How the Bold Dream of a Small Tribe at J.P. Morgan Was Corrupted by Wall Street Greed and Unleashed a Catastrophe," Free Press, 2009, 304 p.

Richard A. Posner, "A Failure of Capitalism: The Crisis of '08 and the Descent into Depression," Harvard U P, 2009, 368 p.
(2)

Kate Kelly, "Street Fighters: The Last 72 Hours of Bear Stearns, the Toughest Firm on Wall Street,", Portfolio, 2009 256 p.

William D. Cohan, "House of Cards: The Crisis of '08 and the Descent into Depression," Knopf Doubleday, 2009, 480 p.

As H. G. Wells noted in *Experiment in Autobiography*, "Impermanent realities are not to be rendered without an abundance of matter" (Macmillan,1934, p. 424).

The 1408 pages of the four above books are a small part of what a chemist could call "experimental part" of a yet unfinished investigation. The experiment is a one-time event, an evolutionary episode, launched not by the will of a single human being but by the nature of things. Its incomplete and expanding record consists mostly of observable and unambiguous acts, guesswork, and their free interpretations.

From what I heard, I suppose the books are high class. I am not reading this literature anymore, however, because I am interested in what is invisible to a naked eye (a typical habit of a chemist) and not limited by any particular field of human action and reaction (a typical habit of a pattern addict).

Anyway, I must end my personal search for understanding the pattern chemistry of the Crisis. Since I have arrived to a perception so simple that I cannot simplify it anymore, this seems like the natural exit point. Besides, if I do not stop now, I will never come to finish. Pattern chemistry is indeed addictive.

Is there any law of nature behind the Crisis? In this concluding **Chapter**, I make an attempt to summarize what I have found mostly to my surprise.

Pattern chemistry is an attempt to answer the question:

> What is so different about human matters, including history, politics, economy, etc., as compared with subjects of natural sciences?

That was, in essence, the question asked by George Soros in his "*The Alchemy of Finance*" and subsequent publications on "reflexivity." The roots of the question are as old as science and philosophy.

Pattern chemistry is based on (1) ideas of Pattern Theory developed by Ulf Grenander and (2) generalization of some fundamental concepts of chemistry, in particular, the concept of transition state.

Under various names, the concept of **pattern** (idea, form, abstraction, type) has been in circulation **in both sciences and humanities** at least since Anaxagoras and Plato. Although outside Pattern Theory it is one of most evasive notions, pattern always implies a kind of "invariance" or "regularity" which appears in a range of different objects. What distinguishes the approach of pattern chemistry is that the focus lies not within a certain discipline or field of study, such as, for example, patterns of history, language, behavior, in image recognition, etc., but **across the interdisciplinary borders.** Obviously, this makes little academic sense today, unlike the times of Plato's Academia. This is why so few mathematicians (if any at all, except Ulf Grenander and René Thom) have ever ventured in this risky area. In the total economy, of which academia is part, anything which is not credit is debit.

The central object of pattern chemistry is **exystem**: evolving complex system for which the unpredictable novelty is the main property of interest. A typical—and the largest—exystem is **economy**, which today includes all spheres of human activity and incorporates not only art, science, technology, markets, finances, ideology, religion, education, politics, warfare, family, etc., but also the fate of all living organisms on earth, climate, mineral resources, and large scale trends of human civilization. Exystem is entitled to a single copy or specimen and, like human individuality, straddles the divide between arts and sciences. H. D. Wells, already one third into the twentieth century, put it much better than I ever could:

> In this paper [*An Englisman Looks at the World*, 1914] I insisted that in sociology there were no units for treatment, but only **one single unit which was human society**, and that in consequence the normal scientific method of classification and generalization breaks down. "We cannot put Humanity into a museum, or dry it for examination; our **one, single, still living specimen** is all history, al anthropology, and the fluctuating world of men. There is no satisfactory means of dividing it, and nothing else in the real world with which to compare it. …….. Sociology must be neither art simply, nor science in the narrow meaning of the word at all, but knowledge rendered imaginatively and with an element of personality, that is to say, in the highest sense of the term, literature." (H.G.Wells, *Experiment in Autobiography*, Macmillan, 1934, p. 561).

We do not—and cannot—know the future even in the case of the financial markets, although they are studied as an academic discipline and attract a number of bright thinkers, some rewarded by the Nobel Prize. We know only possible alternatives and scenarios, never complete and never peer-consensual. Although variety is part of economy—one needs to offer a unique intellectual brand—the variety of views in economics and humanities is quite natural. The proof of the pudding in human matters is not the eating—tastes are different—but the making done in many ways.

It is the fact of the matter that although some economists had unambiguously warned about the inevitable danger, their predictions made no impression on either politicians, or institutions, or public, not even on the guardians of American finances . On the contrary, the election of Barack Obama was something no serious person could predict before well into the campaign. The stories of global warming and modern China are up for the next case studies.

A striking feature of the financial crisis is that it has been generated by the very economic strategies employed to prevent it and insure against the loss. One may also notice that the global policy of the United States, for decades strategically aimed at the stabilization of the world, has had exactly the opposite effect of deep destabilization—although after a long successful period. Hitler's quest for the rise of Germany from the ruins of WW1 was spectacularly successful and ended in a complete devastation. Stalin had brought Russia to the peak of power and his heirs lost even the acquisitions of the czars. Yet neither result was final: the new rise followed.

The question addressed in this INTRODUCTION TO PATTERN CHEMISTRY is reformulated as follows:

> If we cannot fully know the future and cannot predict the exystemic event because it is irreversible and happens only once, how far can we still look into the future and what can we still know about it with certainty?

The hypothetical answer is that patterns, unlike configurations "covered" by them, can have a relatively long term validity, although at the price of high generality and abstractness bordering with triviality. In order to extract the scant but reliable and important information, we must **generalize the principles of natural sciences** as much as possible, so that they would be applicable to both physical and human matters. Patterns, unlike equations, thrive in both sciences and humanities because they are basic and universal forms of human—and even animal—understanding.

For example, we should probably speak about **instability** instead of energy, **event**—with the beginning and the end—instead of process, **inequality** of distribution instead of entropy, **waste** instead of heat, and a measure of **fluctuations** instead of temperature. In addition, we should abandon the use of the concept of probability for non-repetitive events and incomplete (open) event spaces. The improbable event has no probability. Thermodynamics applies only to well defined systems, while the future of exystem is the least defined and the description of the present is always incomplete. Moreover, we should abandon all absolute estimates and monitor only the **trend** in terms of MORE and

LESS. Finally, we should regard an event as a triad of consecutive **stable initial, unstable transition, and stable final** states, which is the typically chemical approach to the phenomenon of change.

Without going into further details, the financial crisis, for example, is the result of wealth concentration and inequality of income distribution. This opinion alone does not require any pattern theory or pattern chemistry. It has already been expressed by some analysts and looks quite commonsense. The question is: can we find any **law of nature** behind the unfortunate turn of events? Or is it just a bad luck? Or somebody's malice? Or is it indeed unfortunate?

The journalistic accounts expose the size and shape of the crude complexity of the subject. This is the very reason why we consider the economy and the Crisis complex: thousands of pages are needed to describe it even though the descriptions partially, but never exactly, overlap. For example, the view that the Crisis was a consequence of the shift from private partnerships to giant public company looks very credible. Huge rewards encouraged risk taking without risk sharing. Nevertheless, this can be disputed because it does not explain the catastrophic character of the consequences. This is a typical example of the detailed plausible cause-and-effect explanation. It appeals not to any theory, but to universal human experience. It is quite like a physical or molecular-chemical explanation, except that no proof can be found. Suppose, however, that some new government regulations counteract the trend. The question is: will the system be stable in the future even though we do not know what the future can bring us in the form of another "in**nov**ation" or, in medical language, **neo**plasm, i.e., **new** growth? We do not have any experience with what we have not yet seen. We can say that greed will always find a way, but the desire of success and superiority is as natural and necessary for progress as innovation. By greed we call derisively the natural human drive which we follow with less success that the lucky greedy rivals.

As I believe, it is exactly the law of nature, human or otherwise, that any inequality of distribution of the resource of generalized energy, whether in calories or in dollars, is synonymous with the overall instability of the exystem. It follows not from any scientific or pseudo-scientific theory, but from the way we use the basic axiomatic concepts which could not be defined other than in a circular way through each other. **Energy** is the best example of an axiomatic notion: it is conservative by definition and its **change** (transfer) manifests in **change** of whatever kind. The triumph of beneficial circularity. **Stability**, however, is more open-ended: it means little or no change for a long time. **Instability** means pending change. **Change** is what we can notice observing an object in time. **Time** is a sequence of events. **Event** is what has beginning and end, etc. We are firmly within human and animal ability to remember (don't ask me what **memory** is, please, ask yourself), but pretty far from energy.

What this approach gives us is the ability not only to speak about human and physical matters in the same language, but to see the world, including human matters, as a unified system. Wherever in the world we find a non-uniform (better to say, non-equilibrium) spatial distribution of energy, concentration, and temperature, we should expect a change.

The stability of the social system cannot be an ultimate political goal because the ultra-stable exystem cannot evolve and adapt to external and spontaneous internal changes. It can only undergo a rare—actually, one-time—radical change exemplified by the fate of empires and dictatorships of the distant and recent past. Yet the uncontrolled and unrestricted growth of **concentration of wealth and power**, whether globally or nationally, will inadvertently increase exystemic **instability**. This is all we can know about the future, but whether we should resist or resign to any particular trend, no law of nature can say. If we **understand** that we deal with a law of nature and not a passing accident, and if we understand the **few** fundamental alternatives, then our choice can be truly intelligent. The ability to reduce the analysis to **FEW** instead of **MANY** is the essence of the transition **from COMPLEXITY to SIMPLICITY**.

During the Cold War, I lived on the totalitarian side of the divide. I witnessed the promoted from the top fear of America in Russia and I have some idea of the even higher anxiety of the threatened by Russia Western Europe. Now, while on the side of democracy, I can see a somewhat similar fear of China and the slowly taking shape problem of choice between compromise and resistance to an authoritarian rival. Unfortunately, the problem of natural resources and late arrival to the feeding trough that China faces has unpleasant historical parallels. Until the monument to the victims of Tiananmen massacre is erected on the square, China will remain in a very bad company of patterns.

The collaborators and resistance fighters of the future are being born today.

My bifocal life long observations tell me that over-concentrated power tends to create a historically short time rise as well as short time collapse (Nazism, Communism), while a distributed power (Democracy) can maintain stability through roller-coaster rides.
The ultimate problem of who wins and who loses **in the long run**, however, is not so much concentration as the **overall quantity** of energy—or the bulk of power—which can be directed toward both creation and destruction. From this point of view, which is profoundly chemical (the "kinetic *versus* thermodynamic control" principle). I would be worried about America with energy dependence and the combustive mix of politics and religion. I also find the concentration of political power in just two parties engaged in a Cold Civil War a troubling conundrum of American democracy. Two is dangerously close to one. This is not pattern chemistry, just look at your two fingers.

I have lived in America long enough to believe in American dynamism and long enough in Russia to be worried about the concentration of power in China, America, or new Russia, as well as, probably, about dilution of power in Europe. America must be strong, but it is not strong enough for me.

To take the most recent illustration, the turbulence in the Middle East was ultimately caused by the enormous concentration of energy resources within a limited and compact geographical area and in a few joined hands. If Israel did not exist, it would be invented as another kind of Satan. It is characteristic that the device that was used to create stability—the literalistic interpretation of religion, known also in America—had the opposite effect. The oldest historical illustration that I know is the policy of the balance of power in Europe after the defeat of Napoleon. Henry Kissinger has been a practicing expert in such questions and one of the designers of the next specimen of stabilization: creation of the US-China-Russia triangle.

The US debt and trade deficit is a nuclear money-bomb, the largest Chekhov rifle on the American wall. To see why, let us present the problem in terms of inequality of distribution. Here it is the preamble in the words of Henry Kissinger, translatable into Chemglish patois.

> Intellectually, the concept of the balance of power reflected the conviction of all the major political thinkers of the Enlightenment. In their view, the universe, including the political sphere, operated according to rational principles which balanced each other. Seemingly random acts by reasonable men would, in their totality, tend toward the common good, though the proof of this proposition was elusive in the century of almost constant conflict that followed the Thirty Years' War. (Henry Kissinger, *Diplomacy*, Simon & Schuster, 1994, p. 21)

As Kissinger further writes, this idea of Montesquieu found its way into the pattern of thinking exemplified in Adam Smith's *The Wealth of Nations* and James Madison's articles in *The Federalist Papers*. Settled in the US Constitution, the concept pursued not the harmony and complete stability, but the absence of despotism and **critical** instability.

From the chemical point of view, however, for this system to work, a large enough pool of agents, i.e., the **market** of goods, acts, and ideas is needed. The monstrous trade imbalance between just two huge agents, US and China, **concentrates** all debt on one side and all surplus on the other. Similarly, the party discipline, maintained by financial stick and carrot, **concentrates** all Democratic "rational principles" on one side and all Republican "rational principles" on the other side, recreating the situation of the Cold War in the Cold Civil War. Let me exude a droplet of poison: the stick and carrot was also the Soviet way to maintain the sheep herd unity of the Communist Party. To tell the truth, the Democrats are more democratic than the Republicans because the conservatives know only one thing which is right for all, and the liberals do not know what is right for all, but know many things which are not right for them, different things for each. There is a natural free market of ideas for liberals, and a one-shelf market for conservatives, all the more, if they are bent on religion.

Discloser: I do not sympathize with the conservatives, but I am not a full-blooded liberal, either. See Essay 16: On Somebody Else.

Another example of polarizing inequality is privatization of reward and socialization of risk, which is another way to say the Crisis (of 2008).

The 80-20 Pareto principle… but I am repeating myself. It is the right time to end.

The uncontrolled growth of **concentration** of money, energy, and vital resources in few hands, also known as **inequality of distribution**, results in growing economic and political instability, for better or worse. This is something we can know for sure about the future.

Raphael. The School of Athens, 1500-1511.

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PAGE UNDER CONSTRUCTION

Yuri Tarnopolsky

INTRODUCTION

TO

PATTERN CHEMISTRY

PART 4

AFTERTHOUGHTS AND FORESIGHTS

2009-2011

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1. EXPLANATION

I had finished the first three parts of INTRODUCTION INTO PATTERN CHEMISTRY without any desire to continue. Very soon I discovered that I could not ignore economy anymore because it was the very fabric of all current events and, therefore, of a good deal of thoughts in my head. I found myself unable to stop thinking about **econochemistry as seen by a chemist** and looking for new names, facts, ideas, and testing grounds.

By the twenty-first century, economy has become Everything Human, which is to say everything on the astronomically small globe populated by humans, animals, and other life and irradiated by the sun. At this point I can tentatively define econochemistry as the study of stability of evolving complex systems (exystems) represented by life and human history.

I begin to believe, however, that economy has always been pertinent to everything on human scale and life itself. I am not original in the idea that current human history is a continuation of a process which started with the emergence of life, but I want to focus on post-tribal human history where traditionally understood economics and traditionally understood history can hardly be decoupled. Here is a fresh illustration from an old source on hand.

In the beginning of the 1964 paperback edition of *The Arabs* by Philip K Hitti (Henry Regnery, Chicago), old but still popular and re-published, I found the following paragraph about the rise of Islam:

> The enfeebled condition of the rival Byzantines and Sasanids, who had conducted **incessant wars against each other** for many generations; the **heavy taxes**, consequent upon these wars, imposed on the citizens of both empires and **undermining their sense of loyalty**; the previous domestication of Arabian tribes in Syria and Mesopotamia, particularly along the borders; **the existence of schisms in the** Christian **church**, together with the **persecution by the orthodox church**—all these paved the way for the surprisingly rapid progress of Arabian arms (p. 57).

By the end of the book we read:

> Egypt began its history under proud and triumphant rulers who had cleared Syria of the last vestiges of Frankish dominion and had successfully stood between the Mongols and world power. By the end of the period, however, with its military oligarchy, **factions among the dominant caste, debased coinage, high taxation, insecurity of life and property, occasional plague and famine and frequent revolts,** both Egypt and its dependency Syria were all but ruined. Especially in the valley of the Nile, superstition and magic were prevalent, coupled with the triumph of **reactionary orthodoxy**. Under these conditions no intellectual activity of high order could be expected. In fact the whole Arab world had by the beginning of the thirteenth century lost the intellectual hegemony it had maintained since the eighth. Mental

> fatigue induced by generations of effort and **moral lassitude** consequent upon the **accumulation of wealth and power** were evident everywhere (pp 243-244).

It is difficult to ignore the vision of some hidden algebra, in which Byzantium and Egypt, Europeans and Arabs, Christianity and Islam are the arguments of functions such as taxation, reactionary orthodoxy, accumulation of wealth and power, and even "domestication of X [Arabian tribes] in Y [Syria and Mesopotamia]." It is equally difficult and even naïve to draw a too close parallel with mathematics. The pattern perception of history has little calculating and predictive power because it abandons the very foundation of mathematics as we know it. The mathematical structure, with its terms and axioms, is closed for as long as we can rely on it, while evolution in complex open systems—exystems—always brings **novelty** which requires a revision of the knowledge structure with its terms and dogmas. I call such systems Heraclitean to distinguish from Aristotelian ones which, like our planetary system, mixture of chemicals, and internal combustion engine, are based on solid axiomatic foundation and principles which **are not expected** to change overnight. Of course, never say never.

The pattern description of complex systems is also a branch of mathematics—see Pattern Theory of Ulf Grenander—but the doubt will remain about its predictive ability in human matters, of which economy is both most powerful and most evasive factor. My position is that this ability may be very limited in the scope of application but very strong and reliable, unlike the perishable fruits of the science of economics.

The question is about what patterns have to do with the study of exystems where mathematical equations have brought us nothing but economic disasters. The story of Long Term Capital Management is the most dramatic example, especially in an acerbic historian's rendering (Niall Ferguson, *The Ascent of Money: A Financial History of the World*, Penguin Press, 2008, p. 320). The Almost-Great Depression of 2008 is another example, more tragicomic than dramatic.

My answer, which has been emerging gradually, is that patterns in exystems are much more lasting throughout history than equations, but we cannot expect from them the same accuracy and imperative power. The most lasting patterns are those that apply not just to exystems, but also to the rest of the nature. They give us just a few warnings, but they are grave.

What everybody—except mainstream economists—is trying to apply to exystems is thermodynamics. It originated from the study of the simplest possible large system—the ideal (not even real!) gas—and it has little to do with the most complex open evolving system like economy. What if we start not with molecules but with society and try to develop a doctrine capable of overlapping with thermodynamics at some level of abstraction? In other words, can we try to reconstruct the common rational ancestor of a "gas-ape" and a "citizen-human"—a very crude creature, robust enough, however, to generate the understanding of both? In other words, I am suggesting to replay the intellectual history and reconstruct the evolution of thermodynamics as if we started not with gas, but with the complexity of human society, which we experience first hand every day.

As a matter of fact, that was the actual intellectual history. It started with philosophers of Antiquity, especially with Aristotle and Lucretius, and was continued by philosophers, poets, and writers of Enlightenment. As soon as science diverged from the totality of human knowledge, however, it became the highest authority for *homo faber* (man the maker, or the man who does "what a man's got to do") because, unlike humanities, it was consensual and testable.

As soon as we start thinking in such terms, we will be forever carried by the unstoppable river of current events, without a hope to come to any final destination. We need to test our few principles on each new large scale event because any final, complete, and rounded theory is out of question by the very nature of our belief in evolutionary novelty. This is something a natural scientist would not find attractive—how can you sell it?—but a creative artist, whose universe is inside, could consider natural.

This **PART FOUR** of **INTRODUCTION TO PATTERN CHEMISTRY** is a monologue of a self-interrogation, doubts, insights, and recapitulations. Gaps could be filled out from **Parts 1** to **3**. A lot of supplemental and illustrative material has been caught and stored in spirospero.net. Just knock on the doors there.

I borrowed major pattern-theoretical concepts from Pattern Theory of Ulf Grenander and added to them the chemical perception of the transition state. The latter is the **irregular configuration** of Pattern Theory. For the first attempt to apply pattern ideas to society and other human matters see *History as Points and Lines* by Yuri Tarnopolsky and Ulf Grenander (google it for other sites).

I remain (alone) wholly within **econo-chemistry** and make no claims whatsoever on **econo-economics** or any hard science.

Ulf Grenander

2. PATTERN CHEMISTRY ON ONE FOOT

A Gentile asked the great Jewish sage Hillel to explain the Torah while standing on one foot. Hillel said: “What is hateful to you, do not do to your fellow.”

Let us start with Pattern Chemistry on one page:

1. Evolution (history) of **exystems** (Evolving Complex SYSTEMS) consists of longer stretches of relative stability alternating with shorter stretches of relative instability (**change**). Instability is propensity to change. History is irreversible and non-random.

2. The act of change is the transition from the initial stable state through an unstable transition state to the final stable state. It takes memory to perceive change.

3. We cannot measure absolute stability, but can compare the stability of two states in terms of MORE and LESS. In physical sciences, energy is a concept somewhat close to instability: the higher the energy the lower the stability.

4. For a given stable state, the more stable the transition state, the more likely the transition to another (not necessarily MORE) stable state. Chemistry focuses on the question “how soon?” This is the most difficult question about exystems.

5. For an exystem, the act of change consists in the **change of structure**, i.e., combination of stable blocks and mobile bonds between them. In terms of Pattern theory, state is configuration of generators (blocks) and pattern is, roughly, a class of configurations.

6. Paradoxically, it is the large size of exystems which makes their complexity comprehensible. **Change is often local** and involves only some subsystems.

7. The behavior of a real exystem in the future is comprehensible only partly because its structure is logically open and axiomatic assumptions are subject to unexpected novelty. Patterns are generally more stable than configurations, but they provide less detail.

8. Temperature is the measure of **spontaneous** chaotic change. Freezing stops change, melting ruins structure. Exystems must be warm.

9. The less equal the distribution of a property over the system in time or space the less stable the system. In physical sciences, entropy is the closest to inequality of distribution. It is low for sharp gradients, imbalances, and localized concentration.

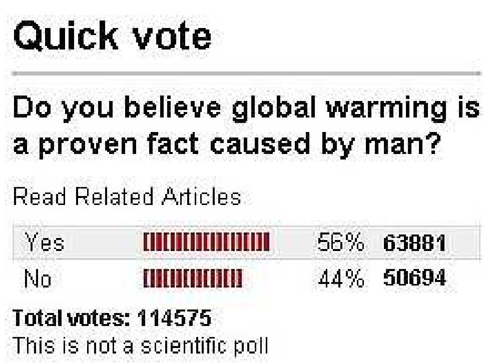
10. Economy is an exystem. The pattern-chemical reason for economical instability is inequality of distribution of properties, provided the temperature is warm enough. Same applies to human history in general, which merged with economy after WW2.
The tenth point is Pattern Chemistry on one foot.

The phenomenon of **novelty**—spontaneous evolution of axiomatic base—is the cardinal difference of exystemic structure from mathematical one. The current science of complexity, however, attempts to emulate physical sciences. The financial crisis of 2008 could be an awakening to the real world in which the chemistry of money is as powerful and perplexing as the chemistry of love. It comes as no surprise because love, with its aura of madness and fever, is a pattern and it embraces love of money, too.

Note that the approach of Pattern Chemistry to the world is different from that of physical sciences, including molecular chemistry. Flying across interdisciplinary borders, Pattern Chemistry is not fit to land and tackle scientific and practical problems, for which only hard science and technology are equipped. What it promises is some understanding of the future of the human condition in a few trustworthy statements. Pattern chemistry does not contradict physics, but keeps it at arm's length.

It happened so that we understood how steam engine works before achieving a consensus on the basic principles of human life and society—and are still far from it. Physics tacitly assumes that the laws of nature will remain unchanged tomorrow and at least hundred years later. This belief makes calculation of the physical future of an object, such as a space station or bridge, **largely successful** and predominantly **consensual**. Predictions of the human future—and even assessment of the present—are **contentious** because the irreversible exystems do not satisfy requirements of scientific method. They are unique, complex, and changing while we observe them.

ASIDE: With all my belief in science, I do not completely trust it regarding the global warming because the climate change is **for the first time in history** contaminated by human participation, as well as by our love of nature, love of God, love (or hate) of the neighbor, and love of money. →
I believe that we should cut the use of mineral fuel, play by ear, and if there is anything 100% certain as a remedy it is an adaptation through **population decline**. As soon as I have typed those words, I hear Sarah Palin screaming about Obama's "death panel". Can you talk rationally to Sarah Palin or Rush Limbaugh or any lover of God, pretty face, and/or money? Yes, you can, but only about money. As an evolutionary fatalist, however, I am sure that adaptation will come anyway and in the form we cannot reliably predict.



CNN, 12/8/2009, ~ 10:05 AM

Next, I will comment on the points.

> ***1**. Evolution (history) of **exystems** (Evolving Complex SYSTEMS) consists of longer stretches of relative stability alternating with shorter stretches of relative instability (**change**). Instability is propensity to change. History is irreversible and non-random.*

Life, human or not, individual or social, displays a particular kind of randomness. It is called scale-free or, better, scale-invariant.

This area of hard-scientific research , not yet of unifying name (scale-free networks is part of it, movement ecology yet another) , has been growing and flourishing with the advent of the Internet. Its modern roots go back to the very influential concept of punctuated equilibrium (Niles Eldredge and Stephen Jay Gould , 1972; punctuated equilibrium "consists of morphological stability and rare bursts of evolutionary change") .

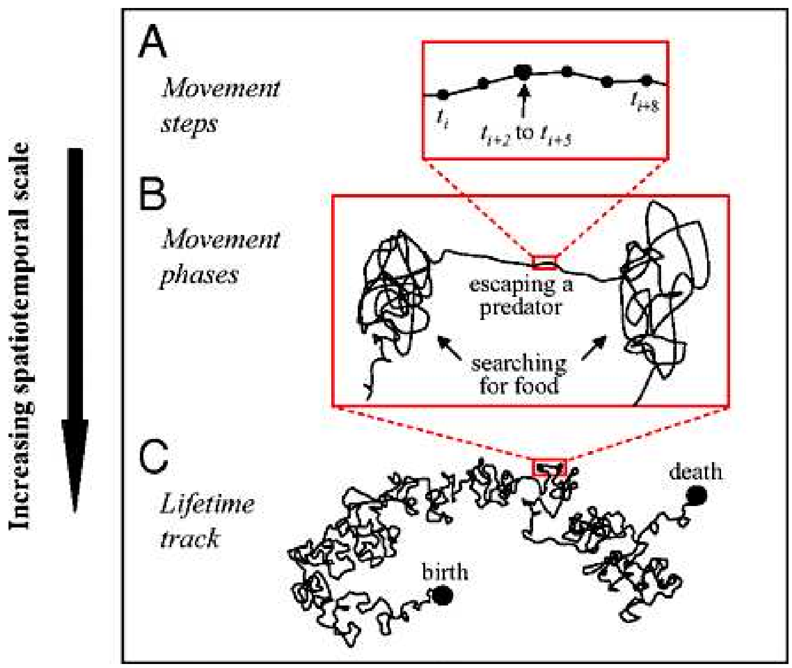
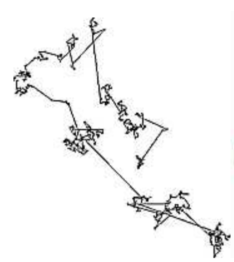


Figure 2-1: Animal behavior at different scales.
From: Ran Nathan, Wayne M. Getz, Eloy Revilla, Marcel Holyoak, Ronen Kadmon, David Saltz, and Peter E. Smouse, *A movement ecology paradigm for unifying organismal movement research*, http://www.pnas.org/content/105/49/19052.full.pdf



Levy flight

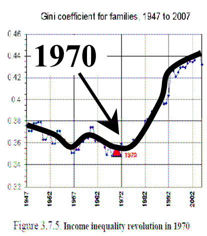
Floating bead necklace

This "floating bead" pattern invokes an even older views of George Cuvier (1769 – 1832) , who over time had gained some weight in the shadow of Darwin, not exactly contradicting Darwinism. Cuvier saw extinction and emergence of species as result of periodic natural catastrophes (cataclysms).

The most recent and very general reformulation of the idea belongs to Greg Paperin, for example, Greg Paperin and Suzanne *Sadedin, The Dual Phase Evolution Framework for Understanding Evolutionary Dynamics in Complex Adaptive Systems* , from which I quote:

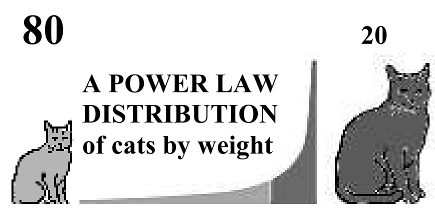
> There are several possible explanations for punctuated equilibrium (Gould and Eldredge, 2000). However, the strong geological association between disasters (such as asteroid strikes, volcanism and climate change), mass extinction and subsequent radiation events suggest that these external drivers are crucial in that they force the switch from stability to variation phases by altering the connectivity of food webs and landscapes.

Figure 1 illustrates the pattern from a different source.



The scale-invariant structure and behavior, with statistics governed by power laws, strongly unites economy with other exystems. The most popular example is wealth distribution. The degree of inequality in America began its relentless ascent around 1970, see **Part 1, ← Figure 3.7.5: Income inequality revolution in 1970.**

To illustrate power law distribution, let us imagine 100 cats of different size, from the skinniest to the fattest, 20 of them weighing as much as the remaining 80.



As I intuitively suspect, the ultimate reason for the power law distributions in exystems is the combination of reversible self-replication with competition for a limited resource, which is just another way to define large exystems. Here is a possible reference for a start: Kunihiko Kaneko and Chikara Furusawa , Consistency principle in biological dynamical systems, Theory Biosci. (2008) 127:195–204. The initial fundamental work in this direction was done by Manfred Eigen around **1970**, the year of a fabulous explosion of great ideas and the ascent of Total Economy.

What I find remarkable in all the above examples is the use of term stability/instability. It confirms in my pattern-tuned eyes that **instability is a more general term of physics than energy.** The latter is reserved for the world in which the laws of nature are themselves stable. Pattern Chemistry is a kind of physics, as any chemistry is, with laws unstable in time. Human history is the most intimate example of chemistry we feel skin deep and in the guts. See comments to **Point 7**.

How much our knowledge is contaminated with human participation is the eternal problem of philosophy. I believe, very much and this is why knowledge evolves, although not yet to the extent that our future is controllable. We should be happy about that because “we” is pure chemical fiction. Control means a single manager with big ego, big stick, and a small plastic carrot.

> 2. *The act of change consists in the transition from the initial stable state (IS) through an unstable transition state (TS) to the final stable state (FS).*

The concept of transition state is the main motive of Pattern Chemistry. There are plenty of illustrations in **Parts 1 – 3**. Here is a fresh one: the battle over the healthcare reform in US.

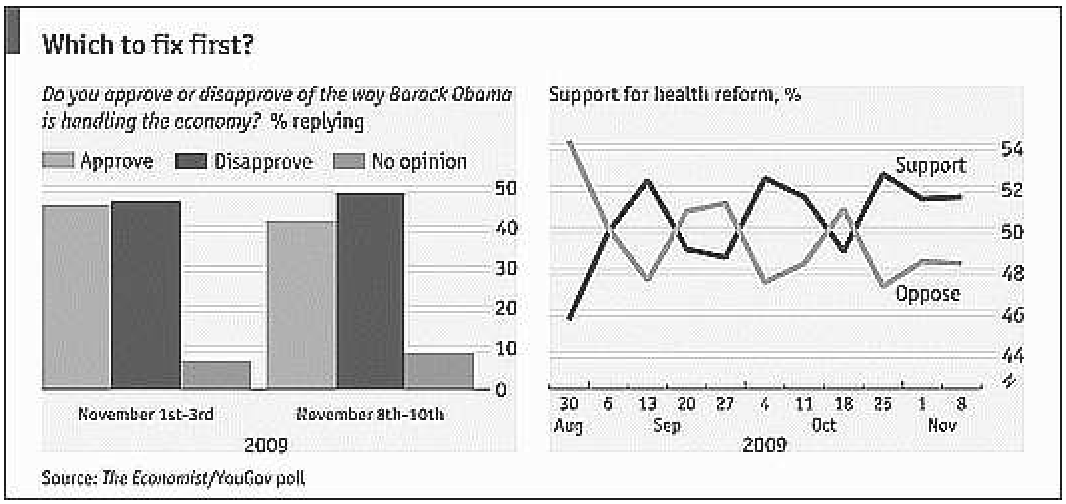
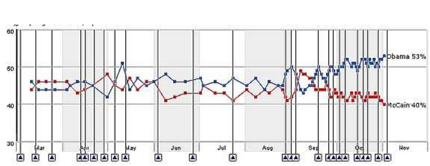


Figure 2-2: From *Passing the baton. The Economist* , November 18th 2009, p

After the election of Barak Obama, the healthcare initiative, which had never before entered even a transition state, caught fever and may end up again in either death or, for a change, recovery. **Figure 2-2**, borrowed from *The Economist*, November 18th 2009, exemplifies instability: neither the reform itself, nor the President’s action—or inaction—finds a clear support. The attitude toward the reform fluctuates within a narrow range.



← **Figure A9** in **Part 2** (from CNN) discloses the nature of some disturbances and clearly shows that it was the financial crisis that toppled the Republican candidate with his Alaskan albatross.

At this moment (November, 2009) we are still far from the final state, but probably much closer than a year ago.

3. *We cannot measure absolute stability, but can compare the stability of two states in terms of MORE and LESS. In physical sciences, energy is the concept somewhat close to stability: the higher the energy the lower the stability.*

The mechanical instability is exemplified with a ball on top of a hill (**Figure 2-3A**), the Devil's Marbles in Northern Australia (**2-3B**), and a man-made stone arrangement against a view of Macleod Tables in Scotland (**2-3C**). The man on stilts with a high bicycle (**2-3D**) is in the same row, but why?

A B C D

Figure 2-3: Unstable mechanical systems (A – C) and a not quite stable exystem (D)

The extreme cases define patterns best. It is instructive to ask even in what sense a stone and a man can be similar. To ask what an individual and a society have in common and why both are exystems is more to the point. As a possible answer, a whole "society of the mind" (Marvin Minsky, 1986) is hidden in human head. The human body and mind expressed in numbers and the variety of generators makes this modestly sized system an exystem with its constant flow of many interacting processes, dependence on previous evolution in the form of learning and training, and perpetual consumption of energy. The stilt walker and bicycle rider maintain balance not just by constant movement and dissipation of energy, but also with memory, code, and feedback. It is neither equilibrium, nor, strictly speaking, steady state, but **homeostasis**. It keeps disturbances in check and fluctuations within the limits which are **selected and remembered** as safe.

Jumping on a pogo stick seems to be an extreme case on the edge of homeostasis because the pogo stick has no clear zone of relative stability and no alternation of periods of intense correction and safe routine.

It is as good to ask questions as eat healthy food, drink clean water, and be reasonable. Let us then define memory in Pattern Chemistry as just as an exercise.

MY ANSWER →

Memory is ability to store configurations and patterns
ans classify them as initial, transitional, and final.

It follows from the answer, that there is no sharp distinction between real and imaginary loads in memory or their Minotaur-like hybrids and no border between true and false. To err is human, but so is to fight fantasies. This is where the high wall between mind and computer runs. In Pattern Chemistry "Memory is ability to store configurations and patterns and classify them as initial, transitional, and final."

I suggest to explore Etienne Jules Ramey's *Theseus and the Minotaur* (Jardin des Tuileries, Paris) as a snapshot of a transition state. For example: (**A**) Darwinism against creationism; (**B**) Apple against Microsoft; (**C**) deliberation on divorce; (**D**) optimism and pessimism concerning global warming; (**E**) the West against terrorism. Note that unlike the story of Minotaur, we do not yet know the outcomes.

The mindless mechanically unstable systems are sensitive to fluctuations such us accidental jolt, earthquake, or, in case of the multi-stone balance, strong enough wind. The human presence (or technical after-presence in the form of a regulating system with feedback) makes the transition to a more stable configuration reversible. The case with human presence makes the loss of balance reversible, but the rider is himself the main source of instability because of spontaneous internal fluctuations. The reason for that is the liquidity of the **brain** cell content; we are mostly water, which means that we are thermodynamically warm: sandwiched between ice and steam. Brain is the thermostat for the mind.

ASIDE: Homeostasis is the function of both the mind in the head and the government in Washington, DC. I mean the same government which the citizen militia in some states is preparing to fight with firearms and the Republican Party wants to shrink as the Amazonian Jivaro tribes used to do process the heads of the enemies.

Exystemic order is not the "order from fluctuations" introduced by Ilya Prigogine in the very beginning of the science of complexity. It still maintains its grip on the physicists, but it is the stable order of a solid template, like DNA, laws of the land, handbook, and blueprint which maintain order in an exystem, even if it is on stilts. I cannot imagine how order from fluctuations can be inherited and how it mutates.

If the mind is an exystem, is there any inherent power law distribution of thoughts? I am not aware of experiments in this direction, but I dare to predict that not more than 20% of recurrent thoughts during the day occupy us for not less than 80% of the time.

4. For a given stable state, the more stable the transition state, the more likely the transition to another (not necessarily MORE) stable state. Chemistry focuses on the question "how soon?" This is the most difficult question about exystems.

Why is it so difficult? The predictions about the motion of planets and solar eclipses were pretty easy even in Antiquity. The reason is trivial: the celestial mechanism works like a clockwork. Yet I want to change the vantage point: the life span of human civilization, let alone human life, is much shorter than life span of the solar system and the times when the clockwork will show some temper seem irrelevant. Human life and the time horizon of relevance are so close that history shows its full bandwidth of caprice and derangement, which religions and ideologies have been trying to tame by their own nutty zeal.

In our context, Shakespeare's comparison of life with stage performance misses the existence of the script making repetition of the performance by another, **better** actor possible. Our DNA is all the script we have, but continuing the metaphor, the audience constantly interferes with the actor, either pushing and punching him or carrying high in triumph. The DNA of society aims at keeping the public in check.

> Life's but a walking shadow, a poor player
> That struts and frets his hour upon the stage
> And then is heard no more: it is a tale
> Told by an idiot, full of sound and fury,
> Signifying nothing.

The exystem can be compared to riding a bicycle or walking on stilts. It requires a constant change of position to adapt to instability of the high center of gravity and small footprint, for which a constant supply of energy is necessary. This is why "stable state" of molecular chemistry is a rather poor metaphor for exystem. Exystem goes from one **steady state** to another through a perturbation. Homeostasis is the best term, in my opinion.

Self-replication ("Be fruitful and multiply") commanded to living creatures by God and to things by economists is the guaranteed way to never achieve any steady state for a lifetime of a generation. In American and Middle East politics God is feared as nowhere else.

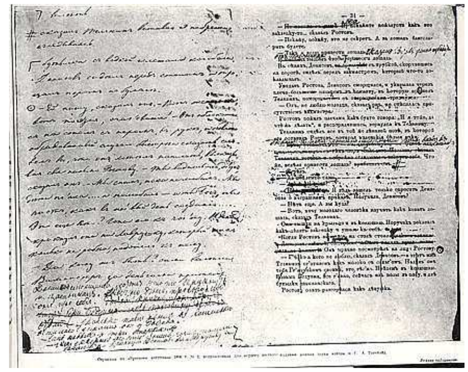
> *5. For an exystem, the act of change consists in the change of structure, i.e., combination of relatively stable blocks and relatively unstable bonds between them. In terms of Pattern theory, state is configuration. Possible states are possible structures.*

Here is how Amos Oz, a writer with roots going back to Hillel, describes the process of writing in his remarkable book:

I work like a watchmaker or an old-fashioned silversmith: one eye screwed up, the other fitted with a watchmaker's magnifying glass, with fine tweezers between my fingers, with bits of paper rather than cards in front of me on my desk on which I have written various words, verbs, adjectives, and adverbs, and bits of dismantled sentences, fragments of expressions and descriptions and all kinds of tentative combinations. Every now and again I pick up one of these particles, these molecules of text, carefully with my tweezers, hold it up to the light and examine it carefully, turn it in various directions, lean forward and rub or polish it, hold it up to the light again, rub it again slightly, then lean forward and fit it into the texture of the cloth I am weaving. Then I stare at it from different angles, still not entirely satisfied, and I take it out again and replace it with another word, or try to fit it into another niche in the same sentence, then remove it, file it down a tiny bit more, and try to fit it in again, perhaps at a slightly different angle. Or deploy it differently. Perhaps farther down the sentence. Or at the beginning of the next one. Or should I cut it off and make it into a one-word sentence on its own?

Amos Oz, *A Tale of Love and Darkness*, Harcourt, 2004, p.268

That the craftsmanship of creative writing has its chemistry is no revelation, but nobody has ever expressed it in such beautiful pattern-chemical language. Naturally, the process of selection of configurations ends with the most stable text **under circumstances**. Openness of a system means that there are always external circumstances. Leo Tolstoy used to endlessly edit his major novels and his wife had to rewrite them by hand. To say that we are married to our computers is not so facetious as it may sound. Marriage is a pattern, not a configuration. It evolves, too, bringing new instability resolved by adaptation and change.



Tolstoy's proofreading of *War and Peace*

*6. **Change is often local** and involves only some generators and bonds. Paradoxically, it is the large size of exystems which makes their complexity comprehensible.*

Local episode of global change

This statement is natural for molecular chemistry. The typical chemical transformation occurs, with few exceptions, within the neighborhood of a single atom or a pair of atoms. We can reduce it to an alternating sequence of breakup and formation of single bonds. DNA is a giant molecule, but the process of protein synthesis occurs within a small moving area, exactly as reading a text aloud.

ASIDE: Why aloud? Because, strictly speaking, we do not know what happens inside the mind. Probably almost nothing when you silently read 2074 pages and 336000 words of the Healthcare Bill., but who knows?

Social transformations, revolutions, and reforms also develop within a small part of the exystemic structure, like the sex revolution and digital revolution, even though they may spread like wildfire within a particular area.

7. The behavior of a real exystem in the future is comprehensible only partly because its structure is logically open and axiomatic assumptions are subject to unexpected novelty. Patterns are generally more stable than configurations, but they provide less detail.

The war against the guerillas who do not wear uniform and have no national identity is an example of a novelty which can present a debilitating challenge to the most powerful democracy. War in general is nothing new in itself. Neither is liberalism and humanitarian necessity to spare the innocent. It is the schizophrenic necessity to combine both which is historically new. The two modern American hot wars fluctuate between cruelty to our own troops, put through the meat grinder of Afghan roads, and cruelty to the innocent and even "guilty." The paralysis regarding piracy at sea is another example.

The above examples, however, point not to new patterns, but to a new combination of the old ones in the oxymoron of human war. The truly new phenomenon is what I call **privatization of power**. I define power as amount of effort (measured in energy, money or lives) for a single goal (Essay 53. Power: Hidden Stick, Shared Carrot). It is nothing but a generalized counterpart of chemical **concentration**.

Wireless communication, Internet, and land-to-air rockets are radical evolutionary novelties which immensely amplified human power and made it cheap, so cheap that a single human mind of a hacker can successfully wrestle with the power of the state and corporation, especially when the state is torn by its own cold civil war and revival of mindless fanatical pseudo-religiosity.

8. Temperature is the measure of internal motion. Exystems must be warm. Freezing stops change, melting ruins structure.

I am turning to Amos Oz once again for an illustration to the notion of a warm exystem:

> Thinking, but not right to the end, that everything that's hard and everything that's cold will stay hard and cold forever and everything that's soft and **everything that's warm is only soft and warm for the time being.** In the end everything has to pass over to the cold, hard side. Over there you don't move, you don't think, you don't feel, you don't warm anything. Forever.
>
> Amos Oz, *A Tale of Love and Darkness*, p. 243

9. The less equal the distribution of a property over the system in time or space the less stable the system. In physical sciences, entropy is the closest to inequality measure. It is low for sharp gradients, imbalances, and local concentration.

For the inequality of temperature distribution, melting ice is the best illustration. →

As for another inequalities, here are some:

A. Lender-debtor inequality between USA and China. An instability is imminent.
B. Red-versus-Blue inequality of geographic distribution of political allegiances on the US map.
C. Inequality of political power distribution in authoritarian states. Watch the news from time to time. Remember Communist Russia and its satellites.
D. Wealth inequality in America which leads to economic earthquakes.
E. Inequality of global distribution of water resources (water wars)
F. Size inequality of market players: a few are **too big to fall**.

G. Size inequality in Islamic guerilla war: the solider of a regular army wears a uniform and is in a company of other soldiers. The insurgent or terrorist is alone and indistinguishable from civilians: **too small to target**. The Russians went home. The Americans will, too.
H. Concentration of wealth, regardless of inequality, is a source of risk-driven instability.

3. REVOLT AGAINST MONEY

Although I mentioned Nicholas Georgescu-Roegen several times in **Part 2**, by that time my knowledge of his work was limited. I had not read his *The Entropy Law and the Economic Process*. That omission, as I am now confessing with relief, was bothering me like the splinter under a fingernail. Finally I got hold of the book and found it a difficult and even disconcerting reading.

The year of publication, 1971, was a special time in intellectual history, similar to Cambrian Explosion in natural history. The variety of new large scale ideas, each of them promising a further diversification, was so dense that some of them were left unexplored. Those that advanced to dominance were driven by the prospects of immediate profitability. Science was happy being fattened, devoured, and digested by economy.

William Ross Ashby's (1903-1972) concept of homeostasis, pushed aside by algorithmic computation, usually comes to my mind as an example of a lost treasure. It was a cardinal idea promising understanding and simulation of the mysterious human thinking. Still well remembered, homeostat remains a curious little animal waiting to being rediscovered.

The non-pecuniary (i.e., not in terms of money) representation of economy was another cardinal and heretic idea, left to languish in the slush pile of heterodox economics.

Ashby occasionally—because he does not separate economy from other complex systems—refers to economy in his *An Introduction to Cybernetics*, 1957, Chapman & Hall, London.

> In the study of some systems, however, the complexity could not be wholly evaded. The cerebral cortex of the free-living organism, the ant-hill as a functioning society, and the human economic system were outstanding both in their practical importance and in their intractability by the older methods. So today we see psychoses untreated, societies declining, and economic systems faltering, the scientist being able to do little more than to appreciate the full complexity of the subject he is studying. (p.5).

Discussing the problem of stability—the main problem in my version of econochemistry—he notes :

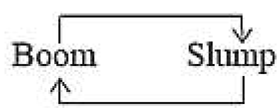
> The question "what will this system do?" applied to, say, an economic system, *may* require a full description of every detail of its future behavior, but it *may* be adequately answered by the much simpler statement "It will return to its usual state" (or perhaps "it will show ever increasing divergence"). (Ashby, p.85).

This passing remark not only resonates with my view, but also suggests a truly practical idea: we will **probably never** have a consensus on “what will this [economic] system do?” Neither will we agree on what should the system do. Both questions have a great variety of answers each. But we will be able to radically simplify the situation by regulating the stability of the system and asking ourselves only the following question with yes or no answer: Do we want the system to be more stable?

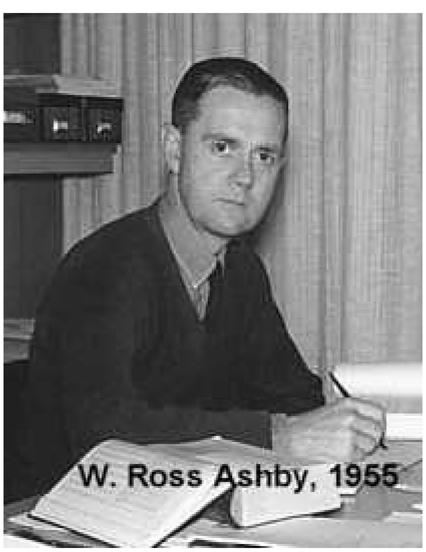
> **ASIDE**: I have forced myself to put **probably** before **never**. There is still a chance that we will have a social and economic consensus and economy will be as predictable as a good engine, if by that time good engines are in existence. For long periods of time, although not forever, such stable civilizations existed, from Ancient (Egypt and China) civilizations to closed tribal societies. The freezing of human society into a rigid but shaky order, as Sci-Fi writers see it, a kind of global tribe—or global anthill with a dictator—can make economy predictable, even if shocks are perpetual. Sci-Fi is nothing but a **search for alternative configurations**. It is part of everyday thinking process of molecular chemists and scientists in general. Moreover, it is one of two components of any creativity. The other component is test and selection. The best source: Henri Poincaré, *Science and Method*, Book 1, Chapter 3, Mathematical Creation. Available online. I will return to Poincare’s ideas.

Simplification is the essence of econochemistry. While we lose in content, we may gain in significance.

> Near the bottom [i.e., being most radical] lies such a simplification as would reduce a whole economic system with a vast number of interacting parts, going through a trade cycle, to the simple form of two states:



(Ashby, pp.108-109).



Ashby has nothing against money and hardly mentions it at all (“And a money-amplifier would be a device that, if given a little money, would emit a lot,” p.265) . He clearly explains why, joining the Penniless Country Club by default:

> It takes for granted that the ovum has abundant free energy, and that it is so delicately poised metabolically as to be, in a sense, explosive. Growth of some form there will be, cybernetics asks “why should the changes be to the rabbit-form, and not to a dog-form, a fish-form, or even to a

> teratoma-form?" **Cybernetics envisages a set of possibilities much wider than the actual, and then asks why the particular case should conform to its usual particular restriction.** In this discussion, questions of energy play almost no part—the energy is simply taken for granted. Even whether the system is closed to energy or open is often irrelevant; what *is* important is the extent to which the system is subject to determining and controlling factors. (p.3)

We believe that money moves mountains and buys immortality, but Ashby is simply not interested in what drives transformations. He is preoccupied with the other, not so dazzling aspect of econochemistry, which (I speak for myself) in **chemistry** is called **catalysis**: the art of **achieving the desired** change **in spite of tight competition** with other trends. Note that the language I use is equally applicable to molecular chemistry, business, politics, career, scientific problem solving, and love life.

In a similar negative way Ashby defines what I call novelty by defining non-novelty through the **property** of closure. This is much better that Aristotelian **axiom** of closure which I used.

If Ashby looked so far ahead, how about an advice to the FED chairman or, for that matter, to the chief executive?

> Let us therefore approach the very large system with no extravagant ideas of what is achievable **(p. 245).**

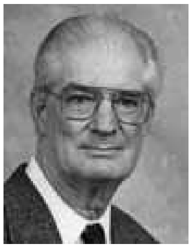
The Russian edition of *An Introduction to Cybernetics* appeared in 1959 and I have been infatuated with Ross Ashby since then. There is much more to take from Ashby, but I have to move on to other luminaries in the Penniless Country Club. I promise to come back soon.


Nicholas Georgescu-Roegen

In Georgescu-Roegen's *The Entropy Law* I found a goldmine of shrewd observations and witty remarks, notably about the concept of novelty, event, and the inherent anthropocentrism of economics. I enjoyed it, but this nectar is not for six-pack guzzlers. More than half of the book was just sweet philosophy and bitter polemics and the rest looked either too behind or too ahead of our times.

The author seems to believe that mathematical equations in economics, which he prophetically criticizes, could be improved and ultimately applied as soon as economy was acknowledged an open dissipative system. Alas, as physicists, including Einstein, already saw, calculation of entropy would need a detailed and complete representation of the system—the more complex the more detailed. In economics it would require reading the minds of billions of people, as I would reformulate George Soros' reflectivity. (True, stock traders are simple creatures and there are swarms of them, but investment banks are not and there are but few of them—even less than a year ago). Yet the book left on me a deep subconscious impression, which has been only gradually rising to conscious level: I saw something like author's wrestling with God on the subject of the nature of things.

Georgescu-Roegen's name guided me to Herman E. Daly, whose *Beyond Growth: The Economics of Sustainable Development* (Beacon Press, 1996) I truly enjoyed. While Georgescu-Roegen was a fountainhead of answers without questions, Daly stirred up great and painful questions with no answers acceptable to the ruling elite of the world: politicians, economists, and businessmen. His concise essays on the history of the field of Sustainable Development directed me back in time to Frederick Soddy (1877 – 1956), a Nobel Laureate, one of the founders of nuclear chemistry, who introduced the very term isotope and anticipated nuclear war. Soddy was greatly skeptical about any science of the substance called "money" which can be overnight made with a bang or lost without even a puff of smoke. When exactly that had happened both ways during the current decade on a grand scale, Soddy's noble ghost was conjured from the dawn mist of the twentieth century by Eric Zencey (*The New York Times*, April 11, 2009). I hurry to acknowledge that I have only cursorily looked through the main Soddy's book *Wealth, Virtual Wealth and Debt*, but Zencey's eloquent article and other secondary sources say all what is important. Zencey's later article on GDP ("G.D.P. R.I.P." , NY Times, August 9, 2009) joins Herman Daly's fight against GNP and the crushing tyranny of growth.



Herman E. Daly

Frederick Soddy

By educational background, Ashby, Soddy, and Georgescu-Roegen were a psychiatrist, chemist, and mathematician, respectively. Is being an economist a kind of a disability? Or the opposite "Is not being an economist…" is the right question? If the question is half the answer, both provide it.

My personal impression is that Soddy's invasion of economics was motivated by his perception of WWI as the evidence of the catastrophic instability of unstoppably growing economy. It seems that he wanted to return to the predictable quasi-mechanical order of the last half of the nineteenth century. Other than in form of grants money did not fit science.

I think that the *baskets*—"new system of economic units of measurements" indexed to inflation—proposed as "part of the subprime solution" by Robert Shiller, the influential, original, and authentic economist, meekly continue the anti-money line going back to Frederick Soddy (and probably somebody else whom I do not know).

> In contrast, the traditional currency units used by countries all over the world are a poor measure of value, since their buying powers changes unpredictably over time.
>
> Robert J. Shiller *The Subprime Solution: How Today's Global Financial Crisis Happened, and What to Do about It* , 2008, Princeton U.P, p.142.

Now let us listen to Soddy:

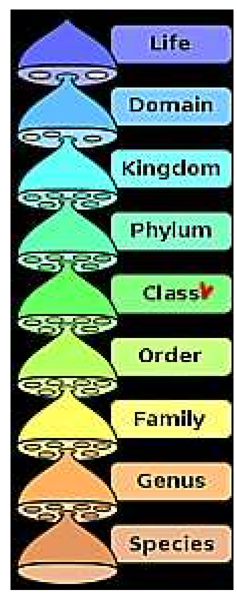
> It is true that the nation must act, and continue indefinitely to act, as if it possessed more wealth than it does possess, by the aggregate purchasing power of its money, but the important thing is that this Virtual Wealth does *not* exist. It is an imaginary negative quantity—a deficit or debt of wealth, subject neither to the laws of conservation nor thermodynamics. But it is a quantity which has reference to *wealth* and not to *money*. It is not the amount of money people have that is of any real importance, but the amount of wealth they are in a position to obtain any time in the future on demand, and therefore go without in the present, that is of importance. It is the quantity of goods that the community abstains from possessing that is definite, and the number of units of money this definite quantity is worth is all the money, whatever that all may be.
>
> Frederick Soddy, *Wealth, Virtual Wealth and Debt*. London: George Allen & Unwin Ltd. , 1926, pp. 139-140 [There is a 1987 edition].

It looks like Soddy forgets the **quality** of goods, without which no possessing can be definite, but the principle is clear.

As an amateur, I would not mind the above quotation from Robert Shiller containing the word **new** in the title of section *A **New** System of Economic Units of Measurement* , Chapter 6. Shiller points there to the Chilean prototype and he has an earlier book on the subject. But it seems to me that Shiller also forgets quality and the simple fact that the rich rarely use goods for the poor, while the poor almost never use the goods for the rich.

ASIDE: The rich and poor have different habitats and ecological niches. They do not compete for the same food and territory. Nor have they the same predators, not even the IRS. They may come in close contact, but intermarry only as aberration. This is in my eyes a sufficient evidence that they are different species, probably even different families, orders, and, apparently but not surprisingly, **classes**. Sources: Barbara Ehrenreich, *Nickel and Dimed*, Robert L. Frank, *Richstan*, Wikipedia, → and limited but close personal observations of both symbiotic lifestyles.

Example: frogs and mice are in different classes of the superclass *Tetrapoda* (four-legged) of the phylum *Chordata* (Vertebrates). Actually, close enough for brotherly love. They are said to have common predators: owls, same phylum, class *Aves* (Birds).

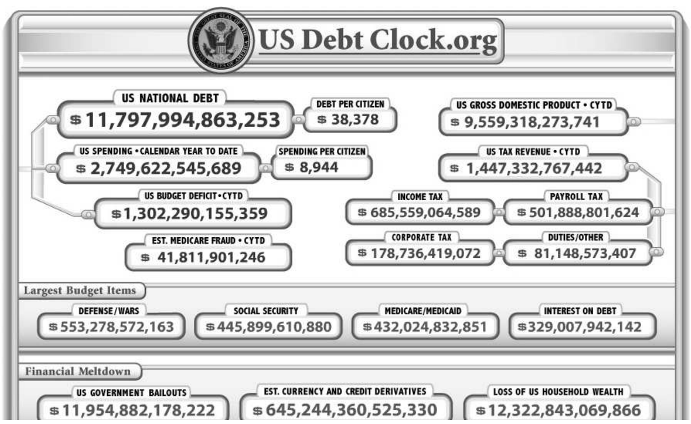


Besides, only big money buys power. The daily baskets for two **economic** classes (for the class deniers in America, let us call them not Marx but Pareto classes) have not only different size, but also dramatically different compositions. Indexes like human development or happiness, suggested instead of gross indexes, never reflect the Pareto 80/20 inequality of what they represent.

While I am writing this, another high rank economist Joseph E. Stiglitz suggests to “rethink GDP fetish” and abandon not only GDP, but also any other single numerical index of economic progress.

I see no reason to bury any gross monetary index of progress by growth, however gross it is. I would rethink it as an **index of danger**. GDP should be a ticking reminder of what is similar to the situation of astronauts stranded in space with a limited stock of oxygen. Of course, *dum spiro, spero*.

There is another, more sinister ticking device, **The US National Debt Clock**, http://www.usdebtclock.org/ , a negative quantity which I believe Soddy would immediately interpreted as the time bomb set to start WWIII.



US Debt Clock, 9/10/2009 6:48 PM ET, fragment; 12/8/2009 : ~$12.1·10^{12}

The **stack** of dollar bills equal to the US debt on **9/10/2009** will be over 3 times higher than the distance to the moon (238.857 miles between the centers). The same amount of money in $1000 bills would weigh about 12,000 ton. The terrifying fact is that American GDP is of the same order of magnitude!

My reading of the founders of economic skepticism has had an unexpected effect: I now firmly believe in the traditional economics that counts money, whatever slips between its fingers or magically appears from behind the ear. It cannot be replaced by anything else. Neither can GDP. We simply have no other hard numerical measure of economy, however devious this one is. But we have to rethink it.

I split the following quotation, where Soddy acknowledges the factor of variety, into two parts:

> [1] It is difficult or impossible to get a physical means of measuring wealth—as, for example, in the units of physical energy and of human life-time expended in ifs production—which shall be capable of common application to all the numerous varieties of wealth ; [2] but this difficulty must not blind us to the palpable absurdities in conventional economics introduced by always measuring wealth by exchange-value or money price (p. 62).

Another reason is the factor of individual “quality inequality.” Yet another is corporate and individual privacy, legally non-existing only under Communism. But how is justified the second part of the above quotation? It makes no sense to rely on the pandemonium of mainstream economists who make predictions. As for the skeptics, unfortunately, what we gain in predictability we lose with triviality. As Herman Daly noted, Georgescu-Roegen's insights were "really elementary by virtue of being so fundamental" (*Beyond Growth*, p. 193). Fundamentals are feather light. Besides, skepticism has no market value.

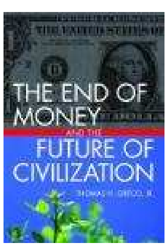
Traditional—monetary—economics is exactly the technology of **making and losing money** on micro and macro scale. The energy economics represented by Soddy, Georgescu-Roegen, Daly and supported by money economists like Shiller and Stiglitz, argues in terms of conservation of energy during the process of **making and losing order**. One cannot exclude the other, but can the "alchemy of finance" (George Soros) and the somber hard-knock chemistry of human condition meet? As for econochemistry, which is about stability, money has no place there. Alas, if no money out, no money in.

I hope to return to this inexhaustible subject. Right now I have a peacemaking proposition. Let us count economics and ecology as one science, not two. Living economics today is ecological economics. There is no other macroeconomics, or, as Herman Daly says, "macro-macro" (p.50) economics. Ecology is hijacked by economy. Economy is in the tightening ecological straitjacket. **Eco** in **eco**nomy and **eco**logy has the same meaning: our *oikos*, planetary home. Ecological economy is a tautology like "new innovation" and "free gift."

ASIDE: How about egonomics—the individual human economy of well-being?

To conclude, I venture an explanation why money makes sense as a universal economic measure. Because it is a **conservative** value indeed: the balance of debit and credit is always exact in honest accounting. It is the only keyhole for hard scientists to peep into the giant halls of economy and earn some living.

/==/



P.S. August, 2011. The revolt against money continues.
The End of Money and the Future of Civilization, by **Thomas Greco, Jr.** ,Chelsea Green Publishing, 2009

4. ENTROPY AND MATERIAL WASTE

Nicholas Georgescu-Roegen considered material waste, of which the discarded plastic yogurt cup is an appropriate example, →

a manifestation of the entropy law. This is true, but not in the same absolute sense as regarding energy. Contrary to his view, I do not see it as irreversible loss. For a chemist, matter is what cannot be lost except in nuclear transformations, which are outside molecular chemistry.

The unwritten corollary of molecular chemistry means that any chemical compound can be converted into a set of its pure chemical elements, as well as synthesized from that set, provided the conditions of chemical laboratory and availability of **energy**, **time**, and **knowledge** of chemistry. For example, 100 g of aspirin, $\mathbf{C_9H_8O_4}$ can be converted into approximately 60 g pure carbon, 4.4 g hydrogen, and 35.6 g oxygen of which aspirin consists. Of course, there is absolutely no sense in doing that. The constituents from aspirin are in no practical way different from carbon black and the elements obtained from water. Note, however, that to reconstitute aspirin from elements is a much more complicated task than the decomposition. It would require an excess of components because of the losses during the synthesis. The reason why it is so reflects the very essence of the idea of entropy.

The synthesis requires the arrangement of as many as 21 atoms in ONE of MANY possible ways, while the decomposition results in only ONE final result. For example, the same 21 atoms can be arranged in MANY different stable ways, three of which are shown in **Figure 4-1**.

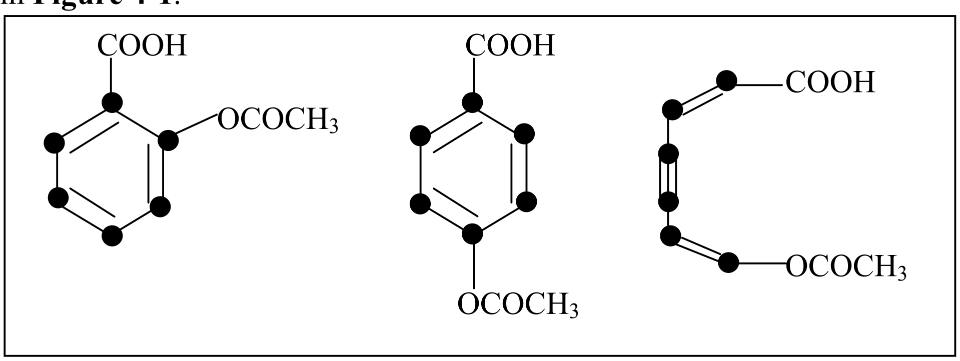


Figure 4-1. Aspirin (left) and two of its isomers

Black points stand for six out of nine carbon atoms. I see no practical way to arrange them in a hexagon in one step. The actual pathway to make aspirin from elements—carbon, hydrogen, and oxygen—could be very long, tortuous, and wasteful: sheer madness.

Although the first aspirin was made from natural coal quite easily, it was only because coal (**Figure 4-2**) already contained six-member carbon rings, created by nature step-by-step.

It is crucial for the set of ideas which I put forth as the foundation of econochemistry—and Pattern Chemistry in general—that the chemical idea of entropy does not necessarily involve any numbers and calculations. All it needs is the awareness of the difference between ONE and MANY, as well as MORE and LESS.

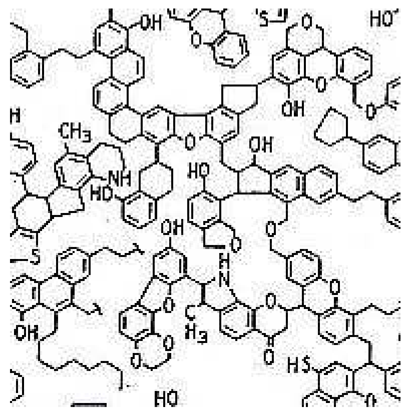


Figure 4-2. One of many suggested structures of coal

> **ASIDE**: I am indebted by the realization of a profound difference between ONE and MANY to my outstanding high school teacher of mathematics Rimma Hirsh, who used to say, so long ago,"one is one, but two are many." I hope that some young minds will be similarly imprinted by the idea that chemistry is not just about atoms and molecules, but about anything that can be counted one by one, joined, and taken apart.

Chemistry prays on very general combinatorial ideas like owls on mice. Thus, any structure made of Lego blocks can be split into a pile of individual blocks and reassembled back or into any other structure, provided the set of spare blocks is big enough. In chemistry, however, the price of synthesis of a complex substance from chemical elements can be very high. Chemists play no such games and use commercial reagents of low and medium complexity, which can be used for a wide variety of purposes. Chemical synthesis proceeds stepwise, the same way technology progresses historically. Human history proceeds in the same manner, as a sequence of more or less dramatic steps.

To take an example of practical reversibility of material waste, all growing carbon dioxide in atmosphere—the main reason for our global pessimism—can be, in principle, converted into pure carbon and oxygen: $CO_2 \rightarrow C + O_2$. The plants come pretty close to this. They absorb water H_2O and convert CO_2 into oxygen and carbohydrate, typically $(CH_2O)n$:

$$\mathbf{n}\,(CO_2) + \mathbf{n}\,(H_2O) \rightarrow (CH_2O)_{\mathbf{n}} + \mathbf{n}\,O_2$$

By heating a carbohydrate to a high temperature in a closed space we can split it into carbon and water. This can be reproduced, for example, with common sugar or starch in the kitchen. Any severely burnt food is mostly carbon. Same process of pyrolysis has been used for millennia to make charcoal from wood.

All we need to split CO_2 into carbon and oxygen or convert back into hydrocarbon and oxygen is energy. We have approximate knowledge and time to develop it. But the fact that we generate CO_2 from carbon and hydrocarbons makes this economically senseless, unless we have an external—non-coal, non-oil, and non-gas—source of energy, which we, of course, have: sunlight, wind, and tide. To simulate vegetation is not easy but possible in principle. The easiest way is to just plant trees. But what makes more sense: (1) to wait until we switch to renewable energy which would still be insufficient to maintain unlimited growth on the limited planet, (2) to voluntarily decrease the global population to ensure steady state economy, or (3) to re-establish slavery and keep the majority of global population oppressed and regulated to ensure the sybaritic life for the ruling elite? Those who have read about Ancient Rome and other empires, up to the Soviet one, know how little the sybaritic life was guaranteed for the elite: it was in turn regulated by the will of the tyrant, who himself was never sure he would not part with his head tomorrow. That kind of meta-stable economy could last for centuries, however.

Let us take a more mundane example: aluminum is the most abundant metal in earth crust. Yet its production is extremely energy-consuming. A soda can made of aluminum and thrown into garbage is a waste of aluminum and the energy spent on its manufacturing. As for energy, when supplied by hydroelectric power stations it is considered renewable, but is ultimately supplied by the sun. China is the largest manufacturer of both aluminum and hydroelectric energy.

In principle, the dispersion of metals like aluminum or much rarer lithium, used for batteries, with waste is fully reversible. Moreover, practically any destroyed man-made thing can be resurrected. Metals, for example, can be concentrated and recovered from highly diluted solutions with organic extractants and ion-exchange resins. The material waste, therefore, is not an irreversible entropic waste; only thermal waste—dissipated heat—is irreversibly lost. We lose energy, not matter. Only in nuclear transformations we lose both. This illustrates my thesis that economy is assembly, separation, and rearrangement of atoms and molecules. All we need is energy. In fact, energy is all we need to generate knowledge, while we still have heads on our shoulders and not cabbage. It looks like China realizes that the American careless and ignorant attitude toward material waste will fuel Chinese economy by the mid-century. In spite of temporary snags. →

In practical terms, however, the recovery of human-generated material waste may require either less, or as much, or often more energy than the original production.

Human history is by its nature an optimistic undertaking, but with macabre undertones: optimism is not granted on the individual human scale. Money in modern society is the **pocket sun** but there is no individual pocket clockwork generating tides, winds, and seasons. The society—American capitalism, French socialism, or Afghan tribalism—is the evolving use of solar presence in the sky.

No wonder, the outlandish ideas of Frederick Soddy and Nicolas Georgescu-Roegen failed to captivate economists. The sun, the moon, the tide—it is all for poets, farmers, and fishers. Few of them are on the gravy train.

5. HENRY POINCARÉ ON BEAUTY

As promised in REVOLT AGAINST MONEY, I turn again to ideas of Henri Poincaré about thought process in *Science and Method*, Book 1, Chapter 3, Mathematical Discovery. Available online.

Since I had read the book at least 30 years ago in Russian, I returned to it many times and it has been on standby in my memory. In an ASIDE to REVOLT AGAINST MONEY in the present text (page 18) it readily sprang up, prompted by the word "creativity."

I am reading again Poincaré's *Mathematical Creation* and this time see it in quite a new light. It helps me that the 1921 edition of his book is in public domain an I can freely quote it.

Poincaré asks: "And further: how is error possible in mathematics? " He wonders how he can be a good mathematician with poor memory. Here is his explanation why he does not get lost in a long mathematical reasoning (my emphasis):

> A mathematical demonstration is not a simple juxtaposition of syllogisms, it is syllogisms ***placed in a certain order,*** and the order in which these elements are placed is much more important than the elements themselves. If I have **the feeling, the intuition, so to speak, of this order,** so as to perceive at a glance the reasoning as a whole, I need no longer fear lest I forget one of the **elements**, for each of them will **take its allotted place in the array**, and that without any effort of memory on my part.

Pattern Theory for children

I read it as a description of what **pattern** is: an order in the form of slots or bags connected in a certain order, a pile of items that could be put into slots, and the rules of filling the slots.

But how can we **feel** the order, keep it in memory, and convey to somebody? Poincare is looking for an exact word, but finds only "feeling," "intuition," and, characteristically, "so to speak." I can imagine only one way to do that: the empty slots belong to the pile of the items that can be placed inside the slots. Thus, the Christmas socks can store a wide variety of things, including real Christmas socks in turn stuffed with Christmas socks. The order can be linear, circular, or any other, as if the socks were atoms in molecules. This is what comes to mind when a pattern chemist "feels" order: a structure of points and lines.

Next, Poincaré seems to express the idea of novelty:

> In fact, what is mathematical creation? It does **not consist in** making new combinations with mathematical entities **already known**. Any one could do that, but the combinations so made would be infinite [?] in number* and most of them absolutely without interest. To create consists precisely in not making useless combinations and in making those which are useful and which are only a small minority. Invention is discernment, choice.
>
> > * **NOTE**: There is a problem with the English translation of this paragraph. "Infinite in number" is the opposite of "*d'un nombre fini*" (finite in number) of the original French text. Indeed, what could "most of infinity" mean? Poincaré was not a fan of Georg Cantor.
>
> They ["the mathematical facts worthy of being studied"] are those which reveal to us **unsuspected** kinship between other facts, long known, but wrongly believed to be strangers to one another. Among chosen combinations the most fertile will often be those formed of elements drawn from domains which are **far apart**.

Some elements were always far apart and **now** , suddenly, they are forever close. This is what I mean by novelty: not just a new combination, but the combination whish had been impossible, illegal, and irregular until it became new. Note that this combination, once it is stabilizes, is a **new** element.

Poincaré's discussion of many subtleties of creative process never ceased to fascinate scientists, probably, because his explication is never formalized and based on metaphors. His essay on creativity is often quoted. As he remarks,

> Again I beg pardon, my comparison is very rough, but I scarcely know how otherwise to make my thought understood.

This remark concludes a comparison so chemical, that I want to quote it in its entirety and, thank Google, I can:

> Permit me a rough comparison. Figure the future elements of our combinations as something like the **hooked atoms** of Epicurus. During the complete repose of the mind, these **atoms** are motionless, they are, so to speak, **hooked to the wall**; so this complete rest may be indefinitely prolonged without the **atoms meeting**, and consequently without any **combination** between them.
>
> On the other hand, during a period of apparent rest and unconscious work, certain of them are **detached from the wall and put in motion**. They **flash in every direction** through the space (I was about to say the room) where they are **enclosed**, as would, for example, a **swarm of gnats** or, if you prefer a more learned comparison, **like the molecules of gas** in the kinematic theory of gases. Then their mutual impacts may produce **new combinations**.
>
> What is the role of the preliminary conscious work? It is evidently to mobilize certain of these atoms, to unhook them from the wall and put them in swing. We think we have done no good, because we have moved these elements a thousand different ways in seeking to assemble them, and have found no satisfactory aggregate. But, after this **shaking up** imposed upon them by our will, these **atoms** do not return to their primitive rest. They **freely continue their dance**.

> Now, our will did not choose them at random; it pursued a perfectly

> determined aim. The mobilized atoms are therefore not any atoms whatsoever; they are those from which we might reasonably expect the desired solution. Then the mobilized **atoms undergo impacts which make them enter into combinations among themselves or with other atoms at rest** [pure chemistry! – Y.T.] which they struck against in their course. Again I beg pardon, my comparison is very rough, but I scarcely know how otherwise to make my thought **understood**.

The parallel between molecules and thoughts was the main idea of my *Molecules and Thoughts*. It was further developed regarding the linearization of thoughts into speech, see linguistic essays in complexity , which I do not want to rehash here. I must confess, however, that Poincaré's libretto for an atomic ballet completely escaped my memory and, while writing this **Part 4,** I read it as for the first time. Before, I was focused on another great idea of Poincaré expressed in his *Mathematical Creation*: competition of thoughts for the place in consciousness.

Finally, I ask, together with Poincaré, what is beauty?

> Now, what are the mathematic entities to which we attribute this character of beauty and elegance, and which are capable of developing in us a sort of esthetic emotion? They are those whose elements are harmoniously disposed so that the mind without effort can embrace their totality while realizing the details. This harmony is at once a satisfaction of our esthetic needs and an aid to the mind, sustaining and guiding.

I suspect that mathematical or, more generally, intellectual beauty and harmony, is nothing but pattern-chemical stability. The intellectual configuration is beautiful and harmonious when it is stable, and it is stable when it has minimal number of internal contradictions and weak bonds. Obviously, the smaller the size of the intellectual construct the more elegant it is, the less room there is for flaws and contradictions and the easier it is to see them half way to the completion of the construct. Compare with the 2000 pages of a congressional bill. Ughh! Or, to take the opposite example, imagine that the entire Christian Scriptures consist of the Sermon on the Mountain.

I conclude with Poincare:

> "I … shall confine myself to saying that the majority of witnesses confirm my conclusions; I do not say all, for when the appeal is to universal suffrage unanimity is not to be hoped."

This is the natural consequence of size.

6. TRAVELS IN TIME WITH RICHARD FEYNMAN

In this Chapter, I will make some crazy mental jumps from a beer mug to newborn galaxies and from murder to enzyme inhibition, but this is exactly the point.

The whole idea of pattern chemistry comes from an observation that chemical phenomena and human matters have a profound similarity. Yet molecular transformations follow the laws of physics while exystems, to which human matters belong, seem to resist clear cut physical equations for the reasons which I have already presented earlier. The next question I am trying to answer is:

What is the physics of exystems, if any?

I have a temerity to ask this question because the green grapes of physics keep teasing me, although my physical and mathematical competence is inadequate to reach them. As a non-physicist, I can rely only on quoting grandmasters of science. Is the "profound similarity" more than just intuitive?

Richard Feynman was, in my opinion, a physicist who could not only naturally speak the

language of common mortals but also step in their shoes. Feynman had an all-encompassing view of physics, as if from outer space, but did not hesitate to say, "we don't know." His monologues, preserved in videos (also), are as breathtaking as mountain scenery. He takes us, mortals, to a summit to watch a sequence of receding backdrops separated by increasing haze. Moreover, although Feynman acknowledged his dismissive youthful stance toward humanities, his published heritage shows a deep natural immergence in all human matters as a source of intriguing questions the answers to which existed and had to be found. In his memoirs, science and life are inseparable. He designed his *Lectures* as a course in mathematics and real life.

Feynman had a hands-on experience with biology, chemistry and biochemistry, was interested in new fields beyond physics, and saw the romantic side of organic chemistry: "This is one of the most fantastic pieces of detective work that has ever been done—organic chemistry" (*Lectures*, Vol.1,1-8). He was an artist, musician, linguist, and concerned citizen. I take him as my guide into physics where I would be lost after a few steps. (I will be lost, anyway…).

There is no consensus on what energy is, see a witty commentary.

Compare two definitions from Wikipedia:

(1) Energy in physics is a " scalar physical quantity that describes_____ ____________________the **amount of work** that can be performed by a force ."

(2) Work in physics is "the **amount of energy** transferred by a _______ force acting through a distance."

Richard Feynman:

> It is important to realize that in physics today, we have no knowledge of what energy *is*. We do not have a picture that energy comes in little blobs of a definite amount. It is not that way. However, there are formulas for calculating some numerical quantity, and when we add it all together it gives the same number. It is an abstract thing in that it does not tell us the mechanism or the *reasons* for the various formulas (*Lectures on Physics*, Volume 1, 4-1).

Feynman discusses general problems with definitions and their circularity in *Lectures*, (Vol.1, 12-2). In my interpretation, the result is: tell but don't ask. If there is a relation, do not ask what the related things are. In mathematics it does not matter, in real world everything is approximate.

The word "energy" (*energeia*, "in work") was first used by Aristotle in the 4th century B.C. What Aristotle meant by that is still disputed, but it was certainly not physical energy. Most commentators agree that it was activity or actuality, as opposed to something potentially possible. This opposition is very familiar to chemists—and criminal investigators—who can imagine a whole series of **possible** transformations but must decide (or explain) what has **actually** happened or will happen next. This ultimately depends on energy considerations, so that the word of a chemist is worth taking to account.

The term energy first appeared in physical literature relatively late, in 1807. It was introduced by Thomas Young, "The Last Man Who Knew Everything" (the title of a book about him by Andrew Robinson, Pi Press, 2006) . Young, himself an encyclopedic thinker of almost Aristotelian gift, in his *A Course of Lectures on Natural Philosophy and Mechanical Arts* (1807) used the word energy in at least five meanings:

> **(1)** kinetic energy, proportional to mass times velocity square ($mv^2/2$);
> **(2)** "the tendency of a body to ascend or penetrate to a certain distance, in opposing to a retarding force;"
> **(3)** electrochemical energy, which is not mechanical;
> **(4)** human creative energy ("Yet with talent, energy, and courage, he almost literally died…");
> **(5)** "nervous energy," which is exhausted at the moment of animal's death.

Today the words **energy**, **work**, and **force** are used in such non-physical areas as economy, management, politics, medicine, and personal life: strong economy, energetic interference, weak health, strong incentive, creative energy, large body of work, political force, workaholic, etc. None of those qualities can be calculated in calories or Joules. Money, measurable exactly to the cent, changes its value day to day, can evaporate without a cent left, and even turn negative. **Entropy** has penetrated common language as a synonym of chaos, disorder, as well as tendency to spontaneous decomposition, disintegration, decay, and collapse.

We use the four key words of the previous paragraph without giving a thought to their meaning because we largely agree on what they mean outside physics. Thus, energy can be defined in dictionaries in non-circular way:

> **1 a :** dynamic quality <narrative energy> **b :** the capacity of acting or being active <intellectual energy> **c :** a usually positive spiritual force <the energy flowing through all people>
> **2 :** vigorous exertion of power **:** effort <investing time and energy>
> **3 :** a fundamental entity of nature that is transferred between parts of a system in the production of physical change within the system and **usually** regarded as the capacity for doing work
> **4 :** usable power (as heat or electricity); *also* **:** the resources for producing such power (Merriam-Webster Online) .

I find these definitions admirable: linguistics, strangely, wins over physics. The capacity for **work** appears here with the adverb *usually* and **force** with the adjective *spiritual*, not as categorically as in physics. Nothing has been left from Aristotelian *energeia* , so that there is nothing to argue about. The definitions apply to the common non-professional language.

But what exactly does **physics** say?

Here is what Richard Feynman says (my emphasis):

> There is a fact, or **if you wish**, a *law,* governing all natural phenomena that are known to date. There is no known exception to this law—it is exact **so far as we know**. The law is called the *conservation of energy.* It states that **there is** a certain quantity, which we call energy, that does not change in the manifold changes which nature undergoes. That is a most abstract idea, because it is a mathematical principle; it says that **there is** a numerical quantity which does not change when something happens. It is not a description of a mechanism, or anything concrete; it is just a **strange fact** that we can calculate some number and when we finish watching nature go through her tricks and calculate the number again, it is the same. (*Lectures on Physics*, V.1, 4-1).

What seems odd to me is the use of the word **law** , even with "**if you wish**." The law that there exists something timeless and unconditional looks like the closest analogy to the belief that there is God. I thought that law always looks like: **if**…**then**, but not with "if you wish**.**" If something happens, is there something which does not change? Obviously, if nothing happens, nothing changes, but something is not everything and everything never changes all at once on human scale. By definition, change is partial. If everything changes, we and our memory change, too, who knows in what way, and so we lose the point of reference. "Everything" is the most evasive beast in philosophical jungles and it has a match in mathematical infinity, with probability roaming nearby.
In 1915, physicist Emmy Noether formulated and proved a law (theorem) behind conservation of energy and other principles of conservation in physics. Richard Feynman, of course, told about it in his *Lectures*, but without mentioning the author (why?!):

> In quantum mechanics it turns out that the conservation of energy is very closely related to another important property of the world, *things do not depend on the absolute time.* We can set up an experiment at a given moment and try it out, and then do the same experiment at a later moment, and it will behave in exactly the same way**.** Whether this is strictly true or not, we do not know. **If** we assume that it *is* true, and add the principles of mechanics, **then** we can deduce the principle of the conservation of energy. It is a rather subtle and interesting thing, and it is not easy to explain (*Lectures*…, V1, 4-4).

Aha! **If** and **then** are in place, although with an "if you wish" tinge. Here is the crux of the law: behavior of physical systems does not depend on time. It is, actually, a law about laws, which looks like a vicious circle. The physicist Lee Smolin believes that physical laws may evolve and I see no possible objection *a priori*. Feynman admits that conservation is true only for as much as we know. For exystems, however, like economy, society, technology, and individual human beings like you and me, this is not true. I get the best illustration from Richard Feynman himself:

> That symmetry [i.e., time independence] means, of course, that if one bought General Motors stock three months ago, the same thing would happen to it if he bought it now! (*Lectures*…, V1, 52-2).

This tells me all I need from physics to answer George Soros' questions about what is so special about markets as compared with physical systems: You cannot wake up in the same economy twice. If only all market players and investment bankers had partaken of Richard Feynman's irony, we would never have the Great Recession. They were smart enough to use "seize the day" as the rule of thumb.

I could leave here the difficult for me terrain, but I share at least one trait with physicists: I am searching for laws of Everything, however idealistic it may seem.

I am encouraged by Richard Feynman:

> All scientific knowledge is uncertain. This experience with doubt and uncertainty is important. I believe that it is of very great value, and one that extends beyond the sciences. I believe that to solve any problem that has never been solved before, you have to leave the door to the unknown ajar. You have to permit the possibility that you do not have it exactly right. Otherwise, if you have made up your mind already, you might not solve it. (*The Meaning of It All*, available from Gutenberg-Australia; copyright laws, fortunately, are not as universal as the laws of nature).

Everything changes irreversibly in human matters and, more generally, in biosphere. Moreover, exystems are unique, they do not form statistical ensembles, and there is nothing to generalize, except that they all (1) come, grow, change, exit the stage in due time and (2) consume energy, matter, and produce thermal and material waste.
At the end of Volume 1 of his *Lectures* (52-2 and 52-3), Feynman returns to the conservation of energy and Noether's theorem, but again without mentioning her name. He adds that principles of physics may change with the change of spatial scale, but not with the change of time. This is where he sarcastically mentions the stock market.

Do economy and economics change with time? This is a rhetorical question. Exystems evolve. For this reason alone economics and physics do not mix, except in econophysics, where this mix is potentially explosive.

The fear of analogy is wide spread among natural "hard" scientists relying on logical and experimental proof and research grants. On the contrary, metaphor and analogy, the fraternal twins, preside over humanities and human matters in general. They have been greatly influential in the developing our thought and language.

> The use of analogy in reasoning, far from being the work of the devil, is today a major research topic in cognitive science and is widely considered a key to what makes us smart (Steven Pinker, *The Blank Slate*, Viking, 2002, p. 106).

This is why physicists and mathematicians, with their equations instead of analogies, gut feelings, and other "work of the devil" were embraced, patted on the back, given each a desk, telephone, computer, and check with impressive number of digits when they had knocked on the doors of investment banks. Since the classic and devilishly funny Michael Lewis' *Liar's Poker*, a whole library, still expanding, has been published on this topic.

While hard natural sciences assume that the laws of nature are unchangeable—otherwise logic could not be used—the human condition changes while we speak. Regardless of whether economics is hard, soft, or scrambled, it is the best illustration of the difference of exystem from the typical systems of physics and chemistry.

One of the reasons that the crisis of 2008 happened was not because the equations of the "quants" were wrong, but because they were believed to be true at least for the foreseeable future. The future of an exystem is indeed foreseeable, but we never know for how long. There is nothing wrong with the quantitative analysis of investment and econophysics as science, as there is nothing wrong with a new car, which sooner or later will let you down, unless you sell it in time.

> There is nothing wrong about making money on the future, see INTRADE.com, until you sell it in time—long or short.

As it becomes clear with time, for most people in investment banks and related institutions, the truth did not matter for as long as the checks were coming. Optimism pays in the brave old world. Does it mean that we can once and for all fix both problems and whatever else will come up? The limited size of the foreseeable future gives us no certainty unless we are staunch optimists. The same Michael Lewis in his latest *The Big Short* (W.W.Norton, 2010) shows that pessimism pays big in the brave new world. To be a pessimist, however, you need to stay away from the optimists: they spray the germs of optimism around when they sneeze. Besides, most Americans are inoculated against pessimism since childhood as if it were smallpox.

The main question I pose in **INTRODUCTION TO PATTERN CHEMISTRY** is, in short:

In spite of their morphing and contorting right before our eyes, what is that we still can know about the future behavior of exystems for a long time ahead?

But what is "long," anyway? Let us say, long is as long as you care. In human matters I would take a human life span as the basic unit of "long." I do not know anything longer. Do you? More optimistically (or, if you wish, pessimistically) "long" means for as long as the sources of energy on planet Earth last. This is a very long time, even if oil, coal and gas are exhausted after a few "longs." If the solar energy alone was sufficient to generate lush life on earth, it will be sufficient to sustain it. See, I am an optimist. I am not sure about clean air and water, but you have a good chance to keep your solar cell phone available in many colors and with fancy ringtones.

In short, I see no way to clone and transplant the notions of energy, entropy, and temperature from physics to the exystems which by definition are complex and evolving. Neither do we have a good understanding of behavior of open complex systems far from equilibrium, as far as I know. Paradoxically, we understand well only the life of the cell in biology because biology is less ambitious than physics. Come to think of it, how could be otherwise? If the system is open and interacts with another system, than both must be considered together as an open system. In nature, there are no closed systems which are **forever** closed, as there is no forever. Forever is supernatural. Living cell, however, has a distinct border with exact accounting of import and export of energy and matter.

Probably, only the planet Earth as a whole, simplified to the status of astronomical body, is stable enough for the time span so large that it means practically forever for us. Something can happen big time on that scale, too, as the giant ancient bones and teeth testify. In a way, the Earth is a lonely living cell of the universe.

> Is the planet Earth an exystem? Is Gaia a realistic idea? Atmosphere and the oceans are an interesting test case. Exystems are quasi-solid: they have a long range structure which changes stepwise. Fluids undergo only limited stepwise changes (phase transitions), like ice→water→steam. There is no sharp borderline, however, and this is why the emergence of life from the fluid layer of the earth enveloping the slowly evolving geological skeleton seems like a natural pattern idea. From this angle, the living ocean of Stanislav Lem in *Solaris* does not look like an exorbitant mental construct. What the fluid skin of the Earth over the hard mineral skeleton lacks to be fully alive is its own replicable template. One can say that the earth has already acquired its code in human atmospheric science, but isn't this too far-fetched? Yet nothing in patterns can be qualified as "too far." Go to the beginning of this Chapter.

In human matters, if not energy, entropy, and temperature, if not numbers and equations, and if not laws, then what instead can tell us about the future?

I am watching daily news with pattern eyes. I saw the signing of the Healthcare Bill on March 23, 2010. I kept track of all preceding and subsequent events with the physical sensation of increasing social temperature and pressure. After reading Richard Feynman, I am more than ever convinced that patterns in the sense of Pattern Theory are the

surrogates of physical laws for human matters: they can hold for a very long historical time.
Protesters against the Healthcare Bill shouted racial slurs at John Lewis, a Black congressman and a leader of the civil rights movement of the 1960s . The reporter **Tim Henley** , apparently, born well after 1960, commented on March 22, 2010:

> So, excuse me if I am a little confused about which century this is. For a second, I thought I accidentally stepped into a time machine that sent me 60 years into the past.

Regarding time travel, here is a page from my own travel diary.

Reading Steven Pinker's *The Blank Slate*, Chapter 6, *Political Scientists* (p. 115), I myself was transported over 60 years back into the dusk of the Stalin's era in Russia.

The name of Trofim Lysenko, the butcher of Soviet biology, is remembered in America. Around 1950, the science of formal genetics, which contradicted Lysenko's ideas and, to some extent, the Communist ideology of creating a "new man," was declared bourgeois pseudo-science. Dozens or maybe hundreds of biologists were denounced and expelled from scientific institutions. It is less known that similar campaigns, in the style later mimicked by Mao's "Cultural Revolution," were launched also in other fields of science: physics, neurophysiology, linguistics, cybernetics, and what not. Only mathematics and applied sciences were spared. As a teenager interested in science, I personally read some published transcripts of "scientific" trials of anti-Marxist pseudo-scientists in chemistry and psychiatry and I well remember the general tone of the speakers.

Steven Pinker quotes a letter (2002) of Professors of Anthropology Terence Turner and Leslie Sponsel, regarding the book of journalist Patrick Tierney who accused anthropological field studies of James Neel and Napoleon Chagnon on Yanomami tribe of Venezuela of being, so to speak, the work of the devil. I reproduce the quote from a Web source.

> This nightmarish story—a real anthropological heart of darkness beyond the imagining of even a Josef Conrad (though not, perhaps, a Josef Mengele)—will be seen (rightly in our view) by the public, as well as most anthropologists, as putting the whole discipline on trial. As another reader of the galleys put it, this book [by Tierney] should shake anthropology to its very foundations. It should cause the field to understand how the **corrupt and depraved** protagonists [Neel and Chagnon] could **have spread their poison for so long** while they were accorded great respect throughout the Western World and generations of undergraduates received their lies as the introductory substance of anthropology. **This should never be allowed to happen again.**

I swear that the quote reproduces exactly the spirit, and largely the letter, of Stalin's pogroms of science in late 1940s and early '50s. The words in bold font copy the Russian words said and published countless times in those frightening for scientists years. There is an incomplete overview of the suppressed research in the Soviet Union**.**

The patterns I keep thinking about most often are the American Civil War, Medieval Europe, the Monkey Trial, and the long and rich history of suppressing historical and scientific truth, to which the Texas Board of Education , which revises American history, and Ahmadinejad, who calls 9-11 a big fabrication and the Holocaust a myth, add new configurations.

The explicit declarations of a Civil War from the American Right have recently sprung up on the Web, but I do not want to quote them. Death threats to some congressmen and their families, including their children, followed, in the name of saving unborn children. Actual violent acts followed. That prompts me to continue my little experiment on time symmetry in exystems, started in 2006.

> In my Essay 43, The Cold Civil War in America (2006) I googled out less than 1000 links to **"cold civil war" America** . On March 24, 2010, the Google dragnet is bringing something less abstract:
>
> **35,900** **"cold civil war" America**
> **93,800** **"cold civil war" America healthcare**
> **99,600** **"cold civil war" healthcare**
> **266,000** **American "cold civil war"**
>
> 98,200 American "cold civil war" healthcare
>
> 99,600 healthcare "cold civil war"

I see Google as a working prototype of an exystemic instrument capable of gauging the energy accumulating along the fault lines of American society. The tandem of the American Google and the Chinese search engine Baidu is equally or even more sensitive. It measures the stress at the top of Chinese power elite by what Baidu blackens out from the Web. As far as measurable physics of exystems is concerned, the **word cloud** (or **tag cloud**), based on search engines, works as a version of the exystemic thermometer. This principle of measuring exystemic temperature is much older that the Web, however. It was first implemented in the size of the newspaper headlines.

By invoking headlines and word clouds I am obviously trying to imitate, naively or maybe not, experimental physics in order to incorporate pattern chemistry together with physics and molecular chemistry into a single picture of the world. I do not expect any numerical calculation of the future, however. I am looking for a deeper interdisciplinary unity.

I suspect that it is impossible to arrive to a unified world paradigm by generalizing a single field of science. But we can attempt to synthesize this paradigm from most general ideas regardless from where they are coming.

The word cloud of a [Ben Bernanke's speech]

Old headlines

Figure 6-1. **Two social thermometers**

Biology contributes the idea of evolution with novelty as the central abstract idea. Chemistry looks into the intimate mechanisms of transformation, physics separates known from unknown and possible from impossible. From this point of view the interdisciplinary borders disappear, but so does science as we understand it. Until global civilization becomes a king of a dystopian clockwork (an extremely remote possibility, explored by sci-fi writers), we cannot promise knowledge of the future, except that any clockwork breaks down, but **understanding the future as a natural phenomenon** is possible.

It seems to me that physics can contribute a specific conceptual cement to the unified picture.

Let us turn to Richard Feynman once again.

> Experiment is the *sole judge* of scientific "truth." But what is the source of knowledge? Where do the laws that are to be tested come from? Experiment, itself, helps to produce these laws, in the sense that it gives us hints. But also needed is *imagination* to create from these hints the great generalizations—to guess at the wonderful, simple, but very strange **patterns** beneath them all, and then to experiment to check again whether we have made the right guess. (*Lectures*, Vol. 1, 1-1).

A great generalization and a strange pattern, although only in my imagination, come from the template of **symmetry**. (Template in Pattern Theory is a **typical configuration**, the starting point for exploring similarity transformations).

The following reasoning walks over a few stepping stones, mostly borrowed from the final chapter of Richard Feynman's *Lectures* (Vol.1). They are pretty slippery in the context of human history and, in general, pattern chemistry. But I have nothing else to cross the river from one bank to the other: from human matters to physics.

(1) Noether's theorem attributes a certain conservation law to a particular symmetry. Thus, conservation of energy is inherently connected to symmetry under translation in time. The latter can be compared to traveling in a time machine and observing the laws of nature.

(2) Symmetry in physical phenomena can be imperfect: "almost symmetry" (Feynman).

(3) Exystems are physically fully conservative: energy is conserved, but not configurations.

(4) Some exystemic patterns reappear in time (I cautiously say **reappear** instead of **are translated in time**) while configurations change.

(5) Pattern in Pattern Theory is a conservative notion: it is invariant under the similarity transformation, but not necessarily under translation in time. Patterns of history can fall asleep, hibernate, and wake up.

(6) HYPOTHESIS: Pattern picture of the world is compatible not only with the chemical picture of the world, but also with the physical one. The unifying idea is symmetry.

We can make this statement with more certainty if we formulate what in particular is conserved while being "translated" **from the physical world into the exystemic worl**d of human matters and back—not in physical space and time. The answer may sound awkward: **conservation along the timeline is conserved.**

In physics energy is conserved in time, while in exystems it is pattern. The symmetry under time is not perfect: patterns of history (and personal life) from time to time change, although they can come back. In physics energy changes form back and forth, although with some limitations. In the very long run, we do not know what happens to energy.

Does it mean that evolution, which does not leave anything unchanged, is also conserved in the physical world, as Lee Smolin suspects? If the world is deeply symmetrical, then yes.

I really cannot look outside the solar system. As far as our planet is concerned, it is the conservation under transformation (symmetry in the physical sense) which makes the world survivable and understandable. We are sustained by hope that the laws of nature and the patterns of our existence will last until tomorrow and this hope is statistically well founded.

"This is so trivial," somebody may say. Trivial? Good! Then I don't need to prove it.

> **NOTE**: **(1)** I am still having a problem with deep foundations of physics. Noether's theorem states: "For every continuous symmetry of the laws of physics, there must exist a conservation law". But symmetry is conservation! My doubt arises because I look at

the world trough the pattern filters and see only the common property of conservation, being blind to differences. I suspect a kind of pattern tautology in Noether's theorem. Richard Feynman remarks, in pattern language: "So, with certain symmetries something which is true initially is true for all times. But isn't it just a conservation law? Yes!" (*Lectures*, V.3, 17-4). This looks like yet another definition of pattern, but it is incomplete. Patterns are true also across all abstract but realistic spaces: chemical, biological, social, economic, psychological, etc.

(2) My second problem concerns time in physics. Feynman, allegedly, said that "time is what continues when everything else stops." I haven't found the source, however, but noticed a different view:
We could also say here that time must have started with the first motion and will only stop when everything else stops moving. (Riadh H. Al Rabeh, *New Ideas for the Extra Dimensions and for Deriving the Basic Laws of Physics* , Progress in Physics, 2010, V.1. p. L14).

As I see it, Pattern Chemistry knows only one kind of time: if nothing changes, it does not move. I call it "Leibniz time." The idea that we can translate anything in time may have limited sense only regarding a closed isolated system. We cannot find isolation at least within the solar system. In Pattern Chemistry time is synonymous with irreversible change, i.e., in line with Ilya Prigogine's view of time.

I feel like I have indeed crossed the chasm from human matters to physics. I believe we can have exystemic surrogates for the conservation laws. This may be sufficient for understanding, but I am not sure about calculated hard knowledge. Physics always generously supplied us with metaphors, but stood far apart from human matters. Now that we have made an attempt to peek into the hall of complexity in which physics is still a wallflower, but at least inside the walls, I am going to cross the divide back and return to life and humans. My steps are:

(1) If the inequality of pressure on both sides of a piston in the cylinder is high enough, the piston moves in the direction of equalization of pressure as far as the resistance allows—and stops.

(2) If a sugar cube is dropped into a cup of coffee, it will dissolve as fast as the temperature allows—and nothing more happens.

(3) If an ice cube is dropped into a glass of water, it will melt as fast as the temperatures of water and ice differ—and that will be the end of show.

(4) If the distribution of power is sharply unequal, people rise to resistance and can change the laws of society toward more freedom—until the next round of concentration of power.

(5) If the concentration of money under individual control is too high, the owners start behaving more risky because loss would not completely destroy their wealth. They destabilize the economic system. This means that the wealth of lower population strata can be completely destroyed. The stagnating masses then begin to look for a strong hand promising a pie in the sky and slaying of the monster of socialism (or capitalism). Then GO TO **(4).**

(6) If a powerful military, industrial, financial, technological, scientific, or any other empire spreads the said power all over the world in the form of business, education, technology, and military bases, its concentrated power can dissolve like a sugar cube in a cup of coffee and become concentrated somewhere else—until it starts dissolving there.

(7) If the military power of a nation or a supranational agglomerate is too high, its leaders become prone to a risky behavior and lose the advantage for as much as the difference of the brainpower between the nation and its enemies allows—until they wake up to reality and try to reverse the process.

Physical systems (1) to (4) come to a "quieter" state—equilibrium or not—while exystems (5) to (7) cannot stop going through the periods of stability separated by more or less turbulent transition states, never returning to the same state twice.

We may feel reassured about conservation laws, but philosophical comfort does not decrease the pragmatic uncertainty of the future. Philosophy does not sell well. What about thermodynamics and equations of econophysics with their confident and sellable equality sign 2 + 2 **=** 4 ? What about **energy** and **entropy**?

As I believe, exystems require pattern chemists to sacrifice the equality sign and limit ourselves to inequality sign, as in **LESS < MORE**. This is a rather habitual situation for molecular chemistry where stabilities of the transition states with not exactly known structures and energies are compared. For a related problem of quantifying humanitarian values, see my Essay 13. On Numbers (also in complete Essays).

From a clear and simple notion of thermodynamics, entropy has developed into another Science of Everything—from elementary particles to stars. The range of approaches is well reflected in the open access journal Entropy.

There is a big problem with entropy in physical systems of sufficient complexity (see this **INTRODUCTION , Part 2** (and on SCRIBD) , **February 26** and further to the end of **Part 2**). It turns out that inequality is by no means a well defined notion, either. There are dozens different measures of inequality, as there are dozens of various entropy measures. The MORE/LESS criterion can simplify the situation.

> I use "MORE/LESS" to avoid ambiguity in the use of the word "inequality" or "relativity," or "comparative method." In fact, I mean "partial order."

Since 1905, Lorenz curve and Gini coefficient have been used almost exclusively for measuring economic inequality, as originally intended by Max Otto Lorenz . The method, however, has been slowly creeping into other areas, such as biodiversity, distribution of scientific publications, and selectivity of some enzyme inhibitors (very interesting!). Lorenz curve was praised for its unique absence of ambiguity among other measures of inequality (F. Gosselin, Lorenz partial order: the best known logical framework to define evenness indices")

Recently I was happy to see the use of Lorenz curve in the study of purely physical process of foam decay and bubble size distribution (Sonja Sauerbrei, *Lorenz Curves, Size Classification, and Dimensions of Bubble Size Distributions*, *Entropy* , 2010, *12*, 1-13). The bubbles of beer foam undergo the process of demixing, i.e., increasing inequality ("away from equality," as the author writes).

Regarding exystems, I would expunge entropy completely, together with freedom, from consideration.

> The opinion that entropy is the notion closest to freedom had already been expressed (references **A** and **B**), although not often. The so-called Maximum Entropy Production Principle ("MEP," see a recent publication: James Dyke and Axel Kleidon, The Maximum Entropy Production Principle: Its Theoretical Foundations and Applications to the Earth System, Entropy 2010, 12, 613-630)

Entropy for exystems is a complicated and controversial issue, to which I am not qualified to contribute anything but skepticism. Privately speaking, planet Earth is, probably, the least complicated case because the source, interface, and the balance of energy are well defined. There is a much simpler reason for simplification, however: the local parameters of land, water, and atmosphere are distributed in Euclidean space and continuous Newton time, although they can be represented as a fine or coarse grid, quite in tune with the concept of histogram, essential for Lorenz curve. Human civilization is described in physical time and space only to a small and uninteresting degree, however. Yet the distribution of a value over a set of elements is universally applicable, regardless of whether large enough statistical ensembles are involved. A hostility between just two neighbors creates enough local tension to turn into violent conflict, no statistics involved.

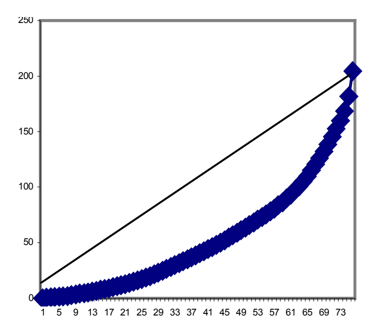


Figure 6-2. **Cumulative distribution of murder per capita in 76 US large cities. 2008 (data source).**

The distributions of income, education, unemployment, probably, even gravity of crime and political partisan strife, have no "physicality" in space. In **Figure 6-2**, I plot the Gini coefficient for murder rate per capita in 76 US cities .

It shows a high inequality (Gini = **0.47**), while total violent crime distribution for 75 cities is even less equally distributed (Gini = **0.34**).

I do not venture either to interpret the data, although it is possible ("crime begets crime like money begets money and sheep beget sheep"), or to discuss the validity of entropy calculation for this subsystem (a provisional rule: "no entropy outside probability theory").

For comparison, I present an illustration from the area of biochemistry, Figure 6-3. Three inhibitors of the enzyme group kinase ("crime") were tested against 85 individual kinases ("cities"). The non-selective inhibitor has a very low Gini. It means that it acts on all kinases indiscriminately in the same way, not that it is inactive.

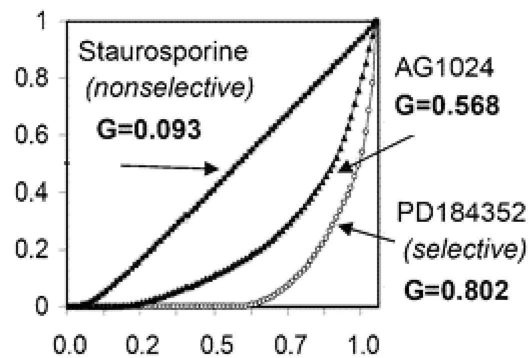


Figure 6-3. Cumulative distribution of kinase inhibiting activity over 85 kinases

By reverse analogy, some crimes are sensitive to particularities of the cities. But are there non-specific crimes?

In **Figure 6-4**, I plot the cumulative distribution of murder for 31 US cities with population under 400,000. Gini = 0.01 (no "selectivity").

I have already written about the MORE/LESS approach on many occasions because that was one of the main contributions of chemistry to pattern chemistry. The idea of equality of distribution as an exystemic counterpart of physical entropy follows not from either chemistry or Pattern Theory but from observations of processes in nature, whether inanimate, living, or human, as well as from general meaning of entropy as the measure of order.

Local tensions, i.e., concentrations of energy (high thermodynamic potentials), lead to discontinuous changes, from earthquakes to revolutions and from extinctions to emergences. This can happen in solid and quasi-solid structures. By quasi-solid structures I mean any configuration, like molecule or system of government, not solid in physical sense, in which some bonds require energy to be broken. I call such bonds positive, to distinguish from negative bonds, which require energy to keep them locked. Fluid systems mostly dissipate the local concentrations, unless at high enough speed or specific circumstances. This is why chemists strongly prefer to conduct chemical

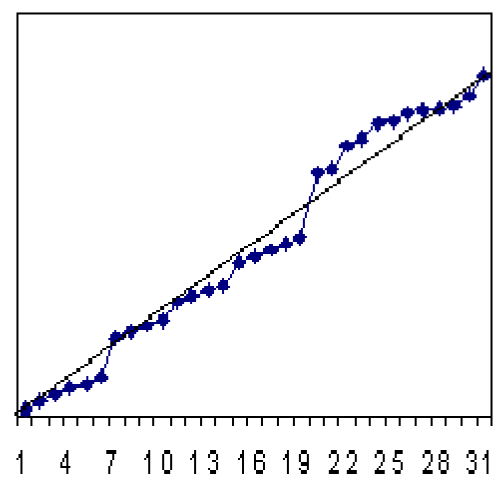


Figure 6-4. **Cumulative distribution of murder per capita in 31 US cities, population under 400,000; 2008 (data source).**

transformations in stirred solutions and skilled leaders try to quickly resolve internal conflicts.

To create a stable structure in a fluid system, a significant level of energy dissipation is needed. This is where the tax dollars go, if you wonder.
In pattern chemistry, where relative values are sufficient, any measure of inequality is fine for as long as the inequality is preserved for any two objects. This may not be so in the real world.

If we accept pattern surrogates for temperature and entropy, what about energy? I would say in the MORE/LESS language of inequalities that (1) the higher the temperature, the higher instability, (2) the higher inequality, the higher instability, and (3) instability is surrogate energy (I skip clarifications).

I realize that this kind of primitive physical chemistry looks childish, but the more I think about it, the more I believe in the potential of children. As soon as we lose the Euclidean ground under our feet, we have to learn flying on the wings of featherweight ideas. We cannot conquer grave complexity with grave complexity.

I do not moralize inequality. I am no egalitarian. Concentration of money and power—and inequality in general—keeps civilization far from equilibrium and makes it plastic and adaptable to external changes. Nobody wants America to be poor and weak except its enemies. Low concentration of power and money brings no benefits.

I call Richard Feynman again:

> I started to say that the idea of distributing everything evenly is based on a *theory* that there's only X amount of stuff in the world, that somehow we took it away from the poorer countries in the first place, and therefore we should give it back to them. But this theory doesn't take into account the real reason for the differences between countries—that is, the development of new techniques for growing food, the development of machinery to grow food and to do other things, and the fact that all this machinery requires the concentration of capital. It isn't the *stuff*, but the power to *make* the stuff , that is important. But I realize now that these people were not in science; they didn't understand it. They didn't understand technology; they didn't understand their time.
>
> (*Surely, you are joking, Mr. Feynman!*, W.W.Norton, 1997, p. 283).

Concentration of capital boosts up the economy with the Aristotelian *energeia*, the ability to turn possibility into reality. Only the government or the crooks can redistribute wealth within the constant sum. What happens when a machine for concentrating the income and profits—the yearly new crop of money which is not yet taken from anybody, but generated by economy—is invented and privately put up for sale? I am certain that Richard Feynman could crack our economic conundrums faster than any safe because he would see it as a scientific problem.

I greatly enjoyed the incomparable *Gone with the Wind* as a whole but one moment was most striking.

"What most people don't seem to realize is that there is just as much money to be made out of the wreckage of a civilization as from the upbuilding of one," Rhett Butler was coaching Scarlet O'Hara.

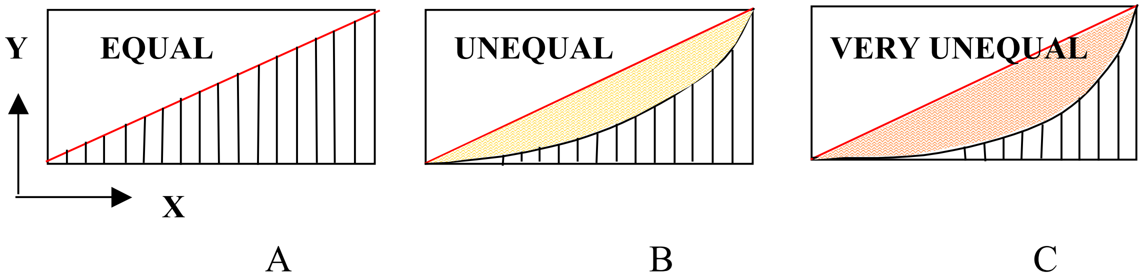
I consider the Great Recession of 2008 a direct result of the realization of Rhett Butler's idea applied to the civilization of money. The modern financial engine, which combines long term investing, short selling, and risk reduction (derivatives), is a miraculous invention of practical human mind possessing hardly anything above the knowledge of arithmetic and human nature. It has been involving for at least 400 years but grew into the present MMM on electronic hormones.

MMM stands for Money-Making-Machine, as well as for Money-Money-Money and Magnificent-Majestic-Marvelous, although is sometimes seen as Murky–Malicious-Mean.

The machine, the posterity of donkey, sail ship, caravan, and windmill, is effectively concentrating wealth. The hedge fund follows the pattern of the watermill or windmill where the miller takes his pay in the form of grain. The more grain is brought to the mill, the richer the miller, while power is free. The money mill, however, works regardless of whether the harvest is good or bad. In lean years, the miller can sell his stock. This is not really analogy, but just a pattern of profiting on change of a parameter in any of two directions. There is nothing mystical in that. Tidal power stations can work at both flood tide and ebb tide and the wind turbine follows the wind direction. The water mill is also an MMM, but it works on external source of practically inexhaustible (some say "renewable") energy. The markets work on a fluctuating but **limited** money supply, aptly called liquidity, maybe in nostalgic memory of water and wind. This is a far cry from the ocean liquidity and atmospheric fluidity, however. In addition, money itself changes its value, ostensibly violating the principle of conservation. The latter applies only to accounting, unless it is cooked.

Therefore, the wealth concentration results only in skewing the distribution of wealth toward more inequality which, in Pattern Chemistry stands for the main internal cause of instability. Is there an external cause? As far as I know, Jesus does not want you to be rich.

Figure 6-5 illustrates the measure of inequality called Gini coefficient, based on Lorenz curve. I have already mentioned all that in previous parts of **INTRODUCTION** (for example, **Part 2**, November 23, 2008) and good explanations can be found on the Web. I repeat some points because of a different context and some new personal discoveries.



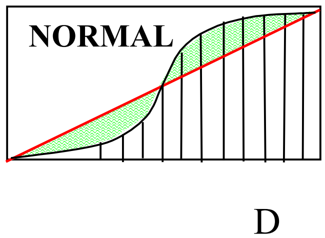


Figure 6-5. **Lorenz curves for some distributions**

Difference in shape (as between A and D) is reflected in Lorenz asymmetry coefficient

Figure 6-5 shows four Lorenz curves used for representing distribution of some value over a population split into equal narrow slots along **X**. Each is a **sum** of all slot values (**Y**) from 0 to **X.** The slot values are strictly ordered from minimum to maximum. Since it is more difficult to measure wealth than income, economists prefer income to wealth while estimating inequality, although Lorenz curve is a universal abstract representation of any inequality. Thus, it can represent the distribution of the passengers across the deck of a ship, as well as of the cash in their pockets.

EQUAL (**A**) means that everybody has the same wealth (or some other value). The sum of all individual possessions increases at the same rate. VERY UNEQUAL (**B**) shows the presence of large number of poor individuals and a minority of a very rich owners. Normal distribution (**D**) is a special case of random allotment of wealth with probability decreasing with the distance from the average value.

Growth, weight, and IQ follow the normal distribution (Gibbs distribution). Wealth, income, and stellar mass (**Figure 6-6**) distributions do not. The difference between the two groups of indexes is that people exchange money and bargain for income, but do not exchange IQ , height, and weight.

As for the stars, I am not into astrophysics, but their non-Gibbs , i.e., non-normal, distribution (mixture of Weibull and power law distributions) , probably, follows from their interactions during formation from gas clouds when the process consists of fragmentation and merger.

> In other words, stars "compete" for a limited resource like humans, animals, and, probably, even the bubbles of beer foam. Similar phenomena show up in other physical systems with exchange, for example, phase transitions, like ice→water→steam, which is somewhat similar to condensation of interstellar clouds into stars. Note a dramatic difference of freezing, melting, crystallization and dissolution: they run on surfaces instead of volume. Information replication and expression runs along a line.

If most passengers of a small ship or ferry gather along one side of the deck, the ship can become unstable and turn over. When wealth is hoarded by one segment of society, the economy boat can roll and get water into the hull or even capsize.

That inequality distribution in an exystem results in instability seems to me the most important exystemic law compatible with physical laws. It applies also to internal conflicts in human soul, cognitive dissonance, small social groups, and societies.

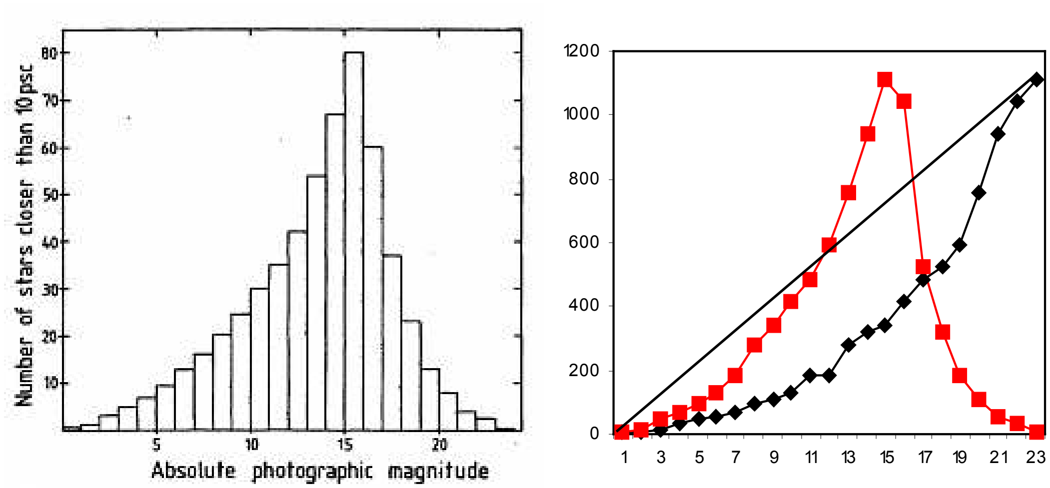


Figure 6-6. **The number of stars closer than 10 parsec of the Sun versus their photographic magnitude (left) and Lorenz curve (black) for their distribution (right). Source.**

What I am afraid of is that the exystemic earthquake, unlike the roll of a ship, does not return the exystem to the initial state. My fear seeps out of my close familiarity with the history and reality of the Soviet Russia, to which Cambodia, Cuba, and South Korea have added each its own postscript.

In 2010, observers register an unprecedented concentration of political poison, fringe aggressiveness, demagogy and violent trends, which, in my view, is a typical warning sign of a possible exystemic change.

What can it be? Either a *de-facto* one party system or a more than two party system. But I do not see it on INTRADE :

> No matches found for **"one party system"**
> No matches found for **"three party system"**

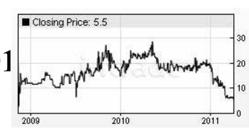
And yet the price of Sarah Palin goes up, **Figure 6-7**

C. P. Snow was, probably, not the first to discover the great divide between sciences and humanities, but he was the first to put it on the map of culture, where it remains. He was an interpreter across the divide, but more from the humanitarian side, although he could put himself into scientific shoes. This is how he formulated the laws of thermodynamics in the language of humanities:

> You cannot win (that is, you cannot get something for nothing because matter and energy are conserved).

> You cannot break even (useful energy degenerates into non-useable, disorganized energy, because there is always an increase in disorder).

Figure 6-7. **Contract 2012.REP.NOM.PALIN displayed on Intrade.com , Sunday, April 11, 201**
UPDATE: April 3, 2011: Last trade: 5.9 →



Can they be applied to economy as a whole? Yes, but only in a statistical sense. An individual can always count on his or her luck. The society can expect lots of wreckage. A few win big, a few lose a little, many lose all, and some never lose. This is the Darwinian essence of the evolution in exystems: the whole survives at the expense of victims, the large the whole, the better the chances. But the exystem changes and dinosaurs may become lizards or, at best, crocodiles.

Michael Lewis' *The Big Short* , in a way, continues and confirms the story of Rhett Butler. A few can indeed make big money out of the wreckage of a civilization, but then another one could be built, possibly, with neither money nor freedom, as it happened in Russia in the twentieth century.

> **TEST QUESTION**: **Can the three- or four-party political system in America add to stability as compared with two-party system?**

Finally, who invented the MMM?

Jacob of the *Genesis* (30: 27-43) could file the first patent on wealth concentrator. I will quote only the beginning and the end of the invention description.

> And he (Laban) said, What shall I give thee? And Jacob said, **Thou shalt not give me any thing**: if thou wilt do this thing for me, I will again feed and keep thy flock (30: 31).

Concentration, unlike dissipation, will not happen on its own, unless in geological time. There is always some intricate technology behind it. Better read the original source, it is interesting. Here is the end:

> And the man (Jacob) increased exceedingly and had much cattle, and maidservants, and camels, and asses (30: 43).

The next chapter begins with the nonsensical complaint of Laban's Marxist sons that "Jacob **has taken away** all that was our father's."
Are the lost jobs taken away by the Wall Street sharks (and their bloody Socialist friends) or is it a configuration of a very old pattern? But this is a different story and the question should be better left for homework.

The great charm of the Bible is for me the treasury of pattern templates. After so many long jumps, how about one more, from the success of insurance in Ancient Egypt to the collapse of AIG, the American company in the same business ?

The story of Joseph in Egypt is probably known better than the story of Jacob and Laban. Here is its end:

> And he (Joseph) gathered up all the food of the seven years (of abundance) , which were in the land of Egypt, and laid up the food in the cities: the food of the field, which was round about every city, laid he up in the same (41:48).
>
> And the famine was over all the face of the earth: and Joseph opened all the storehouses, and **sold** unto Egyptians; and the famine waxed sore in the land of Egypt (41:56).
>
> And all countries came into Egypt to Joseph to **buy** corn; because that the famine was so sore in all lands (41: 57).

There is a delicate nuance in the story, however. Apparently, the Pharaoh did not pay money for the grain, all the more it was, the story says, as abundant after seven good years as sand. But he definitely put it up for **sale**. Moreover, it was actually **bought** by the people.

> In the story of Joseph, the Hebrew Torah uses the same word for both **buy** and **sale**: שבר (*shabar*). A few translations dissent, however. For example, *The Torah: A Modern Commentary* (Ed: W. Gunther Plaut) , The Union of American Hebrew Congregations (New York, 1981) translates it as **ration** instead of **sell** and **procure** instead of buy. My personal impression, confirmed by dictionaries, is that שבר was used specifically in the meaning of "**trade grain.**" There is also a translation by "**retail**", which is probably the best.
>
> There are other different words for **buy** and **sell** in the Torah, as well as in modern Hebrew, but one episode of the story of Joseph leaves no doubt that his brothers came to Egypt to **buy** food: they brought some silver for that. In modern Hebrew, the main meaning of שבר is **fraction**, but **sell** (food) is also mentioned.

Rhett Butler, probably, had a point. What I want to note is that Egypt would not be saved if people of the land and around could not have **saved** enough **money** or valuables. Saving looks like a forgotten art in America. Those who have a lot will not give a damn for anything, and those who have nothing drown in the synthetic saccharine syrup of individualism. But what can be more individualistic than **saving** for a reader of the Torah?

7. NATURAL HISTORY OF EXYSTEMS

Draft, unfinished

EXYSTEM

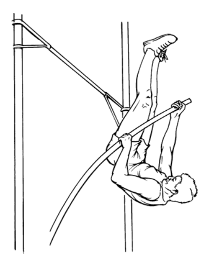
We have big gaps in understanding how people lived thousands years ago. The origin of the giant stone heads of the Olmecs (Mexico) is still a mystery, although the heads are open to inspection and apparently do not have inside anything else to tell. We have a better—imperfect, though—understanding of how we live now, but we can literally lose our house by betting on how we will live in ten years. Indeed, many people have lost their houses during the Great Recession of 2008 in exactly this way.

Olmec head

Thirty years ago, a few people could have predicted the global digital network, waning of Russia, rise of China, global economic earthquake, the epidemic of terrorism, and the internal polarization of America, although much more experts can explain all that with a hindsight, disagreeing with each other, though. Consensus would mean that no guru was better than the other. Just because of the large number of the experts and small number of alternatives somebody can always turn out right.

Some specialists are right because they understand how the world works, if not as a whole then in some of its domains. People at the controls of the world are expected to see above the crowd, but the height of a public figure does not always correspond to the cast shadow. If a man of Alan Greenspan's caliber acknowledges that he had a wrong understanding of how the world worked, it means that this understanding cannot be found either in a book or in experience. Yet if even the snowflakes are surprisingly imperfect, what to expect of people?

In this Chapter, I return again—like a stubborn athlete who is training to beat a record—to the basic idea of Pattern Chemistry: let us explore exystem as we explore physical and chemical systems, but with patterns instead of equations, and see how far we can go. This is a very high bar to pass. My pole for the vault is made of a composite material combining Pattern Theory with chemical kinetics. This time, at my last attempt, I am trying to take a very long approach, but not along a straight line.



Pole vault

EXPECTATION
SURPRISE
NOVELTY

What is the origin of exystems? They emerged at some point—or interval—from the state of the earth without life and passed the whole distance to human societies and further to the modern civilization. They can further evolve into new forms. **Can we foresee them?** This is one question, not two: there must be a single pattern of emergence for past and future. It can be generalized: **What is novelty?**

The reconstruction of the past and prediction of the future are ancient human tasks. They range from the tribal myths of origin to divination and from origin of life to global warming, with the past market performance and its prediction somewhere near the center of worries of affluent species of modern life.

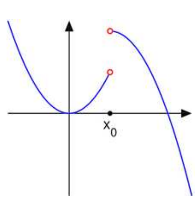
The problem of expecting the unexpected—as I can rephrase the task again—arises because of the relative shortness of individual human life in comparison with the lifespan of exystems. For an eternal being it would be of no importance: eternity has neither past nor future. The brevity of life and its constant transformation from progress to decline—under capricious blows and nudges of events—remains the main source of our creativity. I see its subconscious goal as stability.

GENEALOGY OF EXYSTEMS

In order to approach the origin of exystems as a pattern chemist, I have to classify the exystems and their forms. I need to select a pattern template, i.e., a configuration which I consider typical, analyze it in order to obtain a set of generators (atomic blocks), characterize the rules of connection, if there are any, and check other configurations in question against the analytical pattern. I can also synthesize configurations under the same pattern, regardless of whether they are real or imaginable. Pattern is what configurations preserve while being transformed one into another by the same rules.

Thus, I can select life (Bios) as pattern template and show that all other exystems on earth are configurations under the same pattern. For example, technology (Technos), i.e. mode of existence and propagation of man-made things, has essential components of life: cyclic processes, non-equilibrium states requiring consumption of energy, birth, death, competition, elements of metabolism, multiplication in the form of production along a blueprint, mutations (inventions and discoveries), and evolutionary history. In this representation of technology humans (just plain humans) play part of enzymes, or, more generally, catalysts. They connect and separate things and perform the changes that are highly improbable on their own.

If we expand the concept of "thing" to printed or spoken word, the previous paragraph expands to cover ideas, doctrines, cultural practices, superstitions, etc., which does not seem such a big stretch after the convincing argumentation of Richard Dawkins regarding memes—configurations under the same pattern with genes.



Singularity

Ultimately, I have to arrange exystems in order of their appearance. This is not so difficult to do for the last five to two thousand years, and even millions of years deeper, but there must be an ultimate point of origin not just of life as a sequence of chemical processes, but the exystemic pattern itself. It must be represented not in chemical or other equations but in some highly abstract symbolism. The appearance of exystems was a point of extreme singularity where exact definitions cannot be given and continuity breaks so sharply that the mathematical sign of equality cannot be used.

WHAT? WHEN?

Most ideas of this Chapter have been already expressed and illustrated in my previous e-publications in **complexity** and, occasionally, **simplicity**. Some even sneaked into **poetry** or crawled out of it. Here I am attempting a pattern-chemical overview of exystems in evolutionary and systematic dimensions by sketching some branches and offshoot of their evolutionary tree. I want to show that life on earth and its current creations, up to culture and technology, not only emerged from molecular chemistry—it is pretty obvious—but took chemical patterns as a guide for the rest of the evolutionary road, at least up to present day.

Water drop

This is a recapitulation of the subject in the most abstract way I am capable of, which means crossing very large intellectual and subject-matter distances over the stepping-stones of concrete examples, some as simple as a drop of water. I am trying to make a chemical contribution to the pattern map of Everything initiated by Ulf Grenander. The endless and probably annoying digressions should be seen as the branches of the tree because the natural history of exystems can only be presented as a phylogenetic tree. Birds, squirrels, and pattern chemists, can traverse the tree from any leaf and any branch to any other along the shortest path, without clinging to the bark. On this tree a drop of water and the planet Earth are neighbors.

The soft Science of Human Matters, unlike the hard science, based on measurement and experiment, should use inequalities instead of equations, the space of ideas instead of Euclidean space, and Leibniz time instead of Newton time. It should expect the unexpected instead of relying on a manual. Its foundation is Pattern Theory of Ulf Grenander, to which I add a generalization of kinetic ideas of chemistry. Plainly, its main question is: what is going to happen and when? Certainly, to ask this question in human matters takes a lot of hubris, not to mention answering it.

CONTINUITY AND BREAKS

The drop of pure water on a plate is a simple system. It contains ~3.3×10^{20} (hundreds of quintillions) of practically identical molecules moving in a chaotic way. Some molecules leave the drop and others come from the air. At normal conditions, the drop will evaporate after a while. It will disappear in a paper napkin.

We understand what water is and what it is not, why it preserves its volume, but changes its shape, how it behaves on different surfaces, and why it cannot be too big. The shape of the drop follows **continuous** deformations of sphere, but drops can split and fuse in a **break** of continuity.

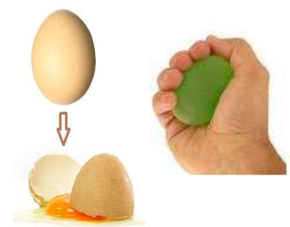
We understand the difference between drops of oil and mercury, as well as why a paper plate does not immediately absorb water. Properties of water are in the domain of hard sciences. Do we have good reasons to believe that any drop of water was the same as today a million years ago, long before the paper plate appeared (in 1904), and will be one million years later, when, most certainly, all paper plates will disappear? We do not really need to know the answer, but the question addresses a soft spot of any hard science.

The physicists, who believe in the permanence of the laws of nature, confidently use the symbol of **equal**ity " **=** " in physical **equat**ions describing the behavior of the drop.

> For example, the shape of drops (and bubbles) is defined by the Young-Laplace equation $\boldsymbol{\Delta p = \gamma\ (1/R_x + 1/R_y)}$, where $\boldsymbol{\Delta p}$ is the pressure difference, $\boldsymbol{\gamma}$ is surface tension, and $\boldsymbol{R_x}$ and $\boldsymbol{R_y}$ are radii of curvature in each of the axes that are parallel to the surface.

Strictly speaking, we still may learn something new about the droplet of water, but we can safely bet our house on our current knowledge at least for the term of our mortgage, if not for a million years.

We can continuously and reversibly deform a rubber egg, up to a point, but the chicken egg will irreversibly break under pressure. Continuity and reversibility is something that rarely (to be exact, never) happens in nature and society, but can be imitated with man-made things (Technos), at least for a while.



Egg and rubber egg

PATTERNS WITHOUT BORDERS

Patterns, although never continuous, can be long lasting and reversible. The historical vacillations of France between monarchy and republic and reversal of post-Soviet Russia to centralized authoritarian structure are examples. I believe, their chemistry is the surrogate code of laws for human matters. Afghanistan has been experiencing sharp historical jolts back and forth for over 110 years—the period really instructive, but rarely evoked.

The point on the American political Ring of Fire, the Roe v. Wade can be legally reversed, but the society will not reverse to its state a day before, all the more, to 1973. The opponents of abortion are trying to turn it into a rubber egg. Both sides of the abortion wars have the territory of 266 days (38 weeks of pregnancy) to defend or attack. The whole battlefield situation with abortion reveals a sharp discontinuity between irrational beliefs, as well as belief and knowledge.

Behind the blessed but rarely practiced concept of tolerance is the idea of social continuity: stressful instability can be eased by a little give and take, which is the working principle of business and peaceful politics. While property can be continuously measured in dollars, acres, and square feet up to a cent and inch, ideology is pure patterns, discontinuous like the cast of puppets of a shadow play. It is difficult but not impossible to bargain over religion and ideology in the currency of generators, however, but only if the configuration is large enough. Thus, the Russia of 2011 has incomparably more freedom than the Russia of 1984, but the vertical structure of power remains. Its very complexity leaves a lot of height to be easily cut while the oil is flowing from earth, while the still largely horizontal American structure of power is very hard to add floors for the same reason.

Why then is the rift between Israelis and Palestinians unmanageable? Because one side has a great superiority of strength within the borders of the conflict. But the potential inferiority on a larger regional map is even greater because of the contrasts of population and resources. Why then the situation appears more or less stable? The very size and variety of the Muslim world has been diluting the concentration of power, while Israel concentrates power of resistance, and even more so by the recent shift to the right. This, however, increases the internal stress. The pattern picture has just a few gradients and pattern forces. Its simplicity will not satisfy any participant of the conflict, all the more, any academic observer, but a Martian will have all he/she (it/they?) need to understand what can in principle happen with the demise of the latest dictators in the Middle East in 2011.

We shall return to the subject of inequality as the major force of historic events. In an introductory way, the pattern-chemical reason for the Great Recession of 2008 is that inequality of distribution of an intensive parameter in an exystem means instability **by definition** of a dynamic system, i.e., a system with exchange.

Pattern chemistry does not discover any new laws of nature. It reveals how we understand the nature and ourselves. We do it by using universal patterns that do not recognize borders.

SIZE AND COMPLEXITY

Snowflakes (**Figure 7.1**) exemplify complex order. They consist of the same water molecules as drops, but display a great variability of shape, both **discrete and continuous**, although they are more fragile than the chicken egg.

Snowflakes are still being studied by science. Some believe there is no two alike, while all drops or water look the same. The Russians would translate the English “as alike as two peas in a pod” with “as alike as two drops of water.” The reasons why snowflakes show individuality is that they their complexity has room for countless symmetry imperfections, as well as continuous size variations of components. To paraphrase “you cannot step into the same river twice” of Democritus, you cannot see the same snowflake

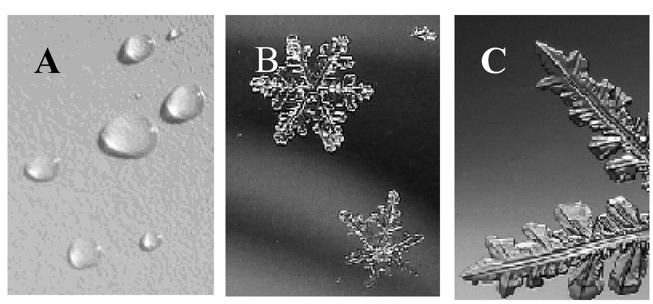


Figure 7.1. Water (A) and snowflakes (B) in groups; imperfection of snowflakes (C)

twice. The original dictum tells about irreversibility of time, while its derivative hints to the reason why it is so. It draws attention to the often-neglected significance of **size**.

Small systems are reversible, large ones do not go back, and very large ones are slow to go forward.

Size is a prerequisite of complexity and one of its components. Another one is the diversity of building blocks. Although both snowflakes and drops consist of the same molecules, structure made of building blocks is possible only in solid state. The drop of water has shape and a certain degree of order, absent in steam, but no structure in the sense of Pattern Theory. The concept of structure is linked to the concept of stability.

I am wading in icy water with a purpose: very abstract concepts, such as structure, order, complexity, individuality, building blocks, and even temperature, solidity, liquidity, etc., are meaningful and useful over the entire human experience, up to culture and stock market. Even the term "culture" spreads its wings from the Petri dish to—surprisingly, but for a reason—the Wall Street and even Washington, D.C. Culture is something complex and somewhat fluid that perpetuates: an exystem, a life form, but as the order of relations and interactions and not the material substance.

INDIVIDUALITY

The individuality of snowflakes follows from their complexity, which increases with size. Small snow crystals are less individual. At low temperature, snowflakes, as all normal solids, are stable while droplets, as all normal fluids, have no stable shape. Yet there is nothing stable on earth in the very long run.

The difference between two drops of water and two snowflakes (**Figure 7.2**) is noteworthy for a deeper understanding what chemistry is about. Two snowflakes can be transformed into each other only with a breach of continuity (C → D), unlike two drops of water (A → B). The difference between continuity and discontinuity (or quantity/quality) fascinated outstanding minds from the great Aristotle (384 BC – 322 BC) to the philosopher Georg Hegel (1770 – 1831) to the mathematician René Thom (1923-2002) and it is incorporated in Pattern Theory.

Source of photos: Individual snowflakes, Kenneth G. Libbrecht, water drops on paper plate, Meg Newberg , groups of snowflakes, Charles Russel "charlesimages". Each site is remarkable in its own.

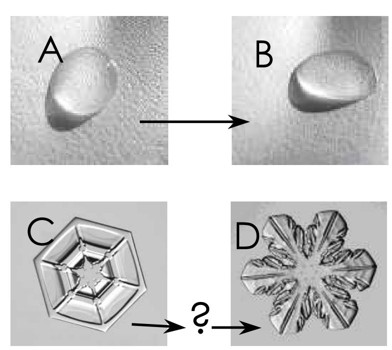


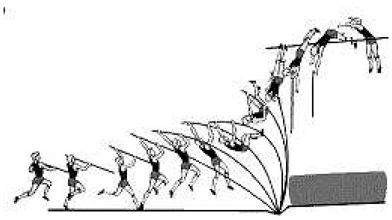
Figure 7.2. Continuity and discontinuity

Chemistry is about qualitative transformations, leaving everything quantitative—together with the equality sign—to physics and borrowing it back with the certified equality signs of equations. In short, new quality arises from combining discrete atoms, similarly to assembling and re-assembling Lego structures. We can see the entire process in detail while observing a child playing Lego. What we cannot see happens in the child's mind and we can only guess that both processes are in some way similar (I am sure they are). Today we often can not only see very well how a radical social transformation happens or fails by watching events by the hour or relying on historic records, but also have some access to the documented processes in the minds of the actors.

EXAMPLE: "My own view is that we may be able to develop a defensive shield so effective that we can use it to rid the world once and for all of nuclear missiles. Then—since we all know how to make them we preserve sdi [Strategic Defense Initiative] as we did our gas masks in the event a madman comes along some day and secretly puts some together." Ronald Reagan, letter, 1986 (source).

THE FUTURE

Pole vault is a continuous process observable in high resolution. Chemical reaction is similar to the vault because it goes from one long lasting state to another of the same kind through a relatively short high-energy transition period. The same can be said about social revolutions and even reforms. In spite of its continuity, the pole vault consists of several distinct states: run, plant, takeoff, pull, turn, push, clearance, and landing.



A social (economic, technological, cultural, geopolitical…etc.) transformation is like a pole vault: it is a single irreversible event, full of uncertainty, in the life of society that can fall back or clear the bar or crush it. If we take the vault as a pattern template, then chemical transformation belong to the same pattern and *vice versa.*

The chemical reaction is a template for the same pattern that also comprises any exystemic discontinuity. There is a simple practical wisdom in that: if something was regular, continuous, and expectable (all three words are synonymous here) it would stay this way. If not, then some obstacle was preventing it from happening. The exystemic obstacle is the instability of the transition state. The latter is associated in physics with high Gibbs energy known also as free energy.

To give a chemist's **simplification** of what Gibbs energy may look in case of pole vault, it is the physical force of the jumper (kinetic energy) plus the correct orientation of the body over the bar even if it does not change the energy. A finger in a wrong position can knock down the bar. This importance of orientation during interaction is typical for chemical reactions, which run in the same 3D space as high jump and pole vault. Note that it is difficult, if not impossible, to measure this kind of factor unless there is a sufficient statistics, which in case of chemistry always sufficient. Gibbs energy is not used for mechanical systems, but no system operated by a human is either mechanical or plain chemical.

Chemistry can rarely, if ever, directly observe the very fast changes in atoms and molecules that happen between two different structures. They consist of fast rearrangements of atomic nuclei and extremely fast, almost instantaneous changes in some electrons. Yet chemistry possesses a kind of a practical philosophy, also borrowed from physics, which—important!—allows for predicting the future and explaining the past by analyzing what can happen between the beginning and an end of a discontinuous change. The difference between a chemist and a political figure is that the former can immediately test a hypothesis while the latter and the rest of participants and onlookers have to wait, like the lottery players, for the fateful drawing.

EXAMPLE: While I am writing these lines (Friday, February 11, 2011, around 11:00 AM), a radical transformation is about to happen—or fail—in Egypt. There are three possible general outcomes: success, failure, and compromise, each in many shades of gray, each unstable. An hour later, while I am still writing, President Mubarak steps down. It took 18 days. But a much longer wait for stability is ahead.

Chemistry seems to believe in continuity even where physics does not: in events at the atomic level. But in fact it just splits the transformation into smaller discrete steps and radically simplifies the complexity of the process.

SIMPLICITY

Simplicity of choices is a blessing in any decision making because small discrete systems or small simplifications of large continuous systems have a limited number of alternatives.

Let us consider a real-life chemical example in which I substitute letters **A** and **B** for atoms of two chemical elements. How can **A—A** and **B—B** interact if all they can do is to break and lock bonds?

The simple answer is that **A—A** and **A—B** collide and exchange their halves.

A—A + B—B → A—B + A—B

There is also another way, however. If we have only two A and two B, the following **mechanism** (as it is called in chemistry) can take place:

A—A → A + A ; A + B—B → A—B + B ; A + B → A—B

If we have a large number of **A—A** and **B—B**, a new possibility arises:

A—A → A + A; A + B—B → A—B + B; B + A—A → A—B + A;

A + B—B → A—B + B ; B + A—A → … and so on (chain reaction).

There are also other ways, but not many.

The extreme minimalism of choice in US presidential elections forces the two candidates to shape the platforms for maximal appeal and not for the maximal concentration on the solution of current problems. Religion, medicine, and economic philosophy could be in one bundle and meteorology, employment, and education in the other, but a third candidate with a focused agenda would have no chances.

TRANSITION STATE

I have already illustrated the concept of transition state many times in **complexity**. Here I am only reproducing a typical illustration:

A—B + C—D → [A B C D]* → A—C + B—D

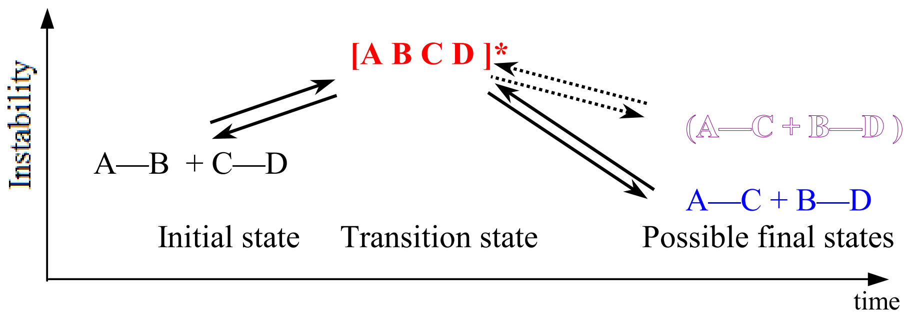


Figure 7.3 Transition state

Transition state is not really a state, but a process, "the state of transition," **Figure 7.3**. Chemists prefer the term "activated complex," which is internationally defined:

In other words, it [activated complex] refers to a collection of intermediate structures in a chemical reaction that persist while bonds are breaking and new bonds are forming. It therefore represents not one defined state, but rather a range of transient configurations that a collection of atoms passes through in between clearly defined products and reactants (Wikipedia).

SCRIPT CODE TEMPLATE

Back to **Figure 7.2.** We can disassemble **C** into molecules of water or their very small Lego-like aggregates, but how can we reassemble them into **D** without a manual? Yes, we can do it by random "trial and error," which can take an astronomical time. The manual can be in the form of the photo or description of **D**. By using it as a script, we, like actors on stage, would display the Shakespearian drama of catalysis and DNA-like catalytic templates, playing ourselves the part of **enzymes**.

Figure 7.4 shows a scene of the Japanese puppet theater Bunraku (source, Tzu-Chiao Hsu). I see it as an allegory (pattern template) of the above imaginary performance. The energy for the performance is supplied by the adenosine triphosphate (ATP) molecules in the body cells of the hooded puppeteers. ATP , "molecular unit of currency" of biochemical energy originates from food consumed by the actors and paid for in yen, the local monetary currency.

For the Bunraku scene (A) to run along the script (B) we need dark figures (C) capable of forming bonds with the puppets (D) and the linear script (B) which establishes the sequence of moves (E) within the limited space of the stage (F).

Figure 7.4. Japanese puppet theater Bunraku

For the translation (A) of mRNA (B) into proteins we need enzymes (C) capable of forming bonds with amino acids (D) and the linear mRNA (B), which establishes the sequence of joining amino acids (E) within the limited space of the cell (F).
NOTE: Ribosome plays the role of enzyme here. More exactly, (D) means a complex of an amino acid with tRNA.

From the point of view of Pattern Theory, the previous two paragraphs can be considered two configurations related through a similarity transformation. The pattern is obvious, but similarity is incomplete. The puppets cannot chaotically move on their own, while molecules can. The mechanism of expression makes the absolute majority of spontaneous moves improbable. We can complete the parallel by employing chaotically twitching and jumping puppets while the dark figures are determined to restrain them. Or, we can employ a team of Maxwell demons to move frozen molecules. Instead of either fantasy we can just leave the invariance and disregard differences.

IMAGINATION
INVENTION
FANTASY

The puppet theater template can be modified to generate a different pattern. Let the puppets, which do not possess the ability to act independently, to be in command of puppeteers who do not have a script. This is the pattern of any authoritarian society, institution, or group.

Various fantastic combinations can be designed, but not too many. Patterns are configurations of a small number of abstract generators. They are simpler objects as compared with configurations systems. As Ulf Grenander notes, "A pattern has less information than one of its configurations" (*Elements of Pattern Theory,* 1996, p.103). This explains the nature of science (and Hollywood) fiction, counterfactual history, and utopian, as well as dystopian literature: the authors recombine realistic patterns. The same mechanism works for technological and scientific inventions.

The metaphor of the Black Swan (Nassim Taleb) is contradictive and dissonant: it is something unexpected, but explainable *post factum*. The tsunami of 2011 in Japan was fully imaginable, so was the 9/11 attack on New York. If it is explainable, then it was imaginable, although not in all detail. Would the landing of aliens be a Black Swan?

On March 16, 2011, I ran into the following headline: *Black Swans Now a Regular Part of Market Landscape.* I quote:

> They [supposedly rare occurrences] include the Internet explosion in the late 1990s, the ensuing dotcom bubble burst and stock market selloff a few years later, the 2001 terrorist attacks, the collapse of the real estate market that began five years ago, and now, the events in the Middle East and Japan. (Jeff Cox, *CNBC.com*)

To that list I would add the volcanic activity along old and new American political fault lines and WikiLeaks. I have a ready pattern-chemical explanation for all that: the world is in transition state to a new stable configuration. What can it be? The evolutionary divergence between humans and Technos. In short, the all-encompassing economy does not work to satisfy basic exclusively human needs anymore, unlike what it had been doing for thousands of years. It works for Technos and doles out the upkeep for humans, not too generously for the majority. We cannot stop this transformation, but we must understand it.

The pattern novelty involves new generators corresponding to exystemic realities. What is a new idea, then? Elsewhere I suggested that philosophy has been in the business of discovering or inventing new subtle and sophisticated generators for assembling ideas. They are useless in tilling the soil and weaving baskets. From philosophy they spread into everyday language and thought. For example, the East Asian nations close to China borrowed the words for abstract ideas from their bigger neighbor who had lived a long and rich enough life to develop philosophy. History of science, especially, of mathematics and physics, is a detailed record of new terms, notions, and concepts in the world of explosive of complexity.

PATTERN EVOLUTION

A new generator is a small configuration that crystallizes from old ones, but how? It enters the circulation within an exystem. It takes a new name and exists as an indivisible combination of old generators, which are not remembered other than in dictionaries.
This process is similar to bio-evolution. All evolutions that we know belong to the same pattern, which itself is a family of patterns. They carry in some form the information about their origin—whether in genome, or history, or artifacts. Novelty is always evolutionary and inseparable from time. Elementary ideas and realities behind them undergo Darwinian **natural** selection.

Wikipedia is a great source of histories of ideas and realities, including Darwinian selection. Thus, electricity is based on the concept of electric charge. This looks lice a logical circle, but charge is based also on the concept of force, and force is a very common human experience. Thus, two attracted magnets require a human effort to separate. Electric charge comes not from magnets, however, but from amber, whose name it bears. Electric charge becomes a pattern generator because it is used as a species of human experience, regardless of its origin. It is a frozen configuration.

Not just training of puppies and early development of babies, but the entire evolution of human civilization backtracked to the evolution and origin of life come to mind in connection with the pattern of ordering chaos. Bios emerged as partly ordered molecular chaos. Humanity, in the form of civilization, ordered the residual chaos of human behavior. Technos orders society even more by bringing in contact previously independent domains of humanity.

A—B + C—D → C—**A—B**—D
Addition

A—B + C—D ← C—**A—B**—D
Elimination

A—B + C—D → A—C + B—D
Substitution

A—B—C → A—B—C—**D**
Rearrangement
|
D

A—B—C—D → A—B Cyclization
| |
C—D

A + B + A + B + … →
A—B—A—B— … Polymerization

A + B → A—B (No specific name; example: oxydation)

Figure 7.5 Major topological transformations in chemistry

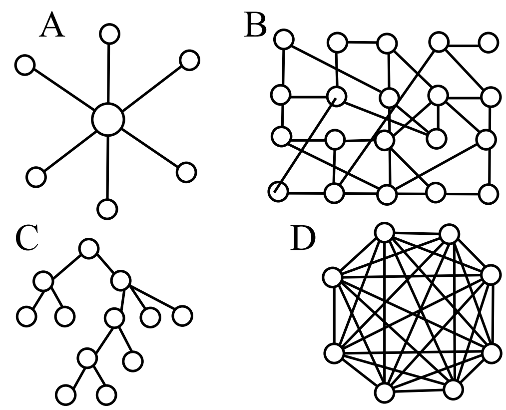


Figure 7.6 Types of social topologies: star (A), network (B), tree (C) and full graph (D)

Following this path we come to a proposition that history of life on earth, which is traditionally a **record of order** in the form of species, institutions, technology, culture, ideas, etc., can be complemented by a **record of chaos** from molecular movement to climate fluctuations, geological disruptions, genetic mutations and further to hunting-gathering societies, accidental discoveries, movement of people and ideas, spontaneous revolts like the Spartacus uprising and storming of the Bastille, the uncertainty of outcome in democratic elections, and the chaos on Capitol Hill and in financial markets. The two records will look like positive and negative images with longer periods of stability separated by outbursts of chaos.

Moreover, at this degree of abstraction we could probably arrive at a map of all possible exystemic patterns arranged as a hierarchy. Furthermore, this map could turn out quite small. Patterns, like basic physical laws of conservation, are manifestations of symmetry and it is known that groups of symmetry can be finite and quite small. Thus, there are not more and not less than seventeen two-dimensional groups of symmetry (wallpaper groups) and 230 groups of symmetry (crystallographic group) in 3D space.

Any molecular chemical transformation can be represented as a sequence of only two moves: breaking a bond and locking a bond, while the number of atoms is conserved. There are larger classifications, reducible to the two basic operations.

Topology is a kind of geometry that is not interested in angles and distances, but only in what is **close** to what and how this closeness remains unchanged under transformations. Topology perfectly suits to represent singularities. In addition to topology, bond between generators in pattern theory has no distance, but has some measure of "strength" or probability, quite like chemical bond.

The transformations in **Figure 7.5** (incomplete list) have nothing specifically chemical in them and are applicable to anything consisting of generators and bonds, including Lego, architecture, engineering, and social structures. Thus, building the border fence is typical polymerization, gated community uses cyclization, and reshuffling of staff may involve rearrangement. In social structures, the predominant topologies (**Figure 7.6**) are star, tree, network, and full graph (as in the circle of friends). The largest social network combines all of them.

Note that **Figure 7.5** relates to processes while **Figure 7.6** shows structures. The typical process in building social structures is catalysis:

A + C → A—C; A—C + B → A—C—B → A—B + C .

CATALYST
MECHANISM
MACHINE

Theoretically, the catalyst can perform its connecting/disconnecting function indefinitely. Molecules do not wear off, but can be blocked or changed. The pattern of repeated performance, often cyclical, is the most ubiquitous throughout the evolution from living cell to tool to machine to institution to computer. In fact, this is one of two necessary conditions for exystem: there must be a machine (mechanism) and source of energy. Mechanism is a chemical term, not just mechanical one.

Figure 7.7 Albert Szukalski , *Ghost Rider* , at Rhyolite, NV, USA ; source

By machine/mechanism I mean any structure capable of actions—identical or different—in a repeatable manner. Examples: organism, Maxwell's demon, Paleolithic tool, human, machine, switch, computer. Only a few tools, like wrench and screwdriver, work both possible ways.

Is bicycle a machine? It can start, move, stop,

and turn repeatedly. The motorcycle, in addition, has a source of energy supplied externally. Both needs a rider to move, turn, etc.
The rider also has a source of energy supplied externally, so, what's the difference?

In its choice of moves, both bicycle (mechanism) and motorcycle (machine) completely depend on the driver who is the source of control. By disassembling the driver we find that it is a machine with the internal "driver" known as brain (nervous system, to be exact). What is the difference between the driver's body and its brain? Brain is the driver of the body, which is the same as to say that mind is the source of control. But the mind itself is not material. It is an information template created by years of life, learning, practice, and correction, quite like the content of a computer hard drive. Some segments of this information, like simple mathematical operations, come from distant past unchanged, others, like a recent tidbit about Lady Gaga to be forgotten tomorrow, come from the Internet.
Information is the key word in exystemic mechanisms, but there is no consensus on what information means in most abstract sense. I suspect that it is quite natural for exystems because of their pattern-chemical nature: all general principles display in concrete circumstances. This is natural for chemistry, but not for theoretical physics, although physicists may not agree.

NEWS
NOVELTY
EVOLUTION

Is there anything wrong with the use of "catalyst" in the following snippet (3/3/2011 10:21 AM)?

QQQQ SPY Goldman on Apple: Here are the Coming Catalysts for Shares **at The Wall Street Journal** Thu 9:49AM EST

The Wall Street Journal quotes an analyst's note: "We believe the iPad 2 introduction and the June iPhone refresh will serve as critical catalysts in the coming months."

The pattern-chemical problem with this usage is that catalyst by definition performs its function as many times as possible under circumstances, while iPad 2 can be released only once. As for "refresh," I am unsure, but the trick looks like a catalyst of limited use. The tablet's introduction with much fanfare was news, "a shot in the arm," which loses its novelty immediately after announcement, but can leave an imprint. If the imprint is long term, it is an evolutionary event.

The world after the Internet is not entirely the same. The fading imprint is a small disturbance or perturbation, as astronomers and physicists call it. A variation in the system leaves a dissipating effect, like most of the daily events in the human short time memory. The **new** (Internet) is a stable change in the pattern of communication, although nothing is forever stable. It may be followed by another novelty. The **different** (iPad 2) will be followed by another different "pad" or "tablet."

What is fanfare, by the way? “Information in newspapers and on television and radio intended to make people interested in someone or something” (definition of fanfare in MacMillan Dictionary). Yet the act of fanfare presentation as promotion pattern happens every day.

WORK AND CATALYSIS

Catalyst does not perform physical work. It does nothing but boosting the speed of a very narrow slice of processes among many possible.

I perform a small amount of physical work almost every morning when I slice my bagel. It takes a different time every day and I am rarely satisfied with the results. I know about the existence of bagel slicers but never actually saw any at work. Some are seen in **Figure 7.87**, from professional **A** to cuddly “bagel hugger” **D**. They look completely different, but the pattern function is the same.

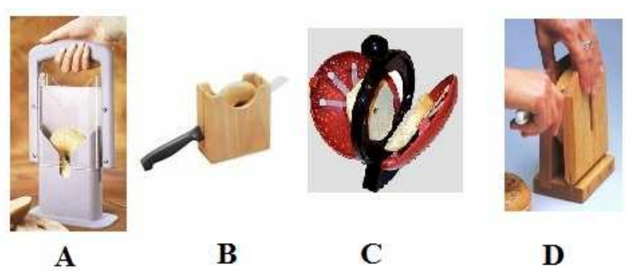


Figure 7.8 Bagel cutters

There is an object of two bonded parts **Tp—Bt** (for bagel **to**p and **bottom**), which should be separated into **Tp** and **Bt** , ideally, along the median plane. It is possible, but not easy to do with the knife alone. The purpose of the slicer is to speed up the right separation by hindering all that can go wrong, and almost everything can. The slicers **A** to **C** do the job by preventing the wobbling of both the bagel and knife, and **D** stabilizes only the bagel. All four slicers do the same pattern work: **Tp—Bt** → **Tp** + **Bt** . This is catalysis in pattern chemistry, but not in molecular one where catalysis is reversible. The gadgets can be ideally reused many times, although some are less ideal than others: the blades in **C** cannot be either sharpened or straightened.

FREEDOM

The stiff bureaucratization—human, mechanical, or digital—is a common effect of complexity, from bagel slicer to computerized cars and appliances, to government, to democracy: the user has longer menus and more buttons, but less power to change them or get rid of.

Michelangelo *Bound slave*

The fruits of the Industrial Revolution—transportation, telephone, medicine, and agriculture—were generally celebrated as a great benefit to humanity born with a stone tool in hand. It is assumed that humans have a full control of man-made things (Technos) and if not, it is just an accident. An inversed question about the influence of Technos on humans has been asked in many forms by many thinkers, especially in the post-WW2 era, after new weapons had demonstrated an unprecedented destructive power. The sacrifice of the environment for the sake of progress cast doubts on the very concept of progress. The advent of computers and the Internet, together with the idea of artificial intelligence, has made another step toward closing the gap between humans an Technos, mostly in two opposite forms of beneficial fusion (convergence) and antagonistic split (divergence) between the two domains.

In "*The Botany of Desire: A Plant's-Eye View of the World"* (2001), Michael Pollan, explores a remarkable idea: when we select plants using their inborn properties, domesticated plants select us using our inborn desires, so that we keep propagating and perfecting them. We are their human bumblebees. They are our servants and providers. It is not exactly a case of Darwinian coevolution of bumblebee and flower, in which no mind is involved and which takes a long time, but a more general pattern. Coevolution is by definition beneficial for the two species, but who can decide what is beneficial for animals and plants if even humans cannot agree on what is good for them? As far as Technos is concerned, the idea that something can be good or bad for things, outside the use, covers maybe just historical and cultural artifacts.

Probably, somebody has already expanded Michael Pollan's idea to the relationship between humans and human-made things, and if not, I am here to add a configuration to the pattern of the coevolution of humans with their non-human dependents on the planet.

Technos exploits our inborn human desires to propagate itself. We are the enzymes for the Krebs cycle of things, ribosomes for their steel, plastic, computer chips, and remakes of old movies. What is not so obvious, our freedom of thought causes their mutations, as if we were a kind of cosmic rays. The things are not less powerful: they can change our behavior and thinking within one human generation and, potentially, our nature within a few decades.

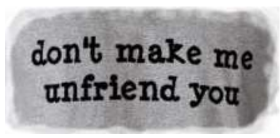
In view of the last twenty years of evolution of Technos, we are trying, still hesitantly, to reconsider the old ideas about human nature, progress, information, and freedom—none of which has ever been consensual. The best way to do that is to get around the non-consensual ideas by substituting observable patterns for their surrogate interpretations.

WORK

Whether we cut a bagel, put a battery into a remote control, break a twig, walk, think, or just sleep, we follow the **pattern of work** shared also by chemical catalysis. By work I mean not the measurable in Joules (J) or electron volts (eV) quantity of physical work, but work as a process with a beginning and end, i.e., **event** which is highly unlikely to happen on its own. Its result is work in the sense of the Latin *opus*. The Earth is in the process of rotation, but it is not an event on the human scale. This concept of work not as a quantity but as a transformation through a series of configurations separates monochromic physical and chemical pictures of the world, to which biology adds the third color: evolution.

Work requires a pattern scenario, similar to the script of Bunraku theater, for the catalytic play in which **interacting** actors prevent the **chaotically shaking** and twitching puppets from wrong movements, quite like the bagel slicers restrain the unsteady hand of humans. Yet there is another alternative: the **interacting** actors move **interacting** puppets instead of the lifeless and passive ones. This case is more or less similar to the social interaction, i.e., “the human use of human beings” (Norbert Wiener). The question about the future relationship between humans and Technos takes then the form of who is who.

Figure 7.9 illustrates the pattern-chemical mechanism of an act of work, i.e., an event with the beginning and the end. The smallest atomic operations of work are a formation of a bond (bonding) or a breakup of a bond (unbonding). The nature of the bond does not matter in pattern chemistry. The **unfriending** on Facebook is an example of unbonding, although not quite pure, however, until the friend is completely forgotten. Yet even forgetting is difficult unless nobody else among friends remembers the former friend and no record of the past exists anywhere. To re-classify a friend into an enemy is the most efficient way to keep him or her in memory. The example of unfriending shows why events in human society are practically irreversible and it takes a long time to forget them.



Ultimately, the irreversibility boils down to the effect of size: the larger an exystem, the more stable to a total annihilation. It applies equally to individual human life, society, and culture. Of course, all exystems have their points of vulnerability and none has as many as individual human.

The catalyst **A—B** , with **A** and **B** connected by a strong bond, must be able to form two weak bonds with its substrate consisting of **C** and **D**. The weakness (lability, more exactly) is necessary for releasing the catalyst after the job is done.

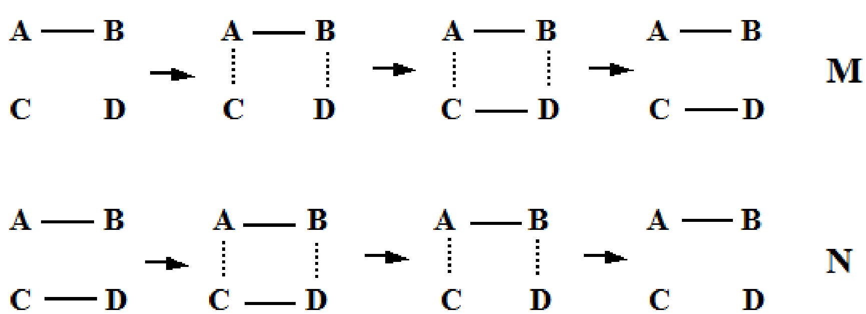


Figure 7.9 Work as catalysis. M: bonding, N: Unbonding, A—B: catalyst, —— strong bond ………… weak bond

Figure 7.9 shows only the pattern mechanism. The stages of catalysis are (1) bonding with substrate trough weak bonds, (2) locking or breaking the bond, depending on which state is more stable, and (3) separating from the substrate due to the weakness of the catalyst-substrate bonds.

The nature of the act can be different. In chemistry, the reasons for the course of events are physical. The reasons for friending and unfriending are neuropsychological, much more intricate, and still quite dark, regarding details. Even the problems with bagel arise from its size: there are too many bonds between its particles. For the same reason, the cutting is irreversible.

In complexity (for example, visible hands) I presented numerous illustrations of pattern catalysis. Here I do not want to use new illustrations.

Let us take an important example of switch, which can be of mechanical, electronic, neural, or any other nature. As a template for the pattern I choose the knife switch, which can be seen in old movies. I believe that **Figure 7.10** does not need an explanation: a big part of it was provided by René Descartes in 1664. The switch is similar to a Bunraku puppet, but not quite: it can be in a **few stable states** well-defined by the script, while the isolated puppet can be in a **continuum** of states, all non-functional .

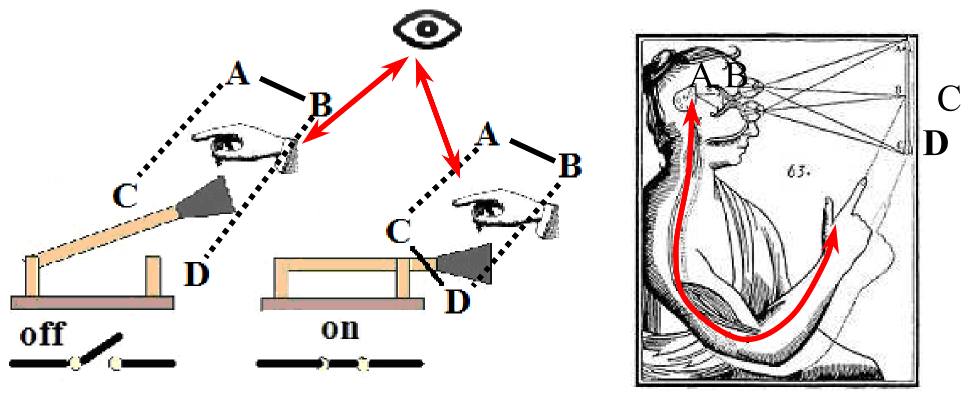


Figure 7.10 Pattern catalytic mechanism of switching (left) and Descartes' explanation (right) of the strength of A—B bond in the mind/body

The catalyst **A—B** in **Figure 7.10** is the bond between two mental images of contacts **C** and **D** which can be in **OFF** or **ON** configurations in the same human mind. If there is a bond of communication between two minds, each can have only one of two images. This is how two space stations can dock in space and, more generally, social mechanisms of match-making work. The GPS system enables a single mind to do the job across big distances. Secret intelligence, like the CIA, is intended to work through the borders, languages, cultures, and communication networks, as well as codes, walls, intent, and human resistance. It is hard to overcome human stupidity, obstinacy, and ignorance, but there are plenty of tricks to profit on them. With catalysts, we can only speed up or hamper a process, but not to change its results.

EXERCISE. What are the pattern mechanisms of fraud? Of politics? Of religion?

The bond between the blade **C** and the working contact **D** of the switch is neither positive, nor negative because a small comparable effort is needed for both ON and OFF states. I call this kind of bond **neutral**. For safety considerations, switches are designed so that it would be easier to stop than to start a machine like electrical motor or nuclear war. **Figure 7.11** shows "MLCS 9072 Safety Motor Power Switch" which makes **OFF** easier to do than **ON** by using some very general properties of the world. A chemist in me wants to call the effect of this switch “a shift of equilibrium.” The states **ON** and **OFF** are equally stable in the absence of humans around. If accidental impacts on the switch are possible, like with a lot of curious children around, the two possible transitions will require different effort and the probability of the states will differ:

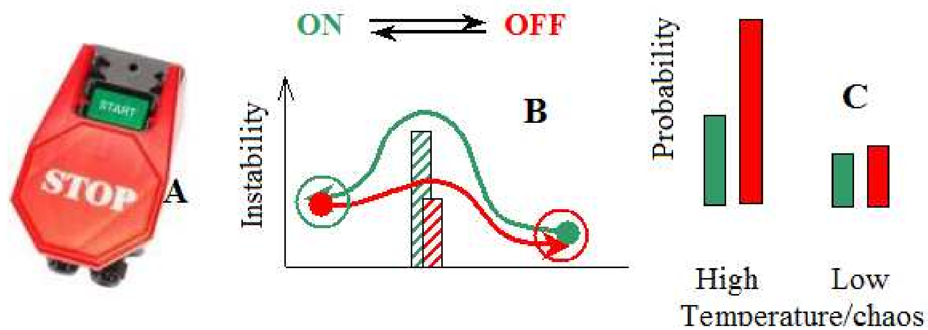


Figure 7.11. Switch MLCS 9072: ON-OFF ransitions (A), instability in chaotic

NOVELTY AND TIME

The respectable business of physics is discovering and studying the laws of nature, which for all practical reasons are permanent. As any science, physics evolves. It generates novelty, which is reflected in the history of physics, but not in its content. History and theoretical biology evolve, too, but their subjects include records of old novelties. Chemistry takes the intermediate position: laws are from physics, novelties are from the laboratory.

The question of the evolution of the laws of nature is frowned upon but not outright rejected. Suppose we come to understanding that physical laws evolve. We would immediately start looking for timeless laws behind the evolution.

Lee Smolin sees the universe and its laws as result of natural selection.

What we see in the skies is not a snapshot, but a historical record almost from the moment of birth because light brings us images of the past, the farther from earth the older. The common objection to Smolin is: we see parts of the universe as they were long time ago, but the laws there are the same as today. This objection has a gap: what if the picture of the old universe changes along the way from the past, with its laws, to our telescopes, with new laws? This gap is neither logical nor factual: it is the gap of imagination, by which I mean either lack or excess of it.

Natural selection presumes adaptation to the environment. A more serious objection, in my opinion, would be the absence of anything external to the universe.

Novelty is a difficult and mind-bending notion. Natural selection also exerts some stress on many minds because it has not just an open end, but also an open beginning. There are questions that do not have answers. We ask them simply because we can combine any words and ideas into grammatically correct phrases.

As a reader of *Foreign Affairs*, I have just found a curious example how lessons of history warp on the way from the past to fit the present.

Malcolm Gladwell denies that social media are crucial for current protests and revolts against authoritarian regimes. He might or might not be right—the digitalized protests are still a novelty—but he asks the following question: "What evidence is there that social revolutions in the pre-Internet era suffered from a lack of cutting edge communications and organizational tools?" He concludes that to have this evidence, one needs "to convince readers that in the absence of social media, those uprisings would not have been possible." (*Foreign Affairs*, March/April, 2011, p.153).

Let us disregard for a moment that suffering does not mean impossibility. Gladwell asks for and evidence which is neither logical nor factual, but coming from imagination. To imagine a part of the world some years ago, but exclude cell phones and Internet from the picture, in other words, to falsify the past and then analyze the fantastic situation as if it were real is like either denying or insisting that the Roman Empire fell because it did not have nuclear weapons. Paraphrasing Rudyard Kipling,

> Oh, **Future is Future**, and **Past is Past**, and never the twain shall meet,
> Till Earth and Sky stand presently at God's great Judgment Seat…

Pattern is something that transcends time, space, and knowledge and, by the way, allows me to put side by side the pairs "revolt—social media" and "Roman Empire—nuclear weapons." Natural selection is a pattern. It is supposed to survive transpositions from West to East and from Past to Future. How about back from Present to Past? We can certainly better understand the past with a larger library of patterns.

WHAT IS GENERATOR

In this Chapter, I focus on the evolutionary aspects of Pattern Theory. Evolution operates with a category not (yet) known as a physical concept: novelty. We constantly perform mental and practical analysis and synthesis by splitting objects and ideas into components and combining components into objects and ideas. In pattern language, we analyze images as configurations of generators and synthesize configurations from generators. Obviously, this is what chemists routinely do with molecules and atoms, whether in their minds or in test tubes. Novelty is crystal clear in chemistry: an individual substance (not just a possible combination of atoms) that has never been discovered in nature or made in a lab, even though it could be easily imagined as a combination of atoms. At the enormous size of chemical records, occasional errors and duplications with novelty are possible.

A chemical substance must exist in a material form in order to be new. Chemistry, however, brings novelty not only with new configurations. New generators are best exemplified with the story of the chemical elements and the Periodic Table, but there are more numerous and less known examples of discovering new stable combinations of atoms as generators of a higher hierarchical level. Three examples are presented in **Figure 7.12**.

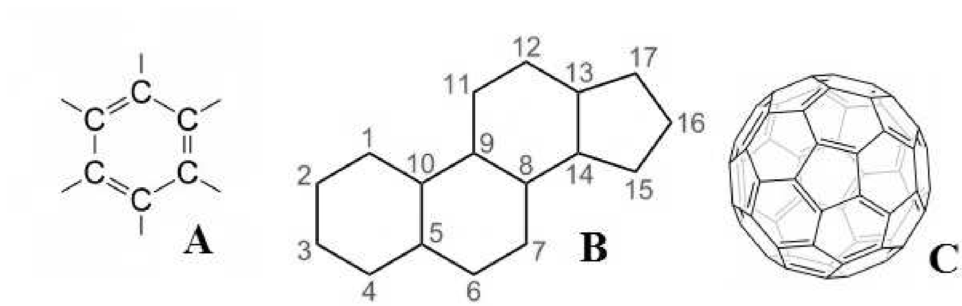


Figure 7.12 Large generators of organic chemistry. A: Benzene ring; B: The core of steroids; C: Buckminsterfullerene. There is a C (carbon) at each intersection of lines in B and C.

Chemistry discovers also new rules of combination of atoms, for example, some exotic organometallic compounds, distant relatives of hemoglobin and chlorophyll. Chemists like to do what looks as impossible as buckminsterfullerene ("buckyball"), which was originally an architectural form invented by Richard Buckminster "Bucky" Fuller.

Patterns, which are classes of configurations, are themselves configurations built of classes of generators. All human activity of any kind can be described in pattern language. This explains the origin of our knowledge, whether true or false, together with the essential vocabulary of human languages. How then can we apprehend the new, which turns into the old right before our eyes?

My position is that novelty starts with new generators. To discover the novelty of a generator is easy: it was not in the list—generator space—yesterday. As for the new rules of regularity, they are configurations, too, and the above criterion applies to them. The complexity increases each time a new generator or a rule of bonding and similarity enters the generator space and becomes old. There are numeric measures of complexity (Kolmogorov complexity is one of many) applicable to specific objects and systems. All a pattern chemist can do is to compare two not too much different pattern spaces and say which one is more complex, which reminds of the pattern of differential calculus.

If everything starts with generators, how can we recognize one? How do we come to the conclusion that a certain observable object **A** is simple, atomic, and can be considered a generator?

I denote any generator as **X** and any other generator as **Y**.

If **A—X** and **A—Y** exist, **A** is generator (analysis);.
If **A—Y** does not exist, **A—X** is generator (synthesis).

By existence ("exist") I mean the absence of novelty, i.e., presence in the memory or record of some kind. The above criterion of simplicity has been directing the evolution of chemistry for its entire history. The suggested above definition of generator or a simple entity uses the notion of bond, but it is not circular in spite of the definition of bond through generators. I define the bond as the state of two generators that requires energy **either** to dissolve it **or** to maintain it. A pair of inseparable, at least for a while, lovers is the best example of "either" and the Democrats and Republicans, perennial enemies in US Congress, exemplify "or."

In plain words, first, being a generator means the ability to combine with other generators and, second, generator which is not in the record/memory, is new until recorded. My position, therefore, belongs to the Kantian conceptual **pattern**: our understanding of the world evolves from our inborn ability to distinguish a part from the whole and the whole from a larger whole. To put it differently, it means to distinguish a set from its subset. Next, it means the ability to perceive patterns, for example, a squirrel as a squirrel regardless of posture, size, movement, background, and source (natural or image). From yet another angle, it involves the category of quantity and the notions of MORE or LESS necessary for distinction between a part and the whole. Finally (or not), it means the ability to tolerate circular definitions—all fundamental concepts are circular.

All those abilities, except the last one, appear at a very early age and not just in human children: animals have them too. As for circularity, the children—and scientists, permanent curious children—are naturally looking for causes and reasons of everything and it is difficult to satisfy them with circular explanations.

To summarize, we understand the complex world because, starting with early childhood, we use our inborn abilities to recognize and manage the simple configurations of everyday life, to stock up a library of typical situations and responses, and then, flooded by novelty, to generalize the **movement** of the toy rattle into the **movement** of electron, Earth, stock market, aircraft, people, ideas, emotional state, history, and abstract time. Equations of hard science do not apply to individual exystems, which are never equal to themselves from one moment to another. Instead of EQUAL (=), only MORE (>), LESS (<) and SIMILAR (~ , ≈) are of some use in the world with novelty, individuality, and singularity.

Cufflinks of time

EXISTENCE
CLOSENESS
BONDING

But what is the state of two generators that do not require energy either to maintain or to destroy it? Whether they are objects or ideas, they can be distant or close: material objects in Euclidean space and ideas in discrete topological space of a semantic network or tree-like hierarchy. I call this state **pre-bond** and award it, together with novelty, with "cufflinks of time."

To illustrate what I mean, I return to my earlier example of the Facebook "unfriending." The link with former friend can be broken, but the "unfriended" person exists in the personal memory, which makes possible a future re-bonding. If the former friend has been forgotten and erased from all records, he or she is in the same situation as somebody totally unknown and living on the other side of the globe. In other words, generator needs a kind of pre-existing condition for another generator to be capable of bonding. For atoms, parts of machines, animals, and transportation, the condition for bonding is closeness in space, for example, of the cargo with the ship. For humans and machines this condition was to a significant degree abolished with telecommunication.

There are four stages in bond formation:

(1) **A || B** Non-bond. **A** and **B** are completely isolated and not aware of each other's existence, but the knowledge of their existence is stored somewhere. What is not remembered does not exist.

(1) **A | B** Pre-bond: **A** has a knowledge of **B**, or it is mutual, but bonding may not be either possible or desirable, i.e., potentially stable. A negative bond can be too expensive to maintain, a positive can be to expensive to "pre-bond."

(2) **A B** **A** and **B** are dissociated (not bonded).

(3) **A—B** **A** and **B** are associated (bonded).

The digital revolution, which started in the middle of the twentieth century, with Claude Shannon, Norbert Wiener and John von Neumann as its prophets, drastically shrunk the world by wireless information technology**.** It continued the trend started by the Industrial Revolution with railways and steamships. The Euclidean geometry has been reduced to topology: either you are close or not. The rising price of reduction has been noticed only with the linked in embrace oil price and atmospheric temperature.

Catalysis is a simple mechanism of turning non-bonds into pre-bonds and full bonds.

CAROLINE THE QUEEN OF ENGLAND

The correspondence between Leibniz (1646 –1716) and Samuel Clarke (1675–1729) is one of the major philosophical documents, still in circulation. It is known that Newton was at least aware of the exchange. I was greatly influenced by it in my youth and I see the concept of time which ticks at each event and does not run if nothing changes as a key pattern idea. Leibniz' idea of space seemed more obvious to me because I was prepared to it by quantum physics and topology, but "Leibniz time" was a revelation.

The two philosophers never met and probably would never established a bond if not for **Caroline of Brandenburg-Ansbach** (1683 - 1737). Leibniz had belonged to her circle of friends before she moved to England and became Princess of Wales and finally the queen consort of England during the reign of George II. There she became friends with Clarke and catalyzed the unique correspondence (1715-1716) in which she apparently was an intermediary. She was a woman of outstanding intelligence, but for the lack of any decent picture of stand-alone intelligence (except the ugly artificial one), I present in Figure 7.13 the picture of her beauty, which was undoubtedly a big part of her magnetism. Intelligence is beautiful, but it can stir up trouble as much as beauty.

The story of Caroline, her involvement with philosophy and science, the place in the triangle in **Figure 7.13**, her connection to the historical feud between Leibniz and Newton, and even, obliquely, to American history, as the grandmother of George III, is a captivating tangle of four strands—historical, personal, religious, and scientific. Accounts about it have minor contradictions, oversized controversies, and remarkable details of dark and bright sides of human nature. The European jewel of Caroline shines there in the double light of royalty and wisdom. It is better to be kept secret from Hollywood. One of more detailed introductions to the correspondence (by Roger Ariew) is accessible on Google. Domenico Bertoloni Meli published an essay, from which I am pleased to quote:

> She was involved in the dispute by arguing with Clarke and even with Newton, exchanging opinions with Leibniz, and functioning as an arbiter and moderator. Her presence helped shape the style and contents of the letters, and characterizes the genre to which the correspondence belongs. (D. Bertoloni Meli, *Caroline, Leibniz, and Clarke,* Journal of the History of Ideas, Vol. 60, No. 3 (Jul., 1999), pp. 469-486).

A real gentleman is always a feminist.

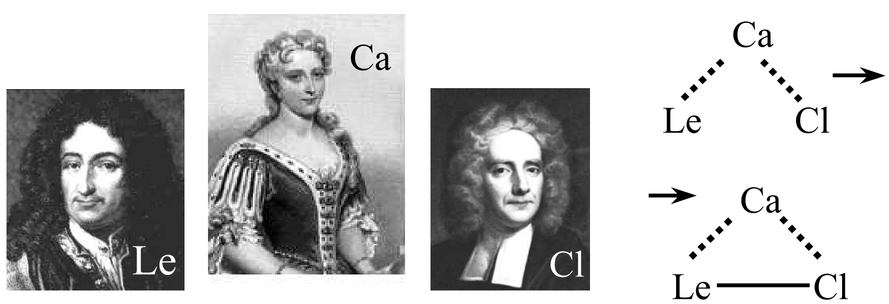
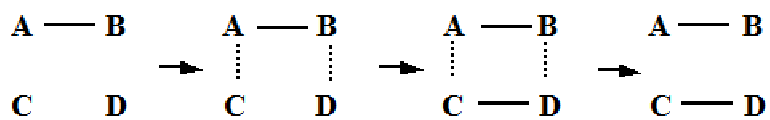


Figure 7.13 Topology of catalysis (right): Leibniz (Le), Caroline of Ansbach (Ca), and Clarke (Cl)

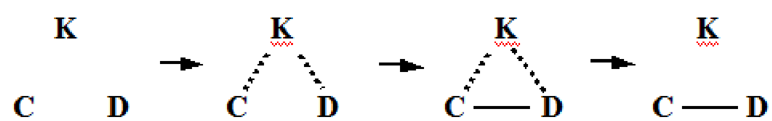
Reading about the quadrangle Leibniz-Newton-Clarke-Caroline, I was intrigued by the intensity and seriousness of religious interests of all four and especially of the two intellectual giants. I am coming to conclusion that there is nothing surprising. Giants are drawn to giant mysteries until one of them—like Galileo, Darwin, or Einstein—solves the riddle.

Pattern chemistry displays in the space and time as Leibniz understood it: space is an "order of co-existences" and time is an "order of successions." Caroline catalyzed the correspondence in two pattern steps. She made both potential correspondents close enough to pre-bond by keeping them in her topological neighborhood, where they could be in co-existence and develop a bond as the second step.

With the Carolina's triangle in mind, we have to reconsider the previous pattern mechanism of catalysis:



Here is our definition of generator comes handy. The catalyst's structure is presented above as **A—B**, but since it does not change at all during the transformation, we can generalize it as a single entity **K**, not necessarily simple one. In other words, **A—B** is a generator of a wider pattern because we never see it split.



Bonding of the catalyst **K** with substrate **C** and **D**, always dual, can happen at different moments of time and space, as the Leibniz-Caroline-Clarke delightfully illustrates. The bond of Caroline with Leinbiz locked in Hanover was the first and the bond with Clarke in London was the second. Therefore, I award catalysis with "cufflinks of time," the badge of the exclusive club of travelers between past, present, and future.

Intuitively I expect every catalyst to have two components ("dockings"), **A** and **B**, but it is not for me to prove it.

> Here is a weak attempt. I am typing this line and want to type "**a**." I have pressed the key "**A**" to get the "**a**" of previous sentence. It was a simple act. Its hidden duality is the bond in my mind between not yet typed "a" and its particular place in a particular line. Or, from a different angle, it is a bond between the two states of the key "**A**," one in present, the other in future.

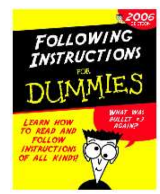
Mind, from this point of view, is a giant catalyst with memory (another mystery for giants), which keeps in pre-bond state generators that otherwise would be in no-bond state and separated in space and time. The mind maps the world and "keeps it in mind."

MIND
LIBRARY
COMPUTER

EXERCISE. Is the mind a computer and if so, in what sense? What is that the computer lacks, if anything, in comparison with mind?
Computer is a tiny, very efficient ("fast") catalyst with very big memory. For all but last 40 years, the library was the main organ of memory for humanity. It was capable of catalyzing links over space and time. Like the mind, libraries offered open access to any of stored items. They were full of surprises and novelty for the young. I think it is a tragedy that computer is killing libraries. I have two reasons to dislike the digital libraries, while enjoying their convenience. They are like paid love in comparison with free love.

1. The Internet gives us limited but free access to the day before yesterday. The excessive greed of copyright creates a gap between today and yesterday, and, therefore, an illusion that today was like yesterday, tomorrow will be like today, and history is old hat. Library smoothly transcends the gap. Internet breaks the continuity of human experience. Fortunately, many authors and readers do all they can to give free access to publications otherwise requiring payment, but I will keep examples to myself.

2. Library gives equal random access to any subject, shelf, and book. The computer monitor gives you a menu and takes back your freedom, especially if bestseller lists, Oprah Club, author's stardom, or titillating title influence the menu. Library is the intrinsic part of education and it must be preserved, at least, in some form. The alternative to the open mind of the pre-digital world is the *Little Red Book* of Chairman Mao (or of Doctor Ruth, Deepak Chopra, etc., or a digest of the Bible, Koran, or Dianetics, or whatever, or *Astrophysics for Dummies*, or *Seven Years to Seven Figures*). See **FREEDOM** above.



Library is not an appendix to be inconsequentially cut off the bowels. It is the pituitary gland of civilization.

NON-EQUILIBRIUM

The pattern picture of catalysis in **Figures 7.10** and **7.11** has one troubling aspect: the catalyst is indifferent to the direction of work. It can change the state of the switch from ON to OFF and back with equal efficiency. What can we accomplish with an assembly manual for a Lego structure which is built with one hand and destroyed with the other? Yet cells, species, large social structures, small groups, politics, economy and exystems in general are always in flux by definition because this is what means to be in non-equilibrium. They need constant supply of energy and matter for maintenance. In spite of all the DNA, laws, traditions, and blueprints, as well as of maintenance, exystems evolve and rewrite sometimes a word, sometimes a chapter in the manual. Such systems, so contrasting with the inanimate world, are called in physics dissipative structures. Physics is perfectly aware that what I call exystems belongs to dissipative structures, but it does not go into details of structural complexity, the home turf of chemistry.

INFORMATION

Definitions of information are as circular as those of energy. Intuitively, if energy is associated with instability, information relates to stability. Information partially converts energy into stability, but only in exystems, starting with Bios. The problem with information in exystems is that it should come from somewhere. The mystery of life and human passions required a source of information and a god was, actually, a good guess. The scientific position, from my strictly personal point of view, sees the source of initial information in the distant pass. What was its original seed? I believe that information originated from chemical catalysis, which evolved into pattern catalysis. I would prefer to do without the term information, but it is here to stay, tease, and mislead us.

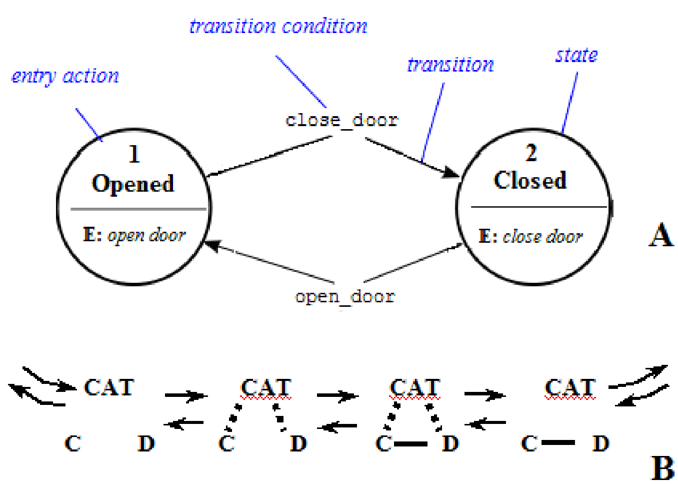


Figure 7.14 Similarity of Final State Machine (A) and catalysis (B)

It is assumed that the switch will be stable in either position. This is possible only if an effort is needed to move it in any direction. This effort is applied to overcoming the transition state between **ON** and **OFF**. In other words, the switch must first receive **information** telling in which state it should be.

The "informed" switch is the atomic unit of information technology: the simplest finite-state machine, which can be in two states alternating in response to an external signal (**Figure 7.14**).

Information enters the pattern of Bunraku stage when it is necessary to decide what to do the very first and any next moment of the performance down to the end.

EXERCISE. Is computer an exystem? Is it a machine? Why?

In a simplified picture, computer processor changes the state of a memory cell by writing 0 instead of 1 or 1 instead of 0. This work is pattern-similar to the function of the switch in the sense that the cell can be in two states only and both transitions require a small effort, although the wall between the states is high. The question is, where is the bond in this picture? There is nothing like two contacts and the blade of the switch.

I am stepping into a busy and well-treaded area as an ignoramus with the superfluous for computer science idea that the bond forms in time, in agreement with Leibniz' concept of time as a succession. This can be a pattern-chemical interpretation of information, based on symmetry between time and space, in the spirit of Leibniz, but I am leaving this potential flower in its unopened bud.

INSTABILITY

The daily waves of information roll over the individual mind like tides, storms, floods, and glaciers, leaving seaweed, fallen branches, garbage, and boulders of wisdom or folly. This pattern of constant periodic instability was the driving force of other evolutions: geological, biological, social, scientific, cultural, and technological. The simplest configuration within this pattern could be the imaginary mechanical watch which slowly changes its face, hands, and gears under the influence of daily winding, accidental shocks, and commute between work and home. The hard-line mechanical watch would come to the state of utmost facelessness, with little sensitivity to the surroundings, but an exystemic watch could finally turn into something totally different, like a gas lighter. A necessary condition for this living watch—one of several—would be some degree of internal chaos and instability, in other words, permanent non-equilibrium. The typical mechanism of translation of the external natural chaos into the order of mind and DNA is Darwinian selection.

EXERCISE. Are there other mechanisms of translating chaos into order? Art? Invention?

Our human brain is capable of accommodating the evolving mind because it is about 77% water, which is a lot of chaotic movement at 36°C. For the same reason our body with 60% water overall is capable of functioning without the help of hooded handlers. It cannot even stand still for too long.

EXERCISE. Is the entire thing in **Figure 7.7** ("Ghost Rider" by Albert Szukalski, at Rhyolite, NV ; source) a machine? What is the black thing that looks like bicycle? What is the white thing that invokes a human form?

Therefore, the chemical fact of the abundance of water as solvent in the chemical systems of life, from the pre-biotic hypothetical soup to the jelly in the tissues of plants and animals, has been a necessary condition of the evolution not only of Bios, but also of the born out of the jelly in our brains Technos and everything in-between. We maintain our human shape because we are mostly liquid water, which has no shape of its own.

SOLVENT: AN IDEOGRAM

Let us take a **pattern look** at solvent.

Two crucial chemical concepts are not associated with a particular chemical structure: solvent and catalysis. The two ideas are closely linked in pattern chemistry. I have written a lot about catalysis, which is the very foundation of all forms of biological and social life. As for solvent, just think about the two thirds of the earth surface covered with water (66% with oceans) and the human body consisting of 60% water in adult males. Water is a ubiquitous and selective solvent, as important for what it dissolves as for what it does not.

The streaming, swirling, occasionally stumbling, sleeping, or paroxysmal time is the solvent of change—from a pattern viewpoint, of course, but this is an overstretched poetical metaphor. Don't take it seriously.

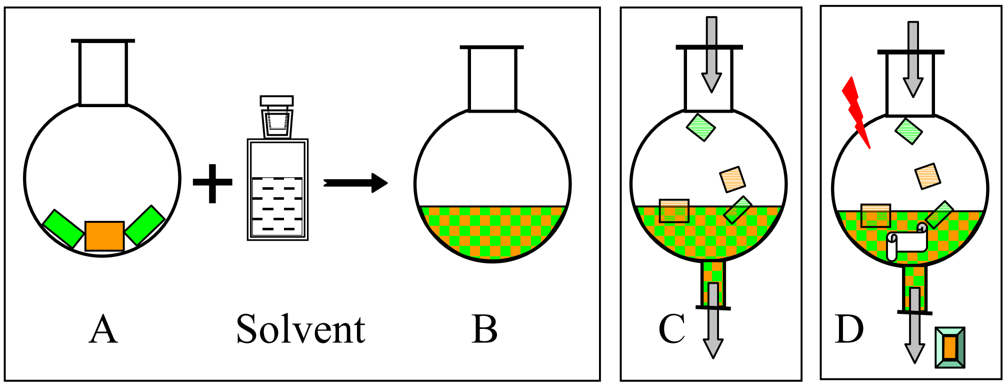


Figure 7.15. Solvent and catalyst ( ) as ideograms

Solid chunks in **Figure 7.15** (**A**) interact only at some surface points of contact. Dissolved substances (**B**) interact at any point of the volume and any molecule is within a limited distance from any other within a limited time interval. The higher the concentration of reagents, the faster they interact. In too much solvent the diluted interactions are slow and sleepy. Exystems, however, live not in a chemical flask but in the tank with a pipe and a drain from school math (**C**). What is too slow to react is carried away unchanged and ultimately everything, which is not renewed, is going down the drain anyway.

SOLVENT NETWORK MEMORY

In other words, the solvent "connects" each molecule with a large number of other molecules. In information science and technology, this situation is called network, in which server computers provide the connections. Inside each computer, server or not, the Random Access Memory (RAM) is a network of the same kind. I am not sure anybody sees it this way and there must be some reason for that. So, what is the difference between a network and RAM plus the processor? In RAM, all its elementary units are in the state of pre-bond, ready to be connected. It is not exactly a network in which some nodes are close, but others are not. Its topology is what is called full graph, **Figure 7.6 D**. In the Internet network, one user may not know about the existence of another and something has to catalyze the connection. This is done in many well-known ways.

The individual human memory is by no means a RAM and most of its cells are never retrieved side by side within a limited time interval, unless the individual has a natural

RAM-like memory for some special domains. For example, the rhyming poet has a developed ability to retrieve rhyming words regardless of their meaning, the artists, inventors, and scientists have the ability to connect subjects that have never been close in the minds of most people, and any professional in any areas has a RAM-like area in the mind.
What does it mean "RAM-like," by the way? It is not the practically instant electronic connection, but at least a fast enough one. Creativity needs some time, but for most people outside their profession (from astrophysics to burglary) this time exceeds the life span.

The most telling fact about creative act, like solving a scientific or technical problem, is that it takes a completely unpredictable time. I interpret it as the pattern similarity of the process of thinking to a chemical reaction with a single set of molecules. The time of a transformation of a quantum object—which is the essence of chemical reaction—is predictable only as an average, but not individually. Thoughts in a single mind, I assume, exist in single copies. Not so in the collective mindset of the crowd, however, which makes opinion polling possible, if not flawless.

In chemistry, a collision between particles is the counterpart of an act of communication between the nodes of the network. The term for both is **interaction**. Molecules run around and collide, exchanging energy, while the telephone and Internet users exchange information from their chairs and car seats. Solvent and network do their job by nearly nullifying geometric distances, but nothing does it better than the solvent. What is in between? The totalitarian state that keeps an eye on every resident and processes his fate when the program requires.

I hope this Chapter segment, bringing solvent, network, memory, and totalitarian state together under one pattern, clarifies the ideas of Pattern Theory and its chemical time-involving branch more than anything else. Water, Internet, and our own twisted and bombarded minds epitomize the modern times and the secret police never sleeps.

DISTANCE

The earlier segment **SOLVENT NETWORK MEMORY** paragraph gives and example of what pattern means by bridging sub-domains of phenomena as distant as lab-bench /kitchen-counter chemistry with the social network of the Egypt revolution of 2011. Patterns nullify not just time and distance: they erase interdisciplinary borders. This is not an easy idea for the modern structures of knowledge, education, science, and humanities. It has never been easy since the novelist and scientist C. P. Snow first drew attention to the chasm between sciences and humanities in 1959.

EXERCISE. Pattern metrics. Pattern topology. What it means?

As for distance in space, the transportation and telecommunication of the recent half-century have been transforming the global pattern topology in the direction of proximization (from Latin *proximus*, nearest). This term has been invented and used in areas as different as Gestalt psychology, quantum physics and chemistry, political discourse analysis, and economic sustainability. It relates in all cases to a system in which all participants are topologically close to each other and involved in one way or another. Thus, in the last case (Peter McManners), it means solving economic problems not by outside control or abstract principles, but between members of community who have mutual interests, local as well as global, and communicate with each other.

> Proximization is a stage beyond globalization in which the imperative of sustainability is used to override raw global capitalism. This is not turning back history. It is progressing to a safe future, building on the best of our past achievements and backing off from the mistakes. The theories of free markets, deregulation and laissez-faire policy have been tried and tested and found wanting. (Peter McManners , also)

The author regards proximization as "return to a natural world order." I see in this quite reasonable idea a return to the **pattern** of democracy of the Greek city-state and tribal council. Any historical return is unnatural, except to a pattern. The proximization in **pattern** sense, in my opinion, is already a *fait accompli* and it is called globalization, for better or worse.

In no way I am criticizing Peter McManners' ideas. Just the opposite: they are so much against the tide, that they must be seriously considered and analyzed, all the more, because the current tide of economic ideas is really low.

CANYON AND TREE

I do not suggest any bridge between both or any radical change in education. I do not believe that anybody but a few poets could walk it back and forth over the dizzying depth. I just want to post a remote, less exotic, quite shallow, and nonetheless intellectually exciting place where both rims of the canyon join, as in any natural canyon or ravine, **Figure 7.16**.

"Patterns" is a place of neither knowledge nor performance but of understanding the landscape of Everything. I believe that poets and philosophers, following Lucretius, their Columbus of sorts, were the first to colonize it. Note that what we now call science was for a long time known as natural philosophy. Aristotelian physics was the point of emergence of natural philosophy.
Figure 7.16 presents configurations with connector topology of tree type (see **Figure 7.6 C**). The Grand Canyon and the oak tree are different patterns at a less abstract level: the canyon is the product of destruction of the earth surface, bit by bit, while the oak tree is the product of construction, cell by cell. One is an inversion of the other and both evolve from the same natural elements: lithosphere (uppermost solid layers), hydrosphere, atmosphere, and the sun (solar sphere) that brings all that in motion.

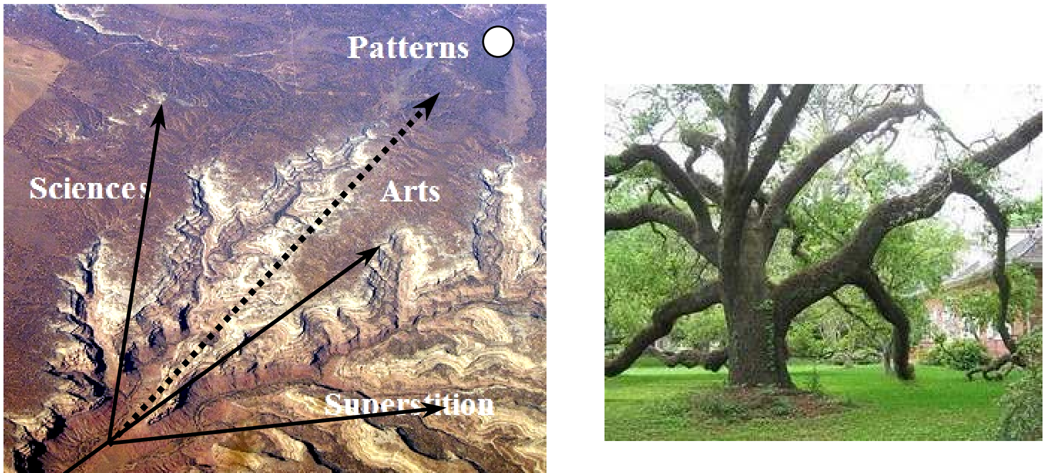


Figure 7.16 Aerial view of a part of Grand Canyon. Background photo: Federico Pozzi (source); old oak tree (source) . Each arrow has branches which are not shown.

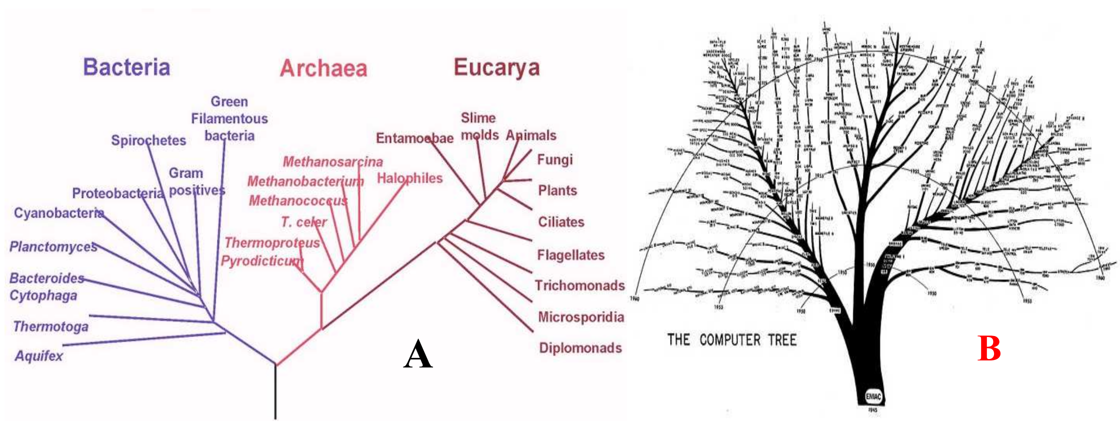


Figure 7.17 Phylogenetic tree of life (A) and "the computer tree" (B).
Numerous Web sources

FUTURE FISSION FUSION

The best-known (and still under the threat of the religious axe) pattern tree is the phylogenetic tree of life representing the origin of species and relations between them, **Figure 7.17**. It is also a great illustration of pattern systematics.

The explanation of an exystem is its history and the tree of origin is the most eloquent way to do that without words. Similar trees can be drawn for any domain of an exystem: law, tools, computers, games, etc.

Numerous trees of computer genealogy can be found on the web, but most of them are too detailed and literalistic, as in **Figure 7.17**. A more telling would be the **pattern tree** of information technology with similarity relations between species, for example, the conceptual relations of computer to TV and two-way telegraph as its pattern parents, in spite of the fact that telegraph was already dying when computer was born. At the root of the tree would be, probably, human gesture or, deeper, bird's song and even smell would sprout a branch each. It would be more like a human genealogy, with parents, progeny, and dense inbreeding. Technology is an exystem, as everything coming out of human touch, including humans themselves.

The main entertaining question of pattern futurology is: will humans and Technos ever split? The question sustains an army of sci-fi writers (and the optimistic eschatologist Ray Kurzweil), but it requires clarification: split as the canyon, with joint history, fragmented landscape and ever-increasing separation—like birds and lizards, humans and apes—or split as the tree, with joint biochemistry and genome?

The globe by definition is a single exystem with joint bio-techno-socio-econo-chemistry, but the roles of humans, Bios, and Technos are already changing. Humans have completely subjugated Bios and are assuming the double role of enzymes and source of dynamic chaos in Technos. Technos exemplifies order and a sufficient measure of chaos is all it needs to challenge humans.

By logical transitivity, Technos is moving toward domination for as long as there is enough energy and matter for it. The humans still have an option of Amish lifestyle as Plan B and of global Imperial China as Plan C.

DOMINANCE

Two more questions come to the foreground of pattern chemistry of the future: what are divergence and domination?

Dominance. Production and propagation of Technos is the leading exystemic process. We call it economy, but this term today comprises everything human, from family to politics. What is called *economy* is a very diffuse term that has no wiki-wiki (quick) definition in Wikipedia. It looks, however, that it is closer than ever before to its original Greek meaning of house management, only the only house we all know is the globe. Economy today is just all things considered, even the climate and distant planets. As in the ancient times, the slaves and even the domestic animals in the big house are skillfully scheming and manipulating the ostentatious masters.

I believe that humans and Bios adapt to Technos, not the opposite, because Technos evolves faster. I cannot logically substantiate my intuitive opinion. To compare, the slowly evolving nature—not the bacteria—yields to the pressure of humans where they breed faster and easier. Yet the humans among cell phones are like elephants among rats and the cell phones are irresistible because they smoothly fuse with human body.

In the Darwinian framework, as well as in chemical kinetics, the fastest breeder wins and the rest adapts to the change. The humans must make and buy things that are not necessary for their daily needs **today**, but will be **tomorrow**. The ads are self-fulfilling prophesies. This moves Technos ahead of the trailing humans.

ADAPTATION REPRESENTATION

On a personal note and as a disclaimer, I am neither a Luddite nor a Communist expropriator. I love intelligently made things and I lived in society that was poor because it had extreminated its rich proprietors, substituting concentration of power for concentration of money. I also feel an instinctive aversion to the principle of the middle road. I am in a pursuit of understanding, as if the present were history for me. I am as much dispassionate as I could possibly be regarding history. I am not pre-judging the future. I believe in human adaptation based on understanding the alternatives—the luxury no other member of exystemic community and participant of the evolution can have at the moment. What the participants—like biosphere, wild nature, pets, machines, young humans, dying humans—have is being represented by human individuals and institutions which pursue the interests of their constituency no matter what, with the zeal of religious wars of the past and present.

DIVERGENCE

Evolution generates new species from their common ancestor. We did not come from apes: both of us had a common ancestor. Following this pattern, the split of the global human civilization into new bio-techno-social (i.e., exystemic) species may follow the pathway for which, sorry to say, the estates (classes) of the *Ancien Régime* in France are a good template. This is what I call verticalization of society. The relentlessly growing demand for energy (oil and food) and commodities like chemical elements, the exploding population of poorer countries, and, more than anything, the growing inequality of richer countries are the signs of the next evolutionary turn of the screw.

Annoyed or entertained by the Tea-Party in America? Wait until the specter of Communism arises with its expropriation sickle and Politburo hammer. At least the Communists eulogized Darwin to prove that they were the latest and highest stage of history. Just joking. No, the image on the right is not my cup of tea.

Historically, there was time when science, arts, and superstition diverged from the common root. Although the canyon has the same topology as oak tree, it divides the whole landscape instead of uniting. It tells something about the nature of similarity transformation: it can be inversion instead of invariance.

Incidentally, "consolidation of vertical power" is the central motto of the doctrine of the Russian autocrat Valdimir Putin, which is effectively enforced in Putin's Russia and even more so in Communist China—two big nations with the doctrine of mandate of heaven for the emperor throughout most of history.

GRAY AREAS

The words life and technology have so many meanings that I need separate terms for the life of organisms and the life of man-made things: Bios and Technos, respectively. I also foresee an abstract possibility, as well as the first steps toward reality, of the life of thing-made things, for which I suggest to reserve the term Demos. No, we are not Humus, just good old humans.

Does anything ever fuse in pattern evolution? I do not mean what is called convergent evolution, like the wing in distant species. I mean a real fusion, i.e., hybridization of two distant types, like the progeny of two very different parents or machines.

I have not found on the Web any consistent comparison of Technos and Bios as systems. My search has been incomplete and I am sure that such ideas occurred to quite a few people. The thinkers in this area are mostly interested in the interaction of technology with humans. One of the ideas with long roots is technological determinism and the general attribution of priority of technology, starting with primitive tools, in human evolution.

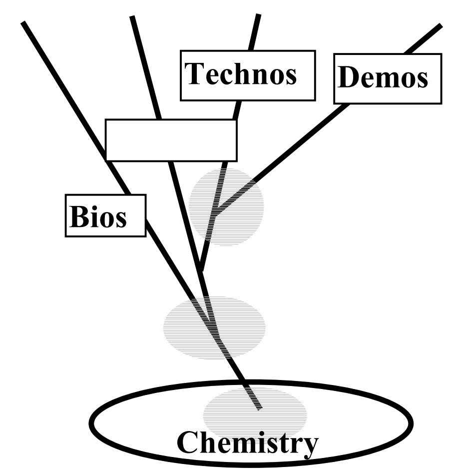


Figure 7-18 Evolution of global exystem and its gray areas

I am interested in the pattern similarity between organisms and man-made things. I see Technos as a branch of the evolutionary tree, **Figure 7.18**, which starts as the tree of life with roots in the chemical systems of Earth's hydrosphere.

Chemistry is the point of emergence of information, with its symbols and signs, from matter and their evolutionary split . Exystems, which are inherently doomed to die or change, produce a manual of their reconstitution or—if they are partially fluid societies of interacting agents—of their maintenance.

Two out of the three gray areas are obvious, but what is the third one? In my choice of Demos for the label of the last imaginary branch I was intuitively guided by the meaning of demos in Athenian democracy. It was not the entire population, but the citizens, i.e. **land owners**, divided into four open to mobility groups according to wealth. In fact, it was not democracy in modern meaning, at least, formally, but timocracy: the power of wealth.

The division into classes, established by Solon, was quantitative (source): those who were able to provide (1) 500, (2) 300, (3) 200, and (4) less than 200 bushels (*medimnoi*) of agricultural produce.

This is a great illustration to the problem of money, see **Chapter 3**. If you want scientific economics, burn the money and measure wealth in bushels, calories and kilowatt-hours.

I cannot give here more space to the fascinating story of Solon, his reforms, and their pattern relation, on many points inverse, to American democracy as both concept and reality. What is significant to me, the individual share of administrative power in society was directly related to the person's share in production of energy in its most human form of food and work, and, therefore, in a city-state, to land in possession.

Those who could afford a horse, were admitted to the second class The poor fourth class, the Thetes, might not have land, but they contributed physical energy to agriculture or to ship propulsion as oarsmen and they had a social weight, too. According to Plutarch, they "were not admitted to any office, but could come to the assembly, and act as jurors; which at first seemed nothing, but afterwards was found an enormous privilege, as almost every matter of dispute came before them in this latter capacity."

Clearly, Demos—citizens of Greek city-state—comprised people who did not need anybody's permission, authorization, or good will, to feed themselves. The slaves did need all that. Note that some of them provided not the physical work, but knowledge and what is called today information technology. If it is not yet clear against the background of the Great Recession, I will be unequivocal: the phenomenon of modern protracted unemployment is, in pattern sense, **similar** to slavery.

It is easy to see, at least for me, a pattern similarity between the social hierarchy and exystemic hierarchy in general, although the phenomenon of power is solely human. Demos, whatever it might be, with the genetic heritage of both humans and Technos, is going to compete with three other domains for energy …but here I reach the current limits of my imagination.

With all incoherence of this segment of the Chapter, I believe that some important new understanding of history may emerge from the **GRAY AREAS**, like the four domains, all with pattern-chemical genes in their branches, have been emerging from the chemical pool. Yet it needs more humans scratching their heads in which mysterious minds are housed.

DISTANCE

The earlier segment **SOLVENT NETWORK MEMORY** in this Chapter gives an example of what pattern means by bridging sub-domains of phenomena as distant as lab-bench /kitchen-counter chemistry with the social network of the Egypt revolution of 2011. Patterns nullify not just time and distance: they erase interdisciplinary borders. This is not an easy idea for the modern structures of knowledge, education, science, and humanities. It has never been easy since the novelist and scientist C. P. Snow first drew attention to the chasm between sciences and humanities in 1959.

EXERCISE. Pattern metrics. Pattern topology. What can it mean?

As for distance in space, the transportation and telecommunication of the recent half-century have been transforming the global pattern topology in the direction of proximization (from Latin *proximus*, nearest). This term has been invented and used in areas as different as Gestalt psychology, quantum physics and chemistry, political discourse analysis, and economic sustainability. It relates in all cases to a system in which all participants are topologically close to each other and involved in one way or another. Thus, in the last case (Peter MacMannus), it means solving economic problems not by outside control or abstract principles, but between members of community who have mutual interests, local as well as global, and communicate with each other.

> Proximization is a stage beyond globalization in which the imperative of sustainability is used to override raw global capitalism. This is not turning back history. It is progressing to a safe future, building on the best of our past achievements and backing off from the mistakes. The theories of free markets, deregulation and laissez-faire policy have been tried and tested and found wanting. (Peter MacMannus)

The author regards proximization as "return to a natural world order." I see in this quite reasonable idea a return to the **pattern** of democracy of the Greek city-state and tribal council. Any historical return is unnatural, except to a pattern. The proximization in **pattern** sense, in my opinion, is already a *fait accompli* and it is called globalization, for better or worse.

Now let us look back at the Athens before Solon through the eyes of Plutarch.

> And the disparity of fortune between the rich and the poor, at that time, also reached its height; so that the city seemed to be in a truly dangerous condition, and no other means for freeing it from disturbances and settling it to be possible but a despotic power. All the people were indebted to the rich; and either they tilled their land for their creditors, paying them a sixth part of the increase, and were, therefore, called Hectemorii and Thetes, or else they engaged their body for the debt, and might be seized, and either sent into slavery at home, or sold to strangers; some (for no law forbade it) were forced to sell their children, or fly their country to avoid the cruelty of their creditors; but the most part and the bravest of them began to combine together and encourage one another to stand to it, to choose a leader, to liberate the condemned debtors, divide the land, and change the government.

There is little direct historical evidence regarding Solon, but it looks like Athens were lucky to have a legislator who, along Plutarch, was "the only one not implicated in the troubles," or who "had not joined in the exactions of the rich, and was not involved in the necessities of the poor," and "did not show himself mean and submissive to the powerful, nor make his laws to pleasure those that chose him." Will any proximized community find such a leader? And who will repeat his unthinkable act of allegedly (no definite proof, however) abolishing all existing debts, even what his dishonest friends owed him and future enslavement for unpaid debt? Not quite unthinkable, however, see the Bible, *Leviticus 25*.

Exystems are inherently unequal: equality means death, equilibrium, deep freeze. Excessive inequality means instability, turmoil, revolution, war, expropriation, and verticalization of power, Russian style.

ROOTS OF UNDERSTANDING

Trimurti

The four domains **in Figure 7.18** are similar (in rich pattern sense) to Aristotle's earth, air, water, and fire. This similarity leads us to the seed from which both threes in **Figure 7.16** emerged.

The pattern of combinatorial creativity of a few basic elements can still be seen in the creation myths of many nations and in cyclic cosmology of major religions of

Asia. In Hinduism, the functions of creation, destruction, and maintenance of the world are performed by Brahma, Shiva, and Vishnu accordingly. The *trimurti*, as the triad is called, is often portrayed as a single entity. Even God the Creator of the Bible made a few later demonstrations of his destructive power. This apparently very abstract and esoteric area, however, is relevant for the understanding of the ongoing global changes, and, as I hope, of the entire pattern paradigm. Otherwise, it would be pure art. The very idea of a limited number of basic elements is a pattern of thought.

Looking into the ancient roots of the modern picture of the world, including superstitions, we find ancient patterns that might be still relevant for understanding modern-day events. Thus, the revolutions of 2011 in the Middle East may be successful in their initial destructive stages, but can they be followed by stabilization? What kind of maintenance and creation is needed? What are the differences between the major national mentalities? What is the connection between Eastern fatalism, Christian hope, and resulting economies? Which pattern is more stable: collectivism or individualism? What does Confucianism mean for the future evolution of China? Why prescriptive religions, like Orthodox Judaism and extreme fundamentalist Islam, produce enclaves isolated from global economy? Why is it so difficult for Russia to get rid of the authoritarian government in spite of the centuries long openness to Western knowledge and culture? Ancient patterns are extremely stubborn. Are new pattern possible? Can the globally deity of growth be worshipped in spite of scientific impossibility of unlimited growth? Isn't the ideology of economic growth just another superstition? Or religion? In a way, to deny that nothing can last forever is the same as to believe in afterlife.

By asking, rhetorically, not as an **EXERCISE**, the above questions, I am trying to justify the building of a Pattern Retreat near the currently uninhabited site where the rims of the canyon in **Figure 7.16** join. It is marked with the white spot.

As regards the construction lot, I cannot resist the temptation to digress on land: the earthy, not the ideal one. Most people in developed nations do not work on land which itself is a mediator between the energy of the sun and ATP in human cells. Technos separates humans from the human source of energy—land—with so many layers of other mediators that the human lifelines can be easily squeezed and cut. It is so easy to do because the currency of energy has to switch from ATP to $$$ before it takes the natural ATP form. Instead of spreading in space (of land), humans have to spread in time, on the promise of tomorrow's money convertible into ATP.

Prolonged unemployment without access to land is the modern plague—whether raging or dormant. It takes a lot of forms, some violent, some self-destructive, some crazy. It works as the opposite of money: not by promise but by despair. Albert Camus identified and named by a medical name a very large social pattern. Depression is another medical name on an equally large pattern. As Camus believed, "it comes for the bane and enlightening of men." It is hardly in any sense creative for the victim.

DESTRUCTION AND CREATION

With all the inverse similarity between the canyon and the tree, what is the reason for the dramatic contrast of geological destruction and biological creation?

Destruction is a change from a definite order to an undefined state. When we take apart a Lego structure and arrange the individual blocks in some defined order, like grouping by color and size, we go from one order to another, even while performing deconstruction. In real world, however, what matters is what happens to the bonds between the "atoms," i.e., generators, in PT terminology. The bonds in inanimate nature, including Technos, are predominantly positive: they require energy to break. The bonds in Bios and society are predominantly negative: they require energy to maintain. Even the strongest family bonds can dissolve in extreme situations. When water erodes soil and rock, its energy breaks the positive bonds between solid particles in the process of destruction. When a tree grows, the energy of the sun is used to lock and maintain bonds between atoms in dividing cells in the process of construction along the inherited template. "The flow of time" is just a metaphor. Time erodes negative bonds in human relations and institutions just because they do not need anything to fall apart or mutate.

Destruction does not need any sophisticated manual. It will happen regardless of whether we want it or not because any non-equilibrium system will move toward equilibrium, unless it is maintained by machine, human, or god. Construction needs a manual, and so does an ordered deconstruction—taking apart—of a complex structure.

IDEOGRAM

Back to the solvent—an exotic but meaningful template for a pattern of interaction.

EXERCISE. The liquid solvent spontaneously dissolves solid matter by breaking **positive** bonds. Where does the energy for that process come?

EXERCISE. Does the Internet and social networks dissolve social bonds? Are social bonds positive? Negative?

Titian: Allegory of Prudence

Scientists enthusiastically use metaphors in their popularizations. The best example that I know is the metaphor of money, which biochemists use to explain ATP (adenosine triphosphate). Alas, money is not as material and full-bodied as water, although it can run between the fingers in exactly the same way.

EXERCISE. Is money material? If not, what is the evidence?

I see water, an exemplary solvent, as an **ideogram** because I take it not as an abstraction, but a full-bodied phenomenon of a real world. Ideogram has its parallel in the allegory in the domain of arts and humanities. It is not a fleeting metaphor, but an extended, detailed, and realistic presentation of a phenomenon similar to another phenomenon in a different area.

Allegory can be verbal (a staple of Socratic method and religious sermons) or visual, as Titian's *Allegory of Prudence*, which is more interesting as an illustration of similarity transformation for a pattern of behavior of humans, nations, and civilizations evolving with age. Since *allegory* has its established meaning in arts, I prefer **ideogram** as a somewhat wider pattern term. Ideogram can be chosen as a representative tag of a pattern, or as its pattern template, or both.

FREEZING

The solvent works only if it is liquid. The solid frozen solution limits the movement of molecules and they slowly interact only with close neighbors. Numerous membranes of cells and their components do the same job of compartmentalization and limiting the solvent effect of water. The same can be said about prisons, allegorically. The federal design of US limits the political influence of government, whether Federal or State, but leaves doors open in the way of business.

Suppose, there is a factor which suppresses the digital communication not because of somebody's ill will—that can happen, too—but because of some reason like general scarcity of resources, lack of energy, standardization of life, limited choice, loss of curiosity, etc. Then the society already dissolved in the total communication created by Technos becomes a solid system with limited numbers of degrees of freedom. It turns into a single mechanism or, as sci-fi writers imagine it, a depleted of energy totalitarian system: a clockwork, which the master sets and winds up.

We are, probably, still evolutionary babies in history, but whether we should enjoy this jovial stage or speed up the transformation into a social clockwork is a matter of individual choice, while the trend is a matter of necessity. The social network is designed as a powerful mechanism of peer pressure (do and buy what the friends do and buy) and is in this sense a giant cooler, if not yet freezer. If this is a progress, then from babies to perennial teenagers.

In the open-ended evolution, every stage is a kind of childhood. Yet if patterns are our surrogates of physical laws of nature, we can more or less predict the adulthood and senility.

> **EXERCISE :** Communication network, as it was often noted, can be used for both connection, as in the successful revolutions of the twenty-first century, and isolation, as in authoritarian repressive societies like Iran and China. Do geological erosion by rivers and repression of communication belong to the same pattern? What about the tree growth and development of social cohesion? [Yes, I know, this is overboard. Skip it.]

CATALYST

The catalyst, represented in **Figure 7.15 D** as a small white banner, contains a plan of the product assembly, which is one of many possibilities of a spontaneous process. The catalyst makes it highly probable, although mistakes are possible, not by any magic, but by speeding it up, so that other possibilities have no time to occur. The catalyst is the part of the system that must remain unchanged after use, like DNA or *The Rules of the Road*. This is so unnatural anywhere except chemistry! Catalysis is the oldest phenomenon in the natural history of exystems.

Catalyst is the most primitive machine: it repeats its act indefinitely. The catalyst has no source of energy. Instead the molecules take up the job of moving the assembly line and supplying it with parts because of their thermal energy and spontaneous movement. Yet in a different design, which is inversely similar to molecular catalysis, a machine uses the catalyst (template, code) and **energy** to perform assembly of blocks by locking **negative** bonds, in spite of internal chaos. In an intermediate design, the social machine/organism uses the law, written and oral, as a catalyst to **maintain** human molecules (agents) capable of both chaos and order within a certain pattern of behavior. In this design, both government and citizens need external energy. What a strange world!

EXERCISE. Is pattern a catalyst? A mechanism? A machine?

STABILIZATION

The observers of the Middle East turmoil in February 2011 ask the most important question in the live prognostics of a revolution: what is the template for the stable state? Is it the harsh mechanical ideal of Stalin and the tribal Stalinism of Taliban (individual as a little screw in the machine)? Is it a blueprint of parliamentary democracy? Is it the Russian or Chinese oligarchy on the dog leash of the authoritarian master? Is it the Turkish model, still successful, which was single-handedly enforced by Atatürk? Is it the Israeli schizophrenic blend of democracy and state religion?

COLLISIONS AND COMMUNICATION

To understand what is happening right before our eyes in human matters, let us generalize the notion of interaction to cover both (1) spatial contacts with the exchange of energy, i.e., physical collisions and interactions, and (2) information exchange requiring little energy and negligible physical action. The emerging picture is the humanity as a drop of "pattern water" in which humans are capable of interaction by talking, calling, mailing, and social networking, as opposite of the physical clash of molecules. In fact, this interaction is still highly ordered by the apparatus of social cells, national tissues, and cultural and economical organisms.

As a bit sinister mental experiment, we can draw an evolutionary line from the exchange of energy, sometimes one-way, by physical collision (fight, predation, robbery) to the exchange of energy in the currency of money through information (purchase, taxation, and fraud). Continuing this evolutionary line we come to the major destabilizing contradiction of the modern digitized world: demanding **instant** gratification with **deferred** payment.

MONEY AND STABILITY

The difference between ATP and, say, the currency of US dollar is truly dramatic: ATP is material, "hard-scientific" and well defined, while the dollar in accounting ledgers and digital files is symbolic, fluctuating, most often just promissory, and sometimes fake. It quasi-materializes only in the act of exchange. The two stages of every exchange (payment and delivery), however, can be separated in time, to somebody's good luck or bad loss.

Home mortgage is an outrageously soft arrangement, in which payment and delivery can be separated by decades, which in our times and places is economic half-eternity. Catastrophic insurance is of the same kind.

Not a good way to wealth

Few things in economics are as often repeated and as poorly remembered as the nature of money: it is only as good as the government that prints it. Nothing else in modern society is so well remembered as the only way to **insure money** against loss: to amass it as much as possible, best of all, billions. It would not harm to convert part of the money into power and freeze the government with a smile on the face turned to business and a painted smile on the backside. Anyway, democracy is also but a promise, although by no means of money.

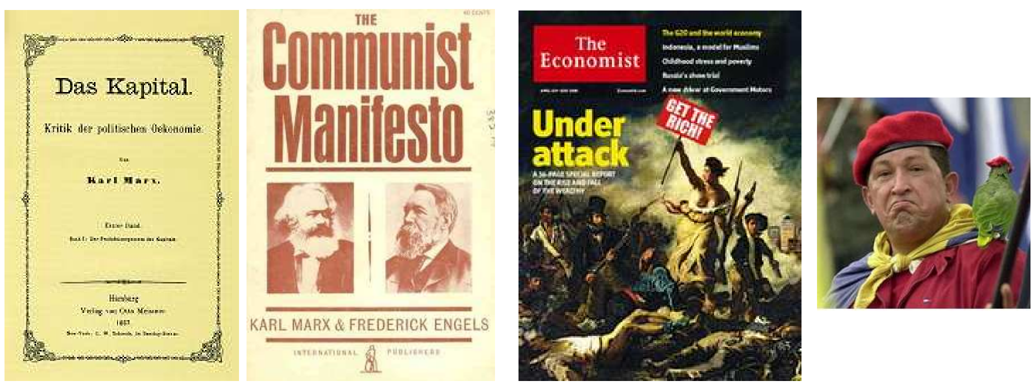


Figure 7.19 The specter of expropriation and its recent appearances.

Left to right: *Das Kapital* by Karl Marx, *The Communist Manifesto*, the cover of *The Economist* of April 4th-10th 2009, and Hugo Chavez (Venezuela)

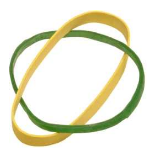
The reliance on a mythical "hard science" view of perpetually soft human matters was one of the deepest causes of the Great Recession—in my view, not just the deepest, but also as hard as the rock of Gibraltar. Whatever does not follow a law of conservation is not hard science. But patterns are conserved throughout history, although they are capable of falling asleep and wake up and are not numbers.

Possibly the craziest idea in modern world would be the fear of too much wealth. **Figure 7.19** offers a hint to one of rare dinosaurs in the pattern world. I do not want to follow this storyline, but I keep Russian history in mind. As for the pattern causes of exystemic instability, I will go on.

ENERGY AND STRESS

From school physics we acquire the notion of energy as a measurable physical property of the same kind as number, mass, speed, volume, work, temperature, and pressure. Energy, however, is a curious exception from the above matter-of-fact solid properties: it is a window into the future. If energy of a system goes up, something is going to happen, although we do not know when. If part of energy is lost, the chances of a future change decrease. At an equilibrium, which is an idealization nowhere to be found on earth, the energy cannot go any lower.

In human matters, energy is a too vague but overused term.



Instant gratification by deferred payment is an example of a subtle logical contradiction. Something cannot be instant and deferred at the same time. Gratification (**G**) and payment (**P**), however, are two different things and plastic money seems to reconcile both stages of the transaction in the smoothest possible way. The problem is that **G** and **P** are not independent: they are bonded. Not only that, but the bond is also stretchable—over time—like a rubber band.

DEBT CREDIT

Rubber band is a stretchable in space material, i.e., not an abstract idea or a chunk of information, and its energy increases with stretching.

The phenomenon of credit is not something you can literally put your finger on. It is the **bond** between the act of possession at one moment of time and the act of payment in another. This bond is negative: it requires the force of social institutions (in the past, the threat of prison), to be maintained in place. Nothing physically prevents me from buying today a thing on plastic, walking away, and refusing to pay a month later, except the fear of a subsequent stressful situation.

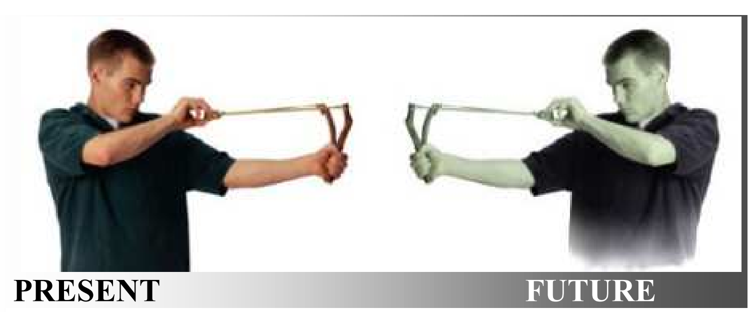


Figure 7.20 Allegory of debt (and financial crisis, energy crisis, revolution, pollution, and God knows what else)

While there is obviously a similarity between physical stress measured in physical energy and social and psychological stress, which has no measure even remotely comparable with physical force, we do not have any scale to compare them. Human matters can be about brute physical force, but mostly they are about a system of relations: bonds in a configuration. Physics does not apply to human matters, unless from a very specific angle. Still, we can feel a growing psychological stress as clearly as the stress of a stretched rubber. We know that the future can strike back.

Here I feel an urge to come back to Peter McManners idea of proximization. It might work in time in the following way: any spread of economic exchange in time must be discouraged. It may even apply to open-end processes of change, like simplification of taxation, greening of energy supply, and all kinds of reform. In times of instability, all good intentions age very quickly.

INEQUALITY TEMPERATURE INSTABILITY

Instead of energy, entropy, and physical temperature, let us use their pattern generalization for any dynamic system with communication (acts of exchange). They are:

(1) Instability:
The higher instability, the more probable spontaneous change.

(2) Inequality of distribution of an exchangeable value:
The higher inequality of distribution, the higher instability.

(3) Generalized "metaphoric" temperature (like in colloquial expressions from "hot water" and "hot potato" to "hot chick" and "hot pants").
The higher the "temperature," the higher instability.

With this kind of metaphysics instead of physics we can hardly calculate the time of the next Great Recession (…Depression, Repression, Revolution, Reaction… etc.), but we can have a clear interpretation of the vital signs of the exystem: the growing income inequality increases instability, the growing number of demonstrations, strikes, protests, incendiary propaganda increases instability, and increasing instability brings a financial crisis, war, civil war, change of power, sharp change of policy, revolution, etc., closer.

Historical experience and common sense would help connecting the dots without any pattern chemistry. But when we deal with probability, we want to know how big or small it is. Even the weather forecast today is accompanied by the likelihood figures for rain or snowstorm.

TRANSITION STATE AND KINETICS

In this segment I repeat, in a nutshell, how chemistry approaches forecasting the outcome of a transformation. For more, see **complexity** and numerous Web materials.

Consider the typical transformation of exchange:

$$\underset{\text{Initial state}}{\mathbf{A—B + C—D}} \rightarrow \underset{\text{Transition state}}{\mathbf{[A\ B\ C\ D]^*}} \rightarrow \underset{\text{Final state}}{\mathbf{A—C + B—D}},$$

Note that we are looking not at anything tangible and "real," but at patterns. It is mathematics without numbers. The number of possible "chemical" patterns at such an abstract level is limited. It is chemistry without molecules and it looks flippantly simple.

Figure 7.20 A presents the typical reversible change in stability for a molecular system. The final state can be either more or less stable than the initial state and the sign of the difference determines the position of equilibrium, which is shifted toward more stable states.

Figure 7.20 B presents irreversible alternatives for a more general situation, molecular as well as exystemic, when there are two (or more) transition states that lead to either the same or two (or more) final states each, with possibly overlapping results. This central for chemistry paradigm is a pattern of low complexity. All stable states are in the topological neighborhood of the corresponding unstable state.
What is the logical necessity of the unstable transition state? If not for that, all chemical diversity of molecules in a closed volume would immediately come to equilibrium and nothing else would ever happen.

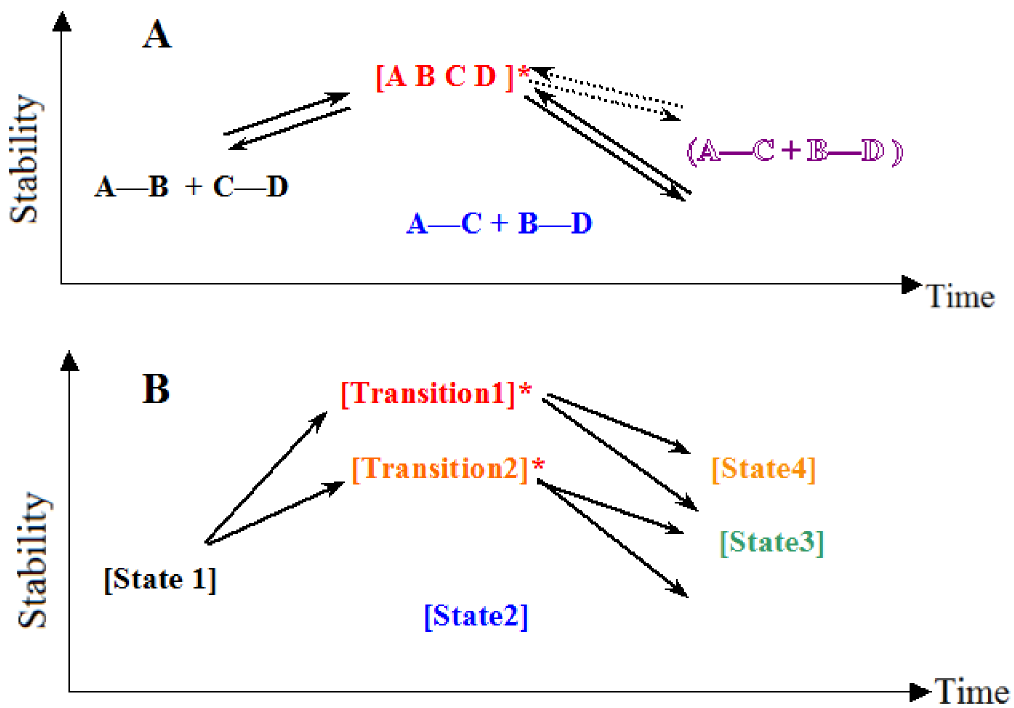
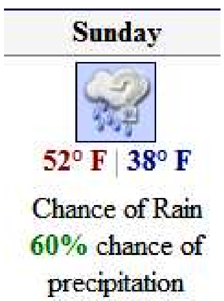


Figure 7.20. Distribution of stability over time of transformation

Social psychology is, essentially, the chemistry of human interaction. It replicates the chemical ideas of bond, attraction, repulsion, and stability. The concept of cognitive dissonance belongs to the simplest chemical pattern with an unstable (stressful) intermediate state between two stable mutually exclusive ones. There are, probably, observations on the speed of such processes as problem solving by a group, reorganization, adaptation to different management, etc., but the speed of wedding and divorce depending on the circumstances is the subject open to all lay people.

How can we use this paradigm in understanding the behavior of exystems?

First of all, we have to reconcile with the simplicity and its drawbacks: for esoteric theorems, equations, and numbers you will be paid by the page, symbol, number, and dollar sign.



Second, we have to reconcile with a limited predictive capability. All we can do at this point is to present alternatives.

Nevertheless, I believe that in the computer era it is possible to have an approximation of the state of economy in real time and predict the next state at least with the average weather forecast precision: "Chance of market collapse 60%" or "Possible severe tornadoes in smart phones, " or "Drought in oil supply."

Third, we have to anticipate possible futility of our efforts: neither business not government needs everybody to know everything. Knowledge is power for as much as it is proprietary and concentrated in a few hands.

AMENDMENT IN THE NATURE OF A SUBSTITUTE TO H.R. 4872, AS REPORTED
……………………….
(2) in paragraph (3)--
(A) in subparagraph
(A), by striking "$750" and inserting "$695";
(B) in subparagraph (B),
by striking "$495" and inserting "$325"; and
(C) in subparagraph (D)-- (i) in the matter preceding clause (i),
by striking "$750" and inserting "$695";
…………………………
A fragment of USHousespeak

Finally, we need not the numeric results, not even like "60% chance of defense budget cuts," but the differences, trends, and comparisons in terms of MORE and LESS. Generally, this would not satisfy either hard science and technology or those mysterious people who write 1000 pages congressional bills full of remarkably specific small numbers and large numbers rounded to billions. But because chemical patterns are discrete and small, the difference between yes and no, more or less, up or down, and fast or slow could be distinct and of sufficient importance.

Patterns are instruments of our thinking with a naked mind, without a sheet of paper and computer, on the fly, off the limelight of consciousness, and they work only because they are small. In a way—pattern way, of course—they are comparable to the Stone Age tools, which can still be functional in dire need.

FINANCIAL CRISIS

What is the pattern-chemical cause of the Great Recession of 2008? It is the critically high and growing inequality of wealth. In all systems, from physical to social, in which molecules or people exchange energy or energy-like money, the inequality of distribution is synonymous with instability. The fine analysis of this universal dynamic pattern is beyond my capacity, but somebody might do that someday for exystems.

Whatever kind of social inequality—wealth or political power—reaches a certain critical limit, stress builds up and a subsequent change of pattern follows.

Pattern cannot change continuously. This is why we feel it as a more or less sharp shock, although it can last long years, as the Great Depression did. This is the most universal pattern of history, unless some Solon the Wise takes the steering wheel, which almost never happens nowadays.

MORE AND LESS

In idealized physical and chemical systems energy by definition is a measure of the potential or actual change. In non-equilibrium systems the picture is much less clear and can be described only in relative terms. "The thermodynamic study of non-equilibrium systems requires more general concepts than are dealt with by equilibrium thermodynamics. " (a very good article on non-equilibrium systems in Wikipedia). Mathematical inequality, denoted with < , LESS, and >, MORE, is a more general concept than = , equality. In particular, the principal difficulty of describing non-equilibrium systems, of which exystems are most complex, follows from the need to measure and calculate order/disorder, i.e., entropy. We can do that—in principle or at least to discuss it—for something with more or less clear boundaries, for example, the planet Earth. We can use for that data that make sense only in space around the Earth, disregarding internal complexity of the planet.

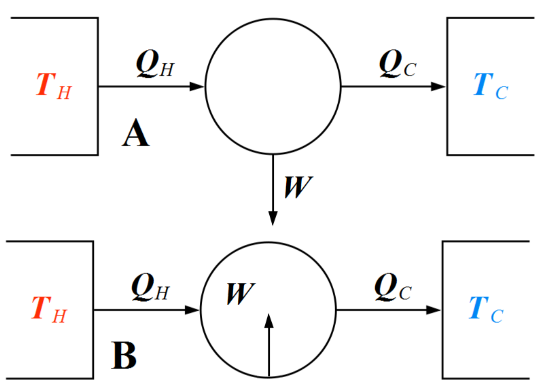


Figure 7.21 Non-equilibrium systems: thermal engine (A) and planet Earth (b)

Entropy is a controversial subject for anything but simple physical models. As I found out, not for export, any measure of inequality of distribution, for example Gini coefficient, does the job in a completely satisfying way.

I borrow **Figure 7.21A** from Wikipedia's articles on thermodynamics. It shows a non-equilibrium system, heat engine, that uses a flow of energy from the hot source on the left to the cold source on the right and performs work W on the outside. This is a pattern and car engine is one of its configurations.

I deform **A** into **B** by inverting the arrow **W**. Now it produces work on the inside of the system by taking organized (convertible into work) energy from the hot source and dissipating it in a less organized form into the space. This is how the existence of Bios, humans, and Technos perpetuates on planet Earth.

GINI COEFFICIENT

Over twenty years ago, when I came to America, I was struck by two economic charts I had never seen in Russia: inflation and inequality (Gini coefficient). They had a point of sharp change of slope. Something radical had happened around 1970, after which both indices rushed up like mad.

While nobody is surprised that decline naturally stops at zero, people have a religious faith in growth that can go on indefinitely and even accelerate. Any acceleration, however, is a sure sign of a coming qualitative change, whether disastrous or not. It means that there is an unbalanced force

In 2011, the third year of the Great Recession, the Gini has been released from the bottle. A remarkable number of economists, observers, and serious politicians look at the getting uglier every day American Gini coefficient with an instinctive fear, which they express and interpret in various ways. Science is a cooperative occupation; at least it used to be. Economics and politics are competitive trades. More about Gini, see Chapter 6.

WEALTH

The way of life and social function of the super-rich begins to attract serious attention. I do not want to be distracted here by this still little researched subject, but all my personal experience and world literature make me think that the super-rich are the best candidates for the next evolutionary split on the phylogenetic tree of humans.

I do not think we should suspect the "superrs" of malice and accuse them of ill intent. This category of wealth has been created by digital Technos and it is very different from the wealth of the past. The same Technos that had created better mousetraps, automobile, space stations, and Internet, invented better money-making machines, as expensive as a space rocket, rather than as a Lamborghini. Without being formally incorporated into government and institutions of power, unlike the aristocracy of the past, the "superrs" influence the course of history by tilting the economic axis of the entire earth without even realizing that. This is a historically unprecedented power, comparable only with the Russian and Chinese revolutions and potentially as destructive. In the previous history it could happen only in selected parts of the globe. If I were and an economist, I would investigate whether the counterbalancing mechanisms are theoretically possible at all. If I were a sociologist, I would investigate whether the government, enabled by computers to generate unreadable 2000-pages bills, can be bought as any other machine, with its computers, pencils, and erasers, lock, stock, and barrel.

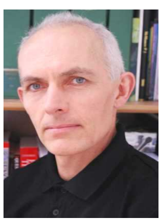
IMPORTANT: **Inequality is natural** and beneficial for society. Concentration of wealth is the source of all progress and national well-being, as well as culture, arts, sciences, and humanities. Egalitarian societies and communities stagnate and end up in dictatorships. The equality has to be enforced, while inequality is naturally self-maintained.

Above a certain level of inequality, however, the society loses stability and changes form. This is a very general property of all non-equilibrium dynamic systems in which components exchange energy (money) and information with each other. Surprisingly little is known about the laws of behavior of such systems and the role of inequality. We have never had 500 emperors in nation. This is the novelty of our current situation and the cause of the financial crisis. We are in a transition state leading to something new. The only tool for understanding the new is and old pattern. I am calling back to the podium Plutarch, who noted that the Thetes, the poorest Athenians had neither wealth nor administrative positions. What they had was the voting power and it caused a lot of trouble to the Athenian hierarchy.

The nature of the recent American stress is the same as in all "de-proximizations." With the growth of inequality and the proximization of communication (Internet, cmart phones, and social networks) , the centers of gravity in financial power and the voting power are becoming as far removed as never before. The rich are a democratic voting minority and the poor are a democratic voting majority. Something has to change and the only way is proximization: the easing—not erasing—of wealth inequality distribution, not its erasing. What I don't see is a Solon-like figure. This is the era of transfer from the military-industrial complex to a financial-digital complex.

ENERGY CRISIS

The accumulation of coal and, probably, mineral oil from the remnants of plants or animals created throughout millions of years by the energy of the sun is an example of the main physical problem with exystems: they create something that can be compressed into a pattern, but not into a calculable parameter: complexity of real-world configurations.


Peter McManners

I can formulate a more specific problem of humanity: there is a huge time span between the creation of the source of energy and its use by humans. It stretches the pattern rubber band between the past and the presence in a way similar to the stress created by the separation of gratification and payment in credit: the stress of distance between present and future. It creates debt that cannot be repaid. I am finding find the *proximization* of Peter McManners more and more attractive as a pattern of thought.

POPULATION STRESS

In Russia and China the revolutions resulted in the historically unprecedented results: the complete eradication of private property in Russia and the severe restriction of the instinctive drive of all living beings to reproduce and multiply. Both have been time bombs, one, made in China, still unexploded, although it had quite rational motives.

The natural waning of the previously powerful reproducing drive in Europe and Russia tells me more than anything else that Technos begins to dominate humans. As "sheep ate men" (Thomas More, 1516), things eat people. The inequality of the birthrate across the globe creates yet another powerful pattern stress. The social and ethnic shifts, already sensed in Europe, can happen anywhere.

HOPE
COURAGE
UNDERSTANDING

I can keep jumping all over the exystemic tree for fifty more pages, but I must stop somewhere and I am going to do it right now. *Sapienti satis*.

My final question is: how we, humans, have to look into the future?

We cannot stop evolution, but we can adapt to anything. To adapt does not mean to submit.

I believe, we need hope and courage. But we can believe only in ourselves. Our only hope is not knowledge—we cannot know the yet unknown—but understanding: the art of acquiring knowledge. We have to try yet another apple from the tree of understanding and bravely meet the consequences.

Draft, unfinished

8. PATTERN CHEMISTRY OF INFORMATION INSECURITY

8.1. Preamble

I am not an information technology professional, but I would not consider information security as my subject if I were competent in it. As an outsider, I do not provide any answers and practical solutions and do not seek any rewards. Instead, I enjoy unlimited freedom of thought.

By the way, what is thought? This Chapter could have a different title: PATTERN CHEMISTRY OF NON-ALGORITHMIC THINKING, but it is too preliminary and narrow in scope. Maybe next time I will be able to expand it.

I intend this Chapter as an exercise in pattern chemistry, which means, of course, exercise in thinking. The idea is to take some complicated subject, as far from chemistry as possible, and look at it in chemical light. Information security is far enough: it is the perfect soil to plant some seeds of productive doubt.

Information insecurity comprises cyberwar, computer crime, hacking, Internet abuse, malware, phishing, and scores of other infractions in the new brave world of digital threat, sin, and evil. In response, it faces a whole industry of pest control with a cornucopia of counter-tricks.

The fight against insecurity is conceptually akin to medicine, traffic control, reliability of bridges, etc., not to mention crime in general. All those areas include events that are, in a sense, natural, normal, and bound to happen. The task is to decrease their frequency. This is where similarity with chemistry starts.

> Chemical transformations of the same starting substance usually run concurrently in many directions. Chemists want to increase the yield of the desired product in its mixture with various unwanted products. The standard chemical method to this end is catalysis: speeding up the desired outcome or slowing down (inhibiting) the unwanted one. This is a very general, if not the only one, pattern strategy of controlling events in exystems.
>
> Chemical catalysis is based on the principle that very crudely can be stated as follows. Suppose we have several possible events starting with **A**: **A→ B**, **A→C**, and **A→D**. If we speed up **A→B**, then there will be less **A** to turn into **C** and **D**. This principle works in chemistry statistically, due to the large number of participating species, but pattern chemistry is intended mostly for singular events. Obviously, digital defense widely uses this principle, which chemistry calls "kinetic" and digital security calls "dynamic." More generally, it is known as competition, or THE EARLY BIRD GETS THE WORM.

Leaving the theoretical and practical problems of Internet security to professionals, I am trying here to do something different: to explore the pattern-chemical mechanism of our **thinking** on the subject of Internet security. This is only a rough sketch of the idea. Indeed, if the digital age floods our life with novelty (which mostly turns into junk next morning) at the speed and intensity of a tsunami, how can we solve new problems if they are dramatically new? I suspect that we do it by using long-lasting patterns of thinking in a way similar to how an engineer uses old physical equations to solve new technical problems. We take a template, probably coming from Isaac Newton (1643–1727) or Daniel Bernoulli (1700–1782)), and transform it to apply to the new object by preserving the invariance of the venerable ancient equations or at least some core in them.
We assume that the physical laws of nature have not changed for a few millenia. Dealing with problems in human matters and exystems in general, we do not have a sufficient stock of hard knowledge because our object is either unique, or singular, or evolving right before our eyes, or all of the above. Patterns are our surrogate "equations." While hard science deplores analogies, except in popularizations, we simply do not have anything else in everyday human matters.

I believe that the professionals have already arrived at the realization that human nature, not algorithms and computation, are the heart of the matter of digital security, regardless of whether there is any matter in bits and bytes. Human nature, made of gold and dirt, with the affinity to both, is the weakest link against the lure of the whole Internet bestiary from junk mail to WikiLeaks.

> While cyberspace has been recognized "as a new domain of warfare" along with "land, sea, air, and space," one more domain is strangely missing from the list: human mind.
>
> In America, a fierce, cruel, and commonly dishonest war has been fought at least every two years on the election battlefields, where the digital media have been the main weapon of disinformation and sedition, as well as transparency and truth-finding. It may seem strange that the rich history of this democratic process has not been effectively used in the war against international terrorism. Its occasional futility in democracy may turn to efficiency against extremist, totalitarian, and tribal systems.

Why is human nature such a difficult, unyielding problem in digital age? I would say it is because all humans are different while all digits are the same. The digital age levels out the battlefield for both the state and the individual by empowering the individual and enfeebling the institution. This sounds like a Tea Party program come true, but the result—of the TP program, too—can only be disarming everybody, except a strong hand, against chaos.

While the physical power of two policemen doubles the power of one, nobody can say that in any sense the intellectual—or physical—power of two people glued to their computers is twice the power of one. After subtracting the power of digits, all that remains is the contest of two human minds of about the same size, not the muscles, terabytes, or gigawatts. In addition, the hackers can also be marshaled into an army very similar to the loosely connected terrorist franchise of al-Qaeda type, which invests its power more in mind than matter. If they have no capital city and not even a beach front retreat, how can you bomb them out?

My main impetus comes from highly stimulating discussions on a wide range of subjects with Benjamin Long (NIST), to whom I am greatly indebted. The additional push came from Defending a New Domain, by William J. Lynn III (Foreign Affairs, September/October 2010). Since 2010, increasingly sinister information on cyber threat has been coming from all sides. It might have been filtered before.

The same year *Cyber War* by Richard A. Clarke and Robert K. Knake appeared (ECCO/ HarperCollins). Since it is impossible for a lay reader to distinguish fact from fiction in this book, the best we can do is to append question marks to all its assertions. As a believer in the simple truth that a good question is half the answer, I see this however imperfect book as an intelligent half-way point of no return on the way to answers.

8.2. Pattern Theory and Pattern Chemistry

I have already described many times in complexity what pattern chemistry is about: novelty in exystems, or, ultimately, understanding the future of evolving complex systems in which we live. The last time I did it in this Part 4, Chapter 2, PATTERN CHEMISTRY ON ONE FOOT. The following repetitions are addressed to those who are interested only in the subject of this Chapter. If the reader is familiar with my other e-publications, this section can be skipped, although I am trying to take here a slightly different angle by asking the following couple centuries old question:

> If the new is what we do not know, how can we understand it?

Pattern chemistry is a small outgrowth of the well-developed **Pattern Theory** (PT) of Ulf Grenander (Brown University). I believe that PT can open a scientific way toward understanding human matters and including the future into the picture of the world commensurable with the human dimensions.

Patterns are counterparts of physical laws of nature in exystems (evolving complex systems). In such systems, to which human civilization belongs, the axiomatic foundation changes with time, which is, probably, the best way to define exystems. Patterns, however, are not only long-lasting and recurrent, but also relatively simple and limited in number because they leave out differences and retain the invariances. Patterns sift complexity off. Simplicity is one of the reasons why people follow old dogmatic ideologies.

Some half-ripe fruits of pattern chemistry can be found in the thorny thicket of my website spirospero behind the doors under complexity and simplicity signs. Numerous references and illustrations can be found in complexity. A unique introductory source for Pattern Theory is: Ulf Grenander, *Elements of Pattern Theory*, Johns Hopkins UP, 1996. Other sources can be found on the Web.

Molecular chemistry manages the enormous complexity of its subject by applying just a few core principles. Pattern Theory, from the chemical point of view, is a generalization of chemistry over all objects consisting of building blocks, real or imaginary, which is practically everything, from things to processes to thoughts to history. For PT there are no illegitimate subjects in human matters and nature.

Instead of repeating all the basics, I offer here, again, a very personal short annotation of Pattern Theory.

> Pattern Theory, like chemistry, represents state as a configuration of atomic generators (stable "particles" of Everything) connected by bonds. Sometimes the configuration is just a set of generators without particular structure and order, for example, a simple list. Large exystemic configurations, like large molecules, typically change only locally, while most of the configuration remains unchanged. This is the most powerful tool of dealing with incompressible complexity.
>
> As any scientific notion, pattern is a label for a possibly open collection (set) of different objects with a common property (**similar** objects). If the collection is open, i.e., not presentable with its exhaustive finite list, how can we define "the same property?" This is an important question related to the concept of novelty and, therefore, both the past history and the oncoming future. How can we know anything about something yet unknown?
>
> Chemists commonly have some expectation of an experiment conducted for the very first time. Whether proven right in expectations or disappointed, the chemist can repeat the same experiment countless times and other chemists can reproduce it. This is not possible in an exystem, of which society and economics, less and less separable, are the foremost example. In evolution of exystems there is no way exactly back, but many ways ahead.
>
> PT sees the world in the light of the mathematical discipline of group theory, i.e., through atomic elements (generators) and relations between them. This explains why PT has something to do with chemistry: atoms are "generators" and bonds are "relations".
>
> Mathematically, pattern is a group of configurations under similarity transformation. Very simplistically, pattern is a collection of configurations that all have not just something in common, but can be transformed into each other in a defined way.
>
> If Pattern Theory stopped here, at the stage of classification, it would be just another abstract taxonomy of everything in the world. It is the attribution of a numerical value of probability or energy (instability) to a generator, bond, or a configuration that turns "metric" PT in a kind of realistic chemistry because it gives a means to distinguish between what is **MORE**, **LESS**, and **NOT AT ALL** probable in the real world, even if it has never happened yet. In practical terms, for example, when making a strategic political, business, or military decision, **MORE**, **LESS**, and **NOT AT ALL** is all what really matters. Moreover, PT

> never loses the connection with the real world, which supplies new generators, configurations, and patterns. A human (or another—animal, virtual, alien, or android) agent decides what is or is not similar.
>
> For a chemist, the "chemicality" in nature and spirit of PT is striking. I would compare PT with an imaginary chemistry based on a giant and never complete Periodic Table, in which the new "atoms" (generators), as well as types and classes (patterns) of "molecules" (configurations) are being constantly discovered. While individual configurations that neither fit an old pattern, nor serve as a **template** for a new one are short-living, patterns can survive long stretches of history. PT, in other words, is open to evolutionary novelty and, therefore, to "bipolar" history: from past to future and not just from past to present. Thus, only a few news threads survive in the daily torrent of ephemeral information, and even less survive a week, all the more, a year. Appearance of mammals, the Industrial Revolution, and the advent of computers and digital rogues, are examples of new large-scale evolutionary patterns, while evolution is the oldest of all.

How can PT fit the overall scientific paradigm? What are pattern laws of nature?

We take the permanence of the laws of physics for granted. There are some ideas and data to the contrary and the permanence could be only the consequence of the limits of human experience, but within the Solar System the laws of nature are fully in force.

> "Qualitatively, our results suggest a violation of the Einstein Equivalence Principle, and could infer a very large or infinite universe, within which our 'local' Hubble volume represents a tiny fraction, with correspondingly small variations in the physical constants." (J. K. Webb *et al, Evidence for spatial variation of the fine structure constant,* source).
>
> The very idea of evolving universe comes from William Herschel (see Richard Holmes, *The Age of Wonder: The Romantic Generation and the Discovery of the Beauty and Terror of Science* , Pantheon, 2009, p. 123; see Section 8.8 of this Chapter).

In human matters, patterns are similar to the laws of physics in the most general sense: as invariance of generators, their relations, and connectivity over time and place.

> Developed religions, as well as primitive superstitions, are also based on immutable laws: mortal sin = burning in hell, black cat = misfortune.

Regarding longevity, patterns of human history may lag far behind the physical laws of nature, but they are potentially durable enough to extend into the near future, which is of more interest for humans than the cosmic one. Although human nature is in the state of a quietly accelerating drift, its biological underpinnings are still the most stable background for social evolution with its war, crime, struggle, and strife.

I see pattern chemistry as a possible bridge over the divide between natural science and humanities. A series of pattern-chemical incursions into human matters in complexity, including this one, aims at testing grounds for a construction site.

While Pattern Theory in the form developed by Ulf Grenander focuses on **regular**, i.e., most stable configurations, a pattern chemist is more interested in the fleeting **irregular** transition states, which define the **kinetics**, i.e., speed of transformations. Such unstable configurations have their place within the main body of PT and I did not invent the concept.

Pattern Chemistry does not add to PT anything but some specific focal points of attention. They are: (1) evolutionary novelty: indeed, what does it mean to be new? , (2) transition state: when something changes from **A** to **B**, what is there between **A** and **B**? (3) the likelihood of a new final state: so much can happen in the future, but what will happen in fact?

While Pattern Theory can be mathematically precise, pattern chemistry is not mathematics in the usual sense, but rather "undermath," as Ben Long shrewdly labels it. All it can promise, without any guarantee, is a possibility of comparing alternatives in terms of **MORE** and **LESS**.

Note that any new social phenomenon is a singular configuration and has no statistics by definition. This is why I use the term exystem (evolving complex system) for such singular and usually **large** systems, which statistical mechanics and other physical weapons of mass construction cannot handle.

8.3. Chemistry in a pill

Two immediate questions a pattern chemist should ask are: if cyberwar is a new phenomenon, what exactly is new about it, and if cyberwar is a war, what is different about this kind of war? The next step would be to look for a similarity of cyberwar to old and familiar configurations under the same pattern.

Following the basics of Pattern Theory, I start with the template: an exemplary configuration from which I will try to draw similarity pathways to other configurations.

The typical scientific thinking is convergent: it draws pathways from different areas of knowledge in order to explain a particular case. As a chemist, in order to build up a presentation of aspirin, I would have to dig into an intimidating spectrum of sources. To illustrate this situation, I reproduce in **Figure 8.1** the contents of the article Aspirin in Wikipedia. My thinking, however, is diverging: from one to many. It could be hyperbolically compared with taking the chemistry of aspirin and deriving from it a general understanding of the entire gigantic area of organic chemistry. To some extent, it is possible: at the level of templates for possible patterns.

I want to emphasize, that in no way knowledge of organic chemistry can be derived solely from the **knowledge** of chemical behavior of aspirin. Nevertheless, I insist that somebody with very little of previous knowledge can get **understanding** of organic chemistry by considering what can happen with aspirin if we bring it in contact with some other simple molecules. Unlike specifics, principles can be generalized.

ASPIRIN

1 History
- **1.1 Trademark in most countries**

2 Therapeutic uses
3 Contraindications and resistance
4 Adverse effects
- 4.1 Gastrointestinal
- 4.2 Central effects
- 4.3 Reye's syndrome
- 4.5 Other effects

5 Dosage
6 Overdose
7 Mechanism of action
- 7.1 Discovery of the mechanism
- 7.2 Suppression of prostaglandins and thromboxanes
- 7.3 PTGS1 [COX-1] and PTGS2 [COX-2] inhibition
- 7.4 Additional mechanisms
- 7.5 Effects upon Hypothalamic-Pituitary-Adrenal Activity

8 Pharmacokinetics
9 Interactions
10 Veterinary uses
11 Chemistry
- 11.1 Synthesis

12 Compendial status
13 See also
14 Notes and references
15 References
16 External links

7 Mechanism of action
- 7.1 Discovery of the mechanism
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- 7.4 Additional mechanisms
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8 Pharmacokinetics
9 Interactions
10 Veterinary uses
11 Chemistry
- 11.1 Synthesis
- 11.2 Polymorphism

12 Compendial status
13 See also
14 Notes and references
15 References
16 External links

Figure 8.1. **Contents of Aspirin (Wikipedia)**

Of course, understanding is far from professional knowledge. To a student in the field, deep understanding comes from a substantial volume of knowledge. To beginners, understanding opens the gate to the patterns of chemical thinking. A general idea of mechanical clockwork would not help us to build or repair a watch, but it places clockwork among other mechanical devices and gives a template for the pattern of irreversible cyclic motion, which we all use as metaphor.

It would be ridiculous for a man to wait for the end of his life in order to understand what his life was, although Plato recommended that to the survivors of the deceased. We understand important things on the go, often from a single instance. Modern life, however, is so complex and noisy and its many aspects are so confusing that people are tempted to rely on simple religious and ideological dogmas. We are drowning in complexity—the main non-material excretion of our civilization.

By understanding I do not mean either inductive or deductive reasoning. I mean pattern reasoning, to which analogy is the closest mental vehicle. Analogy is a taboo between “serious” scientists but a pet tool for scientific education.

Without metaphor, comparison, hyperbole, and other figures of speech, we would not have literature, theatre, art, rhetoric, eloquence, humor, and, for better or worse, politics, advertisement, revolution, vigorous progress, and stale prejudices. We would never use proverbs, like “Once bitten, twice shy,” which in Russian version sounds as “He was scalded by hot milk and now blows on water (*обжегшись на молоке, дует на воду*).” What mysterious chemistry exists between the two?

Without pattern thinking, we could never put the entire problem of digital information security into a nutshell by saying “It takes a thief to catch a thief.” Steve Jobs could not say his “Stay hungry. Stay foolish,” or if he did, we would not understand him.

The problem with analogy is that it does not prove anything and, consequently, can be bought low but does not sell high in our mercantile times. Yet before science, politics, and information technology, people used to learn about the world by pattern reasoning. Once bitten, twice shy—literally, not metaphorically—was the first lesson in the art of survival. Fear of snakes and spiders is what we still remember. (I am a big fan of spiders).

8.4. Pattern Chemistry of disinformation

Norbert Wiener’s initial definition of cybernetics as “the science of control and communication in the animal and the machine” was detached from the notion of electronic digital computing, which was then in its early gargantuan infancy. The definition tacitly included humans as the substrate of communication and control, although I am curious whether Wiener would place humans with animals or machines.

I would say that humans are animals that use animals, humans, and machines, thereby shifting the focus onto the notion of use. The following description of cybernetics , which dominates all Web dictionaries (I could not find its author), does exactly that:

> Cybernetics is a broad field of study, but the essential **goal** of cybernetics is to understand and define the functions and processes of systems that **have goals** and that participate in circular, causal chains that move from action to sensing to comparison with desired goal, and again to action.

It is informative that Wiener’s cybernetics emerged from the task of firing anti-aircraft guns, in which “goal” had the most concrete meaning. What is the most abstract meaning of goal for a pattern chemist?

There is a principal difference between mathematical and chemical equations. The equations $\mathbf{(a + b) = a^2 + 2ab + b^2}$ and $\mathbf{F = m \cdot a}$ are true **always and instantly**.

The research chemist who writes a chemical equation $\mathbf{A + B \rightarrow C + D}$ has in mind that **A + B** is separated from **C + D** by a time interval. When we mix **A** and **B**, they begin to turn into **C + D** at a certain speed until an equilibrium. This is why chemists use arrows instead of equality sign. Double arrows $\leftrightarrows$ are used in the state of reaching equilibrium when apparently nothing observable happens: $\mathbf{A + B \leftrightarrows C + D}$. As for the speed, it can be calculated and expressed by common mathematical equations, for example, $\mathbf{d[C]/dt = d[D]/dt = \boldsymbol{k}\,[A]\,[B]}$, where square brackets contain concentrations of chemical species **A** and **B** and ***k*** is the rate constant.

Individual chemical act happens with single molecules **A, B, C**, and **D**. Exact mathematics of the rate of transformation is possible because of the large number of participating molecules. If **A** is water, for example, a table spoon of **A** contains about 10^{23} molecules. Large numbers of participants make statistical studies of society and markets possible. Society, market, and human soul, however, exist in a single copy and their chemistry is never exact for **structural** transformations. Nevertheless, the principles are the same and they translate into comparative likelihood of two possible pathways. This is the main assumption of pattern chemistry.

Goal means that (1) the initial state and the final state of a process in a system are defined in the present, (2) separated by a time interval and (3) the final state is in the future. This is a typically chemical situation. The chemist, however, similarly to the historian, regularly deals with the reversed situation: reconstruct the initial state in the past from the present state. This **pattern** of thinking is called reverse engineering in technology, reconstruction of metabolic pathway in biochemistry, and is the daily bread of historians, detectives, investigative journalists, and those who fret over a lost wallet. There is also (4) a motivation that drives the entire process. Motivation means that the future looks more comfortable, i.e., **stable** than the present. Goal is the human way to **LESS** instability. Chemistry is a sort of "calculus of molecular goals." Psychology is the calculus of human goals.

Pattern Theory expects the similarity of motivation or something like it in all human ventures. Moreover, a similarity is expected between all spontaneous processes, whether with humans, machines, or even molecules. There is something in common between the desire of a person to become the US President or a baseball star and the "desire" of **A + B** to turn into **C + D** or **E + F**. Pattern Theory is super-disciplinary rather than interdisciplinary.

In short, for a dreamer, the final state of an imaginary venture looks more stable than the initial state. Whether a chemist mixes **A** and **B** for the first time with the yet problematic goal to obtain **C** and **D** or an ambitious young /mature Arkansas /California governor decides to run for president, there is a similarity in the eyes of a pattern chemist. Moreover, in a sense, when a ball starts rolling downhill, there must be something of a "desire," too, and it is called "potential energy". In physics and molecular chemistry it is energy, in Pattern Chemistry it is instability, and in human mind it is the potential energy of motivation that pushes the system toward a transformation.

The goal is the image of possible future. Usually, it is a configuration of known elements. Sometimes the actual effect of moving toward the goal is a different or completely new combination with some new elements.

Humans can set goals to machines and other humans, whether in advance or *post factum*, because the future **in human imagination** has the same essential properties (so different in reality!) as past and present.

The understanding of cybernetics as the science of control and communication in pursuit of goal strongly pulls Prince Hamlet into the cyber-limelight, although computers did not exist in his time. They are conspicuously absent, unlike machine-gun, helicopter and camcorder, even in the Royal Shakespeare Company's modern (2008) adaptation of *Hamlet*. I can imagine, however, a super-modern production of Hamlet, in which email and hacking are the means to destroy people by character assassination, financial ruin, criminal setup, imprisonment, illness, madness, following the patterns, as Horatio says,

> Of carnal, bloody and unnatural acts;
> Of accidental judgments, casual slaughters;
> Of deaths put on by cunning and forced cause;
> And, in this upshot, purposes mistook
> Fall'n on the inventors' heads.

The pattern of the ethical dilemma of Hamlet can survive any transportation in time and space (see the end of Section 8.5).

At this stage I do not want to digress into choice of terminology, but for the study of cyberscam, cybercrime, and cyberwar, the **theory of disinformation** (the term was suggested by several people) is a perfect choice. We need just a few terms more.

The term *cybercrime* today is already inseparable from computers. I prefer *cyberscam* (already in use), whether computerized or archaic (like what Jacob did to Isaac and Esau) as a preliminary generic term for what Hamlet did to Rosenkrantz and Guildenstern while pursuing his goals. Cyberscam is disinformation as a means to achieve a goal. The term **info scam** is already in use, but it is hardly intended for deadly results and I would reserve it for a subspecies of cyberscam. If it all sounds awkward—which it does—better suggestions are welcome.

Note the inherent asymmetry of cyberscam: only one side—the attacker—initiates the action, while the other side defends itself, unless the conflict becomes a cyberwar in which the roles can be symmetrical or switched. In pattern-chemical terms, the attacker hijacks the future. What can the victim do? Where exactly is the pattern battlefield?

Pattern chemistry sees the process of change as a triad of initial, transition, and final states, each of different **stability**. The term stability is more general than the inverse of energy (the lower energy the higher stability) because it is applicable to incompletely defined and singular systems in the realm of which all human matters reside. Although we cannot (yet) quantify this kind of stability—and probably don't need to—we can easily detect whether it goes up or down along the timeline of the event. In most cases it is all that matters. I use the term event instead of process to emphasize that event has a beginning and an end.

Often we can predict the change and even speed it up or slow down.

Catalyst is a subsystem that remains unchanged in the final state. Its function is to speed up the transformation by lowering the transition barrier (typical catalysis) or slow it down (inhibition). Catalyst performs its function by bonding to the transition state for the duration of the transition. A human hand is a good pattern template for the phenomenon of catalysis: it can push the puppy toward the bowl or stand in its way, although the contact would happen anyway. A pair of hands can make possible processes that would not happen too soon on their own, for example, to screw a nut on a bolt. Any machine of repetitive use is also a pattern catalyst. See more in Chapter 7 of this Part 4, Part 1, Chapter 3.15 and The Visible Hands.

Only idealized physical systems are reversible; reality is not. Even repeated bending and straightening of a piece of copper wire is not reversible, which could be a metaphor for any political process, as well as Hamlet's vacillation. Patterns in exystems—trends—are reversible.

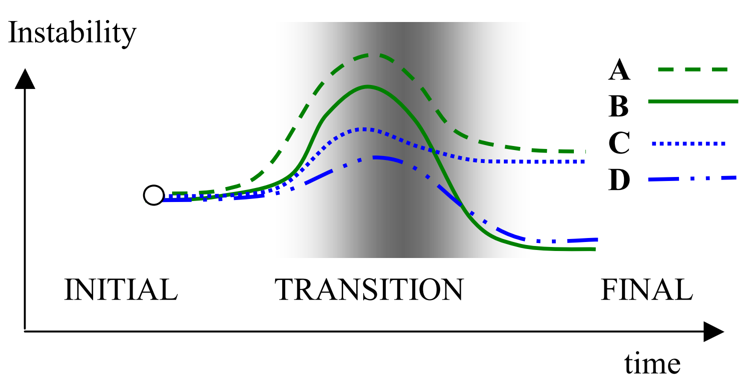


Figure 8.2. Possible states of a changing system as victim's goal (A or B) and attacker's goal (C or D).
Regarding transition, we are often in the dark.

Figure 8.2 presents three stages of a transformation that can be chemical or exystemic.

With molecules, we usually know the initial and final states after an experiment, which can be repeated and modified. With exystems, an event is practically never repeatable and all we know in advance is the present state. The future is not in the picture. After the event, for example, recession or war, we know all three states, although, especially in politics, the transition state and sometimes the final state become known in sufficient detail only much later. This is why an exystemic event generates an incessant and irreconcilable discussion of "human chemists," often through generations, with inevitable revisionism. Patterns, however, are an unpopular subject in academic humanities; discussions are.

The transition state is not really a state: it is an event. It may consist of a sequence of finer intermediate stages. In human matters (politics, economics, society, culture, individual life) initial and final states are also changing. The difference is in the character of the change. Initial and final states fluctuate around a slowly drifting baseline, while the transition state also fluctuates, but around the rising and falling baseline. Human history is a walk over a landscape of a European type, with its Alps, Pyrenees, and Carpathians. Some of its episodes are more like wandering along the Rocky Mountains.

From the same initial state the process can go to:

> **final** states of lower (pathways **A, C**) or higher (pathways **B, D**) stability than the **initial** state through
> **transition** states of stability significantly lower (**A, B**) or moderately lower (**C, D**) than in both initial and final state.

The pattern-chemical battlefield of a cyberscam is in its transition state. The task of the defense is to raise its instability for the attacker, while the task of the attacker is to lower it. The duration of the transition, however short, offers a chance to compensate for the inherent advantage of the attacker by means of invasion detection. The military vocabulary is not metaphoric: Internet insecurity belongs to the pattern of war. The digital Valkyries monitor the battle from the digital skies with stopwatches in hands: the fastest will win.

The final state can be more, equally, or less stable than the initial one, but the transition state is a real bottleneck**: it is significantly unstable and can be only short-living**. This is why many possible transformations either do not happen, or run slowly, or so slowly that something else happens faster. If there were no barriers on the way to more stable states, everything that can happen would happen at once and nothing could happen after that. Thus, in a vacuum, a piece of lead and a handful of feathers fall down with the same speed.

Note that the emphasized phrase "it is significantly unstable and can be only short-living" points to a strange connection between stability, energy, and time. The link suggests the **currency of time** instead of currency of energy for paying the cost of a transformation. The link is not at all esoteric: energy is measured in kilowatt-hours. At constant power, it is just time, and time is money.

High-level encryption is based on the expectation that the attacker will not have enough time to break the password.

The pattern equivalence of time and energy is an intriguing subject. As for global supply of energy, the sun takes care of it. But the time limits of human existence—which is just an event—make time the only truly limited resource on Earth and, therefore, an ultimate currency to measure the cost of inter-human transactions. In the digital age it is slowly creeping into focus. Time is more than money, it cannot be bought, from which the strategy of cyberscam defense follows: let the individual attacker spend more time than it pays off. This strategy is based on the extremely low energy cost of computing. Cyberwar is cheap, or just seems so. As the ultimate general strategy, the attacker has to lower the obstacle created by the transition state, while the victim must bring it as high as possible. The final state has high satisfaction and stability for the attacker and loss and frustration for the victim, which is reflected in **Figure 8.2**. How can that be done from the cost considerations?

> The power of time as currency has been demonstrated in two long American wars—Vietnam and Afghanistan—which look like self-inflicted wounds. While one side places no value on individual life, it has an enormous advantage against the other, more powerful in physical energy terms, which values not only human life, but also the political life between elections. When America entered WWII, the sides had their stakes in the same or at least similar currency. Dictators, however, do not think in alternatives.

I do not claim any discovery here. I simply want to turn attention to the well-known dependency of value on how limited the resource is. Atoms of gold in nature are indestructible and can be extracted and recycled, mineral fuel turned to carbon dioxide can be recycled by solar energy through plants, but lifetime has absolute limits.

In molecular chemistry the transition state is short-living, rarely observable, and often only hypothetical, although a constant progress has been made. Similarly, we rarely know what is going on in human mind between the stable observable initial and final states. In a large-scale historical transformation, historians can in principle reconstruct the fast-paced events, for example, the onset of a war, although some sources could remain hidden or lost. On Pattern Theory of history see: Yuri Tarnopolsky and Ulf Grenander, History as Points and Lines.

In pattern chemistry, the concept of initial, transition, and final state, originally introduced by physicists, is taken from molecular chemistry and simply transposed to other structural transformations. The justification for this generalization comes from Pattern Theory, which offers a universal abstract measure of stability/ probability of a configuration regardless of its place in real world.

8.5. Template: Rosencrantz and Guildenstern are dead

Let us turn to *Hamlet*: Act 5, Scene 2

Traveling by sea to England with Rosenkrantz and Guildenstern, suspicious Hamlet searches their things and finds the order of Claudius to behead Hamlet on his arrival. He substitutes for it a forged letter with the order to kill the messengers. I quote in Figure 8.3 the most relevant lines of the scene.

Now let us look at **Figure 8.3** with pattern-chemical eyes. We are interested here not in the entire story of Hamlet but only in his cyberscam, which I call "cyber" because Hamlet's act included both control and communication. Hamlet intercepts the letter communicating the signal of Claudius and takes over control.

The unusually crafted movie "Limits of control" (Jim Jarmusch, 2009) treats artistically the subjects of message, control, communication, and similarity and uses recurrent patterns for different configurations.

(1) UNCERTAINTY

HAMLET:
Sir, in my heart there was a kind of fighting
That would not let me sleep… …

(2) INVASION
… …in the dark
Groped I to find out them; had my desire.
Finger'd their packet, and in fine withdrew
To mine own room again; making so bold,
My fears forgetting manners, to unseal
Their grand commission; ……

(3) READING
That, on the supervise, no leisure bated,
No, not to stay the grinding of the axe,
My head should be struck off.

(4) ALTERATION
… … I sat me down;
Devis'd a new commission; wrote it fair…

Without debatement further, more or less,
He should the bearers put to sudden death,
Not shriving-time allow'd.

(5) AUTHENTICATION

HORATIO:
How was this seal'd?
HAMLET:
… … I had my father's signet in my purse,
Which was the model of that Danish seal;
Folded the writ up in form of the other,
Subscrib'd it, gave't the impression, placed it safely,
The changeling never known. ….

Figure 8.3. Components of a cyberscam. Excerpts from Hamlet, Act V, Scene 2.

The episode with Rosencrantz and Guildenstern is only a stage in a sequence of transformations. **Figure 8.4** shows, as a possible interpretation, major stages in the evolution of Prince Hamlet: (1) the revelation and request of Ghost, (2) the test of Ghost's message by the dramatization, (3) discovery of Claudius' plot, and (4) the annihilation of all major characters.

Figure 8.4 shows the wavy pattern of instability (anxiety and vacillations) of Hamlet before making the next decision. The plot is not a graph of a calculated function. The curve can be deformed in any way with preserving the sequence and relative levels of peaks and valleys. It can be regarded as a fine structure of a larger transition state between the beginning and the end of the tragedy. Any long enough stretch of history, national, institutional, or individual, consists of the typically chemical alternation of stable states and unstable transitions.

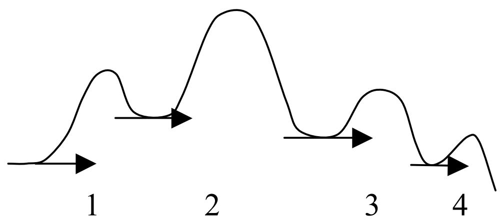


Figure 8.4. Transformation stages in Hamlet : 1, Ghost, anxiety; 2, Test and madness; 3, Travel; 4, Fight and annihilation.

Hamlet had been in a state of anxiety since his first appearance, but his father's ghost elevated him to the state of utmost confusion and frustration up to his departure for England. That state ended with much more determination after the encounter with Fortinbras' army marching to die for a senseless cause. The observation catalyzed Hamlet's acceptance of the possibility of his death and the necessity of revenge:

> … …I see
> The imminent death of twenty thousand men
> That, for a whim and trick of fame,
> Go to their graves like going to bed, … …
>
> … …O, from this time forth,
> My thoughts be bloody, or be nothing worth!

Hence, Rosencrantz and Guildenstern are dead, the victims of a logic bomb prototype.

In this and the earlier "To be, or not to be" monologues Hamlet imagines the final state and evaluates the height of the transition barrier in terms of the cost, which ultimately amounts to the value of human life. Moreover, he describes the structure of the transition state in which conscience, emotion, and thought are main components:

> Thus conscience does make cowards of us all,
> And thus the native hue of resolution
> Is sicklied o'er with the pale cast of thought,
> And enterprises of great pitch and moment
> With this regard their currents turn awry
> And lose the name of action.
> (Act III, Scene 1)

The "pale cast of thought" is an inhibitor bonded to the very beginning of the transition state of action.

Hamlet comes home a changed man. His vacillation is gone. This final state in the episode with the letter is more stable than its initial state. It is high enough to roll down to the final mayhem of the tragedy. On that final stretch, the outcome of the fencing match and intended poisoning is uncertain, as in any war.

"Chemistry" is a commonplace metaphor for the complexity and dynamics of human soul and its interactions. See an excellent collection of materials on human chemistry in Encyclopedia of Human Thermodynamics to which I would add Shakespeare's *Hamlet* . Goethe's Elected Affinities is already in the Pattern Hall of Fame.

For a pattern chemist, metaphor is a pair of configurations in the same pattern, pointing to a similarity, usually distant. Pattern chemistry, however, is more than a metaphor for what happens in human mind. To hypothesize, our imagination builds up a limited set of configurations, few in present, more in past, and some in future, the instability of which (stress) is registered by our emotional apparatus. We take a pathway, not necessarily realistic, toward the future state of maximal stability (low stress, high satisfaction). During the transition, the alternative states and pathways compete with each other like parallel molecular reactions, mostly reversible at each stage, but rarely after thinking has resulted in action.

Sometimes—even most of the times—the imaginary transition pathway is so loaded with stress that we give up the attractive final state. Sometimes we are ready to do anything to get rid of the present emotional dread. We constantly evaluate the configurations by their components, considering their contributions approximately additive. Our mind does not perform calculations. Instead, we simply compare the alternatives by the magnitude of associated stress. As Ulf Grenander suggested in his Golem project (search the Web for his *A CALCULUS OF IDEAS: A Mathematical Study of Thinking*), emotions are part of human intelligence.

The primitive chemistry, which I tried to apply to *Hamlet* may seem unreliable, and so it is: to err is human. "Accidental judgments, casual slaughters " (Horatio) happen. Remarkably, Hamlet, so insightful and cunning in the "changeling" incident, has the same heavy heart before the duel ("how ill all's here about my heart"). Yet he shows no desire to secure himself against possible scam on part of Claudius, although his behavior during the duel with Laertes is inconclusive in this respect. External events, accidents, and coincidences compete with the acting mind and urge it to rely on the fast "mechanical" reason, rather than on the slow "chemical" one.

The role of emotions in reasoning and decision-making is gradually becoming clear, especially after works of Antonio Damasio and progress of behavioral economics and finance. The concept of value (in currency of life, pleasure, money, fame, speed, stability, satisfaction, relaxation, etc.) binds together chemistry, economics, thinking, and metric Pattern Theory.

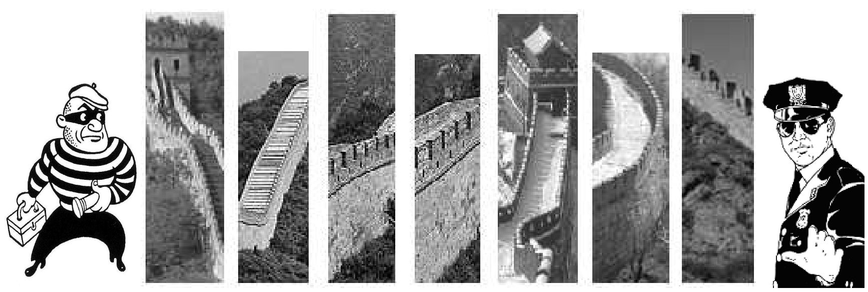
> In pattern language, I would say that emotions are the components of the measure of stability, remotely similar to the Newtonian energy that defines where the ball will roll on the inclined plane: down.

Living organism, however, is, in a way, anti-similar to mechanical systems because life is a constant Sisyphean work on an inclined treadmill: up and down along the median.

Exystems can be better described by "Faustian energy:" at the moment of the highest achievement and satisfaction we want the treadmill of life—and the clock—to stop. The anxiety and dissatisfaction makes us search for the state with the lowest F-energy.

This is not so simple with exystems, however. The supply of energy (which the ball on the inclined plane does not need) is a decisive factor. It can override emotions. Unhappiness and depression combined with the critical shortage of energy lead to simplification and mortal dismantling the entire structure. This concerns both organisms and societies.

Yet we have to stick to our main subject: digital security. What can the story of Hamlet tell us about it if we are the targets? Use inhibitors at every stage. In other words, build up the transition state walls, and better a lot of them.



8.6. The Mini Wall of China

It is easy to say "build walls," but of what? The digital walls are not sufficiently effective against digital invasion and even less effective against the attack on human nature. In the first case, the sides of the conflict are armed with the same weapon and in the second, alas, endowed with the same human nature. It is hard to hide any professional secrets in such a bare playfield, but the sides still do it. Statistically, the defense may have a big but costly advantage, although even the rare loss can be ruinous. One of the most troubling aspects of the cyberwar is that the government does not really want a complete security against spying: it wants a semiconductive wall, quite like the Chinese emperors did.

The defense turns into insurance. This is the pattern contradiction of the war between the state and the individual. I am not aware of any real war insured against losses and defeat, although Goldman Sachs may someday invent it. The recent American masochistic wars look like they better insure the opposite side against the losses than our own soldiers. Protection of civilians is for politics, not for war.

Let us consider some situations along **Figure 8.3**.

(1) UNCERTAINTY

HAMLET:
Sir, in my heart there was a kind of fighting
That would not let me sleep… …

The first line of defense against uncertainty is information. Horatio suggests a partial solution:

> HORATIO: If your mind dislikes anything, obey it.

It requires, however, some knowledge of what should be kept in mind.

The target of aggression is always in the state of uncertainty. Possible ample intelligence and raised alertness of the target increases the transition barrier against digital invaders.

> The height of transition barrier consists of two increments: the "height" (difference) of physical energy and "height" of uncertainty. For molecules, the latter is expressed in terms of entropy (S) and temperature ($- T\Delta S$). For configurations in PT, it is expressed in terms of probability and temperature. For singular events there is no quantitative measure, but MORE/LESS estimates are possible. In the digital world, the physical increment of an elementary computation is negligible, while its physical result can be catastrophic.
>
> Unfortunately, a hard theory of singular events is hardly possible (sorry for the pun). Nassim N. Taleb, who calls rare large-scale events, like financial crash, "black swans," believes that they are unpredictable in principle and must be met with the defense of well-capitalized insurance.
>
> I think that Nassim Taleb's book *The Black Swan* and subsequent publications are the only significant, stimulating, and disappointing for the gurus contribution to the still missing theory of exystemic catastrophes. I am not at all pessimistic regarding prediction of the unpredictable, however. Quite a few economists—almost none among the top gurus—saw the collapse of 2008 coming. It is the very beginning of the transition that makes early warning possible. As for the tsunami of 2011 in Japan, it was always a possibility for any coastal point of the region.
>
> A pair of black Australian swans in the local zoo is part of my childhood memories and I find nothing disturbing in this image. The black swan of the Tchaikovsky's ballet has a more sinister symbolism in the world of money. Anyway, I suggest the name for the ancient anti-Black-Swan trick: Joseph ben-Jacob's defense, see the Bible. This is the same kind of insurance as maintaining the US Strategic Petroleum Reserves. Pharaoh's dream with Joseph's interpretation was simply an exercise in pattern thinking.

The obvious solution is to monitor the state of the material world across all political borders and of the entire digital space, which has no borders. In short, make friends and look out for enemies. Learn and keep secret as much as you can.

The massive spy web of the Cold War has been the most recent—and successful—template of the protection pattern. Expensive, dangerous, and full of gaps, it was a successful—after the loss of nuclear secrets—war of nerves for America. Most probably devalued but never dismantled, it has recently turned into a tripartite contest, with China as the major newcomer followed by a group of minor freshmen. Regarding human nature, the diverse and materialistic America looks more vulnerable in this challenge, but materialism is not ideology-specific.

> As far as I remember the Soviet Russia and Cold War, the tendency to needlessly hurt not just enemies, but also non-friends used to be a pattern of Soviet mentality. Russia, Politburo or not, wants to be loved and kissed three times on both cheeks and it detests indifference.

In terms of the Hamlet template, even a superficial analysis of the political situation in Denmark—the court politics at least—would point to Hamlet as a source of instability. Claudius, of course, had perfect reasons to spy on Hamlet who realized he was in danger. This is the pattern of cold war that can turn hot any moment.

Let us note the important pattern property of human nature: the configurations of conflicts between individuals are small and simple. Like single quantum objects, they are predictable only statistically over time, which is rarely useful in such matters: we die but once. The world is small for large systems and very large for small ones. This is one of the difficulties the national institutions face in hunting an individual or small group in the digital borderless world.

How can we neutralize or suppress the human factor? Typically, the human factor, known as betrayal and treason, is an exchange of information or action for money, fame, or at least some personal satisfaction. It bears a pattern similarity to the chemical reaction of exchange. It can be enhanced by a mediator (catalyst), but can also be hindered by inhibitor. From digital honey-pots to all kinds of decoys, double agents, and sting operations, the weapon against digitalized human nature is borrowed from the pre-digital armory. Decoys are also used in biochemistry.

In short, the inhibition (or boosting) consists of introducing a "third party" to the event. Of repetitive use, like machine, it should increase (or decrease) the stability of the transition state from initial (pre-transaction/attack) to final state (post-transaction/attack). Obviously, the final states are different goals of the attacker and the target.

The catalyst in chemistry and life is such "third party." It is **material** in the sense that its participation changes the energy (in chemistry) and stability (everywhere else) of the transition state. In the digital world, physical energy matters little, but time is crucial.

The dematerialization of the world is the new evolutionary process started with the advent of computers. A neat shortcut term **demat** (it invokes *unfriend*) and sufficient literature already exist. Stock market is the oldest natural environment for demat, the fullest form of which is digital finance.

Back to Shakespeare, the Ghost freely traverses the walls because it is *demated*. For the same reason electronic wealth easily moves through the wallet leather in both directions or just vanishes. Ghosts are not subject to laws of conservation.

"The world is flat" (Thomas Friedman) is the slogan of the Brave New World. I do not see any flatness in the current pictures of Shanghai and Detroit side by side. Detroit looks more like the materialization of dematerialization, but to follow this thread would be a long distraction. The digital world, however, is indeed flatter than a pancake. The end of history is not yet in sight, however.

We are going to take a closer look at materialization. Unfortunately, it is not easy to find a shortcut to this unwieldy word, which is even longer than my full name.

Here is the appropriate image. →

> Hyleation or **hylation** , from Greek ὕλη , hyle , 'whoo-lay,' matter or stuff, is an optional term. It could be pronounced like 'hilation.'
> Finally, **inhibition** is OK. But it is hard to beat **materialization** in digital context.

Materialization (or hilation) is the mounting of a transition barrier between two stable states of a transformation in which physical energy plays otherwise a negligible or small part. This is achieved by linking a material (not digital) object—"m-padlock"—to the transition state. I assume, without sufficient certainty, that the access to the m-padlock is easier to guard than the access to a digital file. Of course, the m-padlock must be converted to e-padlock, but in such a way that no middleman can jam in. This can be done with the usual means of physical protection and even without it. For example: make it as big as Washington Monument and nobody will ever steal it. Impossible? Maybe not.

How can that be done? The digital world has an indigenous currency similar to the currency of energy in the material world: time, which is, as everybody knows, nothing but money, but can money be time?

> In the recent past, Cray (one of the first supercomputers [1976]) time was $1,000 per hour. The use of this "Cray time" was a very common way to express computer costs in time and dollars (source : Introduction to supercoomputers).

The proverbial convertibility of time and money is the strange reality of the digital world. The strangeness comes form the "quantum" structure of everything digital: there is nothing between one bit and two bits of information or H-key and J-key on the computer keyboard, as there is nothing between one and two quanta of monochromatic light or one and two electrons.

The usual way to break a password is to use a high-speed computer for combinatorial brute force assault during which the password file remains resigned to its fate. If the burglar had enough time, up to million years, no digital file of reasonable size, can be protected because of its very digital nature. There is another known way, however: to make the life of the password file so short that no burglar, even with a supercomputer, will have enough time to crack it. Time is the digital equivalent of energy for transition barrier.

The pattern aspect of security and the role of time have been fully realized by professionals. The value of time is in plain view.

> "While in past eras, there was no passive infrared (PIR) based technology, electronic access control systems, or video surveillance system (VSS) cameras, the essential methodology of physical security has not altered over time."
>
> *"Electronic* access control easily manages large user populations, controlling for user lifecycles times, dates, and individual access points. For example a user's access rights could allow access from 0700h to 1900h Monday through Friday and expires in 90 days."
>
> (source: Wiki)

Figure 8.5. Two ways to use the padlock

Materialization applies to digital operations, but here is a fully material parallel. It requires very little energy to open or close the door. The padlock wedges between two states of the door, takes a little energy to lock/unlock with the key, but demands a lot of physical energy to break through the door without the key. Curiously, it can be used for locking the door without the key by bending and closing the shackle, **Figure 8.5**, but probably with even more energy and, in both cases, loss of further use.

If the lock works at all, it is because all properties of the key and lock are material and have no accessible copy. For the same pattern reason, the mechanical lock can be accessed with a mechanical lock pick. On the contrary, the digital alarm or lock is expected to be resistant to mechanical picking. It seems that any instance of digital password picking could be easily identified, as it apparently is in common banking passwords, which freeze after a few unsuccessful attempts, but I am not sure how universal it is.

Since nothing can resist human inventiveness, except a super-human one, the only solution is inhibition by advantage, as in a card game in which one player has incomparably larger resources than others. By the same reason, money can have the upper hand in wrestling with democracy—which it probably already has in the post-1970 America; it does it in very subtle and roundabout ways.

As for the human factor, following the above pattern, the inhibition of the human factor may require a third party in the criminal transaction. The critical issue is that the third party should be **neither human, nor digital**.

OMG! "Go I don't know where, bring I don't know what." Not the barbell sets, really! **(Bureaucracy)**

(2) INVASION

… …in the dark
Groped I to find out them; had my desire.
Finger'd their packet, and in fine withdrew …

Obviously, Hamlet's companions did not think they had a personal stake in politics of the kingdom. Otherwise, they would take guards with them, or sleep in shifts, or just keep the royal mail in a heavy padlocked chest, for the lack of a chained briefcase.

Other modern configurations of invasion protection are web cam, alarm, and similar devices with long historical roots going back to pre-human times. The detection of the invasion would trigger authentication. I see it as the key problem of security: the Great Wall of China must have passes on trade routes, which it had.

Figure 8.6 Jiayuguan Pass, a key passageway of the Silk Road through the Great Wall. (source)

(3) MESSAGE READING

That, on the supervise, no leisure bated,
No, not to stay the grinding of the axe,
My head should be struck off.

It is impossible to hide the Washington Monument, but information carrier can be made nearly invisible.

Here is a fresh example from the stale past.

> 'The document warns of "other methods used by spies and smugglers, according to the skill and education of the criminals", such as "**engraving messages and credentials on toe-nails**".' 20 April 2011 "CIA reveals invisible ink recipes used by WWI spies"

> The entire history of encryption and code breaking can be found in: *The Codebreakers: The Story of Secret Writing* , by David Kahn, Scribner (1996) , **1181 pages**. I have not read it.

Hiding, deforming, use of a rare or mixed language, invisible ink, microdots, toenails, verbal message trough a trusted courier—all that can be considered materialization, but digital encrypting cannot. Let us just reiterate the main **hypothetical** task of digital security: materialization. Period. (I realize that experts have good reasons to disagree).

(4) MESSAGE FORGERY

… … I sat me down;
Devis'd a new commission; wrote it fair…

Obviously, it is difficult—but not impossible—to forge a message written on toenails, as well as on rare parchment, stone tablet, and gold plate. All that is inhibited by the profound materialization, so to speak, super-materialization of substrate, especially, when used for the first time.

Art forgery is an art in its own and it starts with the forgery of the substrate. Forgery is closely related to interception and code breaking, but the similarity is anti-symmetric. The forged message must be in full view. Encoding makes the true message look as what it is not, while forgery makes the false message look as what it is.

(5) AUTHENTICATION

> … … I had my father's signet in my purse,
> Which was the model of that Danish seal;
> Folded the writ up in form of the other,
> Subscrib'd it, gave't the impression, placed
> it safely… …

The following is a fragment of a movie synopsis.

> When she is deserted by her husband, the Stranger (Anna Q. Nilsson) leaves her baby on a doorstep with half a dollar bill pinned to his chest, and a note saying that one day she will return for the child with the other half as identification.

The movie is Half-a-dollar-bill, 1923.

As for real life, the only problem, irrelevant in 1923, with this digital password is that the serial number is printed on both halves and the second half can be forged from the first because of the standardization of money.

The half-bill password is a configuration of a larger **challenge-response** pattern, well beyond B-movies. The military password requiring the counter-password (reply) and common online login-password pair belong to the **split-password pattern** (not the exact technical term). The difference is that the half-bill (like CAPTCHA) does not require digital processing for authentication and exists in a single copy, unlike the military password. It is not only material, but also **rare**: like a key dropped in the ocean. "Rare" means near impossible to find. It is almost unique—almost, because it can also be forged or copied. I prefer **rare** to **low probability** because it is **humanized** , i.e. nothing stands between the object and the human, quite like in the computer. Humanization is a pattern of which CAPTCHA is a configuration: "**C**ompletely **A**utomated **P**ublic **T**uring test to tell **C**omputers and **H**umans **A**part".

The similarity (symmetry, in deeper mathematical sense) of space and time allows for two kinds of rare objects, respectively. Rarity in time is implemented in numerous dynamic password systems in which password changes with time.

I do not know whether the authentication configuration I am going to describe in the next segment is new. I doubt it is, but my purpose is to show a possible template as an illustration of pattern thinking, more specifically, invention, not necessarily practical.

The imaginary system in **Figure 8.7** combines the properties of dynamic, graphical, time synchronized, single-use, materialized, hidden, split password systems, and what not—a true chimera.

> I wonder if anybody ever cared to draw a digital security tree, like **Figure 7.17.** In addition, a periodic system of security methods could probably have, like the original Mendeleev Table, some empty cells to fill out.

From the pattern perspective, what matters is the fragmentation of a (1) unique, (2) highly rare in time and space, (3) complex object, and (4) the humanization of two fragments (CAPTCHA-pattern). Not just by humans: the Kipling's "*We are of the same blood - you and me!*" belongs to the same pattern. Another example is the communication between the Navajo and other code talkers during WW2, based on the rarity of language.
These days, our young wolves learn the digital language before the native howling and snarling.

8.7. Materialization template

Figure 8.7 explains the principle by presenting a template, which should not be taken as a technical solution.

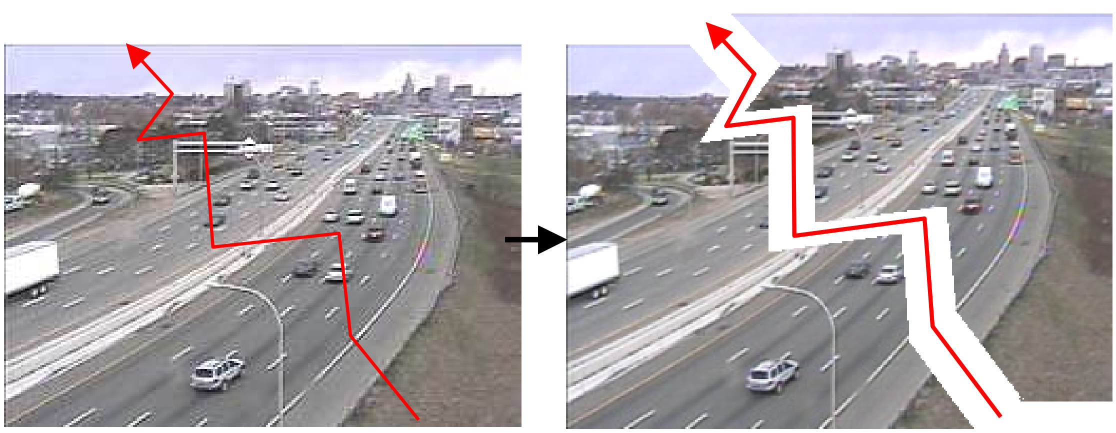


Figure 8.7. Traffic as material inhibitor (hylator) in authentication. An actual traffic camera shot is used.

The actual, not digital, state of highway traffic—or cloudy skies, control panel of a nuclear power station, view from a railway car, etc.—must be included into the transition state of secure communication between two human or robotic sides with half-pictures serving as split password. The access to the highway (maybe on a distant continent) is free, but the camera can be easily hidden.

I have a feeling that somebody has already claimed this idea, but I was unable to find it. The secretive world of national and corporate security is full of dark matter.

It is not for me to decide whether the "highway" authentication makes any practical sense. I wanted to show two things: (1) how pattern thinking can generate hypotheses by using distant templates from formally unrelated domains of knowledge and (2) how matter, usually associated with stability in time, can be combined with a high degree of rarity in both space and time, and used to generate "permanently unique" configurations.

The highway traffic or cloudy skies are natural generators of "quasi-unique" (i.e., highly rare for the attacker) complex material objects. Unlike long strings of symbols, such objects can have a human interface as a kind of "air gap" of digital security.

In my case, the "distant template" was the fictional story of Hamlet, far enough removed from the digital age. This is the main reason why I chose it.

A closely related but formally very distant example of pattern thinking is: Kenji Yoshino, *A Thousand Times More Fair: What Shakespeare's Plays Teach Us About Justice*, HarperCollins, 2011, from which I quote:

> It is not just that I have found Shakespeare to be a universal passport into profound conversation—in China as in England, in Argentina as in Hong Kong, in Italy as in Japan. It is also that his work stimulates conversations about justice that might not otherwise be possible (p. xiii).

8.8. Pattern: the intelligence highway

The highway is an impractical way toward materialization. Since vehicles are small details in the picture, disparate halves of the split image can look compatible, traffic can be very sparse or absent, the place can be recognizable, the procedure of authentication is unclear.

The role of pattern template is to offer not a technical solution, but a point of departure toward a solution. As an idea, it can be right or wrong, practical or not—it does not matter much. All kinds of ideas contributed to the evolution of science and technology.

> Ulf Grenander, in private discussions, often emphasized that whether configuration is "true" or "false" is of no importance in PT for as long as it is regular. It took me a long time to realize the truth and significance of this idea.

I see pattern template as the initial stage of an intuitive, heuristic, subconscious, spontaneous, non-algorithmic mechanism of animal, human, and humanoid thinking, which is the opposite of the algorithmic "thinking" of computers. As soon as there is a template, it is allowed to be deformed, tweaked, and mutated until the conditions of some kind of truth value are met, even if not in the best way.

The previous paragraph is a template of a thought. Here is its next modification:
I see pattern template as the initial stage of **natural** human and humanoid thinking, distinct from the algorithmic thinking of humans and computers.

This is the second modification. I see pattern template as the catalyst for the process of thinking. If there is a template, thought is a walk in a small compartment of the total combinatorial space instead of the entire space.

My third modification is the combination of all three configurations.

But why the highway? How could this idea emerge in my mind? What was it in the state of emergence, how did it manage to self-assemble, and from what initial stuff? Note the pattern similarity of this question to the problem of the origin of life.

As soon as I had formulated the questions in the previous paragraph and after some consideration—not more than ten minute long—I came to the following reconstruction of the emergence of my "highway idea", not necessarily correct, but sufficient to serve as a template for further thinking. I was surprised myself by the result.

> 1. I am working on the current Chapter 8 related to information insecurity. Authentication and **passwords** are parts of the subject.
>
> 2. I also keep thinking about the problem of high interest for me: the Great Recession of 2008. It is all about **money**.
>
> 3. I recollect the use of torn **money** as a **password**.
>
> 4. I am looking for an example of a complex, quickly changing, and non-recurrent material **object** to serve as a split **password**.
>
> 5. Twice a workday I access the local traffic website with cameras along the entire **highway** that my wife takes daily to get to her job and back. Sometimes, when she is in a jam, I inform her about the location and extent of the accident. Traffic is a complex, quickly changing, non-recurrent material **object**.

6. At least this year (2011), the local part of the big interstate **highway**, usually congested during the rush hours, looks strangely empty. My wife gets to work 15 minutes earlier than a year ago and before that. I believe the **money** is the reason: gasoline is expensive, jobs scarce (over10% unemployment), people drive less, which has been officially confirmed.

7. The idea to use the image of the **highway** as split password pops up in my mind because all it components are there at the same time. They form the initial "primordial" soup from which the configuration of the final idea—**highway as password base**—emerges.

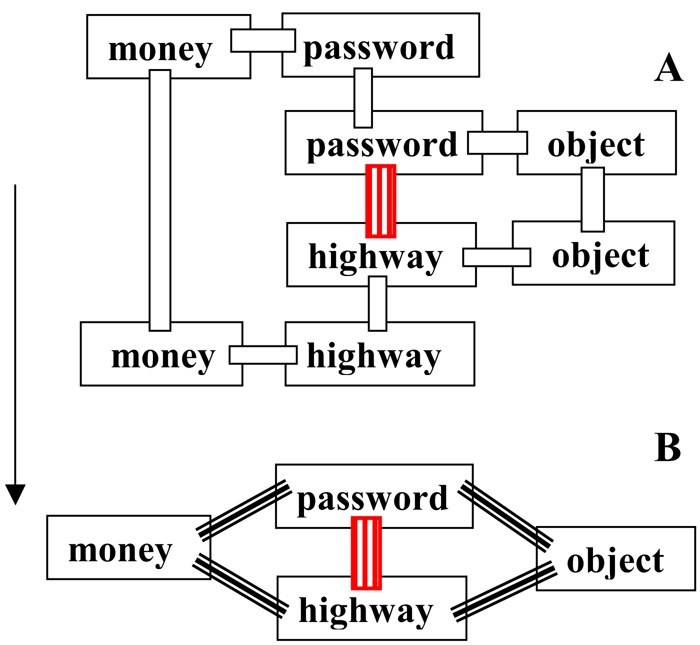


Figure 8.8 Synthesis of the configuration of an idea. B follows from A by eliminating vertical identities. New similarity has been catalyzed.

Figure 8.8 illustrates the formation of the final configuration. The few generators—**money**, **password**, **object** (complex, ephemeral) and **highway**—are connected by horizontal similarities and vertical identities. The resulting new vertical bond is between **password** and **highway**. It does not depend on the catalysts **money** and **object**. This is a new idea catalyzed by ideas of **money** and **object.**

Figure 8.9 illustrates the idea of thought chemistry in a pattern-chemical symbolism. The "elements" are **Mo**, paper money, **Pa**, password, **Ob**, complex ephemeral object, and **Hi**, highway. From the initial green "mental soup" on the left, two catalytic pathways are possible. The bond **Mo—Ob**, however, is destabilizing (negative) because paper money is not a complex ephemeral object. Bond **Hi—Pa** has been generated and added to the final “soup” as a hypothesis for practical tests and an ingredient for further culinary exploits.

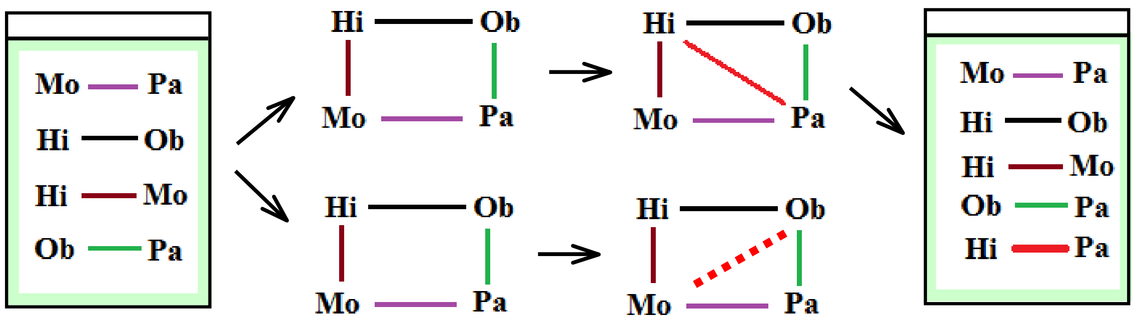


Figure 8.9. Pattern chemistry of non-algorithmic thought.

It is tempting to go into possible technical implementation of the idea, but I will resist the foolish temptation, except (quite like an alcoholic or smoker!) for three last remarks.

1. I see a distant but distinct pattern similarity between the completely demat RSA encrypting and my “highway” idea, which may suggest that there is a universal minimal pattern for any authentication procedure and the whole hierarchy of more detailed password systems. The reader can explore the similarity as an EXERCISE.

A B

Figure 8.10. Time-split material password base
(sources: A, B) .

2. The splitting of a materialized password in time can be substituted for the splitting in space, see **Figure 8.10**. Two different but close enough snapshots serve as

two halves of the password. In this way traffic view becomes much more usable, but not completely.

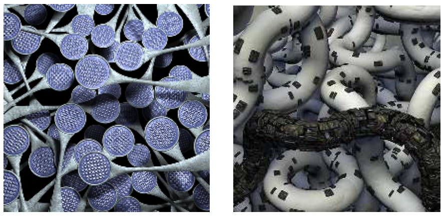


Figure 8.11. Quasi-material base for split password. Two of Kenneth A. Huff's images (source).

3. It may seem a paradox, but a good computer-generated material password base is possible as an option for materialization, see **Figure 8.11**, from Kenneth A. Huff's website (which is a whole world in itself; his work can be characterized as synthesis of individuality). A series of Kenneth Huff's images incorporates prime numbers. See also his videos. These images are quasi-material in the sense that they are computer-generated, but perceived as physical object by a human through the "air gap." Their randomness would make them practically material. 3D images and holograms of moving toys could be an intriguing variation. Note that the images are not random matrices of pixels because of the shape constraints. This is exactly why they are instantly recognized by humans.

A moving quasi-material image can be generated by a completely insulated computer of a higher ranked third party. The so-called air gap security system and top-down principles involved in it provide some useful templates.

8.9. Invention and scientific method

The principle of materialization in digital security means including matter into the transition state of authentication. How to implement materialization technically is outside my expertise and interests. Many modern miniature and elegant inventions, of which smart phones and tablets are the current but not final stage have evolved from the dinosaurs of the short vacuum-tube-and-punch-card era. Someday we'll probably have computers on fingernails, too, and cut the junk with scissors.

I am much more interested in the pattern chemistry of human thinking, in particular, invention, as opposite of discovery. Invention is synthetic activity and discovery is analytical, but I suspect that the mechanism of both has a common stage.

As for the pattern invention, let us compare it with the standard inductive method of experimental science, which consists of (1) observation of events, (2) **generation of a hypothesis**, and (3) experimental test.

But how do we **generate** (invent) a **hypothesis**? There is no algorithm for that. Inventive ideas seem to come out of the blue.

Pattern thinking consists of (1) observation of events, (2) generation of a template, (3) combinatorial deformation (mutation) of the template and (4) test of the new configuration. I believe that this is the actual way we generate anything, whether hypothesis, or a device, or a strategy, mostly subconsciously. This is also the pattern of biological and social evolution. Is the swinging between two parties a real evolution?

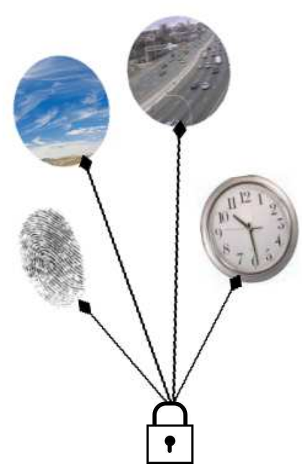
Well then, how do we generate a template?

In order to generate a template, we identify generators and let them recombine in our mind like in a chemical flask) into stable (non-contradictory) configurations. As I tried to show in my essays on pattern chemistry of thought and speech, both processes can be realized using extremely simple algorithmic procedures without anything like evolved human mind, which partly explains how the mind itself emerged. These sources will explain the origin and meaning of **Figure 8.8**. See also previous Chapter 7, segment WHAT IS GENERATOR.

In a few words, the cardinal **hypothesis** of pattern chemistry is that
chemical reactions
origin and evolution of life
origin and evolution of thought and speech
origin and evolution of society, ideas, and man-made things
all belong to the same pattern of search for stable configurations.

8.10. Chemistry and imagination

The Age of Wonder: How the romantic generation Discovered the Beauty and Terror of Science, by Richard Holmes, Pantheon, 2008, 500+ pages, is not for everybody, but it was an extraordinary book for me, and apparently the critics.
With a few biographies as focal points, it shows the scientific, intellectual, cultural, intimate, and everyday life of Europe during the period when science and technology were starting the breakneck 150 year long race toward its modern form, finely fragmented, specialized, and drenched in money. It was time when the very word "scientist" was invented and "natural philosophy" faded into history.



A parable of pattern thinking

It was the time when some newly baptized scientists began to ask the question with which I started Section 8.2, and this is why I allow myself the current sentimental digression.

If the new is what we do not know, how can we understand it?

Captivated by the rich and unparalleled book, I had a curious feeling of time travel into the extinct world populated by giant creatures from which our current numerous species of smaller size would later evolve. Their habitat had been the entire universe, before the actual inhuman and inhospitable dimensions of which were for the first time discovered by William Herschel. Soon Charles Darwin would unravel the similarly inhuman dimensions of human origin. The romantic generation was on the wane. But history has the right of return—as pattern.

I have always considered chemistry the most romantic science. I thought it was my personal quirk, but as I found out, owing to Richard Holmes' book, Humphry Davy, one of the founders of modern chemistry, was of the same opinion. Moreover, he, it seems, anticipated what I call pattern chemistry: chemical ideas applied well beyond atoms and molecules. Anyway, he considered chemistry the central science.

Meanwhile, young Michael Faraday and his generation were preparing to stand their ground and the world was about to switch to electric drive.

Electricity was too fast for romanticism. Charles Babbage, of the new wave, spent his life and fortune on his calculating monsters, but mechanics was too slow for thinking machines. Ultimately, his idea was revived by a jolt of electricity, à la Frankenstein, and as result we have no privacy today. However large the universe, our planet is small.

I present here two quotations from Humphry Davy, "*Consolations in travel, or, The last days of a philosopher*," 1830, Dialogue V, *The Chemical Philosopher*.

> He [the chemical philosopher] sees man an atom amidst atoms fixed upon a point in space; and yet modifying the laws that are around him by understanding them; and gaining, as it were, a kind of dominion over time, and an empire in material space…
> ………………………………………………………………………………..
>
> Whilst chemical pursuits exalt the understanding, they do not depress the imagination or weaken genuine feeling; whilst they give the mind habits of accuracy, by obliging it to attend to facts, they likewise extend its analogies; and, though conversant with the minute forms of things, they have for their ultimate end the great and magnificent objects of nature. They regard the formation of a crystal, the structure of a pebble, the nature of a clay or earth; and they apply to the causes of the diversity of our mountain chains, the appearances of the winds, thunder storms, meteors, the earthquake, the volcano, and all those phenomena which offer the most striking images to the poet and the painter. They keep alive that inextinguishable thirst after knowledge, which is one of the greatest characteristics of our nature; for every discovery opens a new field for investigation of facts, shows us the imperfection of our theories.

The following is a remark of John Herschel (the son of William Herschel) on the phenomenon of electricity and magnetism in *A Preliminary Discourse on the Study of Natural Philosophy* (available online). Herschel writes on the perseverance of Hans

Christian Ørsted (Oersted) in his search for the connection between electricity and magnetism:

> There is something in this [perseverance] which reminds us of the obstinate adherence of Columbus to his notion of the necessary existence of the New World; and the whole history of this beautiful discovery may serve to teach us reliance on those **general analogies and parallels** between great branches of science by which one strongly reminds us of another, though **no direct connection appears**. (quoted from: Richard Holmes, *The age of Wonder* , p. 443-444; online Herschel's text, page 340)

John Herschel had in mind the analogy between electricity and magnetism regarding the property of polarity.

8.11. War and play news

> ## Sony: Hacker stole PlayStation users' personal info
>
> By Mark Milian, CNN, April 26, 2011 7:16 p.m. EDT
>
> (CNN) -- A hacker has obtained the personal information of PlayStation Network account holders and subscribers of the Qriocity streaming service, Sony said in a message to customers Tuesday. ……….
>
> The attack also has crippled Sony's PlayStation Network, which has some 70 million subscribers and has been down since April 20. …………
>
> The hacker could have taken credit card numbers, card expiration dates, billing addresses, answers to security questions and purchase history, but not credit-card security codes, they said. ………….

Security and insecurity may seem as just two ends of the single scale, like order and chaos. This field, however, can have a peculiar transcendent structure in which the difference between both is relative. They make sense only in a context. The latest example is the absence of the telephone line, high walls, and security cameras around the perimeter of the bin Laden's compound in Pakistan. Considered as security measures by the inhabitants, they became the break-in points for outside security specialists. Conspicuous security signals insecurity.

Here is a curious addendum to the subject of pattern thinking (source):

> A 2008 study conducted by US university professors suggested there was a high probability Osama Bin Laden had taken refuge in the town where he was ultimately killed by US operatives on Sunday [May 1, 2011].
> ……….

> The model, which Mr Gillespie typically uses in his work to **track endangered species**, suggested Bin Laden was probably residing in a city compound, rather than in a cave in a rural environment, because people in less densely populated regions would be more likely to take the time to notice him, the university professor told the BBC.
> Using the study, Mr Gillespie and his students then surmised that the compound would have security, such as high walls around its perimeter, and an electricity supply, both of which were found at the site of Bin Laden's residence in Pakistan.

Probably, the information security will never be achieved other than in the context of war rather than of crime.

> **EXERCISE**: What is the difference between the patterns of crime and war, if any? **Borders?**

I compared Internet security with pest control. With my own bleak experience with lawn and garden and the lost war against crabgrass, I don't trust weed and pest control too much. The sellers of chemicals do not want me to get rid of crabgrass. The radical step is to completely replace the soil and relocate some of my neighbors—or myself. In pattern language: start with the template of the global totalitarian state, best of all, of the Stalin's model. (Note: I belong to the vanishing cohort of people who remember life in Stalin's Russia).

As we have (almost) learned to live with the nuclear bombs, reactors, and terrorists, and as we have overcome *Yersinia pestis*, I hope, we will learn to live with *Yersinia digitalis*, the digital plague, and prevail.

Although human nature is extremely stubborn, the digital era makes things more human and humans more material. The future humanoids will celebrate its beginning, counting from [1971](8/15/1971, to be exact), the year when gold, one of the most rugged and robust matter on earth, the idol of materialists, was dematerialized. While we elect the government to represent us, humans, it also represents things to the extent that many refuse to believe and the things are still mute about.

Come on, grow up, America!

THE END