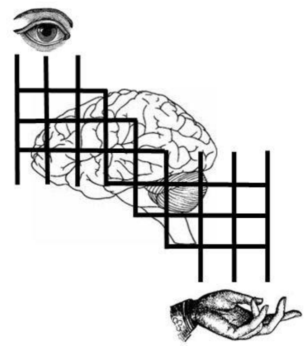

Pattern chemistry of the origin of mind

Yuri Tarnopolsky

This project evolves

In this essay I attempt to formulate a hypothetic mechanism of spontaneous emergence of complex systems. I take mind as a typical example. Other possible particular cases range from the origin of planets to human history and, to jump down the scale, human individuality. By complex system I mean *exystem*: **E**volving **C**omplex **SYSTEM**.

The conceptual foundation for treating such "too big to succeed" problems is Pattern Theory (Ulf Grenander), which represents the abstract structure mathematically, i.e., regardless of tangible properties yet never losing touch with reality. [1]

I cannot give here even a short review of the principles of Pattern Theory except for saying that from the point of view of a chemist it is a perfect abstract chemistry of anything consisting of atomic **entities** (generators) and **connections** (bonds) between them, with probabilities (or energies) attributed to either. Patterns are open-ended collections of similar **configurations**.[2] Such configurations are exemplified by molecules. What I call pattern chemistry deals with intimate mechanisms of transformations of configurations. I list major sources in **Appendix 1**.

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[1] Two most relevant and more accessible books by Ulf Grenander are *Elements of Pattern Theory* (1996) and *A Calculus of Ideas* (2012).

[2] Groups under similarity transformation on a set of configurations.

I can skip introductory explanations because I start *ab ovo* and use mostly visual representation typical for chemistry and engineering. As a chemist, I perceive the world in terms of atomic entities (generators of Pattern Theory or atoms of chemistry) and connections between them. This can be expressed as a connectivity matrix, but I prefer to visualize not only the structure but also the process of its construction, as if it were a machine or a bridge.

In **Appendix 2**, I tell the story of the origin of this essay. I do it because the best way to understand something is either to build it or to study its history. For such intriguing exystems like life, mind, and society building is not an option.

The most important circumstance in my story is that I am neither a mathematician, nor computer scientist, nor a historian but just a chemist with wide interests outside my field. In my current field of pattern chemistry I am alone and without any need of grants, peer reviews, and tenure can frolic as wild as it gets. Regarding Pattern Theory, however, I have been lucky to enjoy discussions with Ulf Grenander, as well as his attention and support, for a long time.

PART ONE: HISTORY AS EXPLANATION

THE PROBLEM

The origin of the problem of spontaneous emergence predates recorded human history. It generated mythological and religious explanations, practically all being description of making or building by a mythological figure. The scientific inquiry seems to get a start by the first half of the twentieth century when theoretical physicists began to ask two separate questions:

Question 1. How is life physically possible?

Question **1** was answered in a very general form by Erwin Schrödinger (1887-1961) in *What is life? The Physical Aspect of the Living Cell* (1944). The modern answer, shaped by Ilya Prigogine (1917-2003) in the second half of the twentieth century, describes life as a dissipative structure far from equilibrium, which needs a constant supply of free energy.[3]

[3] Free energy is directly convertible into work, as, for example, chemical energy, light, and electricity, but not heat.

Question 2. Since life is so complex and spontaneous origin of complex systems is improbable, how could it spontaneously emerge?

Question **2** implies two plausible assumptions, which I share.

2A. Life is complex.
2B. Spontaneous origin of complex systems is improbable.

Both questions **1** and **2**, in my opinion, demonstrate what I call synchronic approach, which I do not share: origin is considered a single event with a beginning and an end. Yesterday there was no life and today—bang!—it is here. There is, however, a different—diachronic—approach, which I prefer: origin is a sequence of events lining up as the history of the object, in our case, still ongoing. It is always debatable which event can be called origin, where the sequence ends, and whether it ends at all.

Simple objects, I presume, do not necessarily exhibit anything long enough to be called history. They can emerge spontaneously because probability of a conjunction of a few favorable conditions can be substantial. Not only that, but simple systems can go through the same states again and again in the same or different order with the same average probability of each state[4] . Thus, a chemical transformation occurs spontaneously because it involves a few atoms and bonds. Even if the molecule is very big and if we somehow label individual atoms, they bond and split indefinitely in equilibrium. A large complex structure, however, can appear only once, diachronically, and in a sequence of simple steps. Origins of planets and of humanity on one of them seem to be two extreme examples of diachronicity. Next, I will consider something less grand than either of them.

EVENT AND PROCESS

While we can understand many physical, chemical, and biological objects and systems *per se* regardless of their origin and history, to understand what society and civilization are at a certain point requires significant knowledge of how they looked some time before that. The fresh example, while I am writing this (October, 2012), is the US Presidential

[4]It is called ergodicity. Exystems cannot be ergodic. They emerge, grow, decline, and die only once.

Elections. To understand what is going on in 2012, we need to go back to Elections 2008 and further back to at least 1994, the beginning of the Republican Revolution.

Understanding is a process in the mind, a kind of intense, sometimes stressful small-scale evolution. To understand means to come to a relaxed stable state of mind when no big questions remain. Once we have understood something, we normally cannot un-understand it.

With the yearbook of history opened on page 1994 we would still have important questions about the origin of the Republican Revolution and would have to go back to the Franklin D. Roosevelt Revolution better known as the New Deal, to which the former is, probably, a counter-revolution asking for a new revolution—a typical pattern of history.

Some questions could be addressed to even earlier periods, and the American Civil War is most relevant. What is important, the more and more distant past would be **less and less relevant** to the initial question about Elections 2012. Some elementary knowledge of world history will do, while the origin of life and humans on earth would be completely irrelevant, unless in the obscurantist politics of the religious right. This is the essence of diachronic analysis.

How the mind originated and how it works is a subject of tens or hundreds of thousands printed and digital pages. The encyclopedic How the Mind Works by Steven Pinker (1997), is over 650 pages long consists mostly of words and begins with the honest "we don't understand how the mind works." The book of the same title by Carlo Lazzari (2007), 121 pages, contains mathematical and graphic material, symbolically, with lots of white space. Daniel Kahneman's "Thinking Fast and Slow"(2011), almost 500 pages, is about how foolish a mind can be, and has just a couple of charts.

Science of the mind is a very large, complex, diverse, fragmented, and unsettled subject, itself in the process of fast evolution. Some central terms still remain undefined and crucial problems unsolved, which makes it all the more interesting. I am not going into details here, however. With so much money on modern mind, for the mind to understand itself is like to win a basketball game on full stomach.

Recently, I have bumped into the ongoing study of the little worm *C. elegans*, including the details of its behavior and **connectome**—the map of connections between the cells of nervous system. It was an additional stimulus to go back to my old idea. The connectome research, very high tech, goes far beyond simple creatures, embracing brains of humans and even their babies.[5] I think that there could be a way to test the ideas of this essay not only on the worm, but also on other detailed records of evolution, such as history. See **Appendix 3**.

My pattern of thinking is entirely chemical and engineering in nature, which is different from the way most mathematicians and physicists think. It also has poetic elements, like the habit of metaphor, which makes me feel at home among patterns. This is the only

[5] See a remarkable video as an introduction to the field.

natural way for me and I will do it in my ideographic manner: by drawing pictures on the sand with a twig. Same applies to the style. Patterns and metaphors do not know borders. And if I go overboard sometimes, so be it.

CONTAMINATION BY MIND

I am interested in a highly general and abstract problem: the origin of complexity from simplicity. It resonates, in a pattern way, with the reversed ancient paradox “heap.”

Direct version:	*1,000,000 grains of sand is a heap of sand* (Premise 1) *A heap of sand minus one grain is still a heap.* (Premise 2) Conclusion: 1 grain of sand is a heap.
Reversed version:	1 grain is 1 grain. 2 grains is 2 grains. What number of grains becomes a heap?

I am asking not **when** simplicity turns into complexity—there is no answer—but **how** it happens.

I propose the following hypothetical twofold **principle of simplicity**:

1. Spontaneous origin of simple systems is probable. [6]

2. Complex systems spontaneously originate from simple systems by a sequence of simple steps.

This kind of reasoning has a counterpart in the method of complete mathematical induction and in recursive functions.

Example: Long molecules of nucleic acids and proteins, as well as polymers in general, are synthesized in organisms by repeating the same simple steps with relatively simple blocks and operations. [7]

Here the term **spontaneous** means: without a participation of human or divine mind. I apply the same term to the evolutionary origin of cognition. The term *spontaneous* does not apply either to newborns immersed into human environment, nor to robots designed

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[6] It is not so simple. For example, sodium spontaneously burns in chlorine, $2\ Na + Cl_2 \rightarrow 2\ NaCl$, but it is impossible to do it without a chemist’s participation. Somebody must bring the two elements in contact. A quantum system is a better example—but not perfect.

[7] There is a chicken-or egg discussion about the beginning of life. I believe, life started with polyphosphoric acids and was kept off equilibrium by tidal and diurnal cycles.

by human mind. Spontaneous is anything that has nothing to do with human mind or, as I would put it differently, **mind-sterile**. Artificial Intelligence, for example, reeks of human mind.

Unfortunately, the words *spontaneous* and *accidental* are both contaminated with human mind that sets the baseline of what is planned, regular, and unavoidable. I would rather get used to *mind-sterile*. Not the *mindless*, indeed. There are only two mind-sterile media that I know: the blind chance generated by microscopic physical processes and the unbending macroscopic regularity of the solar system. In a way, human civilization is the drive to control—i.e., contaminate—blind chance. We corrupt it with order and it fights back.

Any design of the mind that contains an algorithm is already contaminated with human mind and cannot serve as a model of spontaneous emergence.

> Is it possible to create sterile artificial conditions for a natural intelligence? The closest but still distant approximation could be creating the **simplest** artificial mind, just two cells, and letting it evolve to the human level by the principle of **simplicity** in animal or human simulated or duplicated environment by a **simple** recursive algorithm. The problem is that the mind will need not just a body, but a company of peers. This is so-o-o-o complex but maybe doable. I think that Ulf Grenander's GOLEM (in *A Calculus of Ideas*) was the first step in this direction. Some starting elements of my approach can be found in complexity : the content of an empty mind can be filled with ideas by an extremely simple procedure based on the concept of novelty.[8] My main idea is: forget the algorithms, let "it" live its own life and play the game of chance, win a new bone in its own skeleton, pay the loss by death, and have a history.

PART TWO: EMERGENCE OF COMPLEXITY

In this section I will try to dehumanitize the model of emergence of cognition by the disinfectant of randomness for as much as it humanly (oops!) possible.

Let us consider the process of turning a grain of cognitive sand into a heap, step by step. It will take some page space, but in the end I will compress the symbolism to letter "**h**"

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[8] *Pattern Chemistry of Thought and Speech and their Hypothetical Ancestor* and *Molecules and Thoughts*.

as an ideogram for "combinatorial branching" with the main **|** and secondary **˥** branches: **ɦ**.

STEP 1. POINTS AND LINES

I start with a set of receptive **points** open to the stimuli of the external world. The simplest system of representing the world consists of one **point** capable of being in two states. I take a more complex but still simple case of a four point system for representing external world.

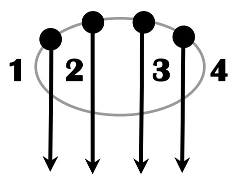

Figure 1. Points and lines

My own representation is by no means formal and rigorous. In Pattern Theory a visual representation of structure consists only of **points** (generators) and **lines** (bonds), although a generator can have its own structure. I am describing a sloppy vague template to be deformed and hardened into something more formal, consistent, and abstract. At this point it is not really necessary.

Figure 1 shows an assembly of four sensitive points and four **lines**. When acted upon, the cell generates a signal traveling through a **line** portrayed by an arrow. This and subsequent figures are only **structures** (configurations)**,** in which the nature of points and lines does not matter.

Simplicity is important for spontaneous emergence by bonding between four simplest singular points. [9] Obviously, its lines (bonds) are only potential because there is nothing at the other end. We will come to the arrow targets later.

The four points and lines in **Figure 1** can serve as a primitive analyzer and their outputs could be used in various ways.

How can it become complex?

Obviously, it can happen by developing complexity "downstream," so that the emerging "mind" can grow beyond singular sensitive points and represent more complex external situations. For the mind they are just combinations of singular inputs. The difference between two states of the world is combinatorial.

[9] Probability/improbability of spontaneous emergence is, possibly, a way to define simplicity/complexity in an incomplete but pragmatic way. The weakest point of all our reasoning about mind is definitions given by another mind. Compare with **Essay 58.**

STEP 2. COMBINATORY DERIVATION

Next, we form, top-down, combinations of signals from the primary sensitive points. We deal with three abstract operators: black circle ●, ring ○ , and square ■ . For example, they can mean logical operators **AND** (multiplication, ×) , **OR** (addition, +) and **NOT** (negation, —). They can mean any other operation, not logical at all, for example, a formation of a neurophysiological contact, or a particular movement, or only its direction, or a spoken phrase.

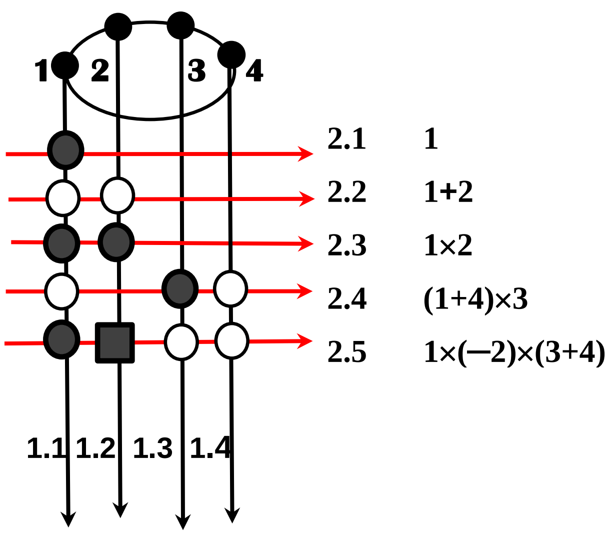

Figure 2. Combinatory derivation

In **Figure 2**, we form five horizontal lines (red arrows), numbered as 2.1 to 2.5, each corresponding to a combination of the **lines** of the first generation. Their logical meaning is in the right column. A single ● means just identity, YES, or "presence."

An operation does not influence the function of the corresponding original (vertical black) line, which can participate in further derivations. The number (5) of derivations in **Figure 2** is arbitrary.

STEP 3. THE SCALE

Figure 3 illustrates the formation of the vertical red lines of the second **generation**, which join the array of the original black lines.

The lines of the second generation are subject to a new derivation resulting in vertical green lines of the third generation.

In order to simplify the symbolism, I use the mesh rectangle to indicate the area of combinatorial derivation without specifying the operators.

The buildup of complexity can be continued further as **alternation of stages of combination and derivation**, as well as an expansion of the primary sensitive points.

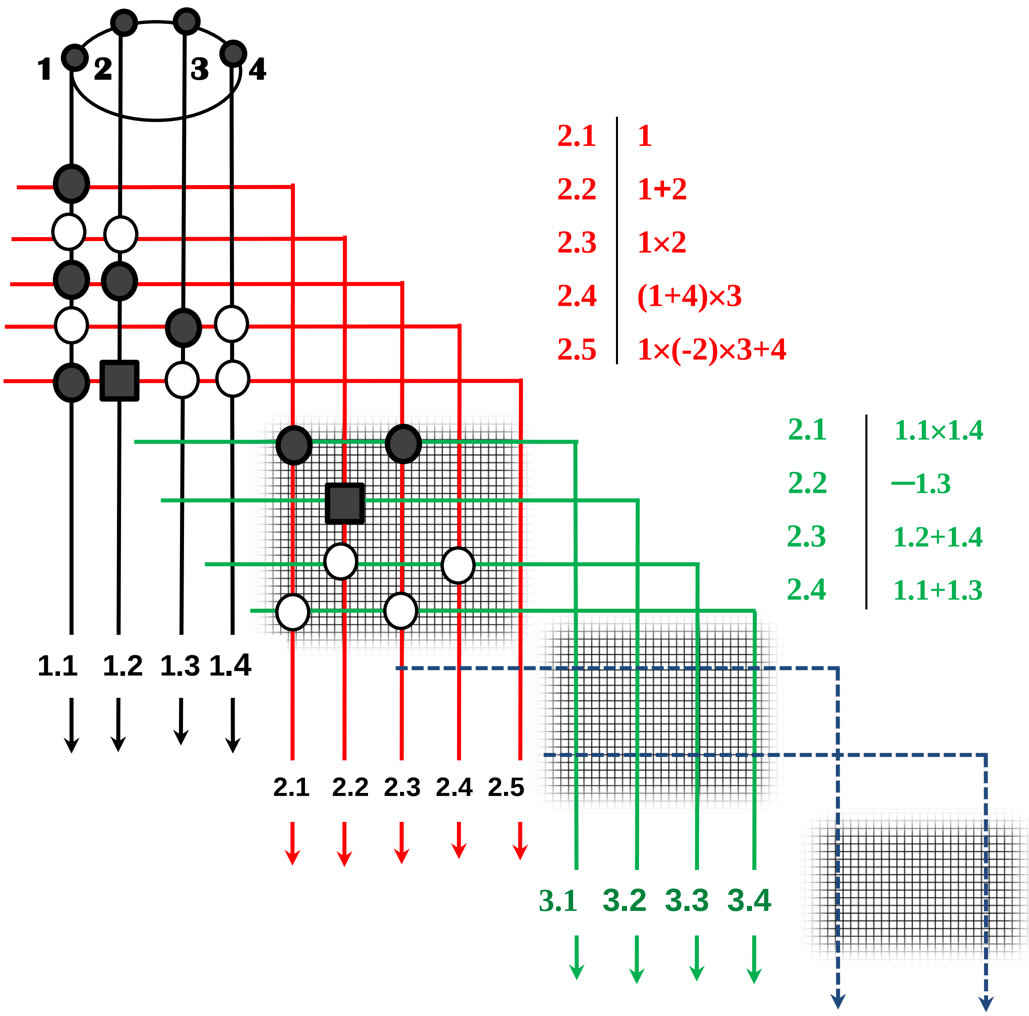

Figure 3. Expansion of the analyzer

TOWARD ULTIMATE MIND-STERILITY

The mathematical representation of the process of expansion exists: it is the scale of sets described in Bourbaki's *Theory of Sets* [10] (1970), p. 383 , See **Appendix 4.**

[10] Nicolas Bourbaki, *Elements of Mathematics: Theory of Sets*, Addison-Wesley, originally published by Hermann (Paris), 1968

In short, there is a basic set *P*. The next step of expansion includes the basic set *P* and all combinations of its members. The next step uses the previous set as a new base set. And so on. The scale quickly goes into combinatorial explosion. The attractiveness of the original scale of sets, however, is that no combination can be missed and the process can be completely random. But its enormity needs some filters. Here is the most mindless one: let us combine elements of the lower step **at random,** preventing some or most from entering the next step. The result will be a subset of the scale of set: a sparse scale of sets with many holes in it. The sparseness can be maintained also at random. The random death of points and lines may or may not lead to any particular direction of evolution, such as, for example, the growth of complexity. Randomness is the only disinfectant in the science of emergence.

I am moving toward the main mind-building mechanism and this is a good opportunity for a reader to exercise his or her mind and predict from where it could come.

Scale of set is a curious and even intimidating creation of the mathematical mind. There are about 150 related web pages—a microscopic volume—and a good part of them are my own pages. As soon as we imagine a real process of a random growth of some biological network, sparse scale might look tamer and more like the very ideogram of evolution.

After the principle of a step has been described, the graphic symbolism can be further simplified, as shown in **Figure 4**.

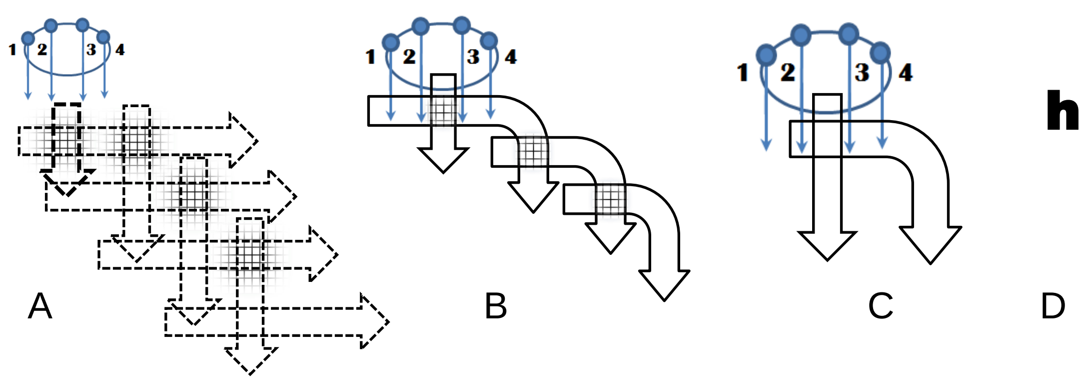

Figure 4. Compact symbolisms of derivation

The derivations do not need to be divided into sharply distinct generations. The combinations can include earlier generations in **random fashion**, as shown in **Figure 5**. We can also consider a gradual **random** dying out of much earlier generations in subsequent derivations, as in my example with American history.

Next, we allow more randomness, up to complete one, of both combinations and derivations. Randomness means exclusion of participation of a second mind because the only thing neither mind nor computer can generate is random number, which can be a negative definition of randomness. [11]

My last remark means that perfect randomness does not exists in any sufficiently complex system because if there is no participating mind or computer, a complex system cannot be in any of its states with equal probability. It is possible only in physical abstractions, like ideal gas. There are constraints of size on complex systems in a real world with Euclidean metrics.

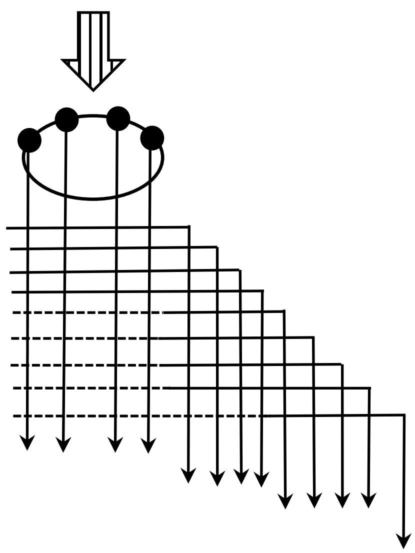

Figure 5. Abstract scale

Next step of simplification is the simplification of operations. Apparently, the absolute minimum is two, approximated as YES and NO. There is no reason to expect that nature somehow learned mathematical logic or information theory. The logic of natural systems can be fuzzy or, let me say, "analogic." Ulf Grenander's Pattern Theory, in my non-professional opinion, introduces probabilistic logic and thus raises a step above over the digital mainstream.

I am aware of the term "neuro-fuzzy" applied to a hybrid of fuzzy logic, with connectionist neural networks, but not more than that. I am not good at mathematics and my mind operates by similarities, connections, and images. I cannot go into this unfamiliar to me field. Instead I am giving some engineering examples in **Figure 6.**

If we attribute weights to lines and thresholds to derivations, with appropriate probability distributions, operations OR, AND, and NOT will become not random, but semi-deterministic. **Figure 6** should be understood not literally, but as analogy. The operators work by weights (**W**) and thresholds (**Th**) . In some cases the outcome is clear, but when **W** and **Th** are close, the dice is rolled. The operators are so simple that each has some chances of spontaneous assembly. Nevertheless, the whole picture in **Figure 3** does not look sterile enough to me because I have designed it. It needs the final purging touch.

[11] While the mind is growing, its mere size can create regularity in the form of gradients, limitations, and selective enhancements. Topology of the world, the order of the previous history, and the constraints of the scull may influence the structure of the mind (not to mention brain) at any step. However, the other mind is not to be blamed for that.

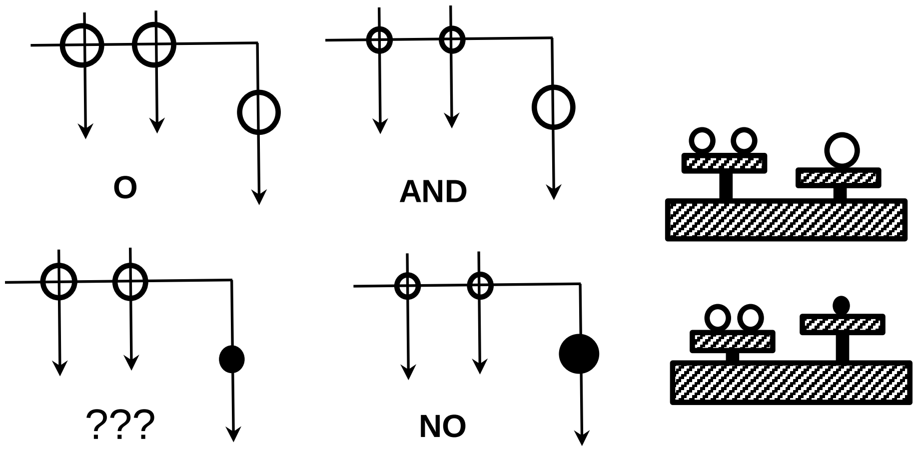

Figure 6. Analogics

HERE COMES DARWIN

The above picture has one big flaw: there is no guarantee that the expansion would go far enough because of the possibility of equilibrium between its elements and their aggregates, in other words, between simpler blocks and larger blocks of blocks. There is no law of nature which would ensure the complexification, especially because chemical—not pattern-chemical—realism predicts this kind of equilibrium for any bonding. Life and equilibrium are incompatible.

Evolution of life is unthinkable without death (or elimination in some form) as a selecting hand. Darwinian selection is the main guiding mechanism I hinted at earlier. Since the substrate if the mind is living tissue, the points and lines are no exception.

Regarding selection, we know about selection of life forms more than about selection in the evolution of the mind. There are several plucking and weeding hands capable of natural selection: diurnal and tidal cycles, daily fluctuations of temperature and humidity, seasonal cycles, and ultimately large scale random but frequent enough bouts of extinction like meteorites, volcanoes, droughts , floods, etc. These hands can rock the cradle of life—keep it off equilibrium—with the purpose of not letting it fall asleep. Note that this mechanism does not mean that all organisms move toward complexity. What it does is to make complex organisms possible. Bacteria coexist with humans.

The weeding moves each species to its niche of stability. Evolution is the survival of not the fittest but the most stable.

The Darwinian selection of thoughts seems to me a very material mechanism. All is needed for selection is memory and a constraint in the form of a limited resource. The competition for the glucose in the blood flow is the most probable mechanism of selection of thoughts. I explored some primitive models of this kind in Molecules and Thoughts and Pattern Chemistry of Thought and Speech, Section *Thinking*.

PART THREE: THE h-HYPOTHESIS

I can now formulate the "**h**-hypothesis" ("**h**" as in **Figure 4D**) of the origin and evolution of the mind, which also covers the origin and evolution of life and society: the pattern tricks are the same.[12]

1. The emergence of complexity in the mind is a random reversible (not in thermodynamic sense) alternation (mutation) of combinations and derivations.

2. It starts with the simplest minds, capable of spontaneous assembly, and continues under the pressure of Darwinian selection so that only those points and lines survive that increase the stability of the mind.

3. Geological events keep the system far from equilibrium.

4. A remarkable paradoxical property of the h-hypothesis is that while the mind **expands**, its content still **converges** to most abstract and therefore useless in "street life" ideas. Mind works like a trash compactor. But this is why a scientist is, preferably, not a man from the street.

4. The mathematical representation of the process is an incomplete, mixed, torn, and sparse subset of Bourbaki's scale of sets.

[12] Compare with: Yuri Tarnopolsky and Ulf Grenander, History as Points and Lines. History is a succession of destructive and creative waves, but the products of old creative waves coexist with the most recent ones. The current coexistence of Amazonian tribes with sophisticated West European societies, 1% of super-rich with 15% poor in the USA, and the intellectual elite with the anti-Darwin and anti-science warriors in the same blessed land is the artifact of the scale-like social evolution.

5. A possible way to test the h-hypothesis is to see if simple minds, like that of *C. Elegance* can conform to it. [13]

But does *C. Elegance* have a mind?

I am a big admirer of many Douglas Hofstadter's ideas and of his poetic imagination. One among them has an immediate bearing on the above question. Douglas Hofstadter believes that any organism has a "soul," but they are very different in size, increasing from bacteria to humans.[14] I agree, substituting "mind" for "soul," although I would not mind "soul" either. Have I really said that? This view of the world is very abstract, but only the high abstraction goes to the deep bottom of things.

Why can we understand the world? How can we generate new ideas? How can we successfully survive in the complex world? My answer is: it is the matter of size. Since the mind is converging by generating the more and more abstract lines coming from sensors, they shrink in number with each new level of abstraction and if relevant ones are concentrated in the mind, there are so relatively few of them that **reasoning occurs spontaneously** and fast, without any algorithm. This is the conclusion one can draw from Ulf Grenander's representation of the mind. Therefore, the "slow thinking" of the psychology of rationality is just a long sequence of fast stages: the size (quantity) matters and quantity translates into quality, as Georg Hegel told us long ago. Is America too big or too small to fail or to stand?

The chemists, who routinely deal with extremely complex structures and transformations, simplify the problem of size-related complexity in a different way. They know that a single act of chemical transformation usually involves only a few atoms in close proximity. They look only at the most probable hot spots and ignore the rest of the structure.

Whether it is a little worm or a theoretical physicist, as soon as the representation of the problem in the "mind"—or **the** mind—is reduced to a small enough size, random pattern-chemical recombinations can generate a very few alternative solutions to choose among.[15]

The above h-model looks like it addresses only half of the mind problem: representation of the world. There is the other part: action in response to the world.

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[13] See Nivedita Chatterjee and Sitabhra Sinha, Understanding the mind of a worm : hierarchical network structure underlying nervous system function in *C. elegans* (2008) . Authors note: "This [assortativity, a kind of hierarchy in networks] may shed light on one of the central questions in evolutionary biology that resonates strongly with the theme of this volume, namely, why did brains or central nervous systems evolve?]

[14] In *I am a Strange Loop* (2007)

[15] That would be a mechanism of fast thinking (Keith Stanovich, David Kahneman, Amos Tversky), but I have a bone to pick with the division of thinking into fast and slow, see Pattern chemistry of rationality (Essay 58).

Although I am not going to discuss it here, in **Figure 6** I reproduce Figure 54.4 from my The New and the Different (1996, Chapter 54, The Mathematical Mind, p. 413), where more detail about the analyzer and synthesizer can be found.

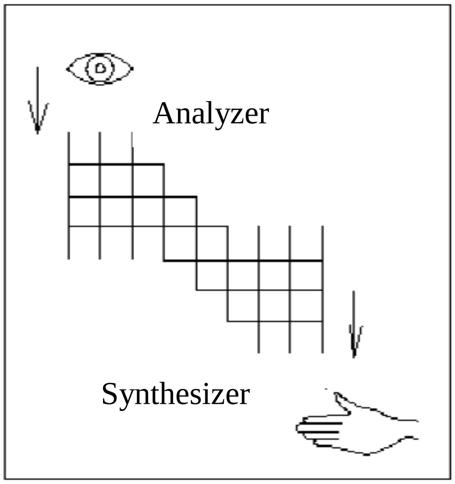

Figure 6 . Analyzer and synthesizer.

The core of the mind, obviously, is the realm of ideas, not of point sensations that come from the outside. The trash compactor leaves predominantly higher levels of the scale, which are less numerous and are not anchored at particular sensitive cells of the organism. Some of lower level ideas hide in the subconscious and probably not all of them can be expressed in words.

This is how the analyzer works. Next question, what to do with its output? This information must have some use and the arrows should find their targets.

The second part of the mind, the synthesizer, is a diverging scale, anti-symmetric to the analyzer. It uses the compacted processed information and converts it into elementary responses of the cells, mostly of muscles, including speech, writing, and work, as well as automatic reflexes poorly controlled by the mind. It is diverging because the number of both sensors and affectors is large as compared with most abstract ideas, although this is only an uneducated guess.

The synthesizer accepts the output of the converging "h-analyzer " and in an IF—THEN manner converts it into the behavior in the same way as in any stage of derivation. What is different, this derivation is diverging into an array of elementary physical movements or their series. For a sufficiently complex organism, a large number of incoming configurations is analyzed into a smaller number of categories and the result used as a signal for a hierarchy of large number of outgoing elementary movements. The derivation matrix is the standard block for both.

Having once invented a trick, nature uses it again and again as pattern in very different areas.

SO, HOW DOES THE MIND REALLY WORK?

We can better understand an exystem by complementing **its history** with the **history of its understanding**. In this regard, I would like to compare the h-hypothesis with the two perfectly indisputable leading ideas presented by Steven Pinker in his *How the Mind Works*. My understanding of both, however, could be disputed.

First idea: the mind works because there is a correspondence between ideas, their symbols, and changes in the state of matter. The Turing machine and its incarnations process information ("ideas") by manipulating symbols and physically writing and erasing them. Brain is the "matter" of the mind. I believe I follow this principle by wiring up the scale and avoiding the mathematical symbolism.

Second idea: the mind, like life in general and other functions of our bodies, emerged in the process of the natural selection of replicators, which is the modern way to say "Darwinism." This is my favorite idea, too, regarding mind, but from a different angle.

My first remark is that any Turing machine must have a set of instructions or "reflexes," as Steven Pinker notes. No picture of mind, however, will be complete without the explanation how this set comes to existence without the pre-existing condition of another human mind present. Now, how does that other mind work? Turing machine had Turing. Whom do we have?

M.C.Escher

My second remark is that since natural selection of replicators is the cardinal pattern of evolution, it would be natural to generalize it further and apply not just to life forms and memes[16] but to thoughts in the individual mind. This is the core of my approach. In my computer simulations I used a particular model of competition for a limited resource: Manfred Eigen's concept of molecular evolution[17]. Ulf Grenander's GOLEM, however, is more general because it uses casting a random number to determine the winning thought. In my view, casting a random number is a competition for a limited resource of the sum of all probabilities (always 1). It has one winner. But what happens with thoughts next in line of decreasing probabilities? I see them living in the subconscious, the less probable the deeper.

I reproduce in **Figure 7** a figure (Figure 8) from *The Three Little Pigs : Chemistry of language acquisition*.

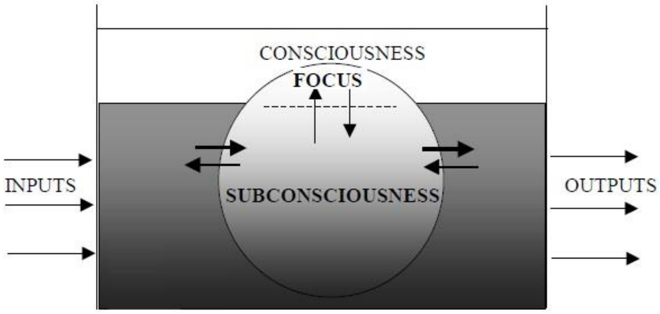

Figure 7. Consciousnes as the winning configuration in competition for a limited resource

ANSWER

Mind is an exystem. It works by maintaining a probability distribution of competing thoughts. The winner (or a few leaders) rise to the consciousness, the rest descend to the subconscious in order of decreasing probabilities. The probability distribution at a particular moment depends on the distribution at the preceding moment. Thus, the question "Whom do we have?" creates—slow or fast—a distribution which pushes up into the consciousness this answer. (I confess, it was ready long before). Until there is a computer that thrives on randomness and can be foolish, careless, forgetful, and deceitful, there is still a gap between thinking machines and human mind.

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[16] For example, the medieval memes spread by some right wing Republican congressmen.

[17] M. Eigen, Selforganization of Matter and the Evolution of Biological Macromolecules, *Die Naturwissenschaften*, **58,** 465-522 (1971).

CONCLUSION

My not so hidden agenda with this essay was to show that the cardinal problem of the origin of complexity, mind and life included, may have a simple solution. Such mundane property as the size of structure plays a role in cognition as large as the size of a company or just a mountain of money in economy. For thinking, however, the smaller, the better. This is all hypothetic, of course.

I suspect that h-hypothesis could be relevant for the origin, structure, and function of DNA (which is, ultimately, a kind of Mother Nature's long and slow cooked thought), but this area is too big and too distant for me. Can anybody try? Here it is in the nutshell: the origin of DNA can be described using h-hypothesis. This would explain the role of the DNA Dark Matter (former "junk") in the chromosomes by its history.

Pattern Theory, as mathematics in general, does not know borders between domains of the world and domains of our knowledge about it. As simplicity is partly measured by size, I am satisfied with these 18 pages (if with anything at all).

Pattern Theory is the bridge between sciences and humanities. I believe my free-wheeling style naturally fits the borderless world.

"I approve this message" is humming in my mind, induced by the din of the election campaign, a show based not on the Aristotelian TRUE/FALSE logic, but on the weights and thresholds expressed in decibels of insanity. [18] It is just another step of combinations and derivations, some of which are potentially fatal for nations.

[18] See Pattern chemistry of 2012 Elections , Essay 57

APPENDIX 1

MAIN SOURCES FOR PATTERN THEORY

Ulf Grenander, *General Pattern Theory: A Mathematical Study of Regular Structures*, Oxford University Press, 1994.

Ulf Grenander, *Elements of Pattern Theory*, The Johns Hopkins University Press, 1996.

Ulf Grenander, *A Calculus of Ideas: A Mathematical Study of Human Thought*, World Scientific Pub Co Inc. , 2012.

Numerous sites on the Web.

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PATTERN THEORY AND PATTERN CHEMISTRY:

Yuri Tarnopolsky, COMPLEXITY, http://spirospero.net/complexity.html

In particular:

Molecules and Thoughts: Pattern Complexity and Evolution in Chemical Systems and the Mind

The Three Little Pigs : Chemistry of language acquisition

Pattern Chemistry of Thought and Speech and their Hypothetical Ancestor

TIKKI TIKKI TEMBO: The Chemistry of Protolanguage

Also:

Essay 57. THE FEW AND THE MANY

Essay 58. ALL RATIONAL MINDS ARE ALIKE; EACH IRRATIONAL MIND IS RATIONAL IN ITS OWN WAY. Pattern chemistry of rationality

APPENDIX 2

The idea of this essay is dated by 1956-1957, when I was a student of chemistry at Kharkov Polytechnic Institute. It was the second oldest technical university in the former Russian Empire. Its "institute" means the same as the "institute" in MIT.

It was the times of Nikita Khrushchev's "thaw," the end of Stalinism, and the end of prohibition on "bourgeois" pseudo-science of cybernetics. The first ever public lectures on cybernetics, organized by Yuri Sokolovsky, a professor of the local academy of military communications, attracted a lot of attention. He also ran a seminar at my Institute for the staff of the department of Electrical Technology and I was the only (future) chemist there and, probably, the only student. The problem for discussion was "the reading automaton," a device for recognizing text, now known as OCR, optical character recognition. I offered an idea and gave a presentation which did not cause any stir.

My "reading automaton" would translate combinations of non-trivial elements of the letter, like the ends and the elbow of letter L or the sharp angles and the ends of letter N, into the name of the letter using the principle of the scale of sets. I still do not know if it would work, but I saw that the principle was much more universal than character recognition.[19]

Norbert Wiener's *Cybernetics*, published in Russian in 1958, impressed me as much as the chemical experiments, which I saw at the age of 13, that made me a chemist. I began to read more on mathematical logic, set theory, and discovered the scale of sets.

After decades of watching development of computer and cognitive sciences, staying in contact with Ulf Grenander for many years, and watching his work on Pattern Theory of the mind, I still believe that my idea makes sense because it is mind-sterile—a kind of an oxymoronic pun. This is why *mindless* is not a good term.

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[19] Yuri Tarnopolsky, The New and The Different

APPENDIX 3

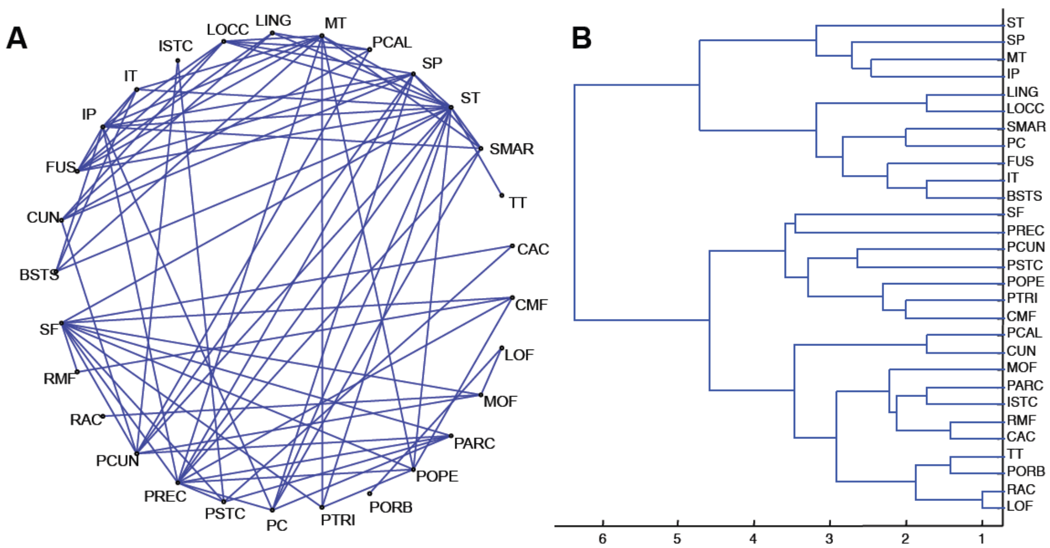

Figure 8 Connectivity in the brain

Figure 8 is reproduced from: Marcus Kaiser, A tutorial in connectome analysis: Topological and spatial features of brain networks, *NeuroImage, Volume 57, Issue 3, 1 August 2011, Pages 892-907* , Fig.4. Marcus Kaiser uses this source.

Abbreviations label some of anatomical subregions of the brain. The cortex has the 2D topography and distances between small regions widely differ. Part **A** shows the **topology** of connections between the areas regardless of the distance. Part **B** (dendrogram) reflects the **metric distance** between the subregions. For example, MT and IP are close, SP is somewhat farther from both. Areas ST down to BSTS are far from areas SF down to LOF. Both show further division.

I see a very oblique—less oblique from the pattern view—confirmation of the principle of combinatory derivation under constraints of natural selection in the detailed (a lot of subtleties!) research of connectivity in *C. elegans*., **Figure 9** is reproduced from: Varshney LR, Chen BL, Paniagua E, Hall DH, Chklovskii DB (2011) Structural Properties of the *Caenorhabditis elegans* Neuronal Network. PLoS Comput Biol 7(2): e1001066. doi:10.1371/journal.pcbi.1001066.

Since I am not a professional, my understanding and interpretation of this work could be grossly wrong.

The map is an extremely detailed 90% complete connectivity (**topological** adjacency) matrix of two systems of contacts between neurons: electrical (blue circles) and chemical (red points) with the size of the mark reflecting the number of contacts per neuron.

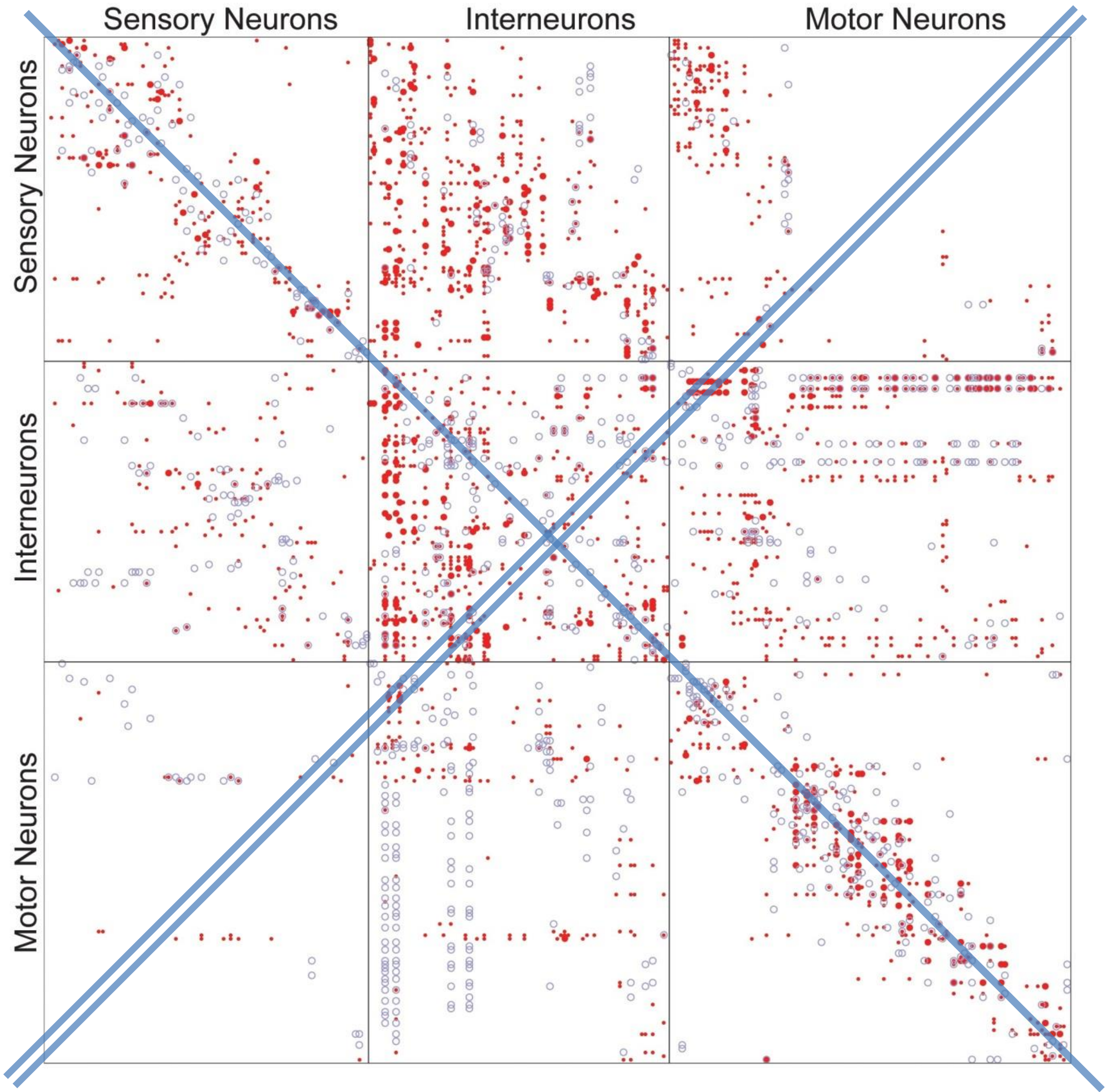

Figure 9. Adjacency matrices for the gap junction network (blue circles) and the chemical synapse network (red points) with neurons grouped by category (sensory neurons, interneurons, motor neurons). See [original work](), Fig.1, for details, most of which I do not touch. I added double "slash" (//) and normal "backslash" (\) diagonals.

The important property of the map is that the neurons in each group—sensory, interneurons, and motor—are enumerated in **topographical** order from head to tail. The map, therefore, reflects not only topology, but also **topography**. The matrices for sensory and motor groups are visibly sparser and are populated along the diagonal. It means that the neurons there make contacts mostly with close **topographic** neighbors. The interneurons, on the contrary, form a rich "small world" network. The communication between head and tail, naturally, is extremely limited. I want to draw attention to the "slash" (/) diagonal of the matrix. To me it shows the pattern similarity of the overall organization of the nervous system as result of their evolution: the sensory and motor neurons interact predominately with topographic neighbors. Analyzer and synthesizer are anti-symmetric. Their type of grid-like continuity, with topographic diversity, reproduces the organization of the continuous Euclidean external space, whether as object of perception or as the subject of action. The central nervous system, a descendant of its precursor in the worm, is where the two bundles intersect into a tight topological knot of a "near-complete" graph. This is the place where dreams and fantasies are born.

The authors of the cited work noted in *Discussion*: "Several statistical properties [in particular, synapse multiplicity distribution] of the C. elegans network are similar to those of the mammalian cortex."

Hypothetically, the "combinatory derivation," or scale, for which the term B-evolution (B for Bourbaki) could also be appropriate, explains how the mind evolves gradually, wavy, and smoothly, the way the little worm wriggles on videos posted by its well-deserved worshippers.

APPENDIX 4

8. SCALES OF SETS. STRUCTURES

1. Given, for example, three *distinct* sets E, F, G, we may form other sets from them by taking their sets of subsets, or by forming the product of one of them by itself, or again by forming the product of two of them taken in a certain order. In this way we obtain *twelve* new sets. If we add these to the three original sets E, F, G, we may repeat the same operations on these fifteen sets, omitting those which give us sets already obtained; and so on. In general, any one of the sets obtained by this procedure (according to an explicit

scheme) is said to belong to the *scale of sets on* E, F, G *as base.*

……………………

Thus being given a certain number of elements of sets in a scale, relations between generic elements of these sets, and mappings of subsets of certain of these sets into others, all comes down in the final analysis to being given a *single element* of one of the sets in the scale.

FROM: Bourbaki, N. (1968). *Elements of Mathematics: Theory of Sets.* Reading, Mass.: Addison-Wesley.

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