

The Law of Chemical Self-Creation in Chemicals Systems Continuously Moving Far Away from Thermodynamic Equilibrium

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In our experiments, we used only a few simple inorganic chemicals to demonstrate chemical systems that exhibit self-creation behaviour and continuously move far away from chemical equilibrium. Chemical systems produce chemical cells that take chemical compounds and move them into a cell, where they then react with another compound to produce a product that will then move outside the cell, while other compounds remain inside the cell. Cells connect to create multicellular organisms. Many different organisms are present at different levels. A few cells produce more complex structures, such as towers. A few towers may react to produce cities. Cities create a larger metropolis. Simple compounds are able to create unusually complex structures, such as machines that can switch between algorithms. Chemical systems may grow to infinity, forming incredible structures and behaviours. Every experiment was performed using two simple inorganic compounds. The duration of each experiment was minutes. The size of the chemical systems was usually measured in cm. We studied complex structures, behaviour's, and level of "intelligence". This study aims to provide insight into the theory of chemical self-creation, which has not been well understood in the past.

Keywords: Self-creation, Thermodynamic stability, experiment, system, Law.**Introduction**

In this paper, we present spontaneous, self-created formations of chemical systems that exhibit complex structures and behaviours. Chemical systems are related to the concept of Chemical Garden, which has been a subject of interest since at least 1646. French biologist Stéphane Leduc wrote in 1911 about how chemical garden structures were similar to living biological systems. Research on the dynamics of chemical gardens began in the 20th century due to a lack of success in studies about the origin of life. Recently, systems chemistry has emerged as a unique field of study, with a large group of scientists. The important question is how simple chemical processes are so "intelligent". These processes are in a middle ground between chemistry and biology. Systems chemistry involves prebiotic chemistry, complex systems, chemical self-organization, self-replication, physics, mathematics, and engineering [1-20]. Chemical systems have been studied in geological systems on the ocean floor that are related to the origin of life. Theoretically, chemical systems can grow to infinity, continuously increasing their intelligence [21-23]. We discuss only simple inorganic chemical compounds, in an effort to understand how small chemical reactions spontaneously create these incredible entities. Complex chemical systems are applicable to many chemical technologies, such as systems for micro- and nanotechnology, self-regeneration in the work of prebiotic chemistry, and a technology known as fabrication by reaction-diffusion [24-25].

Materials and Methods

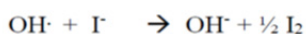
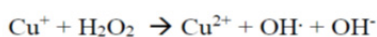
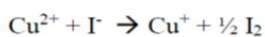
This paper presents a series of six experiments from uniquely simple reactions and synthesizes all of the findings together around the idea of chemical self-creation. All reactions consisted of two inorganic compounds, far from thermodynamic equilibrium. The specific reactions are presented below within each of the sections [26].

Results Self-created chemical cells and their functions; simple cell; system $\text{CaCl}_2 - \text{Na}_2\text{CO}_3$

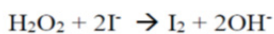
With this reaction, we demonstrate how a few simple inorganic compounds spontaneously create chemical cells. Inorganic chemicals move into the cell and react to produce a product that diffuses out of the cell [27, 28]. A pellet of CaCl_2 was added to a solution of Na_2CO_3 , producing the spontaneous formation of a cell surrounded by a semi-permeable membrane. Water and small molecules diffuse through the membrane. If CaCl_2 is doped with CuCl_2 , and the solution contains NaI and H_2O_2 , the membrane becomes larger and has a violet colour in the presence of iodine. Iodide and H_2O_2 diffused into the cell.

They react inside the cell to produce iodine and hydroxy ions. This process is catalysed by the Cu (II) ions inside the cell. The products diffuse out of the cell. Chemical reactions occur only inside the cell.

The mechanism of iodine formation appears to follow:



The general reaction is:



This is an example of a complex chemical process that moves chemicals to different places, forming complex processes and

removing products at an appropriate place. A chemical cell is a chemical machine. Although at first this may seem like an accident, it is a rule in the chemistry of self-creation. Iodine is an essential component of life.

Self-building complex towers, Ca^{2+} - silicate

In a calcium-silicate system, there is switching from one structure to another [29, 30]. This is a beautiful example of a chemical entity built in many stages.

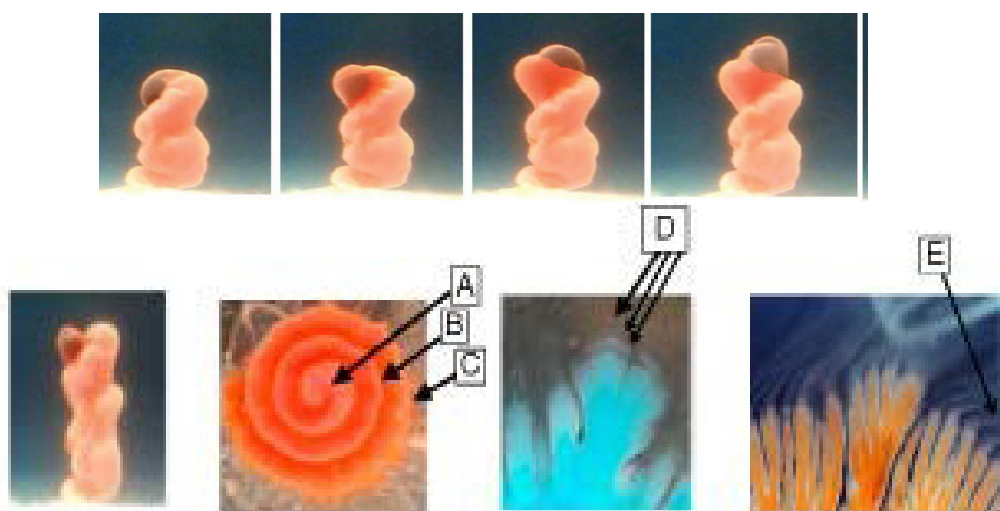


Figure 1: Spirals and Flowers. Top: growth of Solomonic Column. The column climbs by itself, forming spirals upward. Bottom: after reaching the surface, the system then forms three different structures. Solomonic structure changes to two kinds of channels (A) and (B). Next the membrane breaks and internal solution spreads radially producing fingers at (C). These fingers produce channels (D) that grow from the tip toward the crescent, and from crescent toward the tip (the different colour was artificial). This process is repeating. Next, new structures are made from small streams (E) with sizes less than 0.1 mm, and length about a few cm. They are final processes leading to Thermodynamic Equilibrium and resulting in the loss of patterns. The Solomonic column spirals to the right. At the top, it forms a complex structure and then rotates to the left. In Fig. 1(D), a leaf-like structure, but sometimes there are disconnections on top that then move together. When met with another chemical, these chemicals dramatically change into different compounds. Thus, we have six different structures.

In summary, two chemical compounds form multicellular organisms. We have chemical system that started far from Thermodynamics Equilibrium (Th. Eq.) and moved to Th. Eq. created by many chemical processes. This is an example of very complex engineering.

Self-constructing different chemical machines, Al^{3+} - OH^- - CO_3^{2-}

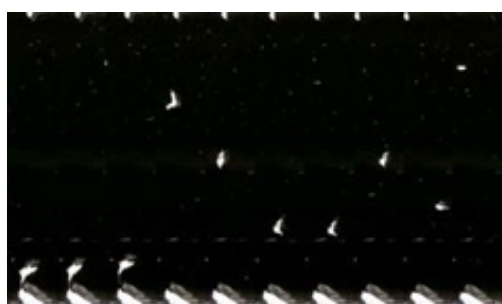
Aluminium carbonate forms three different chemical machines^{31,33}. This is an example of a chemical system built in many stages. Chemical systems may produce different structures and behaviour's that serve different functions.



Figure 2: Cells that grow by themselves, creating legs and using them for movement. (Top) A chemical cell that continuously produces legs. These legs push down and the cell jumps or rotates. (Bottom) Cell creates a new cell underneath that moves like a snail and grows when the mother cell is disappearing.

At the bottom of Figure 2, we see that the cell (mother) creates a new cell, and this cell (daughter) is growing and moving. This is

an example in which two cells can have two different functions, and cooperate together with unusual complex behaviours.



-----> Time ----->

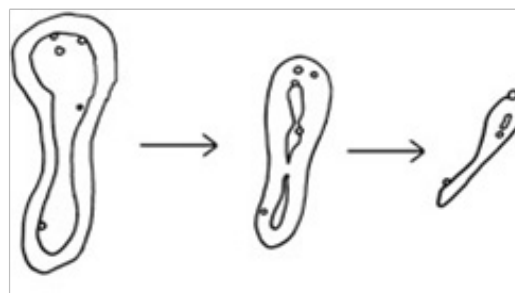


Figure 3: Cell membrane with CO₂ bubbles inside. This cell is continuously moving up and down and is continuously shrinking. When the bubble is released, the cell is moving down, and if the cell is shrinking, it is moving up. This is an excellent example of a chemical machine. (Reproduced from Langmuir, 2014, 30,5727-5731 with the permission of American Chemical Society) Small changes produce different behaviours and structures. With small changes in chemicals, the system creates a chemical machine with unusual properties. A chemical machine may switch from one complex machine to another, with different mechanisms of chemical and physical structures.

Chemistry is considered a science of atoms and molecules, where molecules are connected together. However, in self-creations research, the structures differ. In our experiments, there were very complex structures with tubes, cell tubes, and solutions with unusual shapes and behaviours, as shown in Fig. 1, 2, and 3. For example, the white structure (see Figure 2) grew at the bottom. Next, a new cell was developed, and the first cell was changed into two connecting moving cells/machines. The

new cell at the bottom begins growing, whereas the bigger cell on top shrinks. There are mother and daughter cells that are continuously attached. The daughter cell grows continuously and moves far from the mother, while the mother is shrinking. They have different colours; the daughter is transparent. We have two chemicals (Figure 2, bottom) that know how to work efficiently and communicate effectively.

Self-creation of multicellular chemical organisms that behave as a whole; AlCl₃ – SiO₄⁻²

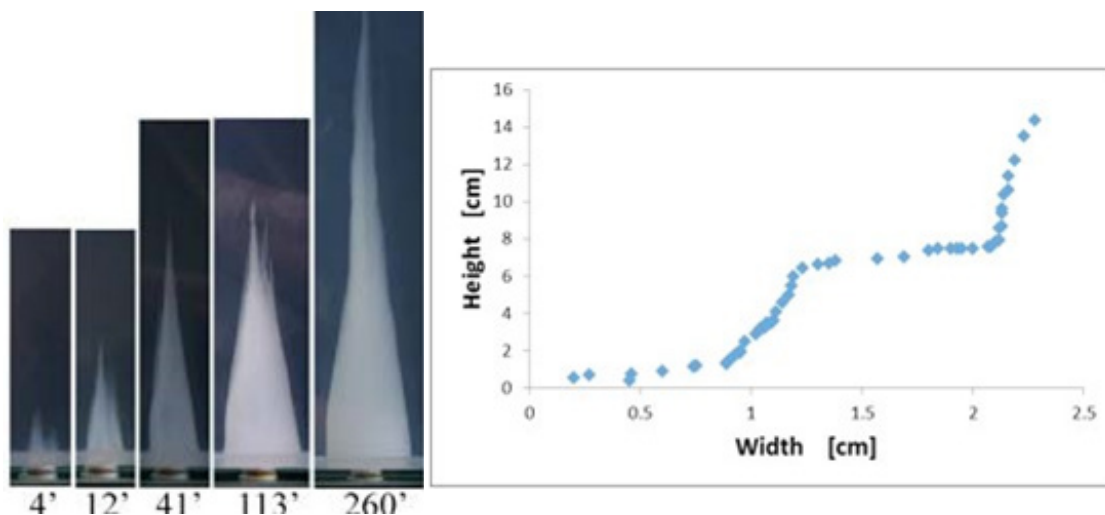


Figure 4: On the left the tower diameter is increasing over time. On the right, the growth of tower is presented. At the beginning, the structure is growing horizontally. Next, the structure is growing vertically, and this mechanism is repeating.

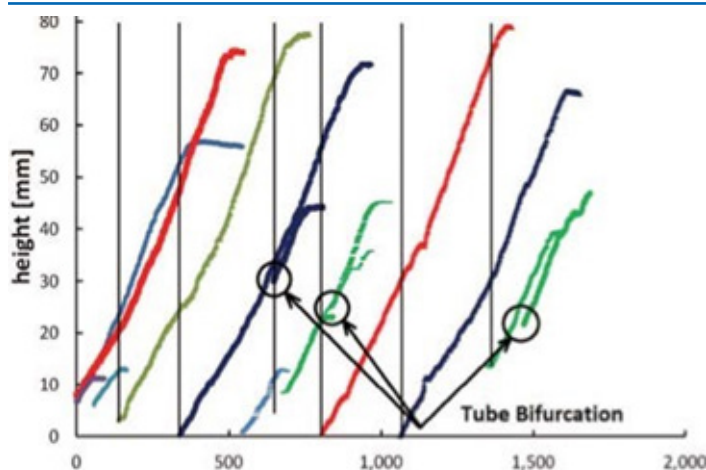


Figure 5: Different vertical towers, as indicated by different colours. The cell grew and then terminated when the cell reached a critical height. Then, new cell starts growing. Sometime new cells bifurcate instead of grow. Only 3 cells grow at the same time. The cells create towers. This is beautiful example of cooperation in complex chemical systems.

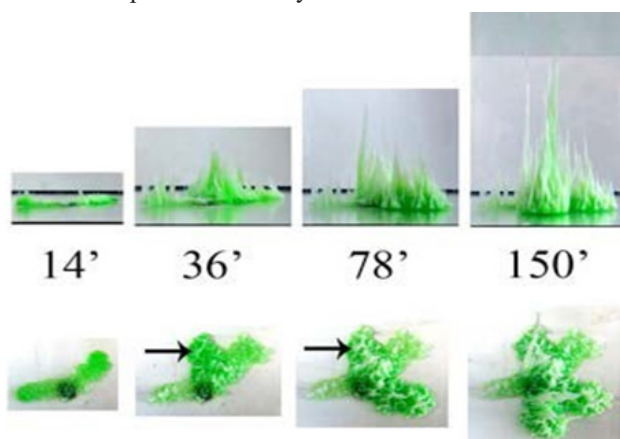


Figure 6: At the top, there are many towers growing. They are very well organized. One tower stops growing, then another tower starts building. When the city reaches its limit, a new city starts growing. When all the city limits are reached, then a metropolis is formed. Tower \rightarrow city \rightarrow metropolis. The youngest tower is always the highest. At the bottom, many towers create cities. First, towers start growing. After the towers reach their limit, then towers start growing in a different location. These locations are connected. Here we have five cities forming a metropolis. (Reproduction from Journal of Systems Chemistry 6:3 20125, A. Dyonizy, V. Kaminker, J. Wieckowska, T. Krzywicky, P. Nowak, and J. Maselko. Cyclic Growth of Hierarchical Structures in Aluminum-Silicate Systems, Journal of Systems Chemistry 6:3 20125.)

The two reactions bring the chemicals together, forming a multicellular organism. The cells communicate between themselves, as shown in Fig. 4, 5, and 6. The number of growing cells stays constant [32, 33]. The important point is that when one tower stops growing, the next tower will grow. Structures grow and switch vertically and horizontally. Different pH values and concentrations determine different structures. Different permeable gels have different shapes, such as cells, tubes, fingers, and cones. These cells may have complex structures.

Cells connect together to form complex structures and behaviours. Then they connect again, forming the next step. This is complex engineering. The towers are composed of many cells connected together. They have complex interior structures. Cities are composed of many arranged towers. Channels distribute resources. Many cities are connected to each other. The highest tower is always the last tower. The addition of different compounds will change their structure and behaviour. The self-creation of structures and behaviour's is very organized. They are "intelligent". All presented complex systems were created without autocatalytic reactions.

Self-controlling unusually complex tube networks: $\text{AlCl}_3 + \text{NaOH}$ system

In this experiment AlCl_3 was injected into NaOH solution through a needle. The injection was approximately 0.01s with 2.5 ml/min, NaOH was 2-4M and AlCl_3 was saturated. The experiments are presented in Figure 7 [29].

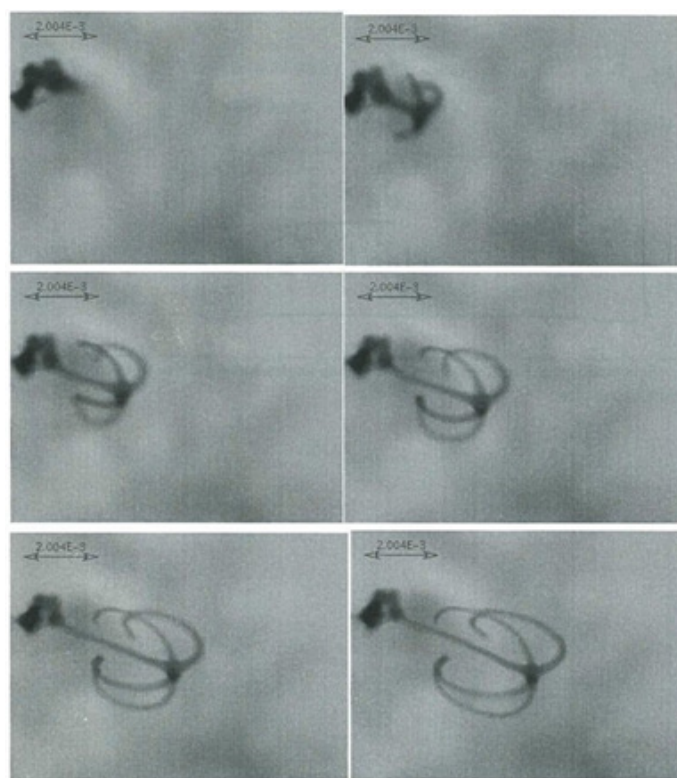


Figure 7: Growing tuba network. At the top left is a small balloon of saturated AlCl_3 and NaOH growing from a needle. The stem is a single tube from balloon to branches. Four branches (always close to balloon) are growing at the same time. They are moving together with the top of the stem. The branches were distributed symmetrically around the stem at the common junction. They moved together with the top of the stem. Branches and stems grew simultaneously at the same rate and radii. This has never been observed in chemical gardens. The stem is smaller close to the balloon and bigger at the junction point where all the branches are connected. The number of branches typically ranges from two to five. A single branch has never been observed. Using a high concentration of NaOH (4M) a more unusual tube network is created, with multiple junction splitting. The circle around the branches was constant. When retracted, the branches and stems did not remain smooth, but became bent

and crinkly. The jets of one fluid into another usually do not move very far. A jet of fluid is split only by an external force transferred to the motion. This is an example of how complex cells are created. In biology, complex tubes are very common for transporting different liquids.

Beginning chemical research, Pb^{2+} - chlorite-thiourea

This paragraph presents the relationship between classical chemistry reactions and the formation and properties of cells. This is not very well understood. This experiment was conducted in 2009 and is based on inorganic chemical reactions. There was a pellet of $Pb(NO_3)_2$ and a solution of ClO_2^- with Cl^- [43, 47]. We discuss experiments where there were chemical reactions and self-creating processes.

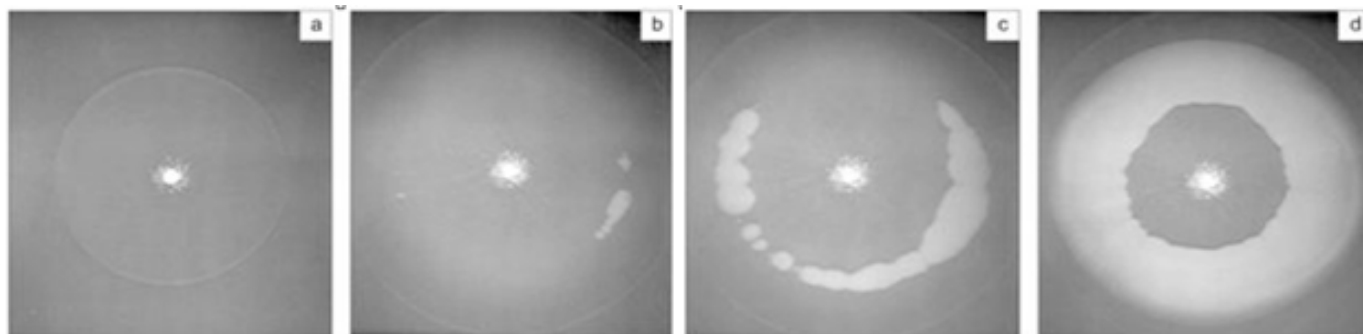
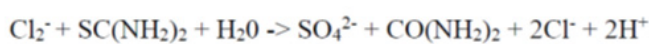
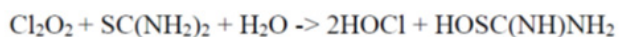


Figure 8: Here we observe where the chemical reaction, in the shape of circle, will start, and where and how it will stop. In this reaction the pellet of $Pb(NO_3)_2$ was immersed in a solution with chlorite and thiourea. The lead was dissolved initially, and lead ions reacted with chlorite, yielding a lead precipitate. The solution moves on the bottom with circular symmetry as shown in (A). Next another white precipitate forms inside circular region. Now a ring precipitate develops. (B)-(D). The ring spreads inward and outward. Then, movement stops. The characteristics of these rings depends on the initial amount of thiourea and chlorite. Only four compounds are visible. Depending on the concentration, the position of the ring can be controlled. This process has four chemical steps: initiation, autocatalysis, inhibition, and sulphate production. At least 22 different chemical compounds are involved in these processes. The total reaction is:



The autocatalytic reaction is:



In autocatalytic reactions, the creation of products is slow at the beginning, followed by exponential growth until all the reactants are exhausted and contraction becomes constant. The autocatalytic reaction can be switched from one state to another, and this can be controlled. These systems also have chemical waves. There are two types of system: processes that are very fast and not visible, and processes that are visible. Gravity forces pull at the bottom and caused movement outward from the pellet. Next, the chlorite decreases due to reactions with lead, and hydronium ions increase due to hydrolysis of the lead ion. These systems also have chemical waves. Only these three compounds were visible. In this experiment, most of the other compounds reacted very quickly, and were not visible. In our systems, we have many chemical compounds and complex structures that can be present in gas, liquids, and solids. Changes occur at different tempera-

tures and concentrations. The systems continuously change, and everything is highly organized.

Toward chemical self-creation

The first law of thermodynamics states that nothing can be self-created or destroyed in an isolated system. This law was developed by A. Lavoisier (1743-1794). In 1960, Ilya Prigogine defined dissipative structures as thermodynamic systems far from equilibrium. These structures led to self-organization systems [48, 49]. S. Jorgenses discussed how if we pump energy into the system, the system will to start to utilize this energy, and Sungchul, Ji said “The emergence is the creativity of material systems; the creativity is the unpredictable reaction.” These comments are about chemical systems; however, experiments on systems that continuously move far from thermodynamic equilibrium (Th. Eq.) were not very helpful.

Chemical Gardens was studied in 1646 by Glauber. In the 17th and 18th centuries, scientists such as Robert Boyle, and Isaac Newton, studied Chemical Gardens. In 1911, St. Leduc carried out important research on synthetic biology. This was the starting point for thousands of papers.

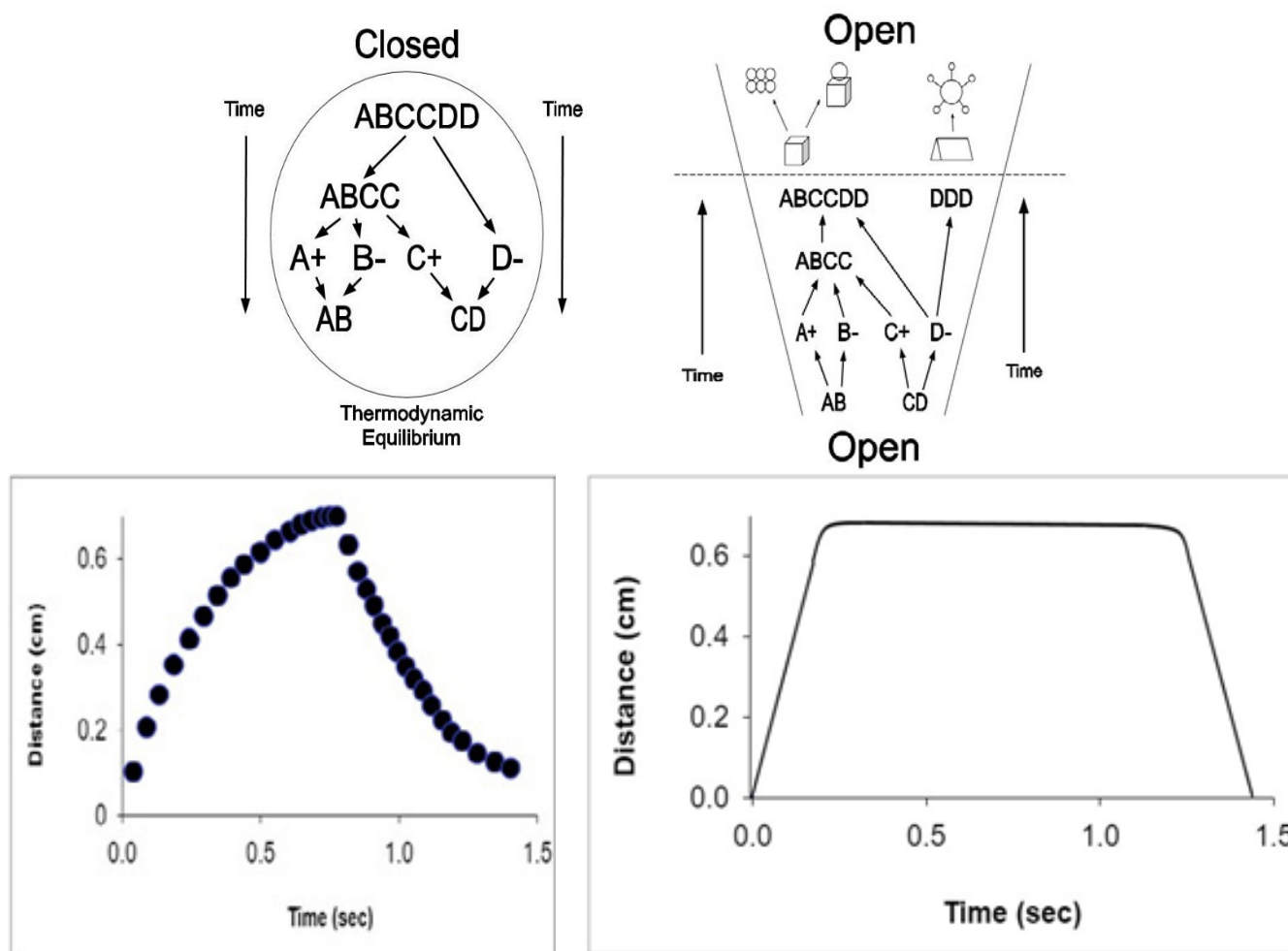


Figure 9: At the top left, Th. Eq. closed systems. At the top right is the law of self-creation (open systems) in action: an infinite number of chemical structures continuously create more complex structures. All of them are self-creations. On the bottom left, when a system is supplied with chemicals then it is growing, when the supply is stopped, the system is moving toward Th. Eq. On the right is a stylized depiction: growth, function, dying.

At the top left, thermodynamic equilibrium. The top right represents chemical self-creation: spontaneous formation of multicellular structures. Next are chemical machines: devices that perform functional processes. The other is a self-growing city or a very complex organism. In our experiments, we observed complex structures, chemical cells, multicellular entities, complex behaviour's, and very complex self-controlling machines. These new chemical complex processes created themselves very quickly. Open systems can create a number of complex entities. In these experiments, the systems were moving continuously far away from Th. Eq. There are many different processes that form complex chemical systems [50].

Discussion

All of our experiments were performed with only simple inorganic compounds to demonstrate the law of chemical self-creation in conventional systems. This law is related the development of systems in chemistry and biology. The intentional self-creation of complex structures and behaviour's is a new technology, where almost everything is able to produce itself. It is a creative process of self-creation through chemical mechanisms. The creation of a single machine is followed by the creation of many

different machines, which is then followed by switching from one mechanism to another. Chemical machines are probably the most important tools for chemical growth. Systems were created with just two simple inorganic compounds. The results of the experiments indicated that self-creating chemical systems involve unusual complexity. The presence of organic compounds is much more powerful; organic systems will grow to the highest level that can be imagined.

The towers are composed of many cells connected together, and have complex interior structures. Cities are composed of many arranged towers. The channels distribute resources. Many cities are connected to each other. The highest tower is the last tower. The addition of different compounds will change the structure and behaviour. The self-creation of structures and behaviour's is very organized. Self-creating chemical systems are "intelligent". In summary, we consider two chemical systems; one Th. Eq. close to equilibrium and another moves spontaneously to Th. Eq. These systems continuously and spontaneously create very complex systems with creative structures and behaviours. These structures and processes are one of the most interesting properties in Universe.

The most important facts

1. Beginning with only two simple compounds, chemical self-creations can grow to infinity.
2. Variety is unusually common in self-created chemical systems.
3. In classical chemistry, reactions are carried out by atoms. A hydrogen atom is 1.66×10^{-24} g. A carbon atom is 1.99×10^{-21} g. In our self-creating reaction processes, we have cells and multicellular structures measured in centimetres, which are not just a meeting between atoms.
4. The theory of self-creation is not very well understood.
5. Chemical systems are capable of complex engineering.
6. The Big Bang occurred approximately 12-14 billion years ago. Subsequently, protons and neutrons appeared. H, He, and Li emerge in the first few minutes after the Big Bang. Next was the formation of chemical structures, geology, self-creating chemical systems, biology, humans, and ...?
7. Elements of chemistry, geology, self-creations, and biology are the machines of the Universe.

Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Author Contributions

J.Maselko designed and implemented all experiments described in this manuscript. He also wrote the entire manuscript.

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