THE THEORY OF EVOLUTION IN THE PERSPECTIVE OF THERMODYNAMICS AND EVERYDAY EXPERIENCE

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In homes, offices, factories and laboratories, chaos never turns into order on its own and proceeds to maintain and expand itself, although the theory of evolution suggests this would be a normal and natural event. Instead, any order turns into disorder sooner or later, as predicted by the second law of thermodynamics. Everyday experience and empirical science seem to contradict the theory of evolution. This contraction is usually explained as a virtual one, by stating that the second law of thermodynamics only holds for closed systems and by reference to the experiments of Miller, Nobel Laureate Prigogine and Dawkins as a proof that in open systems chaos definitely can turn into order by itself. In this study, this argumentation is investigated more accurately, and found to be untenable. The implications for science are explored.

When discussing the theory of evolution, sometimes the second law of thermodynamics is brought up to contradict the theory. This objection from science is mostly answered by stating that the second law only holds for closed systems, and that in open systems - like the earth - chaos can turn into order just by itself. The correctness of this thesis is underpinned by referring to the world-famous Miller experiment, the research of Nobel Laureate Prigogine into chaotic systems (Prigogine, 1984) and the computer simulations of evolution by Dawkins (1991). Everyday experience, however, shows that any kind of order - for instance, a tidied up room or desk, an efficiently moving production process, or a complicated chemical substance - never emerges by itself, but that directed external effort is necessary to establish and maintain it. In homes, offices, factories and laboratories, chaos never turns itself into order and proceeds to maintain and expand itself. Every system appears subjected to the omnipresent property of reality that any order finally turns into the ultimate disorder, if directed external effort to maintain the order is stopped. The experiments of Miller, Prigogine and Dawkins, however, seem to suggest organic molecules have a tendency to order themselves on their own when an advantageous fluctuation of chaos emerges. But is this suggestion realistic? How do the experiments of Miller, Prigogine and Dawkins relate to the second law of thermodynamics, and is it true that the second law only holds for open systems? Has a director of a chemical factory to reckon that one day evolution theory will lead to techniques that will make simple chemicals start arranging themselves into more complex substances without directed external effort? And should software engineers worry that one day they will be replaced by fully automated mutation and selection processes that will expand a program of a few bytes into a complex billion-byte program? In this study, these questions are investigated. First we look at thermodynamics, and the second law in particular, more accurately. Then, we assess Prigogine's examples of chaos

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turning into order, as well as the Miller experiment. Next, we investigate the processes of order turning into chaos in computer programs and in DNA, as well as the provisions that are present to maintain the initial order. Dawkins' computer simulations of evolution illustrate the findings. Finally, we discuss our results and close with directions for further research and some concluding remarks.

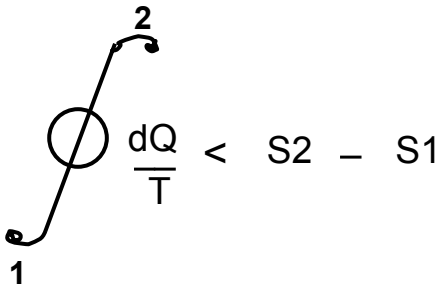
THERMODYNAMICS, CHAOS AND ORDER

Thermodynamics is often looked upon as a specialist sub-area of physics, where complicated calculations of phenomena such as the compression and expansion of gasses are made. This image of making complicated calculations is more or less correct, but thermodynamics is definitely not a backwater corner of physics. On the contrary, it lays down the relationships between the energy, heat, order and probability of systems, varying from motors to molecules, and is one of the pillars of physics and chemistry. Thermodynamics is a science that emerged from the field of engineering. Over the years, empirical knowledge was laid down into general rules that appeared to be trustworthy and finally gained the status of laws. Since thermodynamics deals with systems in reality, which are always influenced from the outside, the laws of thermodynamics relate to *open* systems. The first law of thermodynamics describes how the internal energy of a system changes when energy is passed to the system, or when it affects its surroundings. The second law describes the relationship between the supply of energy to a system and the change of its order. The third law describes the change in the order of a system as the temperature approaches absolute zero, and the fourth (or zeroth) law concerns the way irreversible processes influence one another.

The Second Law

Many inventors have dreamed of constructing a system that keeps moving without the supply of energy. An example of the design of such a perpetual motion machine is an electric motor that is fed by the electricity generated by a dynamo that is driven by the same motor. Disappointingly, the dynamo does not supply enough electricity to keep the motor running, and both stop when the motor is switched to the electricity generated by the motor-driven dynamo. Numerous other methods of constructing a perpetual motion machine have been tried, but time and again it appears that the energy supplied to a system never can be extracted from it completely in the form of work done by the system on its surroundings (A), and that a system can never be brought to a higher energy level without doing work on the system (B). As a result every perpetual motion machine construction always goes back to standing still. The empirical principles denoted as A and B are known as Kelvin's principle and Clausius' principle, respectively.

In thermodynamics, both rules are combined into one principle, which is known as the second law of thermodynamics. It states that the supply of energy to a system resulting in a movement from a state 1 into a state 2 always leads to a smaller decrease of the disorder of the system than would be possible theoretically. The second law has the shape of a mathematical calculable formula (see for instance, Van den Bergen, 1974, p. 29), thanks to the use of the concept of "entropy" as a measure for the disorder of a system:



The left term of the formula describes the supply of energy over the boundaries of a system when moving from state 1 to state 2. The right term describes the decrease of the entropy of the system. Using Bolzman's law S = k Ln W (W is the probability of the state of a system) and elementary mathematics, the entropy S of, for instance, human DNA (a string of 3 billion characters) can be calculated.

The second law indicates that a system can only move to a less probable state (i.e., a state of higher order/less disorder) if energy is supplied to the system from the outside. This corresponds to the principle of Clausius. The second law also indicates that not all supplied energy can be transformed into a reduction of the disorder/entropy, but that always some entropy-reduction is lost. This corresponds to the principle of Kelvin. The second law thus expresses the same properties of physical reality as the principles of Kelvin and Clausius do.

No Conservation of Entropy

The second law not only indicates that a directed supply of energy over the boundaries of a system (hereinafter referred to as a "directed external effort") is always needed to reduce the disorder of a system, it also tells what happens when directed external effort is lacking. In that case, the entropy (disorder) is not conserved, but increases, until the maximum state of disorder is reached. It is clear that for closed systems the left term of the second law is zero and the entropy of the system will increase. But for open systems too, the left term can be zero. If an open system is subjected to undirected external effort, for instance random flows of wind and water, lightning, radiation, or random movement and transportation processes, than the left term will be zero averaged over a longer period of time. After a longer period of time, open systems that are subjected to random, fluctuating energy flows will turn into the largest possible disorder too, as ruins, ragbags, junkyards and car dumps make clear.

ORDER OUT OF CHAOS

In open systems that are subjected to undirected external forces, order can emerge, as Nobel Laureate Prigogine has shown (Prigogine, 1984). At a beach, for instance, grains of sand at random jumping in the wind can form regular ripples, and on a cooling window, complex structures of frost flowers can emerge. In addition, Prigogine shows that in living nature, too, chaos can turn into order. For instance, bacteria in a chaotic environment can ultimately form regular structures, and in a population of insects the great variation in shape of their wings can ultimately reach one stable form. It seems that when circumstances are advantageous, chaos can turn into order just by itself, in lifeless as well as in living nature. Besides, Miller has shown that random forces have the ability to create the building blocks of life, resulting in the interconnection of lifeless and living nature. All together, a continuous line seems to be present, starting at the self-organization of grains of sand into regular ripples, to the self organization of

organic substances into DNA-building blocks, and finally toward cells containing DNA and living organisms.

When looking more accurately into the emergence of order in open systems by the influence of random external forces, firstly it appears that the emerging order is only temporary. Averaged over a longer period of time, the left term of the second law is zero and the disorder in the system will increase, since provisions to maintain the emerged order are missing. On a beach covered by well-structured wind ripples, the wind will blow from a different direction on another day and the wind ripples will disappear. The frost flowers formed on a window pane when water vapor cools and the water molecules are captured into a regular structure of "energetic holes" will disappear as soon as the fluctuating temperature moves above zero, and the water molecules will start moving again. Both the structures of sand grains as the structures of frozen water molecules lack a provision for maintaining the temporary order and will disappear again.

Secondly, order that emerges from undirected external forces not only has a temporary character, but does not expand, unless directed external effort is supplied. This law of nature is clearly illustrated by the famous Miller experiment (see fig. 1). Random flashes of electricity can turn basic organic substances into the building blocks of DNA. But the next moment, new flashes may destroy these building blocks. The larger the building blocks, the faster they will be destroyed again. Therefore, Miller transported the building blocks formed towards a distillation flask, sheltering them for destruction by new flashes of lightning, resulting into the production of a more and more concentrated organic soup. Miller's experiment confirms the second law, and shows that the order in a system can only be maintained and increased by directed external effort.

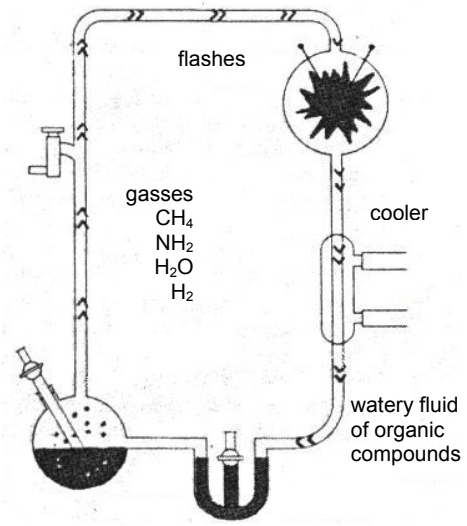


Fig.1: The Miller experiment

Thirdly, Prigogine puts the examples of chaos turning into order in lifeless nature on the same level as the examples from living nature. In doing so, he overlooks the DNA program in living organisms, which controls the material and energy flows of the organism. A sand grain is just a small lump of silicon. A bacterium, however, can be viewed as an entirely automated and autonomous biochemical robot, interacting with its environment, and maintaining and reproducing itself. Therefore the process of chaotic jumping sand grains turning into orderly ripples cannot be compared to a colony of bacteria forming orderly structures.

It is often supposed that organic molecules have a natural bias to order themselves into increasingly complex structures. It is thought that if an advantage fluctuation of chaos arises, the molecules will move to a nearby, higher and maintained level of order; after some time, a subsequent advantageous fluctuation of chaos will arise and another a step of increasing order will be set; et cetera. More accurate assessment of this line of thought, which is handed by Miller and Prigogine, shows, however, that (1) the emergence of order in chaotic systems is only temporary; (2) the maintenance and further expansion of the order that may emerge in chaotic systems demands directed external effort; and (3) the chaotic processes in living nature that sometimes are turned into order are strongly influenced by the DNA programs of the organisms involved.

CHAOS OUT OF ORDER

The emergence of chaos out of order is a property of reality that is as omnipresent and as influential as gravity. Sooner or later, cars break down, paint peels off, ships rust, rooms get untidy and dirty, furniture falls apart, faces sag and become ugly, clothes wear out and tear, houses and factories go to ruins, tools become unusable, books and CDs unreadable, and chemical substances loose their activity. All these open systems finally turn into the ultimate state of disorder when directed external effort to maintain them stops. All of this is fully in line with the second law. Order can only be maintained if directed external effort is present. We will illustrate this by investigating the provisions that are present in computer programs to maintain the order, and subsequently the provisions that are present in DNA programs for this purpose.

The Maintenance of Order in Computer programs

In the ICT-industry, the maintenance of order is a major problem. When information is read or copied, errors can be made, and when storing information, the data can degenerate through radiation, chemicals, or mechanical damage. Therefore, each byte (recording an information entity) contains what is known as a check bit. When a byte is mutated, the check bit changes and the program stops and generates an error massage. The suggestion of evolutionary theory that mutation of a DNA program can lead to the improvement and expansion of it, does not in any case apply to computer programs. The mutation of the bytes of a computer program by mechanical measures or by a software-damaging program will only generate error messages and will never, even after a billion trials, generate any improved or extended program. In evolutionary software development, therefore, only the parameters of a program are changed at random (Koza, 1992). Parameters that lead to an advantageous program output are selected and used as a basis for new random parameter changes, et cetera. In, for instance, the design of aircraft or ships random change of program parameters and selection appears to be a powerful strategy to optimize a certain design within the boundaries of its system space, and adapt it to the demands of a certain environment. Dawkins' evolution simulation program is a clear example of this technique (Dawkins, 1991). The simulation program can draw symmetric structures of branched lines, which can vary in number, gradient and length. If a certain branched structure ("tree") vaguely resembles the shape of a living organism (in general an insect), it is selected and new variations of the parameters are tried, searching for an even better resemblance. This procedure of the mutation and selection of the program parameters finally results in the production of a number of insect-like trees. The program, however, continues drawing trees. Only after the addition of extra lines to the computer program (denoted by Dawkins as the addition of new genes) can the functionality of the program be expanded, resulting in the drawing of segmented trees. Only after a complete rewrite will the program start drawing boats, or cars, or aircraft. Dawkins experiment shows that only by directed external effort the order of his drawing program can be expanded, as the second law of thermodynamics predicts.

The Maintenance of the Order of DNA programs

A living cell can be viewed as a fully automated biochemical robot controlled by a DNA program. In an organism, each cell contains the same DNA program, which is continually read and copied. In humans, the DNA program comprises 3 billion characters and would fill a bookcase of 7 meters long and 3 meters high when printed on A4 paper using a Times 12 font, resulting in 4900 characters per page and 100 pages per centimeter of bookshelf (see fig. 2). As in computer programs, the order in a DNA program is subjected to the basic property of reality that any order has a tendency to decay into chaos. This natural process is slowed down by the 8-

Fig. 2: Bookcase of 7x3 meter, as the information-equivalence of the human genome

fold redundancy of the information in the DNA (in pairs of chromosomes, each consisting of two chromatides, which each consist of two complementary strings containing the same information), and by complex biochemical processes around the DNA that continually compare the redundant information and repair damaged characters. In addition to that, living organisms must surmount numerous obstacles in the struggle for food, shelter and a partner. If a certain mutation of the DNA cannot be repaired and is passed to posterity, the offspring is usually beaten in these struggles by the organisms that possess undamaged DNA. In the end, they appear not fit for survival and cannot pass their mutant DNA to posterity, by which the mutation is still eliminated from the gene pool of the species. Despite the continuous repair of the DNA and the presence of selection processes that hinder the passage of damages to posterity, degeneration of the order in the DNA cannot be prevented entirely. Thermodynamics predicts that the "bookcase of 7 by 3 meters" that is stored (8-fold) in every human cell ultimately will be full of errors and will become unreadable. Environmental pollution will speed up the decay, not to mention nuclear disasters or a nuclear war. The most likely place in the DNA that will become unreadable first is the Y-chromosome, which has no partner, and where the mechanism of comparison and repair are 50% less intensive than elsewhere in the DNA (Sykes, 2004).

The nuclear disaster in Chernobyl in 1992 led to the widespread and far-reaching disfigurements of plants, animals and people. No improvement in the flora and fauna around Tsjernobyl was observed as a result of the massive mutation of DNA. Also in the field of oncology, longtime research has produced no indication whatsoever that the mutation of DNA may lead to improvement and growth of the gene pool of a species. Nevertheless, evolution theory claims that mutation (= damaging) of the DNA and selection of the resulting improvements is the motor of change in living nature. Cancer researcher Prof. Plasterk (1996, p. 28) makes clear that this is a misconception: "There are bunches of biologists who think that evolution happens by the emergence of a mutation somewhere in the species, that brings a selective advantage. It is known for half a century yet that it does not go like this, and cannot go like this…. The forming of species goes by the selection of combinations, not of mutations." Modern genetics has proven that the numerous changes in the shape of organisms that occur in living nature are not the result of a supposed process of gene mutation and selection, but of the process of gene recombination and selection. Dogs, for example, vary extremely in size, color, coat, behavior, etc., depending on the specific combination of genes from the same gene pool (i.e., of the wolf). Dogs that possess an advantageous combination of genes are selected by dog-breeders for reproduction (see fig. 3). In

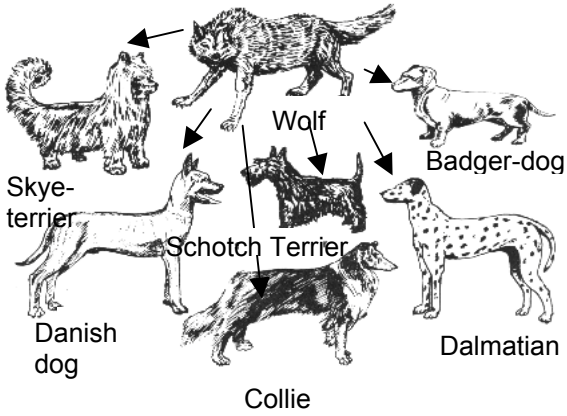


Fig. 3: Gene recombination and selection

free nature, natural selection takes place. Finches, for instance, that possess a gene combination for a broad beak are sometimes able to survive, whereas finches with a gene combination for a narrow beak will not. When the selection criteria of the environment change, the combinations of genes that are advantageous will change too, as well as the corresponding appearances of organisms. Their gene pool, however, stays unchanged. The changes in the shape of the beaks of finches or the appearances of dogs thus have nothing to do with the mutation of genes. The mutation of genes is an absolutely different process, which is combated vigorously by mechanisms of comparison and repair in the cell kernel, and by selection processes in the struggle for food, shelter and a partner.

DISCUSSION

The Tenability of the Theory of Evolution

In this study we investigated the contradiction that seems to be present between both real-life experience and empirical science with the theory of evolution. In real life, chaos never turns into order by itself and starts maintaining and expanding itself, as the second law of thermodynamics confirms. Remarkably, the theory of evolution states exactly the opposite, and claims that the change from chaos into order is a natural process. When assessing the line of reasoning that is followed to prove this, we found that the argumentation is based on (a) a misinterpretation of Miller's-experiment, (b) an unjustified extrapolation of Prigogine's examples of order emerging temporarily out of chaos, (c) Prigogine's overlooking of the DNA programs in living organisms, which strongly influence the change of chaos into order in living nature, and (d) the confounding of a supposed process of gene-mutation and selection by the real process of gene-recombination and selection in living nature. We also found that thermodynamics is concerned with open systems and that all processes of chaos turning into order, both in non-living and living nature, are fully in line with the second law of thermodynamics. We illustrated this with Miller's experiment, Prigogine's results and the evolution simulation program of Dawkins. We also found that the assumption underlying the theory of evolution that (organic) molecules have a bias to start ordering themselves in the absence of directed external effort into ever more complex structures, is false and fully in contradiction with empirical science and in particular the second law of thermodynamics. In view of these results, the conclusion that the theory of evolution is untenable seems inevitable, as 200 scientists, among which 4 Nobel Laureates, found before in 1991 on a conference in Paris (Staune, 1991).

The scientific untenability of the theory of evolution is not surprising. No laboratory staff anywhere in the world seriously consider the possibility that one day they will witness simple substances start ordering themselves into more complex substances that begin to maintain themselves without directed external effort. Likewise, no director of any chemical plant will worry that one day his expensive installations, in which energy is skillfully directed towards basic chemicals in order to produce complicated chemicals, will be no longer necessary because the basic chemicals will start ordering themselves and will be available for free.

Although it seems inevitable that the theory of evolution should be rejected, there is no impetus to do so. The theory of evolution does not lie at the basis of scientific theories, methods and techniques people are dependent on in their daily lives and work. The contradiction of the theory with everyday experience and empirical science, therefore, never becomes apparent in painful practical problems caused by evolutionary theory-based methods or techniques that appear to be inadequate. In fact, the theory of evolution has the unassailable position of a generally accepted myth of the origin of life, which can explain any phenomenon in living

nature, although these explanations are not testable (a must for a scientific theory). Moreover, the theory articulates the enticing notion that "everything will get better by itself." As an optimistic myth with a scientific aura, the theory of evolution has a strong position, which is scarcely threatened by what empirical science and everyday experience have to say about chaos and order.

Integrity and Progress of Science

The history of science shows a continuous rise and fall of theories. The paradigms theories are grounded in, however, are only changed with great difficulty (Kuhn, 1970). If the rejection of a theory were to imply the rejection of the underlying paradigm as well, rejection would be vigorously resisted, as, for example, Galileo experienced when challenging the earth-centered paradigm of the universe. Although the theory of evolution is scientifically untenable, it is not likely that it will be rejected soon, since the theory embodies a powerful and generally accepted paradigm for looking at life, its origin and meaning, which is defended with strong religious sentiments. The contradiction with empirical science, however, corrupts the integrity of science and results in boundaries in scientific theorizing and research that should not exist, to assumptions that are not reliable to build on, and to lines of thought that are false. All of this does not benefit the progress of science.

Belief and Science

The theory that the order in living nature, and in particular the order in the DNA of organisms, has emerged by itself, must be rejected on scientific grounds. According to thermodynamics, this order can only have emerged by directed external effort. Those who want to denote this directed external effort as "God" must realize that the theory "God created the DNA" is untestable, and thus is not a scientific theory but a belief. The theory "The DNA is the result of intelligent design" is also untestable, and thus a belief. Therefore, any form of creationism cannot fill the gap in the scientific domain that results from rejecting the theory of evolution. It can only be filled by a new testable theory that does not contradict everyday experience and empirical science. In the meantime, the position "We do not have a testable theory (yet) that explains the origin of life" can be taken. The appearance of a gap in scientific knowledge may be uncomfortable, but covering that gap by a theory that contradicts empirical science and everyday experience is worse, and corrupts the integrity of science and hinders the progress of science.

Directions for Further Research

If the theory of evolution is rejected on scientific grounds, firstly, room emerges to take new directions in DNA research. In view of the fact that mutations of DNA are continually repaired and eliminated in survival and selection processes, it is not likely that 90% of DNA is junk. It is more likely that a DNA program, like any other construction program or cookbook, not only describes what the intended construction is to be built of, but also when and how the building materials must be used. In complex construction programs, this process can embrace more than 90% of the program. Therefore, it must be expected that the 90% of human DNA that does not code for proteins contains process information, for instance how to realize the structure of the skeleton, the heart, the ear, or the eye. This direction of research may lead to new nanotechnology-based techniques to record process information. In medicine, this may lead to the development of a new generation of smart drugs.

Secondly, on the interface of DNA-research and computer science, new lines of research are opened in the preservation of the integrity of very large data sets, using multi-redundancy and combined comparison and repair mechanisms. Such techniques seem to be interesting in high-risk environments, for instance space traveling and electronic warfare.

Thirdly, it opens new directions of theorizing and research in geology. Since earth layers are dated with fossils and fossils are dated with earth layers, geology and paleontology are linked by circular reasoning. Because evolution theory postulates a high age of fossils, earth layers are dated in hundreds of millions of years, and the assumptions over the initial values in radiometric models are brought in line with that. After removing evolution theory from the domain of science, earth layers need no longer be hundreds of million of years old, and new interpretation of empirical facts becomes possible, for instance the fact that all fossils containing earth layers still contain ^{14}C. (Arnold, Bard, Maurice & Duplessy, 1987; Beukings, Garfunkel & Lee, 1992; Kretschmer, 1998).

Fourthly, in astronomy new directions in theorizing and research become possible when the universe does not necessarily need to be billions of years old in order to allow for the long period of time the evolution theory needs. Assumptions over the initial values of astronomical models can be reconsidered and room emerges for a reinterpretation of empirical findings, for instance the discovery of interconnected red-shift galaxies, and the finding that only 4% of the predicted amount of matter in the universe has actually been perceived yet.

Concluding Remarks

The theory of evolution contradicts everyday experience and empirical science. In this study, the argumentation to prove the virtuality of this contradiction was investigated and found to be false. Everyday experience and empirical science show that only by directed external effort can chaos turn into maintained order. This principle of reality holds for all open systems, including the DNA program in living organisms. Those who want to denote the external effort that must have caused the order of the DNA as "God" must realize that the theory "God or an Intelligent Designer created the DNA" is untestable, and thus is not a scientific theory but a belief. Therefore, the gap in the scientific domain that results from rejecting the theory of evolution cannot be filled by any form of creationism. It can only be filled by a new testable theory that does not contradict everyday experience and empirical science. In the mean time, the position "We do not have a testable theory (yet) that explains the origin of life" can be taken. That is a very respectable position, for non-scholars and for scholars.

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