

Complex Systems and Modern Science

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The science of complex systems, which points to a new scientific direction for the 21st century, focuses on dynamic systems that form themselves from the interaction of countless elements, and reads and incorporates mutual recognition and interaction, such as sensing and perception between elements. Modern science has ignored this complex mutual recognition and interaction, simplifying and abstracting nature and establishing natural laws, which makes it impossible to explain complex, self-forming and evolving phenomena. This paper is a scientific-philosophical examination of science that argues for its instability, incompleteness, and historicity.

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1 Self-formation from interaction

Self-organization

Through the coordinated actions of as many as five million individuals, termites are able to build a dome-shaped nest that is more than 4.5 meters high and weighs more than ten tons. It goes through several stages, starting with the formation of random deposits, followed by the formation of columns and arches, and then the formation of the dome. The nest is magnificent. However, termites do not have a blueprint or plan for the entire nest building process, nor do they have a designer or leader. They have only local and simple interactions with each other. Specifically, each termite perceives a gradient of pheromone concentration and flies toward the higher concentration. Then, when their number exceeds a certain critical point, the degree of pheromone release increases, and a large number of termites rapidly aggregate, which eventually gives rise to a huge organization. This is where the termites' ability to perceive pheromone concentration gradients and link this information to their own behavior comes into play. Even termites have the ability to act and perceive, perceive and act in their environment.

Animals generally have the ability to sense information from their environment on their own and adjust their behavior. Animals are constantly aware of the movements of others and of the ever-changing overall dynamic, and they determine their own behavior. From the accumulation of these actions, a vast order and organization is formed. Life has the ability to organize and form order, but it must have the function of mutual recognition among the individuals that make it up.

However, this capacity for self-formation through mutual recognition is not limited to the life world, but also exists in the material world. Even the most microscopic elementary particles sense and interact with each other, so to speak. By doing so, each particle contributes to the creation of another particle, which in turn creates another particle, and all particles dynamically create each other to form the microscopic world.

The nonlinear oscillation phenomenon of resonance in photons and electrons is another example of how matter must be recognized as having a kind of sensing ability. For example, when light with non-aligned periods is superimposed, the periods may suddenly become aligned and powerful light may be emitted. This is the case with laser beams. This is because, when a group of photons that were initially moving independently crosses a critical point, they are drawn together under a specific vibration, and a dynamic cooperativity is born. Once cooperation occurs, other photons will also cooperate simultaneously. It is as if it were an epidemic phenomenon in our society. If this is the

case, then each photon has the ability to sense the movement of other photons. It is this ability to sense that gives rise to the cooperative behavior of photons.

Benard cells, for example, are formed by the cooperative behavior of billions of molecules operating in synchrony. The formation of Benard cells is caused by a vertical temperature gradient in a horizontal liquid layer. This temperature gradient shapes the heat flow velocity from the bottom to the top. When the temperature gradient reaches a certain critical value, orderly motion of the molecular population begins and convection occurs. At that time, regular geometric patterns (Benard cells) such as hexagonal prisms are formed. Not only Benard convection, but also in general, molecules that cause convection sense the flow of other molecules and the overall flow, and cooperate with each other. It must be said that there is a cognitive ability of molecules to perceive the field in which they are placed. Considering the self-organization phenomena of matter, such as the formation of convection currents and crystals, we should consider that in the material world, as in our society, there are cooperative behaviors and accompanying cognitive actions.

In the life world, which is more organized than the material world, such resonance and mutual recognition can be seen constantly. In our body, too, 60 trillion cells mutually recognize each other and dynamically cooperate with each other to flexibly adapt to the environment.

According to self-organization theory, in general, open systems that exchange matter, energy, and information with the outside world, be it matter, life, or society, have the ability to form order in themselves. Here, even the slightest fluctuation is amplified, and when a critical point is crossed, organization occurs rapidly toward a new order. The flow of information and its perception play a significant role here.

In a self-organizing system, information and its perception are the driving force that enables interaction and creates order. Elements and elements exchange information and recognize each other, and also perceive information about the macro-order that has been formed, moving toward further order formation. The interactions between elements are relatively simple, but each element acts in a coordinated manner, so to speak, in its own locality. From there, a global order is formed. The interactions that make this possible consist of sensing, perceptual, and cognitive actions among the elements. Such self-organizing phenomena can be found at all levels from the material world to the life world and human society, including elementary particles, atoms, molecules, crystals, macromolecules, genes, prokaryotes, eukaryotes, multicellular organisms, ecosystems, and society. For the self-forming world, epistemic action is an essential action.

Without information and its cognition, organization cannot occur. The system that forms order in itself is both an information system and a cognitive system. Our earth is an open system that forms itself through the circulation of matter, energy, and information, and is a self-organizing system. In

this sense, we must say that the earth also reads and perceives information from the universe, including the sun, moon, other planets, and galaxies, into itself. Nature has the order-forming capacity to form itself. And this is caused by the mutual recognition of the myriad elements that make up nature. Each element of nature is an internal observer and an intra-world observer.

Chaos

If matter was not completely homogeneous in its initial state at the birth of the universe, then small differences in the initial conditions would have given rise to many universes, each evolving in its own way, and even today, separate universes are evolving. The structure of our universe as we observe it today is considered to have been generated by the self-propagating amplification of a slight breakdown in the homogeneity of matter and symmetry breaking. This symmetry breaking is possible not only in the initial state of the birth of the universe, but also during the evolution of the universe. In the process of cosmic evolution, it is believed that, as complexity increased, selection in a certain direction due to symmetry breaking occurred at a certain critical point, and a new order was generated through phase transitions. Moreover, the symmetry breaking is caused by the sensing of information by a slight chance.

This universe is one turbulent flow, and not all of it may necessarily be derived solely from the general theory of relativity, which is centered on the theory of gravity. In fact, there are many unsteady expansion and contraction flows in this universe, and galaxies are not uniformly distributed. Some galaxies are being born, while others are dying. New galaxies are growing from the residual material of dying galaxies. In this universe, vortices are born and then die, and then born and then die, just like the rapid flow of a river, and we do not know where the vortices will form or where they will disappear. This universe is one chaos.

In fact, in this universe, not only gravity but also electromagnetic force exerts a powerful force. Therefore, even galaxies that seem to be gravitationally independent from each other are influencing each other and resonating with each other in terms of electromagnetic force. The phenomena of the universe are not the product of gravity alone. Rather, the universe can be considered to be in the vortex of a supermassive electromagnetic field.

If we can think that way, then the so-called Big Bang cosmology is also put in a serious position. The Big Bang hypothesis posits that this universe was born in a brief instant from a single, almost infinitesimally small point in a massive explosion and continues to expand to the present day. This hypothesis was based on Einstein's general theory of relativity. Even in this Big Bang hypothesis, chaotic phenomena have already been read into the exponential expansion theory of the universe

(inflation theory), the phase transition theory of the universe, and the bifurcation theory of forces.

Even if the beginning of the universe is described by deterministic laws, its outcome is not deterministically predictable. A deterministic universe can only be established in a very small locality. This universe is non-deterministic and should rather be thought of as constantly creating and evolving new things, like the biosphere. This universe, like the biosphere, may also create itself, creating unexpected forms and its own laws.

This universe is moving toward a new evolution without a single moment of rest. The universe is creative and evolves irreversibly. Therefore, the universe has a history. Just as our human history has a present and future defined by the choices we have made in the past, so too does the universe have a history. The workings of human history must be part of this irreversible evolution of the universe. The theory of relativity and quantum mechanics were both based on the assumption of reversible time. Then, as already read in today's cosmology, both relativity and quantum mechanics must be overcome in order to describe the evolution, irreversibility, inhomogeneity, and creativity of the universe. This world is a self-forming world that is constantly generating and creatively evolving.

Even in the microscopic material world, for example, chaotic motion occurs when an electron is subjected to two forces, an electromagnetic field and a proton. This is called quantum chaos. Atoms, too, suddenly leap from one quantum state to another. The question of how the classical material world is formed from the world of quantum mechanical particles remains unsolved. In general, the phase transition phenomenon, in which the phase of matter suddenly changes, is a problem that must also be considered as a chaotic phenomenon.

Furthermore, the question of how a lifeless molecular population can leap forward to become a living organism still remains to be explored. This problem is usually considered to be that molecular systems capable of self-replicating catalyze each other, which in turn form cycles, thus advancing chemical evolution and giving rise to life. Again, we would have to consider the chaotic leaps resulting from the interaction of myriad elements.

In general, in a system of countless interacting elements, even if there is a very small error in the initial conditions, the tiny error will be exponentially amplified, resulting in huge changes that are completely unpredictable. From a dynamic many-to-many correlation, the slightest error there would form a completely different trajectory. This is what chaos theory has focused on. Turbulence and other phenomena that occur in fluids also arise from such initial value sensitivities and orbital instabilities of chaos. Furthermore, chaotic phenomena can be observed in which the subsequent trajectories of the system are extremely convoluted due to the itinerant process of the system. In this way, chaos theory has revealed that nature has a record and history of its own, and that it is capable of sudden leaps of creativity, thus demonstrating the limits of the predictability of science.

The essence of chaotic phenomena in the natural world, both macro and micro, lies in the nonlinear interaction of diverse elements. From this nonlinear interaction, exponential leaps also occur. If this is the case, there is naturally an exchange of information among diverse elements. If you focus on one element, that element is sensing and perceiving other elements. One element is the <perceiving event>, so to speak. The elements of a chaotic system are internal observers, intra-world observers. Without such internal observation, chaos cannot arise.

Complex system

Complex systems research is a promising direction for modern science, which has been formed by the confluence of the study of self-organizing and chaotic systems. It has the potential to break through the classical mechanistic view of the world and to fundamentally transform modern natural science. In particular, complex systems theory focuses on the non-determinism and irreversibility of nature, taking out its nonlinearity, emergent nature, branching, and hierarchical nature, and illuminating the aspects of nature's creative self-formation.

Complex systems are worlds of diversity and relationships. The elements of a complex system are interconnected, interpenetrating, and not independent of each other. And many elements interact and fluctuate dynamically. From this element-element interaction, a close nonlinear interaction occurs. This nonlinear interaction amplifies the differences in even the smallest fluctuations, and a new order is formed. Moreover, this overall fluctuation also affects the interaction of the elements, and thus the fluctuation never ceases. The reason complex systems fluctuate constantly in this way is that they are stable enough to store information and unstable enough to transmit information in the interactions among the elements. Phase transitions and evolution of complex systems are also possible because of this. If we think about it, since we see and experience such phenomena all the time, we can consider that the universe, matter, life, society, and civilization are all such complex systems.

Without the interaction between elements, complex systems would not be possible. And it is in this interaction that cognitive action is at work. Whether it is a self-organizing system or a chaotic system, a complex system naturally forms a complex structure from simple interactions among elements, and it is in these interactions among elements that mutual recognition among elements exists. For nonlinear interactions, we must consider cognitive actions such as sensing and perception between elements. Because the elements of a complex system are themselves internal observers and intra-world observers, the fact that they observe has a profound effect on interconnectedness.

Every element is both subjective and objective. Every element is both subjective, which

perceives others, and objective, which is perceived by others. This world is a world that includes such a perceiver. The world, including the perceiver, is in constant motion and is never complete. This is because the perceiver himself disturbs the world and participates in the self-formation of the world. The world is a creative world that is continually forming itself. The world is so because it contains within itself an intra-world perceiver who perceives the world. We must consider this in the evolution of the universe as well.

Mutual Generation

The world in which we live is a complex system that naturally forms itself from the interaction of countless elements, and is constantly creating new things. <Self-formation from interaction>, or <mutual generation>, is what causes the evolution of structure. There are various types of interactions as the world becomes more complex, including weak interactions, strong interactions, electromagnetic interactions, gravitational interactions, and other physical interactions; biological interactions, such as predator-prey, competition, parasitism, and symbiosis; and interactions in human society.

Leibniz, in his "Monadology," recognized only representational action in monads, but this is not enough. We must also consider dynamic interaction, from the action and reaction of matter to human interactions. We must go beyond Leibniz and consider nonlinear monadology, in which various elements form themselves by interacting with each other.

In this case, however, we cannot neglect the fact that this interaction includes cognitive action. In a world that forms itself out of interactions, that is, a complex system, each element senses each other, perceives each other, and is aware of each other. Without this mutual recognition, there would be no self-formation. Here, to perceive is to be perceived, and to be perceived is to perceive.

In fact, the material world is a world of constant interaction. To take it to the extreme, even the movement of a single electron here on earth interacts non-locally with the movement of a single electron at the edge of the universe through electromagnetic interaction. They are, so to speak, mutually aware of each other. In chaotic phenomena, we often see resonance phenomena (synchronization of vibrations), which can also be thought of as mutual recognition between materials. In chemical evolution before the birth of life, there is also mutual evolution between molecules, and here, too, mutual recognition systems such as mutual catalysis are at work. Without such systems, chemical evolution would not have occurred and life would not have emerged.

Even in the life world, for example, the developmental process of an organism is based on the mutual recognition of many cells. Whether a stem cell becomes a liver cell or a nerve cell depends, in a sense, on its partner. Each stem cell decides its own path by recognizing its own position, the

other's response, and other factors. The developmental process of an organism is a process in which the entire group of genes involved in developmental functions work together to create an adult organism. It is similar to the formation of the division of labor in our society. The location of the cell determines what information is read from the genes and what kind of cell it will become. Genes are not necessarily a deterministic blueprint for life. Each organ does not develop independently, but rather, as Waddington says, is formed epigenetically from interactions.

In immune action, various immune cells recognize antigens and produce antibodies in response. In such cases, too, complex molecular recognition is at work between immune cells and between the interaction of antigen and antibody to distinguish between self and non-self.

The phenomenon of mutual evolution (coevolution) in the evolution of life also shows that the life world is a world of <mutual generation>. For example, plants that are eaten by butterfly larvae often evolve to contain toxic alkaloids in order to avoid being eaten. However, the butterfly larva adapts to the poison and digests it. Thus, birds that prey on them also avoid them. Then, some butterflies imitate the mudfly's appearance exactly. The birds, in turn, learn to distinguish between the real and the fake mud butterflies. The plants also change their alkaloid compounds, so the larvae differentiate according to the type of alkaloid compound. In this way, predator and prey evolve in interaction.

It must be said that cognitive action between predator and prey is at work in this mutual evolutionary process as well. If there had been no cognitive action (observation), such mutual evolution would not have occurred. Also, since this interaction is with the other party, it is up to the other party, just as in the development of life, and one cannot decide in advance what it will be like. The evolution of life is also an epigenetic landscape that occurs while recognizing changes in the environment. The world of life is a complex system in which genes, cells, organs, individuals, and species mutually recognize and interact with each other to form themselves.

Cognitive action is at work in the evolution of the universe, the formation of matter, the birth and evolution of life, and all of these processes. And this cognitive action creates the self-forming world.

Mutual recognition

In a complex system, that is, a system in which new forms and structures are formed from the dynamic interaction of countless elements, new order emerges spontaneously. In order to capture this emergence phenomenon, we must take into account observations and cognitive actions within the system.

For example, there is a simulation experiment in which virtual birds (voids) are made to fly in formation on a computer display. By simply loading the extremely simple interaction factors of separation, alignment, and combination between voids, a large number of voids successfully fly in

formation. Even when there is an obstacle, they fly well, avoiding it, and when the obstacle is gone, they merge back together and fly well again. This flexible formation of voids is an order that emerged spontaneously, but it is only the simple interaction between voids that causes it. And that interaction includes the mutual recognition of one void with the void beside it.

Unexpected leaps that occur in complex systems also arise from symmetry breaking and phase transitions that occur in the process of interaction, and here, too, mutual recognition and information circulation among elements must be considered. This unexpected leap is an unpredictable leap, both from observations inside the system and from observations outside the system. For example, parallel evolutionary phenomena can be observed between the mammals of Eurasia and the marsupials of Southeast Asia and Australia. Eurasian flying squirrels have developed interlimb membranes to facilitate their leaping from branch to branch, and the same device was used by Southeast Asian and Australian flying squirrels. For such a leap to occur, which is unexpected even to the flying squirrel itself and difficult to predict from the point of view of animals outside the flying squirrel, the flying squirrel must have the ability to recognize the natural environment and interspecific relationships within itself. This recognition ability is not that complex, and is probably only a very simple recognition action. However, from such a simple cognitive function, an unexpected leap occurs.

In the world of complex systems, which are made up of the interconnection of diverse elements, all elements reflect each other, permeate each other, and resonate with each other. In this world, each element is mutually aware and mutually connected, just like fish in the ocean that emit sound waves and act collectively while communicating with each other. Through this, the world is being created anew from moment to moment.

For example, the life world is a mechanism of mutual recognition. Gene clusters recognize the positional information in which they are located and decode it to promote development, recognize changes in the environment, and trigger evolution. Immune cell groups also recognize each other and create networks to identify themselves. In the nervous, cardiovascular, and endocrine systems of living organisms, various elements exchange information, recognize each other, and form networks. Social insects such as honeybees and ants also perceive and respond to information about their internal and external environments through inter-individual communication and recognition, and sometimes divide their colonies. Ecosystems, in other words, are societies based on the interconnection among animals, plants, microorganisms, and non-living organisms, and are also societies of mutual recognition. If so, the material world as a self-organizing system is also a kind of society in which mutual recognition and interaction among materials are at work.

This universe is also a network of perceptions. Here, all elements everywhere exchange information and recognize each other. From this mutual recognition and interaction, the self-

formation of the world occurs. In such a world, the understanding of motion based on the law of causality of classical mechanics is no longer possible, but rather, the world must be understood in terms of resonance and synchronization. Matter, plants, animals, and humans are all created and formed by the universe. They create themselves in resonance with each other. And by doing so, the universe itself forms itself. The act of recognition itself is within the flow of the great river of the universe itself, and at the same time, it creates that flow. Recognition is deeply related to the irreversible flow of the self-forming universe.

Knowing is one with being and makes it possible for it to become. It is through awareness that existence is generated. We must not separate perception from existence. The separation of being and cognition is the greatest root of the disaster of not only modern science but also modern philosophy. Overcoming the dualism of existence and cognition in generation is the task of the philosophy of complex systems. To do so, the fundamental concepts of modern philosophy, such as existence and cognition, subjectivity and objectivity, and perception and judgment, must be thoroughly reexamined and reconstructed. We must not deconstruct, but reconstruct.

Evolution

The world evolves. This is a world in which new things are dynamically created from the interconnection of diverse elements. Indeed, the universe, matter, life, and society can all reach a certain stage and then leap all at once to another, completely different level. In the biological world also, new species can emerge and new forms can be created almost instantly. This is what is known as macroevolution. This creative evolution, commonly referred to as phase transitions, requires the dynamism of informed cognition and interaction. In fact, the self-organizing system is also a cognitive system that transforms itself by exchanging information and interacting with its environment.

From the dynamism of this informational recognition and interaction, a dynamic hierarchical structure is generated. In the process from matter to human beings, including subatomic particles, atoms, molecules, cells, microorganisms, plants, animals, and humans, hierarchical evolution occurs with increasing sophistication of perception and movement. Here, new properties and laws emerge at higher levels of the hierarchy that were not present at lower levels. The process is dynamic, creative, and irreversible, and the higher up the hierarchy, the more difficult it becomes to reproduce. Because, history is generated in that process.

If we can think in this way, cosmology, which cogitates on the universe, physics, which describes matter, biology, which tries to grasp life, and psychology, which study cognitive action, will have to merge into a science that can remove the barriers between them and view their hierarchy in a unified

manner. The science of complex systems has the potential to do so. The goal of the philosophy of complex systems is to provide the philosophical foundations for such a science.

In fact, since its birth, the universe has repeatedly undergone phase transitions, diverged in power, and produced planets such as the earth. The earth also produced the prototype of life soon after its birth, and has evolved along with the evolution of life. In the process of evolution of life parallel to the process of evolution of the Earth, the phenomena of exchange of information and development of cognition cannot be overlooked. From the very beginning of life's emergence on this planet, it has evolved by recognizing environmental information and adapting to its conditions. This evolution of life has modified the environment of the Earth's surface, resulting in the evolution of the Earth's surface. The evolution of the Earth and life has been a one-time process that cannot be redone. The Earth and life also have life histories.

The evolution of life began with the chemical evolution that preceded it. Long before the creation of life, matter had already begun to evolve through repeated molecular recognition and molecular activity. Molecular recognition is the process by which two molecules come into contact with each other, recognize whether they fit together like a key and keyhole, and initiate chemical reactions. In the case of a group of organic molecules, they also mutually recognize each other and repeat chemical reactions to create protein molecules and nucleic acid molecules. And of these, the nucleic acid molecule has been autocatalytically self-propagating, spontaneously replicating itself and allowing itself and its offspring to persist. This is where the primordial purposeful behavior occurred and life began. The role of molecular recognition there is great. Organic macromolecules also observe each other.

Leaping to the genetic level, the genetic information written on the strands of nucleic acid molecules of RNA and DNA is also read to produce various protein molecules. Molecular recognition is also performed between nucleic acid molecules and protein molecules. Since such molecular recognition gives rise to living things from nonliving things, it must be said that there is no absolute rupture between nonliving things and living things.

Prokaryotes and eukaryotes, which had achieved the accumulation of information by means of RNA and DNA, were also able to recognize environmental information as signals and to act in a purposive manner, as well as to ensure freedom of action. Later, since the birth of multicellular organisms, animals, especially those that followed the path of heterotrophs, developed a primitive nervous system due to the need for cell-to-cell communication, which eventually developed into a central nervous system. This is because it required a high level of environmental information awareness and judgment in order to take appropriate action on the environment. Life evolved by creating a system of cognition.

Among other things, animals must explore, learn, anticipate, and survive in order to adapt to a constantly changing environment. To do this, they have developed behaviors adapted to their environment and sometimes even transformed their habits. This is why they had to develop the ability to recognize their environment. Moreover, their ability to retrieve and recognize new information from their environment also brings about evolution.

A living entity is an acting subject striving toward a goal, a creative subject with spontaneity and autonomy. This self-transcendence of life cannot be analyzed by deterministic causal laws. Moreover, it is undeniable that life's information processing and cognitive capacities play a major role in this self-creation and self-transcendence.

When it reaches apes, behavior is more developed, and with it, cognitive abilities such as perception and judgment are highly developed. However, this is not due to brain development. The opposite is true: the development of behavior and cognition must have preceded the development of the brain. Apes, or humans, who invented upright bipedal walking, became freer in their actions and were able to perceive their environment objectively through the development of hands and the production of tools. The development of the brain is merely a consequence of this.

It is probably due to the completion of upright bipedal walking and the freedom of the hands that humans became able to have conscious awareness and an objective view of the world. At this time, humanity became aware of itself as well as the world. Without being aware of the world, we would not have been aware of the self. Without being aware of oneself, one would not have been aware of the world.

Moreover, the self is an observer within the world and an agent within the world. The universe has created a self-aware person who recognizes the self and the world within the universe itself. Our awareness of the world and self-awareness is also self-awareness of the world. What we perceive is what the world perceives, and what we do is what the world does.

2. Limits of Modern Science

Criticism of Modern Science

In Descartes, who formulated the dualism of thought and being, subject and object, spirit and matter, and clearly separated self and world, the thinking-self existed transcendentally outside the world, and the world was also alienated from the self. Thus, in Descartes, the world was forced into a clockwork, uncreative, passive mechanism governed by causal chains. Such a mechanistic worldview, however, cannot capture living nature, creative nature, nature that forms itself out of interaction. In particular, a Cartesian mechanistic view cannot capture the

living world as an open system that forms itself by adapting to its internal and external environment.

The fatal flaw in this mechanistic worldview would be that it ignores the inclusion of the observer in that world. There, it was assumed that each element of matter is like a part of a machine and does not perceive or recognize one another. The actual world, however, includes observers within it. Even matter senses and interacts with others and creates new information for itself from that interaction. Such a system cannot be explained by a mechanistic view of nature.

Modern science also established the method of decomposing an object down to its ultimate elements and then reconstructing nature as the sum of its elements. This analytical method was also based on Descartes' method of recognizing things by dividing them into as many minute subparts as possible. However, phenomena that cannot be understood by such elemental reductionism account for most of the phenomena in matter, life, and society. For example, even if we reduce life phenomena to the atomic level, we cannot explain life phenomena from the properties of atoms. This is because even if we reduce the phenomena to the various elements, mutual recognition takes place among the elements, and from such mutual recognition, something greater than the sum of the elements appears in the higher hierarchies.

Even in molecular biology, which made spectacular progress in the latter half of the 20th century, elemental reductionism, which reduces life phenomena to mechanistic combinations of genes, is still regarded as valid. However, actual life phenomena, whether development, immunity, or evolution, are emergent phenomena resulting from complex mutual recognition and interaction among genes, which cannot be solved by elemental reductionism. This is because elemental reductionism ignores the fact that matter and life have the autonomous behavior and ability to create themselves.

If we continue to pursue this, we will come to the conclusion that subjectivity and objectivity, consciousness and object, cannot be separated. In other words, self-created nature cannot be grasped unless we recognize the sensory and perceptual actions, cognitive and judgmental capacities of what is called the objective or the object itself, according to the degree of its organizational hierarchy. It must be said that there was a reason why Leibniz, in his "Monadology," recognized micro-representations in matter as well ⁽¹⁾. Unless we overcome Cartesian dualism, which separates subject and object, consciousness and object, we will not be able to understand <living nature>.

Modern physics, too, still tries as much as possible to eliminate the problem of subjectivity and consciousness in capturing the real, and to exclude generation from existence. However, we must not confine existence to mere objectivity or object existence. It is unreasonable to try to describe what is generated, including consciousness, as mere object existence. True reality is objective and generative existence, including subjectivity. And it is precisely because consciousness and subjectivity are at

work that generation occurs.

Certainly, modern natural science has held the belief that nature is governed by deterministic laws of causality and that the future is predictable. However, the nature captured by the deterministic model is only a small part of nature. Because nature is full of uncertainty and unpredictable, the future cannot be accurately predicted by deterministic laws. In fact, it is inherently impossible to accurately predict the weather more than a week in advance. Moreover, even if we find a certain pattern of weather for one year, it does not necessarily mean that the weather for the next year will also settle into that same pattern. The history of nature is uncertain and its future is non-deterministic.

In natural phenomena, as in human technology, there are unexpected accidents. We cannot find deterministic natural laws that are valid for all of human history and society, let alone life, matter, and the future of the universe. This is because nature is subject to sudden changes that have not yet occurred. This sudden leap of nature, this "leap in the dark," as it were, was ignored by the deterministic laws of modern natural science.

Nature is creative, and often new incidents arise that could not have been predicted. Deterministic laws of necessity cannot be applied to such creativity of nature. In fact, simple deterministic laws do not hold for the evolution of life. For example, in the process of life evolution, whether arthropods, fish, reptiles, birds, or mammals, species that fly in the air emerge. They are insects, flying fish, pterosaurs, birds, and bats. They have devised and invented ways to overcome the law of gravity that objects fall from above to below. Newton's deterministic laws of motion do not explain any of this phenomenon of emergence. Not only animal evolution, but nature in general, has this kind of creative action. The historicity and creativity of evolution cannot be solved by natural laws that deterministically prescribe the future from past initial conditions.

In nature and life lurk efforts to seek freedom. As the hierarchy of nature increases, from inorganic matter to man, the capacity for self-creativity increases and the degree of freedom from the domination of natural laws gradually increases. This increase in freedom is not captured by deterministic laws.

Deterministic laws are based on the law of causality, just as the laws of classical mechanics were. The law of causality holds that the law of cause and effect governs from past to present and present to future, and that the present is already determined by past causes and the future is already determined by present causes. But actual nature, even if one counts all past and present causes, cannot predict what will be produced in the future from their interaction.

Even in a chaos experiment, even if the initial conditions are the same, the slightest error in the

initial conditions will cause the results to appear as if they were different. This is because each variable is not an independent variable, but is interconnected, interacting, and, so to speak, mutually observable. This is why the results are unexpected. If we are to penetrate such phenomena, we must consider the internal observation between variables, or intra-world perception.

Our history and society, as well as nature, cannot grasp the present from the past or the future from the present in a causal sense. Both human beings and nature have the freedom to look to the future. Neither human society nor nature can repeat exactly the same changes in the future.

In chaos experiments, no matter how many times measurements are made, the results are different each time, and even the results of the next measurement are often unpredictable. This is because measurement itself is an intra-world observation, which itself interacts with the phenomenon. There is, so to speak, a mutual recognition at work between what is measuring and what is being measured. This is a phenomenon that occurs constantly in human society and is not new, but such phenomena are not uncommon in the world of materials and life. Therefore, if natural science insists on the reproducibility of phenomena, it may ultimately fail to grasp nature. Reproducibility is not necessarily a principle of natural science.

Modern natural science used induction when it was difficult to deduce from deterministic laws. Bacon valued this induction as the method of science. However, induction is based on the assumption that if a finite number of precedents are followed, the next new example can be deduced. Induction assumes that if an inductive law can be found after n observations, it will hold true for the $n+1$ th time. However, this inductive reasoning does not always hold if we consider that matter, life, and society can suddenly leap forward and become creative. Neither nature nor society is like a bureaucratic society that does not do what is unprecedented. The belief that induction is valid in the natural world, like the belief in animals, was a mere belief of modern science.

Natural and social phenomena change from moment to moment, and nothing remains the same. What is constantly changing and developing cannot be grasped from deterministic laws. Moreover, neither nature nor society is ever complete.

This dynamic principle of Heraclitus, "all things flow," breaks with the static principle of Parmenides, "what is present is present, what is not present is not present". and "What exists is one, not many". Generation breaks through existence, and the many breaks through the one. The deterministic faith of modern science, which is based on reproducibility and predictability, has its source in Parmenides' principle of being. Modern natural science could believe in such a simple principle because it ignored the inseparability of existence and cognition. Furthermore, it may be because it ignored the fact that existence is many, and generation occurs when these many existences mutually recognize each other.

Although modern natural science has had as its goal the discovery of deterministic laws of nature, it is questionable whether this can ever be the ultimate goal. Certainly, modern science has promoted the establishment of deterministic laws through a mechanistic view of nature and elemental reductionism. However, we must thoroughly examine the method of science itself to see whether the establishment of deterministic laws and reduction to elements are really the way to accurately grasp nature. It does not mean that science is not science if it cannot establish laws. Science must be transformed into a science of understanding and explaining phenomena and a science of describing phenomena.

What is scientific law?

Science is originally an attempt to discover the laws of natural phenomena cut out from a certain perspective, as far as they are valid for that part of the world. The world itself is, for the most part, outside the laws of the world from which it is cut. Therefore, the laws of science are not, in principle, valid for all of the world. Moreover, since the laws are idealized, they can only approximate actual phenomena. A scientific theory is not a complete and definitive explanation of natural phenomena.

Furthermore, even if the laws of science are described deterministically, it does not mean that all natural motions under them will obey those laws in the future. For example, even in the motion of celestial bodies based on Newton's laws of motion, the mere interaction of three bodies will render the orbits of each of them unstable. This phenomenon, well known as the three-body problem, already implied the possibility of complex chaos even within deterministic laws.

It is similar to a game of baseball or soccer, so to speak. The game itself is played according to simple rules, but the outcome is never known. Here, the rules do not determine the course of any individual game. If there is mutual recognition and interaction between the agents playing the game, the dynamics make the outcome of the game unpredictable from the rules, even if it is within the rules. When the elements of a system interact with each other in a nonlinear manner, what emerges within the system cannot be explained by the laws governing the system.

This phenomenon is amplified in the societies, politics, and economies in which we humans operate. In our societies, even if there are rules, there are actors who act on the basis of the rules, who recognize and interact with each other. They recognize the society as a whole and others within it, and sometimes even try to change the society itself. Thus, the very rules of society are sometimes changed here. In our society, the rules themselves emerge. In our society, rules are shaped by circumstances. This happens because our society is a highly complex system.

Something similar can be said of ecosystems and the developmental process of life, in which countless elements interact with each other. For example, in the case of an ecosystem, the basic

equations themselves change over time because the system itself and the elements that make up the system can learn from the environment and change the rules. In the case of the development of life, the various types of cells that have differentiated from each other emerge on the spot, through mutual recognition and interaction, and the rules of cellular society emerge on the spot as the game is played. Of course, some cells do not follow these rules. The extreme case is the cancer cell. When cancer cells emerge, the rules of cellular society are broken. Conversely, there is such a freedom to break the rules in the world of life.

In the case of development, the genetic information in the DNA built into a single fertilized egg does not determine all subsequent directions. Rather, we should think of the information for living as springing from the interaction of each cell that emerges from differentiation in an epigenetic manner. Therefore, in the living world, even completely new information that is not directly written in DNA may be created and eventually read into DNA. This is the evolution of life. Life is able to transform itself in response to changes in location and environment because it is able to generate its own rules. The rules of the life-world are also changed by the emergence of new life forms in the course of evolution.

In complex systems with nonlinear interactions, the system contains both intra-world observers and intra-world actors, and the rules themselves are changed by them. Therefore, the behavior of the system becomes extremely unstable. The position of the science of complex systems is that such phenomena exist not only in our society and the world of life, but also in the material world. In this sense, we must consider the material world as a society with its own observers within it. The role of perception and action here is important. In perception and action there is freedom.

Instability and historicity of science

In this respect, we must say that nature has the freedom to break the laws. Nature, which is constantly generating and developing, has the creative power to transcend laws. If this is the case, the laws themselves must evolve creatively in order to be able to explain the creatively evolving world. Scientific laws, like the axioms of mathematics and logic, are incomplete in principle.

Our human perceptions, like those of animals, are neither absolute nor complete. Human perception, whatever it may be, is a kind of hypothesis, and like insects, it is merely a fragment of the world taken from a certain perspective. Natural science is also an expression of a kind of preconceived notion of nature that we humans have. In this sense, natural science is ultimately backed by conviction or belief, and has the character of a kind of faith. For example, as Hume points out, when we experience a sequence of events over and over again, we come to believe that what happened first is the certain cause of what happens later ⁽²⁾. However, this is a hypothesis, and reality

is often driven by unexpected events that violate this belief.

Modern natural science also had a kind of faith that nature prefers simplicity and is governed by simple laws. In reality, however, nature prefers complexity. Moreover, simple laws cannot capture something that is complex and that generates and changes without rest. Complex systems cannot be reduced to simple systems. It can be said that the notion of nature governed by simple laws was merely a kind of illusion envisioned by modern natural science. Modern natural science is based on abstraction, which is a method of extracting simplicity from complexity, but this method does not grasp the essence of the matter. Simple laws would be broken by complex facts. And each time, science would have to change its own schemes and hypotheses.

In this sense, one might say that science is the history of science. In fact, scientific discoveries have been made in the process of testing and criticizing hypotheses and overcoming them. Science itself is a history of hypotheses and their modification. Science does not speak of eternal and unchanging truths, but is itself historically evolving. The history of scientific inquiry is the history of the discovery of new meanings of the world through human exploratory behavior. Science itself is historically generative. Science itself is in the process of the generative change of the world. Therefore, the laws of science are constantly changing and being overcome. There is no law that is absolutely immutable, and laws are also generative and changeable. As the laws of science change, nature also takes on different forms one after another. It must be said that nature is so complex, abundant, and inexhaustible.

Existence is activity. All things are constantly moving and changing. There is nothing in the world but generative change. We must see what changes as changing and what moves as moving. We must view the changing and moving things not from the standpoint of existence, but from the standpoint of generation itself. The world is the constant flow and change itself. There is no such thing as an immortal entity. To exist is to generate, and to be is to become.

Moreover, recognition and action are at work there. Knowing by doing. This is what makes being into becoming. Without knowing, there is no being, and without doing, there is no becoming.

<Annotation>

1 Leibniz, *Monadologie*(21)(61), ed. Robinet, P.U.F., 1954,

2 Hume, *Treatise of Human Nature*, Oxford U.P., 1978, p.73f.

Source: Michinori Kobayashi [Philosophy of Life] Collection 5, Minerva Shobo, 2017 "Sequel to Philosophy of Complex Systems," Chapter 1.

