

Freedom in Complex Systems

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If we call a dynamic system that forms itself from the interaction of countless elements a "complex system," then the universe, matter, life, and society are all complex systems. The "science of complex systems," which points to the new direction of science in the 21st century, reveals such a world. This paper takes out the coincidence, non-determinism, and irreversibility of the world and criticizes modern science, which simplifies nature by the law of cause and effect and views it deterministically.

Nondeterminism and Irreversibility

Break in symmetry

The idea that nature has symmetry and is governed by symmetrical laws, as when we reflect things in a mirror, has been a fundamental thought in natural science from classical to modern physics. Even in the classification of elementary particles, fundamental symmetry has always been required. However, the idea that nature is symmetrical is a product of an intellect that has a tendency to view nature as a being rather than a formation, as static rather than dynamic.

Rather, nature has formed itself through spontaneous symmetry breaking. Even if the laws themselves have symmetry, symmetry must be broken in their materialization. It is said that our universe itself was originally formed from the breaking of the symmetry between matter and antimatter. Immediately after the start of the expansion of our universe, matter had a slightly longer lifespan than antimatter, so the symmetry was broken and a universe with only matter was formed. Our universe is composed only of matter, and antimatter is rarely produced in the laboratory only. This is where we see the extreme asymmetry. In the evolutionary process of the universe, it has formed itself in various ways by breaking the symmetry in certain directions.

Even in the natural phenomena described by self-organization theory, symmetry-breaking instabilities appear under conditions far from equilibrium. Small fluctuations in the system are amplified by interactions under non-equilibrium conditions, and at a certain point, the system reaches a diverging point where it becomes unclear which direction to go. At that point, chance kicks in, symmetry is broken, and a self-propagating self-formation (phase transition) occurs in a certain direction, completely changing the overall structure. Spontaneous symmetry breaking plays an important role in the formation of new structures and forms.

The world has become more and more complex, with infinite ramifications occurring as symmetry is broken. In a non-equilibrium state, the stable state is broken at a certain stage, and many ramifications occur. Most of the bifurcation phenomena are accompanied by spontaneous symmetry breaking. Therefore, the world cannot be reduced to a single basic principle with symmetry. Nature has been governed by a tendency to shape itself in a certain direction, as if it had a will of its own. There is always an inclination to nature.

Such symmetry breaking and bifurcation phenomena can be seen in all domains from the universe to society, including the bifurcation of forces at the time of the creation of the universe, symmetry breaking of elementary particles, changes in the state of matter, phase transitions, cell differentiation, growth and evolution of organisms, and technological innovation. Whether it is the universe, the material world, the life world, or human society, there are always <fluctuations> in the process of its formation, and sometimes we are not sure in which direction we should go. In the midst of such hesitation, by choosing one or the other, the world is transformed.

If the term "action" allows us to think not only of human intentional actions but also of natural movements and actions, then it can be said that the choice between space, matter, life, society, and anywhere is limiting the world and creating a world. To act is to break the symmetry and is to choose. And that is what creates the newness of the world. The act of throwing out into the world forms the world. The world is generated. And to create is to act. <To be> is <to become>, and <to become> is <to do>. The world is not necessarily governed by unchanging and immovable laws.

Coincidence at Work

If the world forms itself through the breaking of symmetry, and if this is due to the

choice of action at any given time, the role of chance in this process is significant. Whether it is the universe, matter, life, or society, its creation and change is the result of chance encounters among its constituent elements. Chance encounters create many bifurcation points and create complexity. The world is an improvisational drama created by chance. From space to society, unexpected things happen one after another, and many coincidences come together to create a single flow. The slightest incident can trigger a huge event that is far beyond our expectations. Coincidences determine the fate of life as well as the world.

In the theory of self-organization also, chance plays a role in the <fluctuations> inside the system and the bifurcation points where it has grown and formed. At the bifurcation point of a self-organizing system, the next state of the system cannot be predicted in advance by deterministic laws. Rather, an accidental interaction makes a choice in one direction. Coincidence drives decisions and drives the system in undecided state to a new direction. In chaos theory, even if the equations are described deterministically, a small fudge factors in the initial conditions can lead to huge fluctuations in the results. An initial very small cause produces a huge difference that cannot be ignored. There, chance is included in the inevitability. To be sure, classical mechanics and relativity have tried to eliminate and ignore chance under deterministic laws. However, this is only an idealization of the world and does not describe the real world. The real world, which is self-forming from interconnections, is a complex system, full of coincidences. And these coincidences affect the direction of the formation of the world.

Originally, the birth of the universe itself started from a coincidence of a slight deviation of the life span of matter from that of antimatter. Also, in the birth of life, right-handed RNA happened to be born during chemical evolution, and because of its rapid self-propagation, only life consisting of genes with a right-handed spiral sequence was born on this earth. Furthermore, human society was formed on the African continent when apes, who had been living in the trees, happened to come down to the grasslands and made tools. As always, the beginning starts by chance.

The encounter of celestial bodies with celestial bodies, subatomic particles with subatomic particles, molecules with molecules, life forms with life forms, and people with people, all depend on chance. The world takes a single direction from chance encounters and expands into something that can no longer be reversed historically. Not

only the history of human beings, but also the formation and evolution of the universe, matter, and life itself are always influenced by chance. Indeed, from the birth of the universe to the emergence of life, its creation may have been inevitable, but it also contains many coincidences.

The lily flower that blooms here is an incident, and there is not necessarily a deterministic necessity that exists here in that form.

Non-deterministic nature

If chance plays a major role everywhere in our self-forming world, then we must say that this world is moving in a non-deterministic way.

Well, classical mechanics presented a deterministic view of the world, considering that the behavior of a system is determined by its initial conditions. According to classical mechanics, if the initial conditions (position and velocity) of a system are known, then the subsequent state of the system can be strictly determined. In a sense, the universe began to move with a stroke of God and has been moving like a clock according to an unchanging equation of motion ever since. In fact, in the mechanical view of nature formulated by Newton, the universe was considered to be a huge machine governed by the law of cause and effect, and the future could be predicted accurately in principle. In this respect, it can be said that even in modern physics, the theory of relativity has inherited the ideas of classical mechanics and has tried to defend its stronghold on determinism until the end.

However, this deterministic worldview from classical mechanics to relativity has been defeated by quantum mechanics, which has prepared another principle for modern physics. As is well known, in the microscopic material world, due to the uncertainty principle, the position and momentum of particles can only be predicted probabilistically. For example, if we try to determine the position and momentum of an electron at the same time and irradiate a photon for measurement, the photon interacts with the electron, and the position and momentum of the electron cannot be determined simultaneously. Quantum mechanics revealed this fact and opened the door to non-deterministic nature. However, although quantum mechanics cannot predict the existence of particles or their decay definitively, it can predict them probabilistically, and there is still deterministic thinking in it. The quantum mechanical worldview sees phenomena as occurring according to laws, as if God were rolling the

dice.

However, the theory of self-organization, which emerged from a new interpretation of thermodynamics, emphasized the non-determinism of nature even more than quantum mechanics. According to the self-organization theory, at the bifurcation point formed by the amplification of <fluctuations> in the system, deterministic description becomes impossible, and the entire system cannot be predicted in which direction it will self-organize. Rather, the self-organization in a certain direction is determined by the probabilistic chance there.

In chaos theory, even though the equations are deterministic, the behavior is stochastic due to the acute dependence on the initial conditions. Small fudge factors in the initial conditions are amplified, resulting in the emergence of global indeterminacy. Chaos theory revealed that deterministic laws contain non-deterministic phenomena, and discovered that determinism and probability, necessity and chance, order and disorder are closely linked.

In both self-organization theory and chaos theory, it is not possible to accurately predict the future of a system in a self-forming nature, even if the initial conditions are set, because no univocal result can be deduced. Science has generally been oriented toward the establishment of laws, but here, the limitations of the establishment of laws themselves are exposed. As chaos theory has shown, even the slightest change in initial conditions can significantly change the future behavior, so even if deterministic laws are formulated, they contain unpredictability. We must consider that most of nature is rather non-deterministic in its generation, development, and emergence.

When we try to grasp non-deterministic nature with determinism, we are left with most areas that cannot be grasped with determinism. As soon as we think we have grasped nature through deterministic laws, nature takes on a different appearance and recedes into the distance. There is a part of nature that stubbornly refuses to make predictions. Until now, science has only dealt with the part of nature that is close to the ideal, that is, the part that can be deduced deterministically from initial conditions.

In fact, even in this universe, the determinism of classical mechanics is valid for relatively short time scales, but not for long time scales spanning billions of years. No deterministic laws can predict where galaxies will form and where stars will be born. The universe is a turbulent flow, and the distribution of galaxies and stars is not uniform. Even if the beginning of the universe can be described by deterministic laws,

a small fudge factors in the initial conditions can change the direction of the universe. The universe, like life, has evolved through repeated divergence and differentiation, constantly creating new things. The creativity of such a universe cannot be predicted by deterministic laws.

In the microscopic material world also, chaos occurs in the boundary region between quantum mechanics and classical mechanics, where strict mathematical treatment is not possible, and determinism becomes increasingly untenable especially in the life world. For example, the evolution of organisms cannot be predicted by deterministic laws. In the evolving world of life, it is not possible to describe in advance the forms and structures that will appear later. Genes do not determine the evolution of organisms. Rather, genes themselves are flexibly recombined in response to changes in the environment. In addition, life sometimes undergoes explosive divergence and evolution even without the external determinant of natural selection, as Darwin said. Animal behavior and habits are also acquired independently through interaction with the environment, and cannot be solved by mechanistic determinism. Since life has the ability to learn and improve, the future direction of life cannot be grasped by the initial conditions of deterministic laws alone.

When it comes to human society and history, most of them are dominated by non-deterministic factors. Since human society is based on the mutual regulations of countless members, double and triple coincidences are created, and the future of society and history is uncertain and cannot be predicted. The future of society and history is uncertain and cannot be predicted. No deterministic laws can be established for society and history.

The structure of a complex system, which spontaneously forms itself from the interaction of various elements, can be seen in the material world, the universe, the life world, and society. Deterministic laws are unable to grasp this spontaneity. Determinism cannot predict the new things that will emerge in the next stage of the world. There are leaps that cannot be grasped by deterministic laws. Human society and history are also uncertain and change with unexpected events. Coincidence also creeps into nature, and unexpected events occur. There are only a limited number of areas in nature where deterministic laws hold true, and most of the world is non-deterministic. The world is far beyond the scope of computability. Science must strive to grasp such a non-deterministic world in its non-deterministic form.

By the same token, nature and society as complex systems cannot be grasped by simple laws of cause and effect. In a complex system, the various elements are interconnected, and the cause-effect relationship is complicated. Here, even if there is the same single cause, if the conditions that make it possible and the internal conditions that receive it are different, the result will appear as something different. There is also a circular theory that the result returns to the cause and changes the cause, which in turn brings about a change in the result. For this reason, the simple law of cause and effect, in which one cause corresponds to one effect, does not apply here.

The world is constantly developing and growing, from the past to the present, and from the present to the future. Therefore, we cannot deterministically describe something that evolves in this way by simple causality. The law of causality has a speculative view of temporal causation, in which the past defines the present and the present defines the future. In reality, however, the universe, matter, life, and society are, in a sense, overcoming past experience to establish the present, and overcoming present experience to acquire a new future. Such a world cannot be grasped by a simple mechanistic law of cause and effect. When you get down to the law of cause and effect, we will come to the conclusion that the present and the future are defined by the initial conditions of the ancient world, and that their outcomes are predetermined. Here, however, the present overcomes the past and the future overcomes the present is neglected. The world as a complex system that forms itself cannot be grasped by a simple law of cause and effect.

Irreversible Nature

The process of a world that is constantly evolving is irreversible, as can be seen in the evolution of the universe and the evolution of living things. The world does not go backwards. In this world, even if we go back in time and set the same conditions, the same thing will not necessarily happen.

However, in classical mechanics, it has been believed that its natural laws remain unchanged even when time is reversed. In the reversible laws of classical mechanics, the trajectory of the world can go back in time as per the laws. Just like the video images we see when we rewind, the world of classical mechanics is believed to be capable of going backwards. This is an astonishing preconception of classical mechanics, and rather a flaw in our perception of nature. This assumption of classical

mechanics does not allow us to grasp irreversible nature. The reversible laws of classical mechanics cannot describe the actual nature.

In fact, in the nature we see, an old man does not revert to a mature man, a young man, or an infant, and a broken pot does not spontaneously return to its original state. Nature has grave consequences due to unpredictable events and coincidences. Nature is a history, and history does not repeat itself. Such an irreversible nature cannot be described in reversible and homogeneous time. As Heraclitus said, we cannot stand in the same stream.

Not only classical mechanics, but also relativity and quantum mechanics, which appeared in the early 20th century, all assumed a reversible world. In this respect, both relativity and quantum mechanics inherited the assumptions of classical mechanics. Well, quantum mechanics did capture the non-determinism of nature to a small extent. However, it could not capture the irreversibility of nature. This is where the limitations of quantum mechanics still lie. With the reversible assumption, the <evolution> of the universe, matter, life, and society will be impossible to solve. Neither classical mechanics nor modern physics has been able to grasp the irreversible process of development from disorder to order.

Yet, thermodynamics, contrary to the assumptions of classical mechanics, already discovered the irreversible processes of nature. As the second law of thermodynamics recognized, in a closed system, entropy always increases, eventually leading to a disordered thermal equilibrium. And not the other way around.

Self-organization theory in the late twentieth century reinterpreted this irreversibility of nature that thermodynamics had recognized, and revealed that irreversibility and disorder are rather the source of order. Irreversibility creates order out of chaos. In an open system under non-equilibrium, the interpretation that entropy conversely creates order was proposed. The universe, the earth, life, and society all self-organize by releasing entropy to the outside while decreasing the entropy inside. Self-organizing systems are battle fields against increasing entropy. This idea brought about a major shift in our view of nature. The new direction of today's natural science has also been a major vector shift from a science that describes deterministic and reversible processes to a science of complex systems that describes non-deterministic and irreversible processes. Self-organization theory has played a significant role in this.

Irreversible processes play a constructive role in the world, not only in life and society, but also in the universe and the material world. For example, since the birth of our universe, it is said to have expanded rapidly in a short period of time and evolved through repeated thermodynamic phase transitions as the temperature decreased. Along with these phase transitions, the forces of the universe have branched out, including gravity, strong interactive force, weak interactive force, and electromagnetic force, giving rise to a variety of cosmic structures such as quarks, elementary particles, electrons, nuclei, atoms, molecules, galaxies, stars, and planets. Our earth was born in this process, and eventually gave birth to life, and they have grown and evolved together while interacting with each other.

The process was nothing but differentiation, diversification, and increasing complexity. This is because the expanding universe was non-equilibrium and a self-organizing system. Within a self-organizing system, entropy is reduced and complexity is increased. The evolution of the universe and the birth of the earth and life occurred in the process of such an increase in complexity, all of which are irreversible processes. In an irreversible process, new events are constantly generated and the process is non-deterministic. The universe has been evolving, so to speak, by selecting its own laws. Life and the history of mankind are part of this irreversible evolution of the universe.

The world has an irreversible history. Not only human history, but also nature has a past history, on top of which the present event and its memory is built up and passed on to the new event and its memory of the future. The universe, matter, and life are similar to human society, which has an irreversible history. Science must be sought to describe the non-deterministic and irreversible processes of nature. In order to do so, it is rather necessary to bring the worldview of the humanities and social sciences to the worldview of the natural sciences. Modern physics has only described the way things are at the moment of the "here and now," and has ignored the history of the object unduly.

If the world were governed by deterministic and reversible laws, there would be no such thing as an unexpected and unpredictable occurrence, and nothing new would appear. However, the world is new every moment. New events are constantly piling up in the world. As new events are added, there are leaps and bounds and discontinuities between the past and the present. What once occurred will never occur again, and what

is occurring now will never occur again in the future. Eternal newness, which is the truth of an irreversible world that is always forming itself. As Heraclitus said, all things are in flux, and the sun is new day by day.

Freedom and Creation

Freedom exists in a world where new things are constantly being created. From the present moment of creation, something new is born. The moment always contains newness. The creativity that gives birth to that newness is unpredictable. It is in this unpredictable creativity that freedom resides.

In the process of self-formation of the world, there are junctures, and at these junctures there are many possibilities. As for which path to choose among those possibilities, there is indeterminacy and freedom not only in the human and living worlds, but even in the material world and the universe. Certainly, every system, at its juncture, has times when it hesitates about which direction to choose. However, the formation of a new self begins when that hesitation is broken and one direction is chosen. And therein lies a freedom that cannot be foreseen by extending from the past.

Well, the classical laws of nature generally state that if the initial conditions are kept constant, then all subsequent events can be predicted. All subsequent events are merely the unfolding of what was contained in the initial conditions. However, this deterministic view of nature fails to capture the present moment of creation. In the moment of creation, there is freedom. Therefore, even if the initial conditions are constant, the outcome is not uniquely determined. Many outcomes can arise from the same initial conditions. Self-forming worlds, such as the human and living worlds, as well as the material world, have freedom that is not bound by initial conditions.

The law of cause and effect, which classical natural law follows, tries to grasp the present from the past and the future from the present. However, it is not always clear whether or not the ongoing state of affairs in the developing world itself obeys this law of causality. The present is not constrained only by the past. The future is also not bound only by the present. Freedom does not belong to the inevitability. Freedom is rather close to chance. Freedom includes chance, and from chance new directions are found and new things are created.

Indeed, the movement of our solar system and the fall of objects on the earth seem to follow an inevitable determinism. There seems to be no freedom whatsoever in

them. However, this is only an approximation within certain limits. In the vastness of the universe and the material world, foreseeable and inevitable laws do not always hold true. Rather, the universe and matter have aspects that cannot be grasped by deterministic laws, and we have the freedom to break them. In fact, the universe and matter have aspects that cannot be grasped by deterministic laws, and it has the freedom to break these laws, and the degree of such freedom is even greater in the world of life and human beings. Rather, the world forms itself anew through the free act of breaking the laws.

The world is ever-changing. The world is constantly differentiating itself. The generated world overcomes itself without a break, creates new things, and evolves. Therein lies the progress and leap of the world. The source of freedom must also be sought there.

2. Criticism of Modern Science

Simplification of Nature

Indeed, in his system of mechanics, Newton used only the three laws of motion and the hypothesis of universal gravitation to describe the orbits of the planets in the sky and the motions of objects on the ground in a unified manner as governed by those deterministic laws. Homogeneous and uniform absolute space and absolute time were assumed, and a quality point, which has mass but does not occupy space, was assumed, and the laws of motion between quality points were formulated. Then, by knowing only the position and velocity of a quality point in the initial conditions, the positions of all subsequent quality points can be calculated. Thus, in Newtonian mechanics, the world became a mechanistic system that could be described deterministically by mathematical functions. Here, everything is determined by initial conditions, so the future is predictable without exception. Under such a deterministic description, things only move along a predetermined trajectory, governed by certain laws under the classical law of causality. There is no such thing as freedom. The world has been fixed in a mechanistic order governed by certain equations of motion.

In order to establish such a mechanistic view of nature, we must take into account the social conditions of the 17th century in Western Europe, when clocks were widely

used. The automatic machinery of the clock, powered by many gears and springs, made it possible to measure time by converting invisible time into visible numbers. In the same way, nature is also a huge automatic clockwork machine that eventually came to be thought of as obeying mathematical laws. Descartes and Newton contributed greatly to the establishment of this mechanistic view of nature.

The mechanistic view of nature of modern science was characterized above all by the simplification of the complex. It saw nature first as a machine composed of a collection of simple elements, moving according to simple mathematical laws. Just as Pythagoras saw the universe as an order and harmony composed of simple proportions of numbers, Newton saw nature as obeying simple mathematical laws. This became the definitive model for modern natural science. By nature, it is impossible to reduce a complex system to a simple system and explain it with a simple diagram. Modern natural science, however, has created the illusion of a nature governed by simple laws by setting up a simplified and idealized model.

The actual physical space is occupied by rigid bodies with a certain expanse, and their motions and collisions are subject to friction, errors, and many biases and losses. However, in order to simplify the theory, classical physics ignored the linkages and fields in which such rigid bodies are placed. Classical physics discarded the complexity of nature and made it abstract. The only way to explain nature by simple deterministic laws is, on the contrary, to limit nature to the range that can be explained by mathematical laws, and to treat certain idealized abstractions within that limited range. But if we come back to the real, generative nature, we will find that this simplistic mechanistic view of nature is hardly tenable.

Originally, there is a limit to the idea that everything in the world can be explained by deterministic laws. The events that occur in the world are not necessarily governed by inevitable laws. It is true that classical physics was able to predict the orbits of planets and the motions of objects based on deterministic laws, but these deterministic laws were only valid within the very limited range of nature. The accuracy of classical physics is a kind of fiction. In this sense, the theory of relativity, which still retains the deterministic worldview of classical physics, also has its limitations. Neither classical physics nor relativity can solve nature as a complex system that forms itself out of interconnectedness.

In general, it is impossible to predict what will happen in the complex nature of

reality, not the nature simplified by classical physics. Just as we cannot accurately predict the weather or the occurrence of an earthquake based on the laws of nature, in a system where many variables interact, the more time passes, the more chaos appears and the more unpredictable the behavior becomes. Even more so, when it comes to the evolution of life, it is impossible to predict what form it will take. As the hierarchical order of nature increases, from matter to life to mind, the degree of freedom increases, and it becomes more and more difficult to grasp by deterministic laws. Moreover, that freedom begins with the very creation of the universe and matter.

Generative change, the constant creation of new things, is the nature of reality itself, and it is unpredictable. Nature always has the freedom to break the deterministic laws. If we try to grasp such nature forcibly by deterministic laws of nature, we will end up destroying the nature that forms itself. Rather, we must consider that law formulation and foreseeability are not the essence of science.

Ignoring interactions

The modern mechanistic view of nature is also characterized by elemental reductionism. Elemental reductionism holds that by dividing a complex object into simple components and removing the complexity, as Descartes thought, we can come to a clear perception of nature. If this idea is thoroughly applied, the world can be reduced to the quark level of physics, which determines everything in the world. Elemental reductionism believes that after the world is broken down into its final elements, nature can be reconstructed as the sum of these elements. The mechanistic view of nature and elemental reductionism i.e. determinism and reductionism, were the two wheels that drove modern science forward.

In reality, however, nature is a complex system. There are countless elements that are interconnected, interpenetrating, and interacting with each other, so it is impossible to separate them into independent elements. Even if quarks and DNA are found, it does not mean that all material and biological phenomena can be described deterministically, because the elements exist only in correlation and work together in the field of interconnection. It is not that quarks and DNA determine everything. Rather, it is the actual nature that emerges from the interaction of these elements to create structures that did not exist. Nature is not a mere collection of basic elements. Elemental reductionism has discarded the self-forming capacity of nature to create

more than the sum of its parts. The higher we leap in the hierarchy of the universe, matter, life, society, and mind, the more complex and new characteristics emerge. The elemental reductionism of modern science has failed to grasp this emergent world.

Classical mechanics, moreover, could not describe the irreversible processes of nature. Classical mechanics can only describe reversible systems. But in reality, nature is a complex system of interconnectedness, always unstable, and irreversible. It does not conform to the reversible laws of motion of classical mechanics. On the contrary, time itself is irreversible, like a flying arrow. Classical mechanics ignores such irreversible processes of nature and the irreversibility of time.

In fact, the universe is evolving, matter is becoming more complex, and life is evolving. Society develops, and our minds grow through experience. The process is irreversible, and it is a process of ceaselessly producing new things. Life and society, as well as the universe and matter, have a one-time history. If we consider such an irreversible world, a reversible description of nature by classical mechanics is hardly possible. In fact, even relativity and quantum mechanics, which succeed classical mechanics and still assume reversible time, cannot describe the irreversible processes of nature. On the contrary, relativity and quantum mechanics must be improved to describe irreversible processes, as is being attempted in today's cosmology.

Only, thermodynamics, which was a classical science and described the irreversible processes of nature, recognized non-deterministic processes that are not governed by initial conditions, rather than deterministic processes that are governed by initial conditions. So, the theory of self-organization based on this reinterpretation of thermodynamics taught complexity, not simplification of nature, and self-formation from the interaction of elements, not reduction to elements. The science of complex systems has its source in this theory.

Classical physics, after all, ignored the complex interactions in nature and tried to eliminate them as much as possible. In order to simplify and idealize nature, classical physics neglected the interactions between elements and with the environment, and tried to eliminate the small fudge factors associated with these interactions. However, this interaction between elements and with the environment, as well as the small fudge factors associated with it, actually changes nature drastically. In reality, nature is a complex system that forms itself through the interaction of piece with piece, field with field, part with part, and whole with part.

Nature is, in a sense, like a clock with gears and cogs interacting with each other. It is true that the clock cannot express time as an arithmetically equalized number. But in reality, nature is like a clock that can only display time with instability, disorder, complexity, and unevenness. Classical physics has tried to eliminate complexity, instability, and disorder from such nature.

The fact that nature is complex and non-deterministic due to the interactions between elements is already evident in the inability to solve the many-body problem, even in classical physics. In other words, a system of three or more interacting bodies has an extremely complex trajectory, and its behavior varies greatly depending on small fudge factors in the initial values, and cannot be predicted deterministically from the initial conditions.

Also in quantum mechanics, Heisenberg's uncertainty principle incorporates the interaction between the observed system and the observer into the system. The act of observation disturbs the observed world, and the world becomes indeterminate. The act of observation and the observed system interact. Such phenomena appear not only in the microscopic world, but also in the world of life and society at a larger level. Rather, the world is constantly changing through such interconnections and interactions.

Incompleteness and generation of the world

The universe is not a perfect order or ratio, as depicted by Pythagoras. The universe is not perfected. That is why the universe evolves. The world is generated because it is incomplete. Gödel's incompleteness theorem contains this fact as a metaphor. Gödel's incompleteness theorem states that even a non-contradictory mathematical axiomatic system will always contain logical formulas that cannot be proven true or false, and that the system itself is incomplete. The inconsistency of a non-contradictory system cannot be proved by the system itself. The incompleteness theorem has shattered the belief in the completeness of mathematical and logical systems. However, this must be interpreted rather as an assertion of the development or openness of the axiomatic systems of mathematics and logic by exposing their incompleteness and baselessness. Not only that, but our world itself is incomplete, and it is precisely because of this that it develops.

The world is by nature an incomplete system, and when we try to describe it, a

realm of silence that exceeds the description appears, and we always fall into infinite retroactivity, circularity, and self-reference. Infinite retroactivity, circularity, and self-reference are contradictions in terms of formal logic, but the world forms itself through these very contradictions. Infinite retroactivity makes possible the infinite formation of the world, while circularity and self-reference contribute to the creation of a new world. If we look at the world as something that is always moving and forming, then infinite retrospect, circularity, and self-reference will not be contradictions. Rather, they are necessary for generation. Science should not simplify the world, nor should it pursue perfection in the world. Rather, we need a science that understands the incomplete as incomplete and the generative as generative. The science of complex systems certainly has the potential to do so.

We must make an effort to capture the living, creative nature. Nature is a system that produces itself, a creative system that creates new things and forms itself. The mechanistic view of nature could not explain such a living, productive nature in any way. The mechanistic view of nature cannot explain the development of an individual from a single fertilized egg, nor the growth and evolution of living things. Still, if we try to force the mechanistic view of nature to apply to living nature, we will reduce nature to a mere system of inertia, and we will reduce living things to nothing more than stimulus-response machines that merely react mechanically to stimuli. Modern science has viewed living things too much from the equilibrium of death.

We must see what is generated as what is generated, not what exists. We must see the complex not as simple, but the complex as complex. Nature is a creative nature that is forming itself. To understand such a self-forming nature, we must understand existence as generation. The world is in a continual flow. The world is a world that produces itself and generates a thousand changes. The world is not what it is, but what it becomes.

Annotation

1 Herakleitos, Fragment 6, Die Fragmente der Vorsokratiker (Diels u. Kranz) Bd.I, Weidmannsche, 1961.

(Source: Chapter 2 of "Philosophy of Complex Systems" in Michinori Kobayashi's "Philosophy of Life" Collection, 5, Minerva Shobo, Kyoto, 2016)