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ARTICLE

Understanding the various scientific theories in the history of science

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Abstract

The aim of this research is to explore the philosophical position of various scientific theories based on the history and philosophy of science. This is because the philosophy of science, which has usually dealt mainly with epistemology and methodology, is extended to the concern of problems of ontology, that is, metaphysics. Determinism, which is rooted in the metaphysical belief that objective scientific knowledge exists independently of humankind's perception, is comparable to a well-defined mechanism and can be described as "mathematization" of objective scientific knowledge—this is exemplified in the natural laws of dynamics established by Newton, Einstein, and Schrödinger. Conversely, if we move away from determinism, we need anthropomorphic concepts such as "possibility" and "contingency" to define the laws of nature. This paper investigates the shift from classical deterministic thought to the contingently perceived probabilistic theory, changes in scientific theories from a naturalistic viewpoint, and the convergence of theories achieved through this process. Since Darwin announced his theory of evolution, natural sciences have steadily undergone a shift from endeavoring to name, classify, and measure to emphasizing the transience of things, historical interest, and theorization. On the other hand, weak determinism states that things in the world are inevitable but also coincidental. Because there are coincidences, even if we know the current state of an object accurately, we cannot know its future state accurately; we can only know it probabilistically. It seems that things in the world occur through both necessity and coincidence and are not strictly determined. This kind of probabilistic weak determinism can be said to correspond to quantum theory and evolution theory.

Keywords The philosophy of science · Determinism · Dialectics · Darwinian evolution · Arrow of time · Difference · Metaphysics

1 Introduction

Should it be impossible to embrace a fundamental part of human experience, interest in science would be meaningless. Furthermore, the role of evolution in explaining nature has become increasingly important because it provides probabilistic and irreversible explanations. Weinberg argued that evolutionary patterns should be included in the laws of physics (Prigogine, 1996). Since Darwin introduced his theory of evolution in his book *On the Origin of Species* published in 1859, the concept of biological evolution has been debated for over 150 years, developing into a scientific theory through numerous verification processes not only in the field of life science, but also in all areas of the natural sciences. The position occupied by evolutionary concepts is becoming increasingly central and important in biology; Dobzhansky expresses this as follows: "The concept of evolution is the core principle that integrates all the concepts of life science with an integrative principle that can understand all living things on Earth, including humans, their relationships, and the world surrounding them" (Dobzhansky, 1973, AAAS, 1989, Sober, 1993).

This phenomenon is attributable to the radically reduced proportion of experiments, which used to be modern science's decisive research tool, and the increasing emphasis on the dimensions of activities, highly complex domains, and individual circumstances in contemporary research. We have no means of experimentally exploring the Big Bang, evolutionary processes, and the complex systems theoretical approach. Disciplines in the

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natural sciences now ensure their quality not through verifiable truth but through the acceptance of a sort of aesthetic form of explanations. Researchers have failed to discern any new truth from nature in current times. They are now led to make aesthetic interpretations of nature and pursue an idealistic projection of the human mind.

Science starts from simplicity. However, logical simplicity is neither the goal of science nor the starting point. All disciplines of the natural sciences must pass through a mythical stage. In scientific thought, alchemy precedes chemistry, and astrology precedes astronomy. Science moved beyond these initial stages by introducing a new measure of truth, namely, a logical measure. This study aims to explore the current positions of scientific worldviews by tracking their changes over time.

Metaphysics is a method of understanding that the world as a whole and things under the ontological hierarchy consisting of God, humans (souls), and nature have fixed and unchangeable nature in themselves, independently of the human mind. Metaphysical realism is the view (belief or claim) that there is knowledge that is objective fact (matter) independent of the human mind. The foundation of Western natural science lies in deterministic thinking based on physical realism and reductionism. The basis of this Western scientific spirit can be found in Plato's and Aristotle's ideological trend of a static universe. Astronomical science, from Copernicus to Newton, begins with the belief in the order that governs the world of phenomena. Although the teleology of aesthetic integration is added to the theory creation process, this trend can be said to continue with Einstein, who advocates metaphysical realism.

On the other hand, the way of understanding that sees the basic aspect of the world as constant movement, i.e., change and development, within universal connections is called metaphysics or dialectics. For Darwin, change was quite normal, and he saw the potential for creation. In the end, he breaks up with Plato. The concept of probability is an essential part of evolution theory. Above all, mutations, which are accidental genetic changes in biology, also occur due to quantum mechanical fluctuations. This is also the reason why evolution occurs in the organic world. Quantum mechanics, which focuses more on 'scientific methodology' than the realism debate, can be seen as methodological naturalism. This is because it is only a methodology for accessing the truth and does not substantively define what the truth is.

The aims of this study are to explore the philosophical status of scientific worldviews based mainly on metaphysical belief(Ontology) and to justify and judge propositional knowledge of proposed scientific knowledge, which can be judged as truth.

2 The worldviews based on metaphysical beliefs (ontology)

Metaphysical realism: It is the view (belief) that there is knowledge that is objective fact (materials) independent of the human mind.

2.1 Metaphysical idealism in ancient Greece: a teleological and organic worldview

According to ancient Greeks, the present history is not a development toward perfection, but it is stuck in a loop of eternal repetition of moving from cosmos to chaos and vice versa. Plato and Aristotle believed that the best order is the one with the least change, gradually depleting the original perfect state. This worldview left no room for the concept of continuous change and growth. Instead, the ideal state would be the one in which this decline is slowed down as much as possible. The ancient Greeks interpreted great changes and developments as further decline of the original perfect state, heading toward chaos. Therefore, their goal was to pass on a system to the next generation that was protected from change as far as possible (Rifkin, 1989, p. 28). Additionally, in the chain of existence, the idea of God, the supreme being, refers to a teleological and organic worldview in which value coincides with existence. Truth exists objectively and is independent of our perception.

2.2 Worldviews of mechanistic materialism as a strictly deterministic worldview

The mechanistic worldview dealt only with moving objects. This is because only moving objects can be measured mathematically. Accordingly, this worldview concerns mechanistic behavior rather than human behavior. The founders of the mechanistic worldviews, including Galileo and Descartes, separated and eliminated the quality of life, leaving only an inanimate universe composed entirely of dead matter. This mechanistic materialism view considers the world to be made entirely of matter.

God created the world, humans, and nature; his creations take precedence **(**materialism**)**. The universe of Newtonian mechanics, in which these materials are interdependent by the law of causality, is space, that is, the three-dimensional space of classical Euclidean geometry. This is an absolute space independent of the physical phenomena occurring in that space. In other words, by its very nature, absolute space is always the same and at rest, regardless of anything external. Time is also absolute and continuously flows from the past to the present into the future without any connection with the material world. It is self-sufficient and independent and unrelated to anything contained in spacetime. In other words, time and space are absolute and immutable notions, and nature comprises them; it is also an absolute world that will never change (Greene, 2004, p.34) **(**metaphysics**)**. Even if the abovementioned materials disappear, this absolute spacetime remains, which allows the assumption that the absolute spacetime is necessary for materials to move according to the law of causality. Thus, in the beginning, God created materials and the fundamental laws governing the forces and motions among them. Hence, the entire universe is in motion and keeps moving like a machine governed by immutable laws. As examined above, the mechanistic worldview is closely associated with strict determinism, in which everything in the gigantic cosmic machine is determined by causality. In such a system, everything that happens has a clear cause and yields specific results, and the future of any of its parts can be predicted with absolute certainty if its state is accurately known at any given point in time.

The Newtonian laws of motion and gravitation made it possible to explain the motions of planets, moons, and comets and various phenomena related to gravity, such as tidal currents. The triangular configuration of time, space, and causality remains valid till date as the essential idea underlying classical physics.

2.3 The notion of progress

The most salient feature of the mechanistic view is the concept of progress. In a nutshell, progress is the process by which a "less orderly" natural system is exploited by humans to progress toward a more ordered material environment. In other words, progress is the creation of a value greater than the original value existing in nature. In this context, a methodology is used to explain the laws of nature. Application of these laws to specific cases is termed technology, the purpose of which is to transform some natural processes into forms of greater value, structure, and order, improving their original state (Rifkin, 1989, p. 51).

2.4 Newton's mechanics

In Newton's mechanics, space is described as a large, square box made up of straight lines and right angles. In the box, time passes slowly and uniformly without any interaction. People can easily imagine these things and visually draw them in the mind's eye. Newton combined Kepler's laws about planetary motions with the laws of motion of falling objects discovered by Italian experimentalists such as Galileo and proposed a universal mathematical theory of unity termed the law of universal gravitation. To construct this law of universal gravitation, he had to pioneer a new field of mathematics, calculus. Using calculus, he was able to explain the properties of all laws of motion and gravitation in a simple, clear, and consistent way.

The law of universal gravitation was observed to be accurate. However, there was still an important problem that Newton could not solve. How does gravity work? How does the Earth affect the motion of the Moon approximately 400,000 km away? Albert Einstein (1879–1955) undertook to challenge the question that puzzled Newton, especially since his own special theory of relativity was in direct conflict with Newton's law of universal gravitation. Newton believed that the action of gravity was simultaneous. Conversely, the core concept of Einstein's special theory of relativity is that no object or energy information can move faster than light. Therefore, according to Newton, gravity could not act simultaneously.

To avert this contradiction, Einstein explored a new theory of gravity. He determined that this new theory should not only contain a valid part of Newton's theory but should also explain how gravity works and that there should be no contradiction between this explanation and the special theory of relativity. He achieved this with the general theory of relativity, which is considered one of the most famous theories of physics to date. Einstein resolved the contradiction between Newton's theory and his special theory of relativity by verifying that gravity moves exactly at the speed of light in the general theory of relativity (Livio, 2009, pp. 327–328).

2.5 Einstein's theory of relativity

Although the teleology of aesthetic integration is added to the theory creation process, Einstein advocates metaphysical realism. Newton's notion that absolute space is separated from matter becomes disproved, and the view that space is a form of existence of matter is established in Einstein's theory. Additionally, the slowing down of time by the motion of matter dismantles the notion of absolute time separated from matter and provides a rationale for the connection and unity of time and matter. Similarly, time also becomes a form of existence of matter. Thus, the notion of space and time based on Newtonian mechanics was converted into the notion of space and time as a form of existence of matter by Einstein's theory of relativity. The fact that time and space depend on the motion of matter shattered the metaphysics of the absoluteness of time and space, leading to the establishment of the dialectical view of the relativity of time and space (Oh, 2021, 2022).

For example, when two events occur simultaneously, the simultaneity of these events is proven to vary according to the criterion of observation. In other words, events that occur simultaneously when observed from the viewpoint of one reference object do not occur simultaneously when observed from the viewpoint of another reference object. This proves that the relativity destroys the absoluteness of the notion of time. This can be explained without contradiction using a transformation equation called the Lorentz transformation, which examines the relationship between time and space in a person at rest and motion. The theory of relativity, like quantum theory, uplifts human reasoning far away from the Newtonian universe (wherein the universe is considered a giant machine that runs without problems and is confined to absolute space and time). In the special theory of relativity, space and time appear differently for each observer. Physicists have since then merged space and time into spacetime. However, this spacetime is independent of matter. In Einstein's general theory of relativity, spacetime combines space and time with matter and energy. Special relativity corrected Newton's notion of absolute time and absolute space, but spacetime and matter are still independent in this theory, as in Newton's theory. Spacetime itself had to be imagined as bent or deformed by the existence of matter itself.

2.6 Conceptual change of space and time

God created the world, humans, and nature, and his creations take precedence. The universe of Newtonian mechanics, in which these materials are interdependent by the law of causality, is the three-dimensional space of classical Euclidean geometry. This is an absolute space independent of the physical phenomena occurring in that space. In other words, by its very nature, absolute space is always the same and at rest, regardless of anything external. Time is also absolute and constantly flows from the past to the present into the future without any connection with the material world (Greene, 2004, p. 34). For Einstein, however, time and space are neither absolute nor independent; they can look different depending on the observer's velocity and are closely related to each other. Einstein was 26 years old when he published his thesis on special relativity. He ascertained that he was not influenced by the results of Michelson and Morley's experiment. Einstein, who enjoyed thought experiments, came up with a new theory about the speed of light purely as a result of his thought experiments. Einstein solved this dilemma in a surprising and audacious way. He made two hypotheses. First, he generalized Galileo's principle of relativity, which states that all laws of physics are the same in all inertial systems. Thus, he extended the principle of relativity, which was limited to mechanics, that is, the laws of motion, to all phenomena, such as electricity, magnetism, and light.

The first hypothesis led to the second hypothesis: Light always propagates in space at speed c, regardless of the motion of the light source or the observer. In other words, there is no specific frame of reference for measuring the speed of light because it does not depend on the frame of reference for observation, and light is never at rest in any frame of reference. This notion of immutability of the speed of light in every frame of reference definitively shattered the notion that there is an absolute or special frame of reference. There is not only one frame of reference in which the speed of light is exactly c; therefore, there is no ether, which previously served as the first reference for absolute space. Additionally, because all observers see light at the same speed, all views are equally correct, as confirmed in the Galilean frame of reference (inertial system). In that case, however, this principle was related to space only, with time remaining an absolute concept that flows the same for everyone. In Einstein's hypothesis, there is neither special space nor special time regarding the speed of light (Vannucci, 2005, p. 36). Specifically, Einstein's principle of special relativity did not start with a metaphysical belief but showed logical simplicity by assuming only the absolute speed of light.

The validity of scientific theory is established based on the scope of its application. What the absolute standard of science informs us is the legitimacy of the scope of its coverage.

At first glance, the unique characteristics of accelerated motion posed a problem to Einstein, who argued that space is empty and motion is relative. In the special theory of relativity, Einstein posited that the laws of nature are the same for all systems moving at a relatively uniform speed. In his firm conviction about the universal harmony of nature, he did not believe that a system in a state of accelerated motion could be a special system of motion, that is, something different, in the laws of nature. For this reason, he declared that "the laws of nature are the same for all systems regardless of their state of motion" as the framework for the theory of general relativity. Thus, Einstein established a new law of gravity.

Einstein described the behavior of an object in a gravitational field not as a "force of attraction" but as a "trajectory" followed by the object. Gravity is a part of inertia, and the motions of the planets stem inherently from inertia. The structural properties of space determine the trajectories they follow, that is, the structural properties of the spacetime continuum (Barnett, 2005, p. 130).

Aristotle asserted that the world is analogous to an organism, just as each individual is a biological organism. He considered each material separated from the corresponding original organism, which strives to return to the form of the original organism. An apple falls to the ground and rots because the material that forms the apple is in the process of returning to the form of its original organism, the Earth. According to Aristotle's cosmology, the universe is infinite, with a stationary Earth at its center. Unlike the secular and irregular Earth, celestial bodies are perfect spheres and revolve around the Earth in perfect orbits. Everything outside the lunar orbit is impeccable, and this perfection is visible to the naked eye. From the Aristotelian analogy of the universe as an organism, we can assume that he judged natural phenomena by logic; this is rational thinking rather

Table 1 Premises and predictive abilities of the theories covered in this research

Theory	Premises* <Logical simplicity>	Construction of a theory deduced from premises (axioms, hypotheses)	Predictive ability
Aristotelian theory	An object's a priori impulse of change to transform to its original position <Metaphysics>	All objects are made up of four elements	Difficult to predict
Newton's theory of gravity	Premise of absolute space and time as divine bodies <Metaphysics>	Space and time exist independently without any role regarding matter, Newton's laws of motion, and the law of universal gravitation	Accurate prediction of planetary motions
Einstein's special theory of relativity	Constant speed of light in an inertial system<Electromagnetic theory and direct observation>	Spacetime is intertwined due to the absoluteness of light, but it is an existence independent of matter, and the essence of matter is energy	Wider scope of prediction than Newtonian gravitational theory
Einstein's general theory of relativity	Spacetime of matter as the gravitational field in the inertial system, <Thought experiments>	Spacetime, gravitational field, and matter are one in essence; therefore, spacetime does not exist independently	Widest scope predictive ability; absolute relativity

* All laws of physics, which are the premises of a theory (axioms, hypotheses), are the same in all frames of reference

than empirical experimentation—that is, he delivered teleological and organic explanations of natural phenomena.

On the other hand, Newton argued that celestial bodies do not deviate from their orbits due to the causal effect of gravity acting between objects, explaining the phenomenon from a causal-mechanistic viewpoint. In their explanations, Aristotle and Newton missed a key element: the principle of why materials seek to return to their original form. Aristotle attributed all materials' original locations to the metaphysical principle of God. Nor can Newton explain the cause of gravity. There is no discussion on how to determine the nature of matter. Eventually, he presupposed the existence of a metaphysical absolute God in the same way as Aristotle.

Newton described the motion of a moving object by the gravitational force of universal gravitation following the absolute time in the universal frame of reference of absolute space. This does not give clues to the nature of gravity due to the lack of connection between the absolute spacetime and the matter in it. However, Einstein stated that the speed of light is finite. According to Einstein, although the speed of light is finite and thus limited, the absoluteness of the speed of light is established in the absolute spacetime frame, with its independent status given from an ontological standpoint in the same way as Newtonian mechanics, wherein the spacetime and the matter within it are not connected and is thus relative from an epistemological viewpoint, varying according to the observer. However, from the mass-energy equivalence principle, it is shown that matter is not immutable, which suggests a shift from the physics of substance to the physics of events.

The theoretical proposition that spacetime is also combined with matter is derived from the general theory of relativity. The gravitational field of spacetime explains why objects attract one another. From this, it follows that, in the general theory of relativity, spacetime is in an ontologically different state, subject to matter, relative, not absolute, from an epistemological viewpoint; this differs from the conception of absolute time and space in Newtonian mechanics.

The absolute standard of an axiom, the premise of theoretical propositions, is that the whole universe must inevitably be connected as one. The Aristotelian theory is limited by its teleological and organic explanations of natural phenomena. Precisely, according to this theory, natural phenomena cannot be predicted. In Newtonian mechanics, space, time, and objects are thoroughly separated; this separation acts as a hurdle for integrated thinking of the laws of the universe (Table 1).

The absoluteness and finiteness of the speed of light in an inertial system are explained by the theories of time–space convergence and the equivalence of mass and energy. However, time and space, along with matter and energy contained in them, are still independent in the theory of relativity, making it fundamentally similar to Newtonian mechanics. However, in a non-inertial system, the new premise of the absoluteness of the speed of light and the equivalence of an accelerated system and the gravitational field fall back on a mathematical and logical conclusion in which space, time, and matter are interconnected. Einstein's theory of relativity explains that the whole universe is inevitably connected as one; thus, it is geared toward an integrated theory. However, it operates within a certain predetermined order, which is a type of dialectical thought. Such a quest is rooted in naturalistic thought, which raises a question about the meaning of unity if it cannot be achieved by man in nature and is not generated by a transcendent God. It also suggests that the universe is constantly changing without triggering chaos. In this context, unlike quantum mechanics, which has recourse to a probabilistic worldview rather than strict determinism, this quest for unity in the theory of relativity and the strict determinism reflected in it brings it in line with Newton's thought, despite its dialectical viewpoint differing from that of Aristotle in ancient times and Newton in modern times.

Regarding Einstein's philosophical position, I conclude that the special theory of relativity pertains to Newton's metaphysical materialism, and the general theory of relativity pertains to dialectical materialism. It is also shown that the ontological status of absoluteness of space and time of classical Newtonian mechanics is shifting to a dependent status under the condition of the absoluteness of light. If Newton's space and time are absolutely independent variables, Einstein's spacetime, especially in general relativity, is a variable dependent on matter, subject to the absoluteness of the speed of light. This clearly shows a shift in the ontological status of space and time; however, epistemologically, it provides evidence for absolute relativity.

The theory of relativity does not speak of the relativity of truth but rather the relativity of phenomena for the immutability of truth. In general, scientists tend to disapprove of changing a truth, law, or principle because what they ultimately pursue is something inherently universal and always applicable. Einstein himself is known to have disliked the title "theory of relativity."

When considering physical light in its own coordinate system, we find that time and space disappear. The realm of light seems to transcend time and space. In physics, light is an absolute value (Russell, 2002, p. 110).

2.7 Probability theory and weak determinism in quantum mechanics and theory of evolution

The concept of probability is an essential part of evolution theory, and quantum mechanics deals with 'scientific methodology' more importantly than the realism debate.

The atomic model made in the early twentieth century was modeled on the solar system, with electrons with a negative charge surrounding the nucleus with a positive charge, similar to planets surrounding the sun. However, electrons behave differently from planets. Unlike planets, electrons were observed to jump from one orbit to another without passing through the intervening space. Orbits are not well-ordered orthogonal trajectories, and electrons are spread over them, occupying wide and indistinct loci. In this model, the nucleus was considered a complex of particles composed of protons and neutrons bound by particles and forces that cannot be represented by any visual model or representation by our sensory experience. Atoms are not objects. At the atomic level, the objective world placed in time and space no longer exists (Heisenberg's *The Part and The Whole*). All particles were also shown to have the properties of particles and waves simultaneously.

Heisenberg's uncertainty principle, which is the foundation of quantum theory, is evaluated as weakening causal determinism. Just as Newton's laws of motion became the basis of classical mechanics, this principle became the basis of modern physics. The more accurately a physicist measures the position of an electron, the more uncertain its velocity becomes, and the harder the physicist tries to measure the velocity of a particle, the harder the search for its location becomes. This is attributable to the intrinsic duality of an electron being a particle and a wave simultaneously, making its definition practically and theoretically impossible. The implication of this phenomenon is that at the subatomic level, the world is in a state of uncertainty at any given moment and in a state of somewhat uncertain or free at the next moment. Because of the uncertainty of these ultimate components, physicists' statements about subatomic processes are only probabilistic estimations, never definitive. In a microcosm, the law of probability takes the place of causality. In other words, strong deterministic causality is replaced by weak probabilistic causality. Consequently, nature cannot be strictly predicted.

Causality refers to the connection between an event (cause) and its outcomes (effect). The cause and effect should be temporally apart, at least for the passage of time corresponding to the speed of light. This is termed Einstein's local causality. For example, if cause and effect occur instantaneously or simultaneously, it violates the premise of local causality. This does not mean that there is no causality in quantum theory but that the causality of quantum theory requires a probabilistic causal theory different from that of classical mechanics and relativity, involving the conceptual problems of reality and locality.

For the convenience of this discussion, realism is understood as meaning physical reality, as claimed by Einstein. Einstein's basic assumptions for reality are threefold: (i) the existence of the real world independent of human observation, (ii) the acquisition of universal results through the same experiment, and (iii) satisfaction of the principle of locality (Choi, 2021).

In conclusion, in quantum theory, reality was understood as a physical reality by Einstein and as a relationship by Bohr. Einstein used reality to explain the relationship, and Bohr used a systemwide network of relationships to explain reality. In principle, it is impossible to imagine the essential appearance of the universe other than what we perceive ourselves.

Therefore, there can be no objective matter in the strict sense of the word. In classical mechanics and the theory of relativity, a key characteristic of space is the isolation of one body and another from various influences, whereas that of quantum mechanics is that any two objects, even on opposite sides of the universe, are closely connected to each other.

It stands to reason to view the universe as a gigantic organism, in which every part is inseparable from the whole, rather than as a gigantic clock that can be assembled or disassembled into parts. Ultimately, quantum theory proposes a holistic solution to the relational view of nature and cosmology that understands the world in a network of relationships with relationality and wholeness as the essence. This starkly contrasts the mechanistic view of nature and cosmology presented in classical mechanics.

2.8 Time reversibility in dynamics and time irreversibility in statistical mechanics

Theoretical physics is divided into two research methodology categories: dynamics and statistical mechanics. Dynamics includes using microscopic descriptions of individual particles, and statistical mechanics uses macroscopic descriptions of group properties when a large number of particles are considered. While they are entirely different approaches, it must be taken into account that statistical mechanics is built on dynamics. In other words, statistical mechanics can be generated in a system of dynamics called classical mechanics, and statistical mechanics can be directly generated in the quantum mechanics system. Accordingly, two categories of statistical mechanics can be generated: classical statistical mechanics and quantum statistical mechanics. In dynamics, time is reversible; however, in statistical mechanics, time is irreversible.

Entropy is a central problem in statistical mechanics. Any given system changes from a state with small entropy to a state with large entropy, not vice versa. This is the second law of thermodynamics. More specifically, the entropy of a system cannot decrease in an isolated system. In other words, it is a law of nature that any existing structure of a system isolated from the environment is headed toward decay. However, in an open world, the exchange of information with the environment plays a key role in this regard (Choi, 2010, p. 156). It is often the case that dynamic behavior in a non-equilibrium state is more important than that in an equilibrium state. These are characteristics of complex systems. In contrast, a self-organization phenomenon suggests that when an initially chaotic non-equilibrium system is exposed to a strong external environment, a new second law may emerge that is opposite to the existing second law of thermodynamics. Living systems constantly increase their structural complexity through the manifestation of new structures. This phenomenon can be expressed in terms of self-organization and adaptation.

A living system establishes its internal model of the environment and responds appropriately to the external environment based on that model. This can be compared to a consumer applying economic information acquired from the media to their internal model based on their experience and learning, thereby predicting an economic recession or revitalization and deciding whether to purchase or invest capital immediately.

These internal models continue to change through continuous input of better economic life or learning and evolution, increasing their complexity by creating higher-order behaviors. In other words, a living system increasingly complicates its structure when adapting to the external environment. In doing so, the new, more complex structure tends to accumulate ever-increasing complexity through applications and suddenly display this complexity at a certain threshold. Ecosystems also repeat the process of complicating their structure through evolution from primitive organisms to higher-order species. Briefly, evolution leads to organisms with excellent flexibility that adapt well to a rapidly changing environment.

In some cases, an isolated system is opposed to a closed system. In a closed system, entropy reaches its maximum at equilibrium—in other words, entropy has the maximum value at or near equilibrium in a closed system. It has been observed that order can be established spontaneously in an open system, a phenomenon termed self-organization. Systems capable of self-organization are living beings, chemical reactions, flowing liquids, computer models, and social organizations. They can generate new attributes (emergentist viewpoint).

The most surprising element of the complex systems theory is its goal of determining a single conceptual system that describes the behavior of living and physical systems. The complex systems theory aims to unify physics and biology. The distinction between animate and inanimate matter, as undertaken by Galileo and Descartes, is the first gateway to the complex system because a complex system can be theorized only after obtaining the law governing the motion of inanimate matter (physical systems).

At an earlier stage, far before reaching equilibrium, a complex system is capable of self-organization. After all, the complex systems theory holds clues to a deeper understanding of the regulation/adaptation process. In order for the theory of complex systems to be able to explain biological systems as well, it is necessary to determine the laws of change of complex systems, along with the laws of physics. Newton's laws deal with inanimate matter only, and Newtonian causality cannot be applied to living systems. Changes in complex systems related to self-organization are a cutting-edge research area in the theory of complex systems (Miller, 1996, p. 514).

The theories of quantum mechanics and statistical mechanics also emphasize these relationships. For example, particles constituting matter do not exist independently but are observed to exist only through interactions with other particles. On the other hand, Newtonian physics, a symbol of modern science, is characterized by materialism and reductionism; thus, it focuses on the components themselves instead of their interrelationships. Newtonian mechanics asserts that the universe moves precisely in a certain order, like a clock; it aims to shed light on this predetermined order. In deterministic but nonlinear Newtonian systems, minute errors can lead to unpredictable results. Consequently, in the same manner as the probability of precipitation in weather forecasting, probability theory is the only option available to Newtonian systems to predict the future.

It is not surprising that thermodynamic thinking is introduced in the origin or evolution of life, not mechanics. The development of this new science may be attributed to biological research. Not only does such a complex systems theory provide unexpectedly new perspectives to the scientific areas and methods, including life science, but it is also expected to have new implications for understanding human beings and society.

This can be explained by the example of a sudden drop in temperature caused by a decrease in the density of light, the background material of the universe; this would lead to the expansion of the universe, entailing the emergence of a wide variety of new materials. Researchers are building a research-based body of understanding in this matter by using general relativity, thermodynamics, and statistical mechanics that are within the reach of human reasoning. The problem is that these processes are idealistic pursuits because they rely on logic and reasoning rather than experiments.

Mathematically, the basic equations of physics are not affected by the direction of time. The laws of physics allow, in principle, to go backward in time as long as nuclear force, electromagnetic force, or gravity can go forward. The laws of nature express the symmetry between the forward and backward flowing times.

Hawking (1999, p. 77) defines an arrow of time as "something that distinguishes the past from the future, giving a direction to time" and notes that there are at least three different arrows of time: (i) the thermodynamic arrow of time, that indicates the direction of time in which the degree of disorder or entropy increases; (ii) The psychological arrow of time, that indicates the direction in which we feel time is passing, that is, from the past we remember to the future we cannot remember; (iii) The cosmological arrow of time, that indicates the direction of time in which the universe is expanding rather than contracting.

In contrast to the mathematics-driven time reversibility in the philosophical tradition of Platonism, the thermodynamic arrow of time and the cosmological arrow of time coincide with the psychological arrow of time, giving them a conceptual direction.

According to classical mechanics, there exists "time-reversal symmetry." Time reversal is obtained in Newton's equation of motion by assigning a negative sign to time. Therefore, classical mechanics includes time-reversal symmetry; eventually, there is no distinction between the past and future. Hence, dynamics is an inherently time-reversible phenomenon.

In quantum mechanics, a state function must be squared with an absolute value to have a physical meaning along with a physical quantity. Therefore, the original equation is obtained by taking a state function and its complex conjugate to remove the negative sign. Consequently, the Schrödinger equation also has time-reversal symmetry (Choi, 2021, p. 288).

Darwin's theory of evolution exercised its power by strongly challenging the essentialism that had occupied the throne of ontology since Aristotle. Mutations are essential for Darwin's concept of natural selection; he argued that speciation arises in nature when mutations are selectively preserved. Therefore, diversity of life is possible only when members within a population are heterogeneous, albeit to a greater or lesser extent.

Marxists, who are dialectical materialists, acknowledge the fundamental nature of inertia and that change is the only "absolute phenomenon." The physicist Max Born began his book *The Restless Universe* (1935, p. 1) with the following statement: "It is odd to think that there is a word for something which, strictly speaking, does not exist, namely, 'rest'." The German physicist Kirchhoff called rest a "special motion." Engels welcomed this assertion, saying that Kirchhoff does not know how to calculate but that he can think dialectically. *The Origin of Species* published by Darwin in 1959 presented a new and revolutionary concept of evolution, along with evidence to support previous assumptions about the evolution of plants and animals (Baghavan, 1987, p. 34). Darwin described evolution as "natural selection" and "mutation." Since then, the theory has been supplemented through continued research and discoveries. Eventually, the belief that the species is immutable, which had been held since ancient Greek times, received a fatal blow. Through the theory of evolution, the thesis of immutable species, which had dominated people's thinking for ages, was discarded. To put it more philosophically, the belief that the substance or essence does not change was weakened.

The simple phenomenon of "natural selection" allows living organisms to adapt to their environment and develop into different species. Consequently, diverse species are developed from the original single species.

The theory of evolution triggered a shift away from anthropocentrism by lowering *Homo sapiens* from the honorable position second only to God to the ranks of all other creatures subject to the laws of nature. However, humans still occupy the center of the universe. Spencer's theory of social evolution emphasizes the sanctity of the present, not that of the origin, and served as the ideological basis for the imperialist ideology of that time. In my view, Darwin was attacked for his theory of evolution as it affected the sanctity of the notion of the origin of the world; however, it must be noted that ecocentrism and anthropocentrism are mixed in his theory of evolution, which marks the scientific beginning and spirit of ecocentrism.

2.9 The worldviews of Darwinism

A relationship exists between Darwin's direction of evolution and the direction of time. Evolution has never taken a step backward in its three billion years of history. Subsequently, a question arises: Why? Would it not be an irregular process according to the flow of time between the direction of evolution and the direction of time? This leads to the following questions: (i) What is the force that propels evolution, or at least keeps it from regressing? (ii) How can a mechanism work unless it is planned in advance? (iii) What are the relationships that sustain evolution in the same direction in tandem with the arrow of time?

The key features of Darwin's theory of evolution are natural selection, mutation, and evolutionary time. Mutation is an important mechanism by which diversity is explained; it is a strategy for increasing the chance of survival of a species in a changing environment. Natural selection acts as a brake to prevent time from flowing in a reverse direction. Natural selection and mutation interact within the frame of evolutionary time.

2.10 Relationship between evolutionary time and entropy time

Mechanical phenomena are inherently reversible, but how can dynamic molecular motion explain irreversible thermal phenomena?

Consider the following example. A partition is installed in the center of a container; side A is filled with gas, and a vacuum is created on side B. If a hole is drilled through the partition wall, the gas diffuses throughout the container, giving it a uniform density or pressure throughout the container. Moreover, the gas spread across the container will by no means be concentrated on only one side of the partition, leaving the other half in a vacuum state. The second law of thermodynamics describes a statistical law in which the arrangement of atoms is identical and makes it clear that the average state of such a system is not likely to fluctuate significantly by contingency. This phenomenon is referred to as the arrow of time. In other words, natural phenomena always progress toward a state of higher probability. This is what is meant by an increase in entropy.

Time has only one standpoint in the evolutionary process from simple to increasingly complex forms. Giving direction to time is an evolutionary process. Advancing from the simple to the complex, building stratified stability, is an invariable characteristic of evolution, in which time determines its own direction. Unlike the thermodynamic law called time, evolution acts as a mechanism by which the reversibility of the arrow is prevented (Brenowski, 1977, p. 286). In the end, however, the thermodynamic and evolutionary directions are the same.

2.11 Metaphysical evolutionary worldviews

It is understandable how Aristotle's metaphysics came to be fused with religious and mystical traditions. Plato's realm of ideas is conceptually not highly different from heaven, ruled by a perfect God. Specifically, Plato's description of the material world imperfectly reflects the realm of ideas, falling in with the belief that humans were dissociated from God's grace. It is an aversion to change, not to progress. Plato believed space and time to be fixed and immutable, but the nature contained in them is imperfect.

Newton's metaphysical materialism is the belief that the supernatural reality called God created the universe and is its prime cause but is no longer involved in its operation. It proposes that the universe has been unfolding since its creation. However, the universe has been unfolding since the moment it was created according to the natural and physical laws determined at the moment of its creation (Davis, 2009, p. 248). It is natural that humans, as rational beings, can determine such natural laws and the linear causal relationship. Metaphysical materialists dream of a utopia in this world by exploring inevitable causal relationships rather than contingent factors. It follows the determinism that everything that happens is completely predetermined by a higher force or order created by what has already happened.

Moving away from the metaphysical view that the space, time, and species of the universe are fixed, Darwin considered change normal and viewed it as part of the creation of natural phenomena and their potential. With this thought, he also parted from the thoughts of Plato and Newton. Darwin described a metaphysical mechanism by which species can change over time without the supervision of an intelligent designer. Just as he believed that evolution is not a designed process, he regarded changes in species as a process of perpetually expanding the boundaries of possibility, filling the new space as creatures of nature, and including continuous experimentation with new species (Davis, 2009, p. 24).

2.12 From metaphysical materialism to dialectical materialism

Metaphysical materialism sees nature not as a process including changes but as a fixed, immutable entity. It contributed to the basic understanding of all areas of natural sciences, including physics. In biology, for example, the immutability of species has contributed to establishing the concept of species. However, its advocacy of the immutability of species was replaced by the changeability of species through the theory of evolution, explaining that a corresponding scientific recognition immediately followed any new metaphysical belief or concept. With all natural processes understood as dialectical processes, dialectics and materialism in a unified form were presented as a new worldview.

Dialectical materialism was derived from material and motion. It considers space, time, motion, and matter to be inseparable, with motion being the basic property of matter and constituting the essence of space and time. This position was proved by 20th-century physics. The key conclusion of Einstein's theory of relativity was that space and time do not exist independently of matter, and spacetime and matter cannot be separated from each other as integral parts of a whole. Here, the passage of time and the expansion of matter depend on the speed of moving matter, which was explained from a four-dimensional perspective transcending space and time.

The seemingly absurd claim that evolution was caused by the mechanism of pressure and time of local adaptation signals the birth of a new mechanism that explains the changes in life. Briefly, it declares the beginning of the shift of evolutionary theory from metaphysical to dialectical materialism.

3 Epistemological justification and naturalism

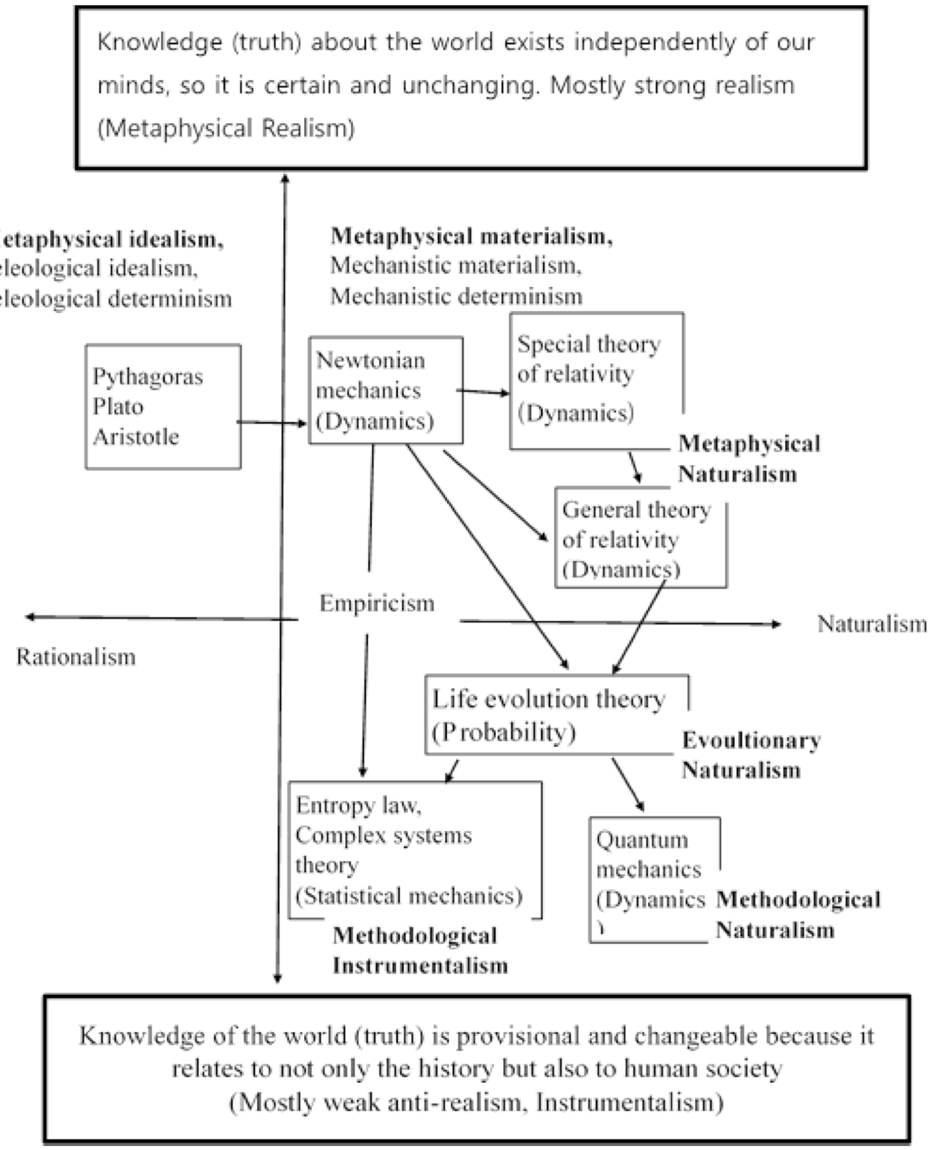
As shown in Fig. 1, according to the metaphysical belief that there is a hidden order in nature, how do we approach such a hidden order, and what is the source that can justify it? It is said that epistemology can be approached in three major ways. It converges on two main sources: reason and experience (Hosper, 1997, p.107). Rationalism is based on reason through reasoning and is a passive observer. Empiricism is based on sensory experience and expands to an active observer. Naturalism is based on beauty and practicality in problem-solving, and the human mind is involved.

First, rationalism develops into a universe of teleological purposiveness, and the hidden order is approached through passive observation. From Plato to Aristotle and the Middle Ages, rationalists viewed perception as inaccurate and easily prone to error, and the possibility of error in this perception led to empirical observation. It has made rational thinking a preference for justifying beliefs about facts. In other words, he is a passive observer.

Second, empiricism developed into a mechanistic theory of causal determinism, and the hidden order was approached by expanding into active observation. On the other hand, Bacon, an empiricist, emphasized that it was through repeatable measurements that a knowledge system began to be created. Both of these separate the subject and the object; the former, the rationalist, sought to tame the rational subject to approach objective objects, while the latter, the empiricist, sought to treat such objective objects as traps, that is, with the laws and theories of nature used (Davis, 2009, p.130). In philosophy, the sources of knowledge are traditionally divided into idealism and materialism. Idealism, which usually views matter as a product of rational ideas, is called materialism, while philosophy, which views ideas as a product of matter, is called materialism. Expands from a passive observer to an active observer.

Third, naturalism or dialecticism combines teleology with causal theory and a hidden order composed of the combination of mind and matter. Interpreting the dialectics we deal with with the content of natural science suggests the possibility that metaphysical dialectics may be combined with materialism rather than idealism. It is strongly implied, but it cannot necessarily be said to be so. This is because the content of natural science itself can be interpreted either through materialism or idealism. This is because it combines materialism, the object of naturalism, with idealism, the human mind.

In the theory of general relativity, Einstein thought that inertial force and gravity are equivalent according to the aesthetic sense that all physical equations are unified. It can be said that it is like setting a kind of answer and establishing a formula toward that goal. In my opinion, Einstein's strategy can be said to be a teleological strategy. It can be said to be a tinge of the teleological explanation of idealism that emphasizes belief in causal determinism. It can also be said to be collecting observational data through 'dependence on the theory of observation.' We can say that naturalism goes beyond causal determinism and has a teleological explanation of idealism. However, because Einstein constructed his theory with strong determinism and an aesthetic sense, he can be said to be a metaphysical naturalist. However, quantum mechanics, which deals with 'scientific methodology' more importantly than the realism debate, can be seen as methodological naturalism. Quantum mechanics is the idea that only data from observation equipment is covered in physical theory and that if the values calculated by the theory match experimental data and numbers, that is sufficient. Therefore, when observing, our human mind affects the observation data. Methodological naturalism is only a methodology for accessing the truth and does not substantively define what the truth is. Unlike metaphysical naturalism, observation is some form of physical contact between our minds and the world. Science is an attempt to exploit this contact between our minds and the world. It may be a form of empiricism that primarily focuses on naturalism. Rather, the optimism of dialectical



Y-axis: Metaphysical beliefs, ontology, worldviews that represents the world
X-axis: How to judge the proposed propositional knowledge, epistemology.

Fig. 1 Status of the scientific worldviews from scientific and philosophical viewpoints. (Modified by Oh et al., 2022)

materialism, the acceptance of change and creation, the explanation of weak causal theory, and the theory of evolution that speaks of the strengths of living things were the starting point of all modern naturalistic science. Darwin's biological naturalism theory already had a revolutionary impact on scientific research a century ago. The argument that material shapes are historically created rather than given and that their differences are not reflections of supernatural shapes but were created naturally starting from small variations is the accumulation of perfect knowledge about this world that was thought possible. It promoted recognition of the fact that this could never be achieved (Davis, 2009, p. 114).

4 Conclusions and suggestions

Quantum mechanics cannot have independent properties when the observed is separated from the observer. In other words, the physical properties of the observed are revealed only in its interaction with the observer. However, according to Newtonian mechanics, the physical properties of the observed are independent of the observer. His claim can be described as a metaphysical belief that constructs the basic framework of a worldview. On what grounds can this belief be justified?

As materialism emphasizes empiricism, classical mechanics is categorized into dynamics and statistical mechanics for scientific theorization.

4.1 Newton and Einstein's viewpoint of determinism

Because dynamics is inherently time-symmetric, it is causal determinism to be determined as one for the future.

First, the relativity and quantum mechanics theory are also time-symmetric, similar to Newtonian mechanics. However, quantum mechanics shows probabilistic determinism in association with observation.

Second, Einstein's theory of relativity has aesthetic beauty, which is an inner characteristic of scientific theory. It provides logical simplicity in the premise of the absolute speed of light, symmetry, and unity of the integration of the two theories and the inevitability of the spacetime continuum.

From a relativistic perspective, even if time increases or contracts, the world does not change. When a moving observer observes themselves, neither is their lifespan lengthened nor is their space reduced. It only appears in this way for other observers. From the beginning, it was postulated that the special theory of relativity should be applied equally to all observers because this world is real and can become a world of immutable reality.

4.2 Darwin and quantum mechanics's perspective of statistical mechanics

The theory of evolution is positioned as dialectical materialism according to which truth is generated and can be changed and which coexists and interacts with the opposites, moving away from the metaphysical thinking of Newtonian mechanics that truth is fixed and polarized into fixed and immutable opposites.

Plato believed that by using mathematical proportions, God created the universe in an extremely harmonious way. Newton and Einstein regarded this Platonic thinking as an immutable truth, not an irreversible assumption. Conversely, Darwin's theory insisted on the idea that truth is generated and changed.

First, Darwin's theory concerns the evolutionary arrow of time irreversibly moving from the past to the future, anchored in modern scientific worldviews such as entropy law and chaos theory. It is also characterized by weak non-teleological causality. Regarding group behavior, the sheer amount of data makes statistical mechanics the only option for analyzing this behavior. In other words, it appears as a probability theory due to the ignorance of the interpretation of statistical mechanics.

Second, conversely, quantum mechanics can predict the existence probabilistically using wavelike overlapping before observation. Once the observation begins, the sites of contraction or wave function collapse are revealed in a state of verification, which is an inherent characteristic of nature, not ignorance. In my view, quantum mechanics also views spacetime as a plane, like Newton. Consequently, in the world of very small atoms within the framework of Newtonian mechanics, the quantity of discontinuous energy rather than a continuous quantity, so everything cannot be judged with a definite determinism, and given that influences between theories are nonlocal, but are transmitted integrally, it is inherent in nature to make probabilistic judgment instead of ignorance in the form of statistical mechanics ignorance.

Lastly, it is obvious that what we call comprehensible and scientific discovery was in the past favorable conditions for survival. However, it is unclear whether this still holds true. A completely unified theory may not assist our survival. For example, the partial theory of Newtonian mechanics may be of more practical use than the unified theory of relativity.

Symmetry of complementarity exists in Plato's abstract and idealistic world of mathematics, which pursues geometric symmetry, Newton's empirical world of physical reality, strict determinism, and Bohr's naturalistic world. That is, epistemologically, there are three worlds. The first two worlds are the worlds in which objective entities exist independent of our minds, and the world Bohr refers to is a weak anti-realism in which the human mind influences the observation of objects. It refers to a world of relationships between things. Aristotle is a transitional idea from Plato's idealistic world to Newton's empirical world, but rather close to Plato as a teleological realist. Also, Einstein is a transitional idea between Newton and Bohr, but rather close to Newton, a physical realist.

If we do not learn and understand science's philosophical and metaphysical assumptions, epistemology and methodology, and the interrelationships with history, culture, and religion, the opportunities for science to enrich culture and human life will diminish. Science that only teaches technical topics and conclusions does not provide legitimacy to science and science education (Matthews, 2009). A key element of this broader goal of science education is learning about the interrelationship between science and worldviews.

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