Scientific Perspectives Of Evolutionary Theory And Integrated Science Education

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Abstract:
It can be said that current science education and liberal arts education do not present the concept of biological evolution as a core concept that integrates the entire concept of life science. Therefore, the purpose of this study is to explore the convergence of science and the humanities, and above all, the integration between sciences, through a biological lens. Through this theory of biological evolution, the possibility of convergence between different disciplines is explored. It can be seen as meaning an essentialist and reductionist integration centered on physics. However, it demands integration from an evolutionary standpoint that speaks of change and creation.
Methodologically, the cosmological goal of stability and the evolutionary product of the human mind, cooperation, should be integrated with the natural sciences as the main goal. That is, the biological evolutionary mechanism (Base Domain) should be extended to other academic fields (Target Domain). A powerful methodology is the analogical strategy.
Reductionist approaches to physics and chemistry and biology are essentially different. The theory of evolution combines biology as well as other disciplines to form a so-called consilience of knowledge. At its core, it can be said that natural selection is based on moral cooperation (civilization) rather than biological competition (elimination).
Through these studies, we argue that interdisciplinary convergence and connection should be made based on the philosophical characteristics of the theory of biological evolution, which requires generation and change. It can be said that integrated science, which is made up of connections between current disciplines, is simply an integration that can be connected academically according to the theory of reductionist classical physics. It is argued that integrated education should be made based on the change and diversity contained in the theory of biological evolution in the current integrated science textbooks. Because, beyond the fixed and unchanging essentialist metaphysics of physics and chemistry, Dewey's philosophical view of change, creation and change, a constructivist world view, biological evolution theory should be attempted to converge.
Keywords: mechanical materialism, quantitative change, immutability, creation of change, evolutionary theory, integration, moral cooperation

INTRODUCTION

According to the current understanding, “integrated science” is a discipline designed to foster the ability to rationally judge social problems in future society by understanding natural phenomena in an integrated manner, understanding the relationship between natural phenomena and humans based on the understanding of the former, and predicting and adapting to future life according to the development of science and technology. The focus of integrated science is the cultivation of basic knowledge as democratic citizens capable of making rational decisions based on an integrated understanding of the natural phenomena around us and the problems of modern society. Integrated education is a

method in which various subjects are integrated, centering on concepts, resources, principles, topics, issues, or problems of living. Curriculum integration is the core of integrated education in which individual subjects are not differentiated and do not have fragmentary independence. Rather, interdisciplinary boundaries disappear by reorganizing the content in various ways. Through this integration, students can link different information items more efficiently and gain a broader understanding of the concepts through self-directed utilization, application, and reconstruction. The objective of this research is to develop specific strategies in interdisciplinary areas, which is also the main goal of integrated science education.

However, a great proportion of the discourses on convergence remain at the level of general theory, failing to transcend the discussion about the necessity of convergence, and unable to present a specific methodology or organically connecting convergence and education (Jang, 2014, p. 229).

Integrated science merges motion and energy, matter, life, earth, and space, which are the foundational elements of existing science, and reorganizes them into the domains of matter and regularity, system and interaction, change and diversity, and environment and energy. For example, the domain of matter and regularity centers on the existing material domain but is configured in a format that connects related parts in areas, such as motion and energy, life, earth, and space, towards supporting the principle of formation and bonding of matter. Each domain is further composed of various ideas.

Eventually, integrated science can be interpreted as a means of essentialist and reductionist integration centered on physics. However, this study calls for integration from the evolutionary perspective of change and creation. Biology, which was heading towards reductionism in the heyday of molecular biology, finally entered the level of synthesis based on evolutionary theory. Biology is fundamentally different from reductionist approaches in physics and chemistry. Evolutionary theory combines biology and other disciplines to form the so-called consilience of knowledge (Center for Educational Research of Seoul National University, 2010, pp. 415-416).

First, Darwin studied the rigorous induction set by the Baconian method, by which facts are gathered according to a predetermined theory (hypothesis). However, he soon began to consider the mechanism he needed, which he termed "Natural Selection." This is very similar to artificial selection used by breeders to create new breeds of dogs, roses, etc.

The idea inspired by Malthus' "demography" comes from the tradition of natural theology, the idea that even the sufferings of this world exist for the good of the whole system (Henny, 2012, pp. 396-397).

Analogous inference that deals with problems belonging to different domains requires th intervention of worldviews and general principles to lower or penetrate barriers between different domains. This type of analogy derived from external factors may pose problems but has been used by scientists as an essential tool to dramatically improve the problem-solving ability in the history of science, where integration sometimes occurs unexpectedly. An analysis of real-world examples of scientific inquiry reveals that scientific integration occurs when theories need to be adjusted to incorporate information into scientific theory. The cognitive tools used here, such as metaphor and analogy, can all be viewed to emphasize the continuity of scientific development (Miller, 1996, p. 314).

Welling (2007) noted that there are several basic cognitive mechanisms of creative convergence and proposed abstraction and associational ability. Convergence is an important creative mechanism. Therefore, my research aims to converge scientific and humanities theories through the lens of biological evolution.

According to evolutionary theory, the human mind was created by selfish genes. Nevertheless, the human mind tends to be social, cooperative, and trustworthy (Ridley, 1996).

Darwin explains that instincts are also selected in natural selection, the very selection that prioritizes favorable biological variations. However, within the human species, selective privilege has promoted the development of social instincts along with increased rationality. These social instincts trigger solidarity behavior, active community relationships, and empathy (Tort, 2008).

We intend to explore the possibility of convergence and connection between different disciplines through evolutionary theory, using the method of analogical inference of our mind and natural selection. Convergent education attaches importance to the integration process. To achieve this goal, I set the following research objectives:

First, exploring the philosophical characteristics of evolutionary theory from the perspective of worldview;

Second' from a metaphysical worldview to an evolutionary worldview

Third, interdisciplinary integration through theory of evolution and proposal of a new interdisciplinary convergence model

The philosophical view of evolution is a comprehensive view of ontology, epistemology, and ethical values, and the scientific world view of evolution is, above all, to explore what ontology, that is, metaphysical beliefs have influenced.

Philosophical discussion about evolutionary theory

Aristotle's teleology regarding the phenomena of life is an invariable result of his four-cause theory, based on matter and form. In living organisms, matter is the body and form is the soul of a living being. Aristotle took the position of vitalism, as opposed to the materialism of atomists, by pointing out that the soul of a living being cannot exist without a body, but it is not itself material. Since the soul is the force that moves an organism and uses it as a tool, it is natural that all the activities of living organisms are directed towards a certain target. However, souls are not identical in quality, and because of their qualitative differences, grades appear in the life activities of the organisms.

According to Aristotle, all beings in the universe form a continuous ladder. In such a "ladder of nature," it is possible to classify species in a hierarchical manner, even though evolution does not take place in a bottom-up manner. The change from matter to form occurs and takes place only within a hierarchical species. Simply put, life can be born between the same species but not between different species. Harvard Zoologist Ernst Meyer defined biological species as a spontaneously occurring, exclusive reproductive community. A biological species is a naturally occurring population that is capable of interbreeding and has common genes that distinguish it from other groups. Therefore, animals of different species cannot interbreed in nature. However, given enough time, Darwin (1809–1882) argues that nature could possibly select beyond the species barrier.

Table 1. Philosophical discussion on evolutionary theory

Category	Ontology	Epistemology	Axiology
Raising a typical question	What does the world look like?	What do we know about the world?	What value does that knowledge have?
Elements of evolution	Natural selection	Modification	Survival

Convergence approacXh (Vollmer, 2008,)	- World exists by natural selection adapted to the natural environment; - All things are products of cosmic evolution.	Our mind is also a product of evolution and seeks to produce evolved knowledge through possible integration with the evolution of cognitive structures.	- Open organic survival (organisms survive because they adapt to the environment); - Integrated knowledge and cooperation are core morals (Smith, 2016, p. 80).
Conventional reductionist and mechanistic approach (Vollmer, 2008, p. 301)	Living organisms arose from inanimate matter in the beginning.	Biology is reducible to physics irrespective of our mind	Value neutrality

Evolution is also associated with materialistic worldviews. Evolutionary theory posits that the universe evolves by chance, without any ultimate purpose or direction. Therefore, in this evolutionary theory, only material things exist primarily, and the universe, which evolves through the principle of accidental change and survival of the fittest, is not related to any purpose or providence. However, materialism denies the claim that reality is merely the mechanical action of matter. In general, it is denied that life or human mental activity can be explained by physicochemical processes. As evolution progresses, it becomes more complex and requires the understanding of new concepts. In this context, evolutionists consider it unnecessary to use divine or teleological categories to understand the world (Oh, 2019).

Given that change has a predetermined end, teleological ontology asks, "What does the world look like?" In contrast, epistemology asks, "What does our knowledge and perception of the world look like?" Evolutionary cognition consists of the faculty reorganizing an external object in an appropriate way (within subjectivity) and matching it with the object.

Although the differences between the human mind and the mind of higher animals are considerable, they are clearly differences in degree, not in essence. Differences in degree refer to the degree of development, the degree of intrinsic sophistication, the degree of significance compared to other intellectual abilities, and the degree of external efficiency of evolution, while differences in essence refer to 'differences in nature' (Tort, 2008). According to Tort (2008), the argument of Putnam (1994), which he agrees with without any objection, is that the social contract between equal beings, that is, the reciprocity of universality between individuals or groups, is the essence of the greatest achievement of society. Above all, it is the product of evolution.

Evolutionary ontology mean? (refer to Table 1)

One possibility for unifying the worldview lies in the concept of evolution. Supposing that complex systems were produced through a single evolutionary process, and a causal law was thus derived from a simple law, it should inevitably be an evolutionary concept (Vollmer, 2008, pp. 341-342). In addition, the world exists in relation to the evolutionary output.

Evolutionary biology should also convince us that the nervous system is an evolutionary product, and that the human nervous system is no exception (Allman, 1999). This is continuously demonstrated by findings on mind-brain interdependence (Smith, 2016, p. 135).

However, conventional reductionist and mechanistic ontology states that living organisms originated from inanimate matter in the beginning (Vollmer, 2008, p. 301) and that this process involves only physicochemical principles.

Is evolutionary epistemology a fundamental question? (Table 1)

How do the (subjective) structures of human cognition fit the (objective) real structures?

Human subjective structures are models, space-time, causal associations, and logical inference. They reconstructed an external object inside the proposed system. Without these, human cognition does not exist.

How can a subjective structure fit an objective structure?

First, if objective and subjective structures are compatible, perception is enabled. They fit together, as individual parts combine to become tools. Without this correspondence (Passung), cognition does not exist (Vollmer, 2008, p. 37).

Second, as perception is valid, so is fitness. In Darwin's concept, this correspondence enhances an organism's fitness (Vollmer, 2008, p. 37).

Third, subjective structures follow the flow of a certain evolutionary time, which has changed integrally because it is associated with survival.

For example, what is reflected in the retina is a flat two-dimensional structure, but we reconstruct it as a three-dimensional structure. While a frog's eye captures only moving objects, the human eye sees objects as an integrated whole with still objects. Because adaptability is associated with survival, it should be enhanced in an integrated manner. The human eye evolved sequentially from a simple structure (Sarashina, 2019, p. 101).

Therefore, from the epistemological viewpoint of evolutionary theory, the human mind is a product of the evolution of survival; therefore, not only every object but also knowledge is interpreted through the process of integrated reconstruction.

According to earlier reductionist and mechanistic epistemology, biology is reducible to physics, irrespective of our minds.

For those who identify the mind with consciousness, the mind is obviously a product of evolution because it is one of the characteristics of the brain. The brain is formed in organisms during the evolutionary process, and its functions have also developed during the evolutionary process. Thus, "mind" in the sense of consciousness can also be considered a product of evolution (Dŭrr, et al., 1997, p. 186). The brain is the most evolved part of the human body. Unlike other animals, Homo sapiens with high intelligence overcome the given environment by creating an alternate, more suitable environment, instead of merely adapting to it. Consequently, evolutionary pressure on the brain is inevitably stronger than that on the rest of the body. More intense brain use is required to adapt to increasingly complex civilized environments. The more civilization develops and expands, the more intense is the evolutionary pressure on the brain, whereas other body parts evolve less.

Emphasis shifts from the sanctity of origin to the sanctity of the present because the present considers achieving the most appropriate level of evolution among the evolutionary stages.

What is the purpose of knowledge? (Axiology, Table 1)

The naturalistic fallacy is a concept created by Hume and named by George E. Moore, which is the idea that what is natural is moral. In other words, it is a way of thinking that deduces "ought" from "existence." For example, almost all biologists who study the behavior of bipedal monkeys are accused by the humanitarian camp of committing this naturalistic fallacy. On the contrary, the humanitarian camp is not shy about committing the reverse naturalistic fallacy. That is, they are deducing existence from ought. According to their logic, if something is ought, then it must exist (Ridley, 1996). Instead of the mind-body dualism that separates ought and existence, Dennett (2023) proposes a scientific and materialistic approach. He follows the evolution of mankind, which started from bacteria, and argues that the human mind and culture evolved through natural selection, just like the body. In other words, rather than the mind-body dualism that the mind and body are separate, our mind also evolved through natural selection along with language, a human

differentiation.

If the mind is an organ designed through evolution and an adaptive system designed by natural selection, ,and knowledge is the product of the mind, the raison d'être of knowledge is inevitably survival and reproduction, as core moral and instrumental values, survival and reproduction, are associated with cooperative benefits through fusion for group and individual salvation (Smith, 2016, p. 80).

Issues surrounding theory of evolution

The Darwinian theory of evolution is based on four basic concepts: environment, inheritance, mutation, and natural selection. If these concepts are interpreted in the epistemological context, adaptation to the environment can be matched with the "problem situation," inheritance with "transfer of knowledge," mutation with "formulation of a new hypothesis," and natural selection with "removal of error with counterevidence." If the development of knowledge is understood as an evolutionary process of theory, the scientific theories currently shared by us can be compared to species that have defined the ordeal of counterevidence and succeeded in their struggle for survival. However, while evolution can explain changes in species in the past, it cannot predict how the current species will change in the future. In other words, formulating an experimental proposition is impossible.

First, evolution is not a directly structured process that proceeds in a straight line. Evolutionary change in a population is not a teleological or a goal-oriented process. Evolution is a mechanistic process devoid of goals. That is, a population does not adapt to survive, but survives because it adapts. The former is a teleological process, whereas the latter is a mechanistic process (Dewit, 2018, p. 512). Considering that Darwin was influenced by Newtonian mechanics, he may have hoped to explain biology using mechanistic principles. This can also be verified by the fact that he regarded the "survival of the fittest" as a phenomenon in which living things gradually advance towards perfection. In other words, the mere fact of survival does not make the survivor the fittest. Rather, an organism that has adapted to the environment in a specific context has the best condition.

Meanwhile, in relation to the dialectical idea that values change and creation while superseding fixation and immutability, there exists a consensus among researchers that Darwin's discovery is the best or only acceptable theory explaining how intention emerges in nature through the naturalization and purification of intention to protect nature (Smith, 2016, p. 67). To explain the convergence with theories of other natural sciences, researchers need to accept the absoluteness of survival and nature's intention as an important presupposition theory.

Darwin, who lived during the Victorian era, believed that natural selection enabled the advancement of active forces. This is also revealed in his "Origin of Species" (Henry, 2012, p. 405).

According to my theory, more recent life forms must be superior to earlier forms. Each new species arises because it is advantageous for survival compared to the previous new forms.

Life forms certainly advance as natural selection continues. Darwin says that natural selection works "for the good of each being." Thus, for Darwin, natural selection guarantees progress (Henny, 2012, p. 406).

Darwin was convinced of the existence of an intrinsic driving force for development in nature. He described: just as "natural selection" works only for the benefit of and by an individual, all physical and mental traits tend to develop towards perfection (Darwin, 1860, p. 486). Biologists have started to talk about a "ladder of progress" with microbes on the

bottom and humans on the top rung. In this way, they rejected the idea that God elaborately designed all living things and created each species separately but left room for the possibility of God being the designer who works in a more elaborate manner, that is, setting the direction of evolution for humans over billions of years (perhaps for something higher than humans in the future) and indicating the path.

Eminent European thinkers such as Bergeson, Spencer, Engels, and Whitehead embraced this progressive philosophy. Based on the view that nature possesses the unique ability to create order in chaos, they all tried to break away from the narrow boundaries of Earth's biosphere and expand their horizons to the universe as a whole. For these philosophers and scientists, linear time was ultimately headed for progress, albeit through staggering steps (Davis, 1995, p. 57).

In my opinion, the choice of cosmology determines the increase in complexity and entropy that explains evolutionary progress. However, there is no contradiction between the two. These processes generate entropy as a by-product and eventually pay to obtain orders from chaos.

Thus, Darwin's metaphysical meaning is clear. Darwinism denied teleology and predestination, and consequently, denied the "first cause of creation." Randomly occurring mutations (i.e., mutations by chance) deviate from the theory of predestination and contradict the theory of teleology. These advances defend teleology. It is important to understand that Darwinian theory of evolution is not progressive but adaptive in essence. The concept of being progressive is accepted in the mere sense that species are more geared towards adaptation to the measured environment, not towards an ideal "higher form." Darwin referred to this when discussing the evolution of species. According to Darwinian theory of evolution, the highest form of life in a tropical swamp may be a frog.

From a metaphysical worldview to an evolutionary worldview

The metaphysical worldview, as a reductionist worldview, is the basis of physical science and a fixed science, while the evolutionary worldview, through change and creation, becomes the philosophical foundation of modern science of integrated science.

Metaphysical worldview and evolutionary worldview

It is not difficult to understand how the term metaphysics used by Aristotle fused with religious and mystical traditions. The realm of Plato's ideas is conceptually not very different from heaven, which is ruled by a perfect God. Expanding this further, the material world, in which the realm of ideas is imperfectly reflected, easily fits in with the belief that mankind is separated from the grace of God. This is an aversion to change and does not progress. It is believed that space-time is more fixed than mutable, but the nature occupying it is imperfect.

From ancient Greek times, the idea of species was based on the premise that it neither had a beginning nor changed. Darwin rid species of this eternity and perfection. It is radical in its attempt to reveal the fictitious perfection and eternity of the ideal world. He also considered the eternal and immutable taxonomy and the Aristotelian science to be transitory.

Newton's metaphysical materialism is the belief that a supernatural entity called God created the universe and is the prime cause, but his involvement stops there, and suggests that the universe has a supernatural and metaphysical origin but has developed according to the natural and physical laws established at the moment it was created (Davis, 2009, p. 248). Undoubtedly, rational Homo sapiens derives a linear causal relationship from such natural laws. People dream of a utopia in this world by exploring invariable causal relationships, rather than accidental elements. It follows determinism that everything that

happens is completely predetermined by a higher force or order created from what is already in existence.

Breaking away from the metaphysical view that space-time and species of the universe are fixed, Darwin saw change as normal, as well as creation and it's potential. Along these lines of thought, he also parted with Plato and Newton. Darwin described a metaphysical mechanism by which a species can change over time without the supervision of an intelligent designer. Not only did he understand that nature does not evolve by plan, but he also understood it as being part of a process that turns into something else while endlessly arbitrarily expanding the boundaries of possibility. He continued to experiment with new species while filling new spaces with nature's creations. (Davis, 2009, p. 24).

From metaphysical materialism to dialectical materialism

Metaphysical materialism views nature as something fixed and immutable, not as a process or change. This perspective has contributed to the establishment of basic perceptions in all natural sciences, including physics. For example, the immutability of a species contributes to the establishment of its concept. However, the metaphysical materialism associated with the immutability of species was replaced by the theory of evolution, which posits that species change. That is, the establishment of a certain metaphysical belief and concept was believed to lead to an immediate scientific perception. With all natural processes established as dialectical processes, dialectics and materialism have gained a foothold as a worldview (Moon, 2018, p. 314). Dialectical materialism is derived from the unity between matter and motion. Dialectical materialism regards time, space, motion, and matter as an inseparable whole because matter has motion as its basic property, and motion makes up the essence of time and space. This position was verified by advances in physics in the twentieth century. The main conclusion of Einstein's theory of relativity was that space-time does not exist independently of matter, but is inseparable from each other as a whole. From this, it follows that the passage of time and expansion of an object depend on the speed of motion of that object. Furthermore, the standpoint of unifying space and time into a four-dimensional space-time was explained.

The claim that evolution is caused by the pressure and time of local adaptation explains its mechanism. Although it sounds like absurd fiction, it signals the birth of a new mechanism that explains the change in life. In other words, the theory of evolution declared the beginning of a transition from metaphysical materialism to dialectical materialism.

Darwin still believed in the Creator God and thought that evolution could only be understood on the assumption that the Creator God made the laws of evolution. At the same time, however, he advanced the deistic argument that God never hindered these laws. This has served as a catalyst for what is called scientific naturalism.Aristotle divided existence into two categories: immutable and mutable. Theology is the study of mutable existence, given that there is only one "eternal and immutable' being, which is God. By contrast, the mutable category of existence pertains to natural science, that is, natural philosophy. Aristotle states that everything we see around us is temporary.

The belief that there is an immutable aspect of existence characterizes the mainstream traditional features of ancient Greek metaphysics. Aristotle inherited the principle of dualism from his teacher Plato, who believed "the true being" to be beyond change and extinction. According to Plato, everything in this world comes into being and passes away; nothing is truly real. In the two basic modes of existence, permanence and change, change is derivative, secondary, and less real, whereas permanence is primary and more real and is thus more valuable than change.

The idea of the ancient Greeks that permanence is "a more true or better mode of being" and that change is derivative and "less true," less true' has little or no communality with

the characteristics of modern metaphysics. In the worldview held by philosophers such as Hegel, Bergson, and Whitehead, change, process, and transition are viewed as primary, and the permanent and fixed aspects of being are regarded as derivative, secondary, and less fundamental, respectively. Today's metaphysicians tend to dismiss not only the general notion that permanence is superior to change but also the individual notion of substance. These philosophers view cosmology, in which the universe is decomposed into fixed and stationary, as inseparable from the idea of substance. Modern science has discovered that the underlying physical substance is not a permanent static piece of matter but an electrical excitement, that is, a dynamic process. This discovery reinforced the conviction of "process philosophers," who see the ultimate unit that shapes the world in the event, not in the substance. They argued that events, not things, truly exist.

The main reason for the shift of dominance from permanence to change, along with the transition from classical metaphysics to modern metaphysics, is the concept of biological evolution, which sent a shockwave through the European and American intellectual milieus with a scientific and philosophical interpretation of the universe and its creation based on the concept of growth and development, greatly contributing to paradigm change.

Aristotle's eternal and immutable taxonomy and modern Newtonian science also speak of the unchanging truth. The Darwinian theory of evolution was a radical idea that attempted to reveal the fictitiousness of the perfection and eternity of this ideal world. Darwin's views were influenced by Christian theology, particularly William Paley. Paley believed that the apparent order and purpose that can be verified around us point to the creator, just as the sophisticated operation of a watch implies the skill of the watchmaker. However, Darwin did not explain the order of the biological world with respect to natural selection as opposed to divine purposes. Rather, he argued that God's conscious creation was replaced by a blind, unconscious, and mechanical process. This may be interpreted as meaning that the purpose was replaced by chance.

The two major ideas of the Darwinian theory of evolution had a significant impact on the pragmatic naturalists' notions of nature and human life. First, the form of nature and species change, which amounts to denying the claim of the immutability of nature. The second factor was related to the survival of various species. The survival of some species may be the result of the production of millions of offspring, but not all of these offspring survive. One species survives by preying on others, and as environmental conditions change, varieties arise in some species and others fade into extinction. This idea instilled skepticism in the so-called teleological view of nature; that is, each species or nature (as a whole) has a purpose. Dewey examined the concepts of evolution in terms of human adaptation in the world (Eames, 1977, pp. 40-43). That is, the Darwinian theory of evolution laid the foundation for Marx's dialectical materialism and Einstein's theory of relativity. The theories of quantum mechanics fundamentally challenge the justification of deterministic and classical physics. According to quantum mechanics, the laws of the microscopic world always involve probabilities. This fundamentally nullified the notion of a "universe governed by strict causality" in the world of classical physics.

Interdisciplinary integration through theory of evolution

Patterns of evolutionarily stable cooperation

Cooperation poses difficult problems for the theory of evolution through natural selection. We observed patterns of evolutionarily stable cooperation (Tomasello, 2016, pp. 32-35). They are (1) Kin selection: Dawkins (1976) presents this view to the extreme, examining all evolutionary processes from this "genetic perspective"; (2) Group selection: a variant called cultural group selection plays a decisive role, although it appeared at a later phase of evolution, whereby cultural group selection was primarily related to cultural evolution, not

genetic evolution; and (3) Reciprocity: Mutual help has an evolutionary dimension at the individual level through the mechanism of mutual reward immediately or at a later point in time.

Symmetry refers to something maintained in harmony and balance. It appears in a shape where several parts are aligned as a whole and united into one. Thus, beauty is closely related to symmetry. Among cognitive values, symmetry is a characteristic that shows the beauty of scientific theory delivered through the understanding of internal characteristics. This is referred to as vertical integration and emphasizes the continuity of all scientific developments.

In the history of science, fusion sometimes occurs unexpectedly. An analysis of real-world cases of scientific inquiry reveals that scientific fusion occurs when theories need to be adjusted to incorporate information. Cognitive tools such as metaphors and inferences by analogy can be considered the core of horizontal fusion.

As mentioned by Toulmin (2001), it is worth paying attention to "reasonableness." In his book *Return to Reason*, Toulmin differentiates between reasonable and rational, emphasizing the need to find an appropriate level of reasonableness rather than excessively clinging to rationality. Instead of attempting a unified discipline seen with a single coherent logic, efforts should be made to establish a discipline as an integrated whole connecting each part with reasonableness of integration (Toulmin, 2001).

Internal and external dimensions of the characteristics of integration

Internal dimension

The academic foundations of specific scientific disciplines were almost complete in the 20th century. That is, since radical innovation, such as a paradigm shift, has already taken place in individual academic fields, we need to place expectations of innovation on interdisciplinary integration rather than rapid intradisciplinary changes.

The basis was established through the theory of relativity and quantum mechanics in physics, molecular bond theory in chemistry, gene theory in biology, and the Big Bang theory in astronomy. Since important theories have almost completely clarified the disciplines of natural sciences, the focus is more likely to be on the activities of identifying and solving problems raised by the existing paradigm rather than on new paradigm changes. In this context, interdisciplinary fields such as physical chemistry, biochemistry, and molecular biology, in which classical disciplines such as physics, chemistry, and biology have been integrated, have become popular since the late 20th century (Song, 2005, p. 223).

Among the internal characteristics of theory, a value that adds an aesthetic meaning to the theory according to the understanding of knowledge can have a great impact on all related disciplines. For example, the discovery of a signal faster than light would require fundamental modifications in mechanics, thermodynamics, atomic physics, and cosmology. A claim of light is deeply and rigidly embedded in the structure of the theoretical description of nature. This inevitably leads to adverse consequences (Kosso, 2007). Inevitability refers to a type of **coherence**. We can understand inevitability as something non-empirical, derived from connections in a theoretical system. More observations lead to more knowledge but not more understanding (Kosso, 2007). For example, there is one important difference between Bode's law and the principle of absoluteness of the speed of light. Einstein valued his belief in the unity of physics and the symmetry (congruence) of information obtained from various fields of physics highly. For example, if the speed of light is constant in one system under observation, it must also be constant in other systems as well (Fischer, 2001, p. 173).

It may sound like abstract physics is a new premise of practical biology. However, it is only

after understanding the basis of the stability of nonliving substances that the question of life can be addressed at the molecular level. (Fischer, 2001, p. 25). We can then consider the cosmological evolutionary value of stability. Gravity and electric forces, which are generated as a product of the evolution of the universe, can be components of matter and the system to which that matter belongs. The cosmological value of cosmology lies in its stability (refer to Figure 1)

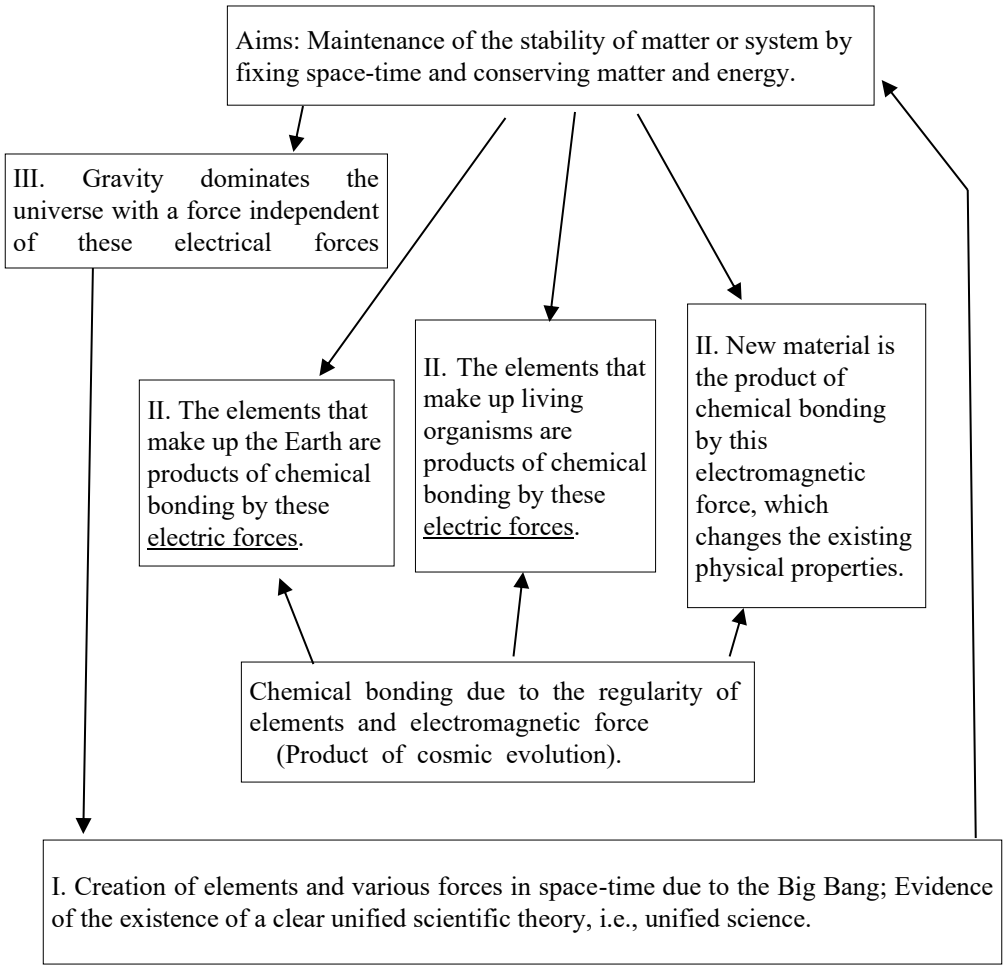

Figure 1. Vertical integration of physics and chemistry with unified science
(Integrated Science in the 2015 Revised Curriculum in Korea, Shin, et al., 2020)

Science can be divided into nomothetic science and historical science. Nomothetic science analyzes the state of movement and structure at the present point in time regardless of the flow of time and finds laws within it. On the other hand, in historical science, inductive data that are the subject of scientific inquiry are extracted diachronically, that is, according to the flow of time, especially according to natural changes. There are two aspects to this historical science. One is astrophysics deals with cosmic time. The other is evolutionary biology, which deals with the history of life. Meanwhile, astrophysics meets mathematics, and evolutionary biology meets molecular biology, these two historical sciences are integrated with nomothetic science (Choi, 2015, p. 94). Therefore, the basis of scientific integration should be the two historical sciences.

The Figure 2 and Figure 3, in particular, the evolutionary theory of life continuously expresses that the cosmic change of emergent change affects relativity and, above all, quantum mechanics by giving probabilistic stability. If there is a revolution in cosmology called Big Bang cosmology and superstring theory, we need to understand it as a revolution in the evolutionary culture surrounding cosmology, no less than a revolution in its content.

The dimension of evolutionary continuity governed by natural selection, the only law of evolutionary theory, it is dialectical logic because it includes the transcendence of the obvious contradiction between selective biological competition and anti-selective civilization. In the goal of continuous evolutionary survival, it can be said that the two obviously contradictory conflicts are combined to realize evolutionary continuity governed by natural selection. In my view, it can be said that the biological dynamics (competition) has been expanded to the ethical dimension of civilization (moral cooperation).

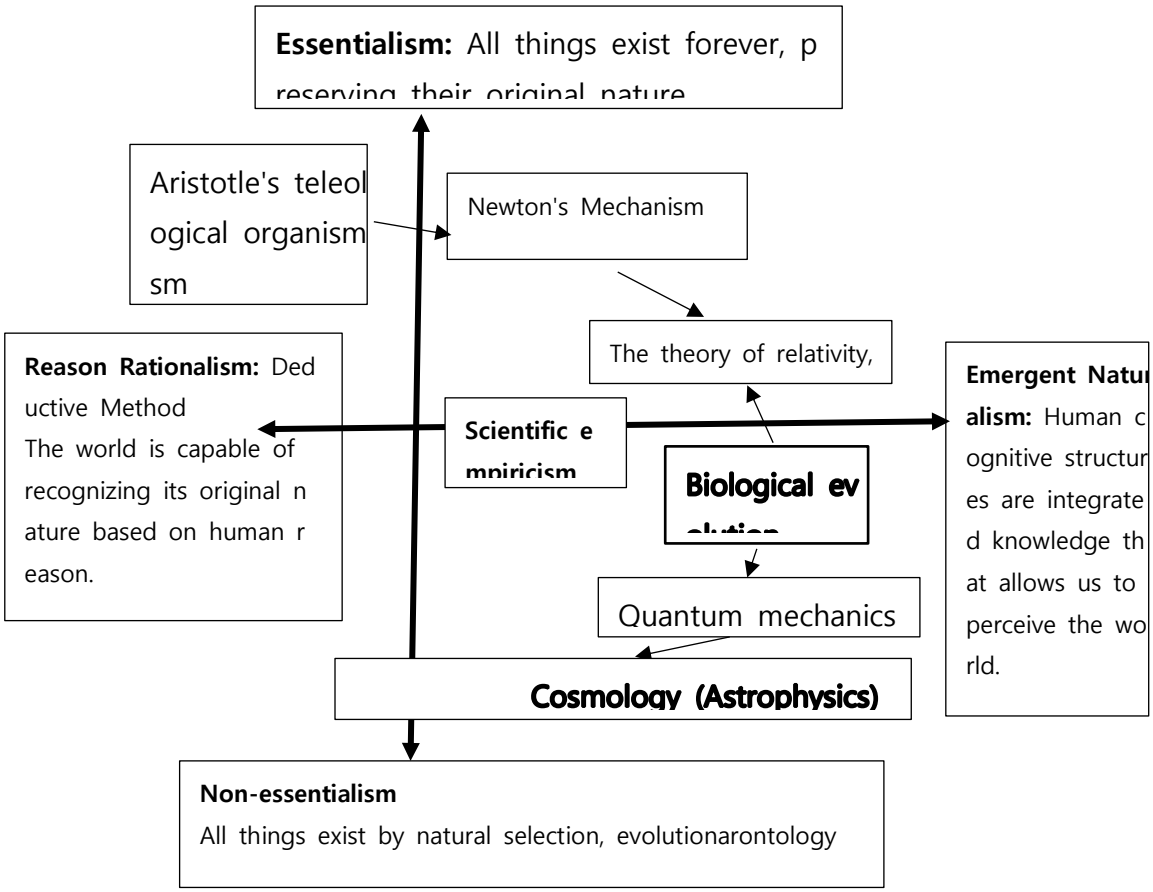

Figure 2. The position of scientific theory based on the philosophical dimension of evolution.

The value that is important in evolutionary theory is cooperation rather than competition. We humans share the important value of cooperation in order to survive.

Various higher-level structures of explanation arise from and depend on lower levels, so lower levels are often given causal priority. For example, molecules behave according to the basic principle that governs both inorganic and organic substances. This means that the hypothesis of molecular biology that violates the solid principles of physics and chemistry is wrong, or it provides a reason to reconsider physics and chemistry. But as we move up the explanatory chain, we witness the emergence of new entities with their own novel and unpredictable organizing principles, the characteristics of which are seen as emergent with respect to the lower-level theories (Slingerland, 2008, p. 413).

For example, even if we know the properties of atoms, we cannot predict the structure and form of molecules that emerge from them. Molecules themselves cannot predict the behavior of cells that emerge from them, and the activities of cells cannot explain the activities of tissues or organisms as a whole. We must understand that the whole is

greater than the simple sum of its parts, and that the evolved state of the whole is more highly organized than the sum of its parts. The evolutionary phenomenon known as emergence is living in an increasingly complex universe. Therefore, as shown in Figure 2, this study calls it emergent naturalism.

However, researchers may consider it necessary to perform interdisciplinary research with a horizontal strategy and a vertical integration strategy as a conventional integration strategy in a practical convergence setting. Such a horizontal strategy may involve the axiological methodology of the humanities.

External dimension

Academic integration often takes place under external influences, and this trend will gain greater traction in the future. Good examples are social and health problems plaguing the world today, such as climate change, which is considered the last problem of mankind, COVID-19, environmental destruction, and ecological crises. To solve the problem of increasing epistemological uncertainty from a comprehensive perspective by considering various perspectives in an integrative manner, the world of knowledge and science must be creatively and flexibly converged and approached.

It is not uncommon to see cases where science and technology (S&T) and humanities, which have been regarded as two cultures, are intermingled. In this context, S&T studies emerge in a variety of ways to elucidate S&T issues from the perspective of the humanities by establishing proper connections to history, philosophy, sociology, and policy. There is also an attempt to create a new type of knowledge by connecting S&T with economy and society through the concept of a "complex system."

Structure of Convergence and Integration

The vertical structure and problems of convergence

One of the convergence approaches currently underway is the so-called "unk-unified science approach (refer to Figure 1). This corresponds to an academic ideal that attempts to explain everything through a single basic theory, as all propositions are derived from a few simple axioms from one basic science. Much progress has been made since most of the disciplines currently classified as natural sciences are based on physics and chemistry. However, the integration of science in this sense means that the discipline concerned moves away from the basic theory. Consequently, connecting all disciplines through such integration is likely to remain ideal without the practical possibility of implementation (Jang, 2009, p. 72).

This argument has several problems (Derry, 1999, pp. 336-337). In particular, this inevitably involves technical problems, and for this reduction to be successful, a clear and precise correspondence must be generated between the two theories or among all technical terms in the scientific field. If this condition is not met (which is often the case), these two scientific disciplines are independent in terms of their terminological system and structure, and cannot be reduced to each other as desired.

Another counterargument was developed by a philosophical movement known as holism. The basic idea is that the whole can be greater than the sum of its parts. A complex system has emergent properties that are difficult to predict through mere component analysis. However, reductionism presupposes an understanding of the whole through the understanding of its parts.

Table 2. Comparison of convergence dimensions and strategies

Convergence dimensions	Internal fusion of theory	External dimension of theory		Indispen-sability of
	Transdisciplinary	Interdisciplinary		

	Rational	Reasonable	Toulmin (2001)	horizontal as well as vertical convergence
	Vertical (structural); Unidirectional change	Horizontal (diversity); Bidirectional change	Duschl et al., (2007) (Big idea)	
	Unified science	Encyclopedic integration	Jang (2009)	
Convergence strategies	Reductionist, precision fusion Unified science centering on the disciplines of physics and chemistry; Coherence	Symmetrical and aesthetic fusion; Evolutionary fusion of analogy and metaphor, system structure. Big idea. Emphasis on transfer with a focus on the subject concept; systematic	The purpose of convergence: - Vertically unified science (Focus on stability) - Horizontally unified science (Focus on cooperation)	
Manifestation of creativity	Convergent and divergent thinking	Divergent thinking	Kuhn (1970)	Tension between convergent & divergent thinking
Scientist	Newtonian mechanics	- Darwin's evolutionary theory of evolution - Quantum mechanics		
Philosophical idea	Metaphysical mechanism	Dialectical materialism		

Humanities scholars who teach humanities at universities emphasize that the key concern of humanities is to provide answers to the questions of "how to live" or "how to live the right life." This was partially justified. However, the problem is that humanities disciplines, such as history, philosophy, and ethics, are not enough to gain a meaningful answer to the question of how to live correctly. To properly answer this question while living in a technological society surrounded by uncertainty, we need to better understand the achievements of science that will help us understand humans, the relevance of S&T to society, characteristics of scientific attitudes and methods of inquiry, possibilities and potential of S&T, and pragmatic problems. In a binary state in which the humanities deal with values and S&T deals with facts, both the humanities and S&T are bound to be lame (Choi & Joo, 2011, p. 294).

In my view, contact and communication between humanities and S&T should be directed at discovering the applicability of the values that are important to S&T in the field of humanities. In this context, evolutionary theory should be derived from biology, which is the closest to humanities among all natural science disciplines.

A value highly appreciated in evolutionary theory is cooperation as opposed to competition. Homo sapiens share an important value of cooperation for survival. Various upper-level structures of explanation emerge from and depend on lower levels, which are often given priority in the context of causality. Molecules, for example, behave according to the fundamental principles governing both inorganic and organic matter. This has two implications: the hypothesis of molecular biology, which violates the solid principles of physics and chemistry, is wrong, or physics and chemistry need to reconsider the related parts of their principles (refer to Figure 2).

However, the higher the level of the explanatory chain, the higher the risk of facing new entities with their own new and unpredictable organizational principles. Their characteristics are considered emergent from lower-level theories (Slingerland, 2008, p.

413).

In other words, even if we know the properties of atoms, we cannot predict the molecular structure and shape emerging from them. Molecules themselves cannot predict the behavior of the cells emerging from the atoms, and cellular activities cannot explain the activities of tissues or the entire organism. It must be understood that the whole is greater than the simple sum of its parts, and that the evolved state of the whole is more highly organized than the sum of its parts. The emergence of the evolutionary phenomenon known as "emergence" is ubiquitous in an increasingly complex universe.

Proposal of a new interdisciplinary convergence model with a horizontal structure rather than a vertical structure (refer to Table 2)

The most powerful strategies for divergent thinking in creativity research are analogical inference (Oh & Jeon, 2017; Oh, 2022) and abductive reasoning (Oh, 2016). Analogical inference is a methodological strategy for interdisciplinary research that involves transfers between domains. Therefore, strategies based on the cognitive tool of analogical inference use an important methodological strategy of horizontal convergence between disciplines in interdisciplinary research, with an emphasis on horizontal rather than vertical convergence (Table 2).

In the dimension of evolutionary continuity governed by natural selection, the only law of evolutionary theory, it is dialectical logic because it includes the transcendence of the obvious contradiction between selective biological competition and anti-selective civilization. In the goal of continuous evolutionary survival, it can be said that the two obviously contradictory conflicts are combined to realize evolutionary continuity governed by natural selection. In my view, it can be said that the biological dynamics (competition) has been expanded to the ethical dimension of civilization (moral cooperation).

Although the difference between the human mind and the mind of higher animals is considerable, it is clear that it is only a difference in degree, not a difference in essence. The difference in degree refers to the degree of development, the degree of intrinsic sophistication, the degree of significance compared to other intellectual abilities, and the degree of external efficiency of evolution, and the difference in essence refers to the 'difference in nature' (Tort, 2008). According to Tort (2008), Putnam's (1994) argument, which he agrees with without any objection, is that the social contract between equal beings, that is, the reciprocity of universality between individuals or groups, is the essence of the greatest achievement of society. Above all, it is the product of evolution.

The main purpose of the vertical structure is the stability of matter and the system, whereas the main concern of the horizontal structure is cooperation for survival, given that the human mind is the product of evolution. Thus, cooperation was treated as a keyword that was important for evolution. The evolution of the human mind is a good example of how cooperation and stability are maintained (refer to Figure 3). At least in science education, stability and cooperation, which are the cosmological purpose and evolutionary product of the human mind, respectively, should be integrated with the natural sciences as the main purpose.

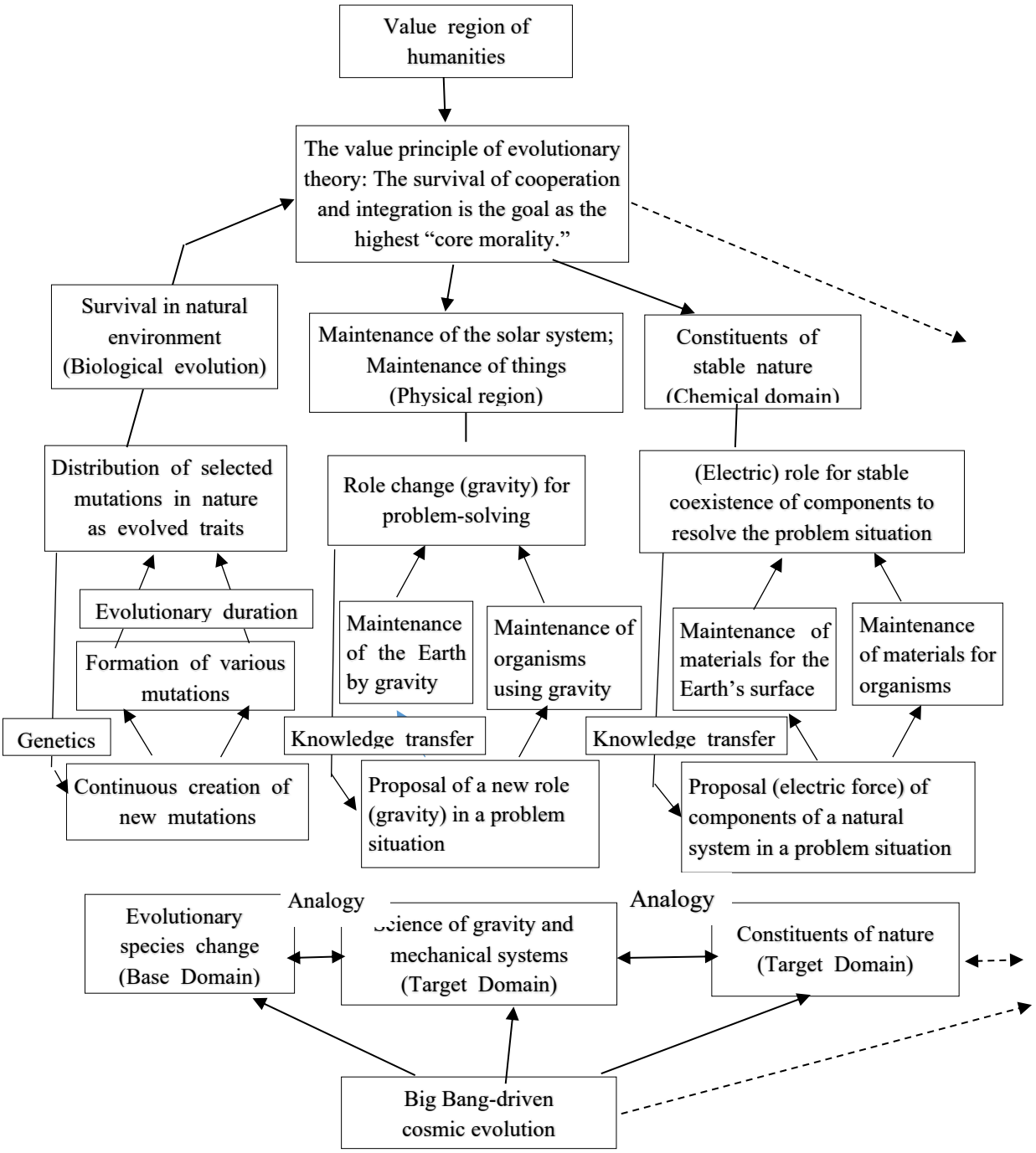

Figure 3. Proposal of a static and dynamic convergence model according to analogical inference and systemic thinking based on the evolution of the universe and evolutionary thinking (The dotted line in the figure means the expansion of integrated science)

Issues and Implications of Integrated Science in the Korean High School Science Curriculum: A Functional and Extrinsic Approach (Ingram, 1979)

A new proposal for understanding evolution and the law of gravity: focusing on common values

Instead of teaching only the fixed laws of physics, we recommend emphasizing the processes of emergence and convergence in the physics curriculum. Instead of attempting to comprehend the present through the origins or essence of the past, we must understand present circumstances as an ongoing set of changes alongside the evolution of nature, as

perceived through history and connected to the past and present (refer to Table 3).

Table 3. Comparison with physics based on the theory of evolution

	Evolution of species, diversity, and unity	Compatibility	Analogy
Darwin's Theory of Evolution	Random variation	Natural selection	Evolution of species
Smith (2016, p. 64)	Blind variation	Environmental filtration	
Analogous structures based on scientific theory	The evolution of human minds enables the creation of knowledge through convergence: the continuous generation of theories, from the teleological illustrations of ancient Greece to Newton's mechanistic explanations and Einstein's theory of relativity.	All existing theories have undergone environmental filtration: the preference for mechanistic scientific theories in modern industrial society is deliberate.	Simple evolution of theory
	Despite the existence of the causal Newtonian law of gravity, Einstein's theory of gravity was created by consolidating the Newtonian explanation of gravity and the theory of general relativity.	Impact—the change in gravity and momentum—was created to aid survival in an industrial society, and then integrated into general theory, alongside applications of the theory of general relativity.	Unification of theory

Scientific thought has two aspects (Vollmer, 2008, p. 14). As a thinking tool developed, taught, and used to overcome the transitional domain aptly understood through our *a priori* cognitive capacity, evolutionary epistemology consolidates the various domains of cognition into a single entity. For instance, the theory of free fall developed by Aristotle involves a teleological explanation—an object's natural impulse to return to its original state (cause)—which is easy to understand and can be explained qualitatively. However, this method is difficult to accurately predict. By contrast, Newton's causal explanation is less easy to comprehend because it must be explained using two forces: gravity and air resistance. However, causal explanations produce accurate predictions on Earth's surface (refer to Figure 4).

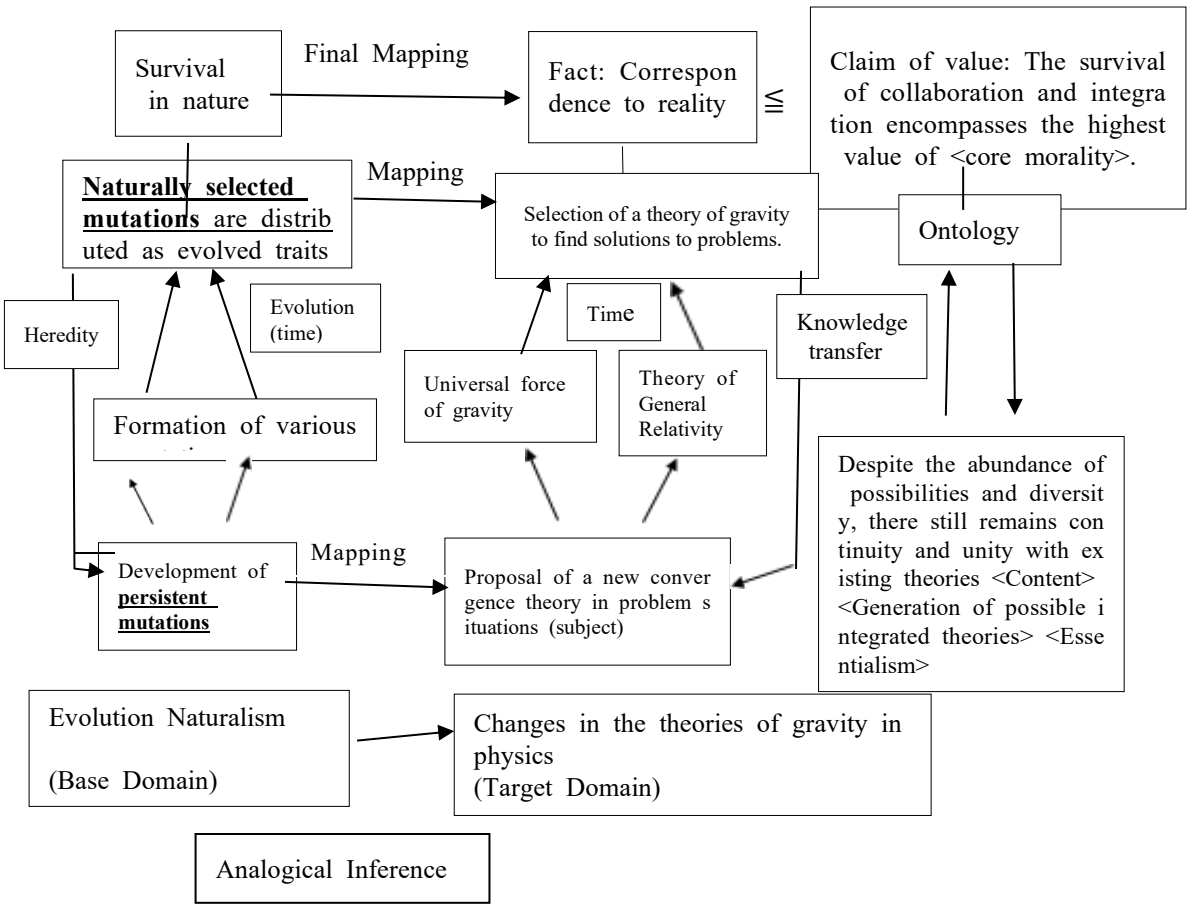

Figure 4. Using the theory of evolution to reason analogically about changes to the theory of gravity

Non-Euclidean geometry, which is difficult to understand (especially in the context of celestial objects subjected to a much stronger gravitational force than Earth), has been used in a novel equation to describe gravity, referred to as Einstein's theory of general relativity.

The assumption that human cognition is a product of matter rather than an object of evolution provides only mechanistic explanations. In this respect, our living minds are not objects that fade away or are buried in history, but instead are programmed to seek diversity in homogeneous environments. Furthermore, from a mechanistic perspective, it is evident that scientific theories have evolved over time from the static propositions of the ancient Greeks (the law of the lever, Archimedes, 250 B.C.), kinematics (the law of free fall, Galileo, 1590), and dynamics (Newton's gravity, 1666).

Structure of moral reasoning

Value advocacy (principle): The theory of evolution (cooperation and survival in biology) posits that the value judgement of the highest <core morality> is correct.

Minor premise: This is characteristic of cooperation and integration (corresponding to facts).

Conclusion: Even in terms of effectiveness (corresponding to facts), the value judgement of the highest <core morality> in conjunction with the theory of evolution is correct.

Although a single theory or collection of associated theories can be integrated into a single unit, central theory causally or temporally leads other theories and their related properties

and relationships. Therefore, it is necessary to identify the central theory in other units. For instance, in a mechanical system where the central theory pertains to the theory of gravity, the central theory of nature's constituent materials must have an impact that resembles gravity. In identifying a theory with an analogous impact, domain transfer may occur through analogical reasoning. Theories of *gravity*, the attractive force between masses, *electric force* that acts between charges, and the *strong force* that binds nucleons in the nucleus, are examples of theories centered on various components. Nevertheless, these theories have come to fruition in a particular order. Thus, an electric force can be introduced as a new force derived from gravity. It is also possible to connect the textbook units. Through convergence in one unit, domain transfer can occur as other attributes and relationships are mapped through the convergence and structure that are already established in other units.

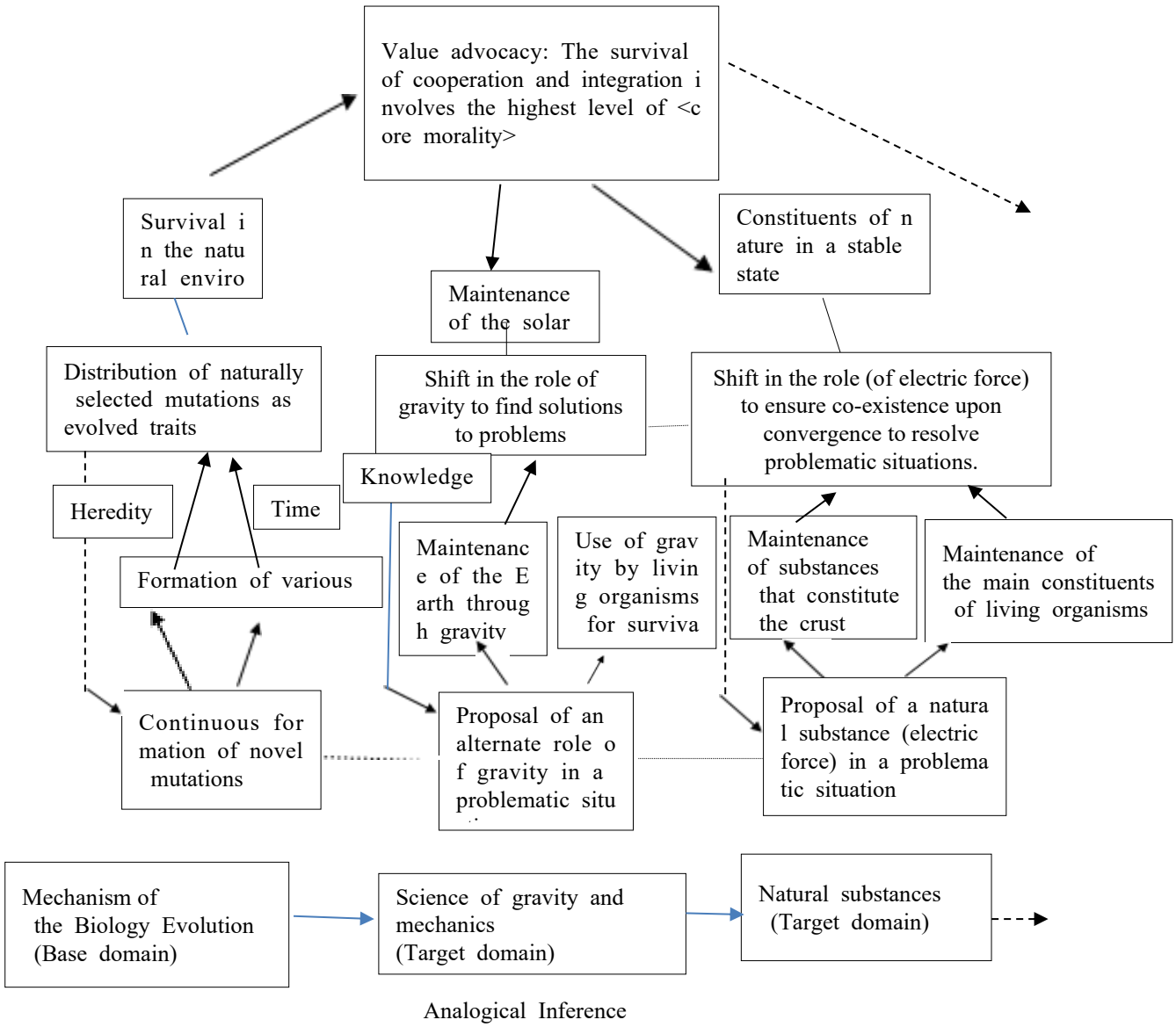

Figure 5. Proposing a novel theory through the transfer of structure and function between domains: advocacy of common values (The dotted line in the figure means the expansion of integrated science)

As shown in Figure 5, the **generalizability** of gravity is often emphasized. Within the domain of atoms and molecules that have such a small mass, the force of gravity is

negligible, and the electrical force provides a theoretical basis for explaining the constituents of matter. This leads to a domain transfer towards living organisms. In essence, the structure of the existing theory was first modified to expand its scope. This process encompasses the common value of the theory of evolution: all things are the products of evolution.

As shown in Figure 5, the main purpose of the vertical structure is the stability of materials and systems, as the human mind is a product of evolution, while the main concern of the horizontal structure is ethical cooperation for survival. Therefore, cooperation, which is an ethical value of the altruistic gene, rather than competition, which is a selfish gene, has been treated as an important keyword in evolution. The evolution of the human mind is a good example of how cooperation and stability are maintained. At least in science education, stability, which is a cosmological goal, and cooperation, which is an evolutionary product of the human mind, should be integrated with natural science as the main goal. In other words, it is to extend the biological evolutionary mechanism (Base Domain) to other academic fields (Target Domain). A powerful methodology is an analogical strategy.

CONCLUSIONS

First, exploring the philosophical characteristics of evolutionary theory, .

We say that evolutionary epistemology has nothing to do with epistemology as traditionally understood. This is because traditional epistemology is understood as a normative domain, although it is related to the evolution and integration of theories as the stage of construction of causal and factual models.

Second' from a metaphysical worldview to an evolutionary worldview

The greatest characteristic of physicalist philosophy is its reductive attitude. It saw everything as reducible to a material basis. As a result, all disciplines thought that physics should be the epitome. On the other hand, evolutionary naturalism is a relational attitude towards creation and becoming.

Third, interdisciplinary integration through theory of evolution and proposal of a new interdisciplinary convergence model

The greatest characteristic of physicalist philosophy is its reductive attitude. The great achievement of physicalism is a worldview that eliminates the supernatural, but fixes truth. Evolutionary naturalism, on the other hand, is a worldview that is transformed and dialectically integrated.

In conclusion, the implications of our study are as follows:

First, we propose the adoption of a methodological-convergence approach. Our ultimate goal is to encompass the convergence process. Even when a topic is situated in a particular academic domain, domain transfers can occur analogically. This process can be seen as a strategy for lowering or breaking the barriers between disciplines.

Second, evolutionary ontology illustrates the evolution of the most common entities through environmental adaptation. Although theories involving physics or chemistry are specialized, they can be connected to earth system theories and explained using this biological, evolutionary ontological lens.

Third, because the human mind has a well-developed cognitive structure, it may naturally be drawn to solve problems through integrated scientific theories.

Fourth, the values and attitudes arising from shared ontology and epistemology may lead to novel behavior and behavioral change, the ultimate goal of convergence education.

Fifth, if convergence subjects are students and convergence objects and outcomes are

curricula, the subjects (students) will never have a chance to learn about convergence because the process of conversion must be learned as a subject. Even if the convergence process can be taught by exploring these topics, this does not imply that students will grasp their general dimensions.

We argue that in the goal of continuous evolutionary survival governed by natural selection, the only law of evolution, we should focus on the moral cooperation of anti-eliminative civilization rather than the biological competition that is eliminative.

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