# ON NATURE: A PROCESS PERSPECTIVE

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## Abstract

Throughout history, mankind has attempted to understand nature in various ways. The way one understands nature has a deep influence upon one's way of thinking and life. The traditional understanding of nature in the West has been as an object, or understood through the perspective of being. This has resulted in an over-reliance on scientific reductionism. This is in contrast to this is a more dynamic view of nature as becoming, which is more common in the East. In this article I try to reconcile these opposing views of nature; between being and becoming, determinism and indeterminism, mechanism and holism, through the approach of process philosophy. Through such a synthesis of these conflicting views, a new perspective of nature can be constructed which can hopefully lead us to a more harmonious interaction with our environment.

## BEING / BECOMING

When considering the philosophy of nature, it is best to start with the early Greek period, where we can see the beginnings of both philosophy and science and the way they work together. The question concerning the relationship between being and becoming has been asked not only by philosophers but also by scientists. It can be traced back to the controversy in the early Greek period between Heraclitus and Parmenides. Anna-Teresa Tymieniecka, in her article *The Ontopoiesis of Life as a New Philosophical Paradigm*, insists on the point that philosophers and scientists should return to working together by quoting the words of Ren? Thom, "even in science, ontology is necessary; metaphysics is not dead" (Tymieniecka, 1998, p.17). She also advocates this kind of relationship and calls for an alliance between philosophy and science. She says,

> Nothing could be more hasty and erroneous. But also nothing could be more preposterous than a philosopher who believes it possible to reach reality through primary experience and the power of speculation while ignoring scientific inquiry. The striking fact of our present situation is that philosophy needs to consult scientific data, inquiry, methods in order to be able to grapple with reality. The natural and human sciences in turn need a philosophy that is appropriately informed by them for the more profound organization and interpretation of their findings and their own advance. (Tymieniecka, 1998, p.25)

Ilya Prigogine, in his book *Order out of Chaos*, accepted this as one of the main problems in science and philosophy, "Science certainly involves manipulating nature, but it is also an attempt to understand it, to dig deeper into questions that have been asked generation after generation….This is the question of the relationship between being and becoming, between permanence and change" (Prigogine & Stengers, 1984, p.291). Prigogine points out that the old science that emphasizes being and denies becoming has found its own limitations. He says,

> The denial of becoming by physics created deep rifts within science and estranged science from philosophy. What had originally been a daring wager with the dominant Aristotelian tradition gradually became a dogmatic assertion directed against all those (chemists, biologists, physicians) for whom a qualitative diversity existed in nature. At the end of the nineteenth century this conflict had shifted from inside science to the relation between 'science' and the rest of culture, especially philosophy. (Prigogine & Stengers, 1984, p.299)

The denial of becoming is also the denial of natural diversity, complexity and novelty. With the birth of quantum mechanics, we know that nature is full of unpredictable and unexpected surprises. Nature does not stand as dead matter, or 'out there' to be explored without any interaction. Prigogine regarded quantum mechanics as the quest for the bridge from being to becoming (Prigogine & Stengers, 1984, p.219). His attempt to place becoming prior to being challenges traditional philosophy and science, which give priority to being. "The subsequent development of Greek, medieval, and, to a considerable extent, modern philosophy was dominated by the antinomy of Being and Becoming. In most, though not in all, philosophical systems Being was given prominence while Becoming was placed in an inferior and subordinate role" (Edwards, 1967, p.76). Prigogine challenges traditional science by giving priority to becoming, but while he departs from Parmenides, he does not totally agree with Heraclitus. His approach seems to coincide more closely with Whitehead's philosophy of organism in that he tries to reconcile being with becoming. As he puts it: "initial conditions, as summarized in a state of the system, are associated with Being; in contrast, the laws involving temporal changes are associated with Becoming. In our view, Being and Becoming are not to be opposed one to the other: they express two related aspects of reality" (Prigogine & Stengers, 1984, p.310). In quantum theory, we cannot use either wave or particle to understand nature at the subatomic level because it can represent both wave and particle. And in this old tragic choice between being and becoming too, we cannot apply either/or in order to understand nature because nature expresses itself in the form of both being and becoming. At this point we deal with the problem discussed by Whitehead as follows:

> Abide with me;
> Fast falls the eventide
>
> Here the first line expresses the permanence, 'abide', 'me' and the 'Being' addressed; and the second line sets these permanences amid the inescapable flux. Here at length we find formulated the complete problem of metaphysics. Those philosophers who start with the first line have given us the metaphysics of 'substance'; and those who start with the second line have developed the metaphysics of 'flux'. But, in truth, the two lines cannot be torn apart in this way; and we find that a wavering balance between the two is a characteristic of the greater number of philosophers. (Whitehead, 1978, p.209)

Through the process view of nature, we may see the possibility how being and becoming can work together. Our ambition, at this point, is similar to some great philosophers who attempt to solve the conflict left by Heraclitus and Parmenides. Empedocles explains Heraclitus' change through two opposite cosmic powers – love and strife – and replaces Parmenides' being with the four distinct elements: water, earth, fire, and air. Plato solves this problem by placing Parmenides' being with the unchanging reality beyond the visible world of Heraclitus' flux. Plato, through the allegory of the divided line, links being with mathematical truths, and places becoming on the level of belief or doxa. For Plato, becoming can be only the shadow of truth. Aristotle, a member of Plato's Academy, explains the timeless truth with his concept of 'substance' as Whitehead mentioned above as 'the metaphysics of substance'. From Parmenidean being to Platonic form and Aristotelian substance, this can explain the main stream of the history of Western metaphysics, which was further developed by Thomas Aquinas, Descartes, Spinoza, Locke, and others. It seems that most Western philosophers have taken this path leading to a timeless truth beyond the realm of becoming. But this placement of being beyond becoming does not only happen in the Western philosophy but also in the Eastern. Masao Abe, a Zen-Buddhist scholar, points out the root of this problem. He says,

> We human beings are living in a world in which everything is changing. Everything including ourselves comes to be, exists, for a time, and finally perishes. We, however, cannot find satisfaction with this changing world because, if everything is changeable and perishable our life is quite unstable, uncertain, and restless, with nothing solid upon which to rely. Accordingly, it is quite natural that from ancient times, both in the East and the West, people have searched for something unchangeable, something which truly is, something solid and self-existing. 'Substance' is a notion that was arrived at through this pressing quest. The unchangeable being was grasped as 'substance'. (Abe, 1997, p.85-86)

While 'being' as the timeless truth or unchangeable reality is considered as the ultimate goal of our searching, the nature surrounding us seems to be involved in an endless activity of becoming. From scientific discoveries, we realize that nature is as what Heraclitus taught two thousand years ago. Even though we know much more precisely and accurately than the ancient Greek philosophers did, we cannot overlook what our predecessors especially Heraclitus have taught. Karl Popper summarizes Heraclitus ideas as follows:

> Things are not really things, they are processes, they are in flux. They are like fire, like a flame which, though it may have a definite shape, is a process, a stream of matter, a river. All things are flames: fire is the very building material of our world; and the apparent stability of things is merely due to the laws, the measures, which the process in our world are subject to. (Miller, 1985, p.235)

Whitehead also used this idea of Heraclitus as a guideline to discuss the chief topic in metaphysics. He writes: "Without doubt, if we are to go back to that ultimate, integral experience, unwrapped by the sophistications of theory, that experience whose elucidation is the final aim of philosophy, the flux of things is one ultimate generalization around which we must weave our philosophical system….The elucidation of meaning involved in the phrase 'all things flow' is one chief task of metaphysics". (Whitehead, 1978, p.208)

From Popper's interpretation and Whitehead's metaphysics we can understand how becoming plays the central role in process thought. Prigogine accepts both being and becoming as two related aspects. The starting point of our creative insights should begin with our considering nature as 'process' rather than 'thing'. According to the process view of nature, all things do not stand as separated entities but in nature everything is interdependent and participates in process. David Bohm also agrees with this starting point, as he puts it: "In order to see the world from the side of its being a unity, we must start from the notion that the basic reality is the totality of actually existing matter in the process of becoming" (Bohm, 1957, p.168). And Bohm also helped us clarify the root of the term 'thing', which alerts us to why we have to replace 'thing' with 'process'.

Now the word 'thing' goes back to various old English words whose significance includes 'object', 'action', 'event', 'condition', 'meeting, and is related to words meaning 'to determine', 'to settle', and, perhaps, to 'time' or 'season'. The original meaning might thus have been 'something occurring at a given time', or under certain conditions. All these meanings indicate that the word 'thing' arose as a highly generalized indication of any form of existence, transitory or permanent, that is limited or determined by conditions. (Bohm, 1980, p.54)

Prigogine explains nature in terms of the process of becoming which agrees with the irreversible process of the second law of thermodynamics. Even though chance or randomness plays a central role in this process, it does not mean that there is no place for stability, permanence, and order. If we consider his evolutionary process at equilibrium without any fluctuations, nature will have some degree of autonomy and stability in the process of becoming (Prigogine & Stengers, 1984, p.300). In this mode of existence, nature has to be conceptualized in the form of 'things'. This means that being can be understood 'within' the process of becoming. But we have to be careful in taking this as a new perspective of nature. When we conceptualize nature in the form of 'things', we have to be aware that the stability of this fixed concept is just temporary and that no given thing can have a complete autonomy in its mode of being because its basic characteristics relate to other things in the process of becoming. We always fail to notice that our concepts of 'things' are only images of our past perceptions in our minds. We may be trapped again if we treat some concepts as independently existing reality. We have to be conscious that our knowledge has to be involved in the living process of becoming that is taking place at the present moment. We are entangled in the process, and any fixed concepts we abstract are only approximate and temporary images under some conditions in the world of becoming. On the contrary, if we hold that all things flow without autonomy and any moment of stability, they will lose their essential significance and cannot be understood. However, being, autonomy, stability, things, could not be understood in terms of substance according to traditional meaning which is eternal, unchanging, immutable, and self-existing. But being has to be understood and taken into part of the process of becoming. We have a concept of being as 'things' by abstracting from the process of becoming. In this process, Bohm explains how being in becoming is possible:

> We conclude, then, that we must finally reach a stage in every theory where we introduce the notion of something with unvarying and exhaustively specifiable modes of being, if only because we cannot possibly take into account all the inexhaustibly rich properties, qualities, and relationships that exist in the process of becoming. At this point, then, we are making an abstraction from the real process of becoming. Whether the abstraction is adequate or not depends on whether or not the specific phenomena

> that we are studying depend significantly on what we have left out. With the further progress of science, we are then led through a series of such abstractions, while furnish ever better representations of more and more aspects of matter in the concrete and real process of becoming. (Bohm, 1957, p.156-157)

When we make abstractions from the real process of becoming, we have to realize that these concepts are to allow us to see the uniqueness of things, but that these concepts must also be understood through the interrelation of all things in the real process of becoming. Without being, we will not have any single idea about things. Without becoming, all things are merely dead matter in a cosmic machine. In order to understand living nature, we have to be aware of conceptualizing things through our abstractions under some conditions and limitations, and these conditions must be viewed under the process of becoming of the larger system of the universe. With this perspective, beings will interact with becoming in the same process, as Prigogine puts it: "Today physics has discovered the need to assert both the distinction and interdependence between units and relations. It now recognizes that, for an interaction to be real, the 'nature' of the related things must derive from these relations, while at the same time the relations must derive from the 'nature' of things" (Prigogine & Stengers, 1984, p.95). All concepts have to be understood through their limitations. Modern science attempted to reach a complete description of nature without realizing the complexity and novelty of nature in the process of becoming. We always situate in the context where we are, and also the same for any concept that we try to abstract. Maurice Merleau-Ponty proposes the idea of 'Lebenswelt', the 'life-world' in contrast to the objective world of science. In his article *What is Phenomenology?* he writes: "the phenomenological world is not the bringing to explicit of a pre-existing truth, but, like art, the art of bringing truth into being" (Merleau-Ponty, 1967, p.373). What he is concerned with is not to conceptualize the essential meaning of phenomenon, but to reflect on what is revealed to our perception in concrete situations. Thought is always situated in history and society. The meaning of what we experience should not be based on a conceptual fixation of essence transcending our mundane experience.  Thus any single concept must be viewed under some conditions, and with this limitation it cannot be applied to all spheres of the universe. Bohm reminds us of the limits from our abstraction, and a better understanding about nature should come from our acceptance of the richness of nature. He says,

> The notion of a thing is thus seen to be an abstraction, in which it is conceptually separated from its infinite background and substructure. Actually, however, a thing does not and could not exist apart from the context from which it has thus been conceptually abstracted. And therefore the world is not made by putting together the various 'things' in it, but, rather, these things are only approximately what we find on analysis in certain contexts and under suitable conditions.
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> To sum up, then, the notion of the infinity of nature leads us to regard each thing that is found in nature as some kind of abstraction and approximation. It is clear that we must utilize such abstractions and approximations if only because we cannot hope to deal directly with the qualitative and quantitative infinity of the universe. The task of science is, then, to find the right kind of things that should be abstracted from the world for the correct treatment of problems in various contexts and sets of conditions… Scientific research thus brings us through an unending series of such revision in which we are led to conceptual abstractions of things that are relatively autonomous in progressively higher degrees of approximation, wider contexts, and broader sets of conditions. (Bohm, 1957, p.146)

According to Bohm's point of view, we now understand more about the limitations of modern science, which denies becoming and attempts to grasp the essential nature of being. But we are beginning to understand that nature is involved in a process of becoming, and being is only abstracted from this process. Being in becoming can represent a new perspective on nature. The mode of being can help us identify things and make the distinction among things by which we abstract from the process of becoming. We create abstractions in the same manner we make a map. If we have no map, we will not know where we are and where we can go. But we have to keep in mind that maps are only maps not the real terrestrial world. Reality is not in our maps but in our real existence, a living stream of dynamic reality. We should allow ourselves be carried along by this current.

## DETERMINISM / INDETERMINISM

The problem of determinism and indeterminism can be regarded as one of the main problems in the Western philosophy. This problem has remained at the root of the Western thought since the early Greek philosophy. The problem of determinism has been discussed among philosophers for thousands of years. Prigogine, in his book *The End of Certainty*, opens the first chapter by focusing on the problem of determinism and gave us a new light as follows:

> Is the universe ruled by deterministic laws? What is the nature of time? These questions were formulated by the pre-Socratics at the very start of Western rationality. After more than twenty-five hundred years, they are still with us. However, recent developments in physics and mathematics associates with chaos and instability have opened up different avenues of investigation. We are beginning to see these problems, which deal with the very position of mankind in nature, in a new light, and can now avoid the contradictions of the past. (Prigogine, 1997, p.9)

To inquire into this problem, we can trace back to the early Greek period. In the history of philosophy, many philosophers considered this problem and have given us various answers. Prigogine persuades us to rethink the search for the proper answer to this problem in our period. The answer we attempt to find comes from the limitations of a modern worldview influenced by the Newtonian theory. In the centuries following Newton's discoveries, many descriptions of the universe were more or less dominated by Newtonian physics. Newton stood as one of the great thinkers in the world and his worldview influenced the people both directly and indirectly for centuries. We will consider the result of Newtonian worldview relevant to the problem of deterministic view of nature. Paul Davies, in his book *God and the New Physics*, described some general characteristics of determinism promoted by the Newtonian theory as the following:

> In the old Newtonian theory, every atom moves along a trajectory that is uniquely determined by the forces which act on it. The forces in turn are determined by other atoms, and so on. Newtonian mechanics permits, in principle, the accurate prediction of everything that will ever happen on the basis of what can be known at one instant. There is a rigid network of cause and effect, and every phenomenon, from the tiniest jiggle of a molecule to the explosion of a galaxy, is determined in detail long in advance. It was this conception of mechanics that led Pierre de Laplace (1749-1827) to declare that if a being knew at one instant the positions and notions of every particle in the universe he would have at his disposal all the information necessary to complete the entire past and future history of the universe". (Davies, 1983, p.136)

Newtonian mechanistic worldview painted the picture of the universe as gigantic clockwork composed of many different parts, which moved in a steady state. All things were seen as nothing more than component parts of the huge cosmic machine. Determinism in this sense carries the implication that we can know exactly and accurately about the past and the future if and only if we have enough knowledge at the present state. It means that everything which will happen in the future of the universe is completely determined by its present state, and at the same time we can retrodict what happened in the past by our present position like setting a clock. Heinz R. Pagels, in his book *The Cosmic Code,* could help us understand more about the general characteristics of determinism from his explanation.

> According to determinism, the universe may be viewed as great clockwork set in motion by a divine hand at the beginning of time and then left undisturbed. From its largest to its smallest motions the entire material creation moves in a way that can be predicted with absolute accuracy by the laws of Newton. Nothing is left to chance. The future is as precisely determined by the past as is the forward movement of a clock….The wheels of the great world clock turn as indifferent to human life as the silent motion of the stars. In a sense, eternity has already happened. (Pagels, 1982, p.16)

The Newtonian deterministic description of nature once inspired some thinkers to dream on being omniscient, that is, to know the 'mind of God'. But such a beautiful dream was terminated by a sudden shock from Einstein's theories of relativity and quantum mechanics. Although Einstein took the side of determinism throughout his entire life, we still consider him as the great challenger to the Newtonian physics. We should also treat quantum theory as the turning point of the great departure from determinism to indeterminism. Popper considers the ambition of the old deterministic worldview as a daydream of omniscience, which leads, apparently, to an inescapable nightmare (Miller, 1985, p.257). Sir James Jeans also compared determinism with a prison and quantum theory with a home in which it might, at least, be possible for us to mould events to our desires and live our lives of endeavor and achievement. (Jeans, 1981, p.216). Thus the Newtonian mechanical model, presenting the world as a huge machine, seems not to be a proper worldview in this period. The Newtonian worldview may be appropriate for the world of industry, which adopts the perspective of mechanical order. Every part of the mechanism has to repeat its own function regularly without any novelty and creativity. Chance and randomness were exceptional cases, which have to be controlled and shaped into regular mechanical order. Frederick Ferr? points out extensively the negative consequences of the Newtonian deterministic view. He says:

> If we venerate the qualities implicit in the image of the Perfect Machine – those of regularity, predictability, control – we lose the values of spontaneity, creativity, responsibility. And those are the values of the personal. If all reality should be seen and felt as perfectly regular clockwork, with each happening being determined by its preceding circumstances, then we are not free to do otherwise than whatever it is we find ourselves actually doing. We are then not responsible agents, capable of initiating chains of events, but we are only necessary links in the causal sequence which looms indefinitely into the future and ties us remorselessly to the conditions of the past….Personal responsibility falls victim to the deterministic ideals of regularity and predictability. And with this loss come serious social and psychological consequences for modern civilization. Human beings, perceived as with-

> out essential responsibilities or need for personal creativity, will more easily be placed into economic bondage to assembly-line production techniques; overwhelming bureaucracies will show less communication in mechanically administering our lives not only without spontaneity but (worse) without personal assumption of moral accountability, from birth to burial. (Ferre, 1988, p.89-90)

However, the Newtonian deterministic model fails when it extends to the larger scale of the universe and also to the subatomic particle level. It seems to be that quantum theory, according to Bohr's principle of complementarity and Heisenberg's uncertainty principle, removes radically Newtonian deterministic worldview and replaces necessity with chance, certainty with probability. John Briggs and F. David Peat, in the book *Turbulent Mirror*, considered quantum mechanics as an indeterminate invasion shaking an old deterministic worldview of some scientists. If the world is strictly deterministic, then all events are locked in a chain of cause and effect. This means that the necessary connection of cause-and-effect determinism can be applied for all realms from an insect to a star. In other words, everything in nature is the result of fixed laws. But Briggs and Peat showed us the failure of such a belief. They say,

> Two pots of soup heated on a stove under exactly the same conditions will behave differently. Conditions for dynamical systems are never identical, but for the most part we can ignore differences with impunity because they don't become magnified, turning the familiar into the chaotic. We have traditionally appreciated the simple regularity of order in our familiar world, neglecting the infinitely higher orders (or chaos) woven within it. (Briggs & Peat, 1989, p.76)

Quantum mechanics has drastically changed our view of nature from the Newtonian deterministic mechanical order to an indeterminate principle. Sir James Jeans explained metaphorically this radical change of perspective from Newtonian determinism to quantum indeterminacy by saying that the ultimate particles of matters would be seen to move, not like railway trains running smoothly on tracks, but like kangaroos hopping about in a field. His comparison of Heisenberg's quantum leaps with kangaroo hopping signified the end of thinking of particles as being in continuous motion. He also stated the result of the end of continuity, “As discontinuity marched into the world of phenomena through one door, causality walked out through another” (Jeans, 1981, p.127). We may have to rethink what we understand about the principle of causality with the rise of the quantum indeterminate principle. To criticize the deterministic worldview does not mean that we hold the idea of an arbitrary universe of pure chance. When we deny the linear causality of determinism, it does not mean that the universe is lawless and irrational. On the contrary, we are looking forward to finding a proper way to understand nature in a new form of rationality. Tymieniecka expressed her own point of view about the new form of order relating to our new vision of nature as follows:

> Today’s science is, indeed, offering us a new vision of the universe, nature, society. In fact, the chaotic and turbulent stream, the innumerable streamlets which make up cosmos, nature, life, society and culture, in which from arbitrariness, chaos, chance there emerges segments of ordered world, such that we may acknowledge through our own existence in relatively stable societal, natural, cosmic existential conditions, opens fascinating newly to be formulated issues, views, expectations. The preeminence given to the turbulent, fluid, accidental, irregular, disorderly in the origination and progress of All does not mean, as I have hinted at a few times, a universal ‘disorder’ or a forsaking of order and rationality. On the contrary, it opens vistas in which we have to ask after the kinds, rules, ways of interlinking, of intermingling, molding….There are no sharp divides between matter and life, nature and the cosmos, nature and human culture, but vast intermediary spheres which fascinate our imagination. (Tymieniecka, 1998, p.24-25)

We have to accept the role of chance proposed by quantum theory playing at the subatomic level, and on the man-sized scale Newtonian deterministic still has a narrow place to play. The main point we refuse determinism is its omniscience, and its ambition to accomplish a complete description of nature. Paul Davies, in his book *The Mind of God*, asserted that both determinism and chance played a role in the different scales of the universe.

> There is a difference between the role of chance in quantum mechanics and the unrestricted chaos of a lawless universe. Although there is generally no certainty about the future states of a quantum system, the relative probabilities of the different possible states are still determined. Thus the betting odds can be given that, say, an atom will be in an excited or a non-excited state, even if the outcome in a particular instance is unknown. This statistical lawfulness implies that, on a macroscopic scale where quantum effects are usually not noticeable, nature seems to conform to deterministic laws. (Davies, 1992, p.31)

Davies explanation is related to what we hope to see when determinism and indeterminism have each own place to play in nature. Prigogine, in his study of the second law of thermodynamics, at far-from-equilibrium condition with irreversible process, attempted to find an intermediate description that lies somewhere between the two alienating images of a deterministic world and an arbitrary world of pure chance (Prigogine, 1997, p.189). His effort was put into an evolutionary process where determinism and indeterminism co-exist in different parts of the same process. In Prigogine's evolutionary process, determinism works appropriately if and only if there is no fluctuation, and systems are in equilibrium. But if systems with some fluctuations move from equilibrium to nonequilibrium and reach a bifurcation point, chance and randomness will play a central role. At the bifurcation point, the roles of dissipative structures will dramatically change the whole system into a new form of order which we cannot predict accurately and know precisely in advance. Within the construct of dissipative structure, nature at the bifurcation point is opened for all possibilities. Prigogine also says, "Let us now look more closely at the critical effect of fluctuations. As we have seen, near-equilibrium fluctuations are harmless, but far from equilibrium, they play a central role. Not only do we need irreversibility, but we also have to abandon the deterministic description associated with dynamics" (Prigogine, 1997, p.68). For him, determinism cannot play regularly and eternally in the whole process as in the mechanistic worldview. But it can play only in a narrow place between bifurcations at near equilibrium in dynamical processes. The stability of dynamical systems at equilibrium can help us abstract the deterministic laws of nature, otherwise we will have no concepts of nature. But the fixed laws we use have to be kept in our minds for their limited periods of time. We have no deterministic laws that can apply to all cases in the evolving universe. Bohm contested the basic traditional Western beliefs in certainty and universality of deterministic laws approaching the complete description of nature. He argues:

> If we take into account the character of the laws of physics implied by the qualitative infinity of nature, however, we can immediately answer this question in the negative. For, as we have seen, the notion of a law that gives a perfect one-to-one mathematical correspondence between well-defined variables in the past and in the future, is only an abstraction, good enough to described limited domains of phenomena for limited periods of time, but, nevertheless, not valid for all possible domains over an infinite time….Thus, we are not justified in making unlimited extrapolations of any specific set of laws to all possible domains and over infinite periods of time. This means that the description of the laws of nature as in principle completely reversible is merely a consequence of an excessively simple representation of reality. When we consider the mechanical laws in their proper contexts of ever-changing basic qualities, it becomes clear that irrevocable qualitative changes do take place, which could not even in principle be reversed. This is because, for systems of appreciable complexity, the fundamental character of the laws that apply cannot be completely separated from the historical processes in which these systems come to obtain their characteristic properties. (Bohm, 1957, p.162-163)

According to Bohm's description, we probably have to shape our own thoughts about the laws of physics. We once firmly believed that we could reveal the inner secrets of the universe with a single formulation. We have to leave our old dream of the deterministic complete description and be open to seeing chance and randomness playing in our lives and nature surrounding us. Popper compares the two different images of determinism and indeterminism with a clock and a cloud. He keeps indeterminism in his mind, but allows a narrow path for determinism to walk. His proposal is similar to Prigogine's evolutionary process where determinism and indeterminism co-present. "What we need for understanding rational human behavior – and indeed, animal behavior – is something intermediate in character between perfect chance and perfect determinism – something intermediate between perfect clouds and perfect clocks. And we also know that our clouds are not perfectly chancelike, since we can often predict the weather quite successfully, at least for short period". (Miller, 1985, p.263)

According to Prigogine's evolutionary process, we cannot choose either determinism or indeterminism in order to take into account nature. We have to use both in order to understand the whole process, as Alvin Toffler stated in the Foreword of *'Order out of Chaos'*. Toffler requests us to put forth new efforts to recognize the co-presence of both chance and necessity, not with one subordinate to the other, but as full partners in a universe (Prigogine & Stengers, 1984, p.xxiii). According to the Newtonian mechanistic worldview, chance and randomness are exceptional cases because deterministic order plays the central role in a mechanical system. But for Prigogine, chance and randomness play the central role, and deterministic order is a part of the process, which plays in a short range between bifurcations. Karim Ahmed, in his article *Causality, Chaos, and Consciousness*, described the role of dissipative structures causing apparent randomness and chance within all systems. He extends this view by mentioning Giorgio Careri's *Order and Disorder in Matter*, which is correspondent to Prigogine's explanation of bifurcations. He says,

> Chance plays a decisive role in the choice of new structures, by taking the system farther and farther away from equilibrium in an unpredictable direction. Thus the forced evolution of the system from one new structure to another must in part have a 'historical' character because of the influence of the preceding situation, but it also has a 'nondeterministic' character caused by the series of bifurcations it must come across….This gives the system several alternative possibilities of evolution that cannot be predicted because each branch of bifurcation is selected at random at the moment of instability (first emphasis in origi-

nal). (Ahmed, 1998, p.258)

According to Prigogine's evolutionary process, deterministic linear causality cannot be applied to the far-from-equilibrium condition at bifurcation. Deterministic linear causality can explain only the dynamic at an equilibrium condition where small causes produce small effects. At bifurcation, on the contrary, a small cause can probably amplify an effect to the large system and sometimes can cause extreme changes to the whole. The amplification of small causes strongly effects larger systems. This is supported by the new discovery of Edward Lorenz, a research meteorologist and mathematician working at the Massachusetts Institute of Technology, who attempts to explain metaphorically nonlinear dynamical system with the *Butterfly Effect*. Lorenz's *Butterfly Effect* is based on the notion that a butterfly flapping its wings in Asia today can transform storm systems next month in the Atlantic. A small fluctuation at a bifurcation point can cause a revolution like the stirring air of a butterfly. James Gleick, in his book *Chaos: Making a New Science*, considers the Butterfly Effect as the starting point of a new revolution causing the unexpected change of systems. "In science as in life, it is well known that a chain of events can have a point of crisis that could magnify small changes. But chaos meant that such points were everywhere. They were pervasive. In systems like the weather, sensitive dependence on initial conditions was an inescapable consequence of the way small scales intertwined with large" (Gleick, 1987, p.23).

Causality, according to the traditional meaning, is a very limited explanation of the connection between cause and effect. The linear causal explanation describes events in a narrow scope and attempts to apply the theory to all realms of phenomena. It may be a correct understanding in one place and a period of time, but it cannot be applied to all places and all periods of time. Consequently, the non-linear causal principle can probably open our minds, extend our limited scope and take the various possible causes into our consideration on account of the complexity of nature. Thus the non-linear causal explanation seems to be appropriate for a new perspective of nature.

Briggs and Peat attempt to expand the meaning of causality to cover the larger part of the universe when they say, "We ordinarily think of an effect as having only one or a few causes. In fact, the cause for any one thing is everything else. To understand completely the cause of malaria in humans, for example, requires understanding not only the life cycle of the anopheles mosquito, but also evolution, ecology, chemistry, and eventually everything in the universe" (Briggs & Peat, 1984, p.96). Bohm also discusses the problem of causality resulting from the deterministic view of nature, and he explains why we have to rethink the linear explanation of our old scientific beliefs. In order to know the real cause, we might have to enlarge our view to all related parts in the complexity of nature. Bohm argues,

> We see, then, that the behavior of the world is not perfectly determined by any possible purely mechanical or purely quantitative line of causal connection. This does not mean, however, that it is arbitrary. For if we take any given effect, we can always in principle trace it to the causes from which its essential aspects came. Only as we go further and further back into the past, we discover three important points: viz. First, that the number of causes which contribute significantly to a given effect increases without limit; secondly that more and more qualitatively different kinds of causal factors are found to be significant; and finally, that these causes depend on new contingencies leading to new kinds of chance… Thus, over an infinite period of time, the determination of even the essential features of an effect is evidently not purely mechanical, because it involves not only an infinite number of contingent factors but also an infinity of kinds of qualities, properties, laws of connection, all of which themselves undergo fundamental changes with the passage of time. (Bohm, 1957, p.159-160)

From Bohm's point of view, we obviously cannot reduce the universe into pieces in order to understand, without seeing, the interconnection of all parts in the universe. We have to listen to Briggs and Peat's explanation about causality from malaria to ecology. Bohm accepts the complexity of nature and argues for the relevance of everything. Ahmed suggests that we reconsider causal explanation by expanding broadly to cosmological context. He says,

> To expand such a causal scheme to its logical conclusion, we should view it from a more cosmological context….For

> example, the preservation of the human beings and the biosphere depends upon a mutual web of causal interconnections between different species on earth – e.g., the nature of the food chain, material resources, energy fluxes, ecosystem dynamics, etc. In such a biosphere model, the causal interconnections are the vast proliferation of extinct and living species, that continue to be related to each other over time and space. (Ahmed, 1998, p.257)

With determinism, we once had a beautiful dream of decoding the mystery of the universe. We attempted to attain the complete description of nature, to be omniscient and to be able to control and master nature. But nature is not our slave who always obeys to our commands. Prigogine quoted Vladimir Nobokov's statement, "What can be controlled is never completely real; what is real can never be completely controlled" (Prigogine, 1997, p.154). Determinism, in the absolute sense, has no room for chance, novelty and creativity because they are beyond our control. Deterministic ideology rises with the desire to achieve a quasi-divine point of view in our description of nature. But, for Prigogine, no human measurements, no theoretical predictions, can give us initial conditions with infinite precision in order to retain the idea of determinism (Prigogine, 1997, p.38). The deterministic worldview, which many scientists supported, collapses, not because of some new philosophy or ideology, but because of the internal development of science itself.

From scientific inquiry, we realize that nature cannot be wholly understood by the deterministic worldview. But we, at the same time, cannot champion the idea of an arbitrary universe of pure chance. Even if we know that chance and randomness play the central role in nature, by no means do we have to totally abandon the deterministic view. If nature is expected to be understood in terms of 'process' rather than 'thing', we will see the possibility that chance and necessity co-exist in the same process. Prigogine proposes the way to reconcile determinism with indeterminism in the irreversible process with the arrow of time. Determinism can work only between bifurcations in a dynamical system at equilibrium where there is no fluctuation. Indeterminism has to be taken into consideration at bifurcation where the dissipative structures play the central role. At bifurcation, the deterministic causal explanation breaks down and fails to give an account of nature. We need some changes from linear to nonlinear causal explanation like Lorenz's *Butterfly Effect*. Then, we have to keep in mind the limitation of deterministic causal explanation that works in specific places and periods of time. The deterministic worldview with some fixed laws can help us conceptualize and understand only some parts of the whole process of nature. If the nature we understand is not a clock but a cloud full of surprises, novelty and creativity, we need an unending process in making a dialogue, not a monologue, with nature.

Determinism in indeterminism, therefore, can be taken into consideration as our new vision of nature. With this vision, we will see the interplay between determinism and chance. Nature is not dead matter, and we are not cogs in a cosmic machine. We should breathe in and out, participating with all humanity out of sense of freedom and responsibility. We should also extend this perspective to not only living beings, but also all beings participating in the universe. To be is to participate.

## REDUCTIONISM / HOLISM

Whitehead once said, "For the essence of great experience is penetration into the unknown, the unexperienced" (Whitehead, 1938, p.62). We used to portray nature with the deterministic worldview and attempted to reach a complete description of nature. But from now on, the modern worldview under the Newtonian domination brings us to a limited understanding of nature. Nature will not be conformed according to our expectation. The transition from Newtonian to a new worldview has been considered in the form of process starting with Einstein's theory of relativity and quantum theory in the beginning of the twentieth century. Sallie McFague, in her article *A Holistic View of Reality*, described this transition from the mechanical model to a new organic model which Whitehead might accept as the great experience because of its ability to penetrate into the unexperienced.

> In the early years of the twentieth century there was a movement toward a model more aptly described as organic, even for the constituents with which physics deals, for there occurred a profound realization of the deep relations between space, time, and matter, which relativized them all….It is a considerably more complex picture than the old view, with a hierarchy of levels of organization

> from the microworld of the subatomic through the macroworld of the biosphere to the megaworld of intergalactic space. But the characteristics of all levels of reality in this picture are similar: the play of chance and necessity replaces determinism; events appear to be more basic than substances, or to phrase it differently, individuals or entities always exist within structures of relationship; process, change, transformation, and openness replace stasis, changelessness, and completeness as basic descriptive concepts. Whereas with the model of the machine, life is patterned on the nonliving, with the organic model the nonliving takes on characteristics of life. The model is most appropriate to life, and hence the quality of life – openness, relationship, interdependence, change, novelty, and even mystery – become the basic ones for interpreting all reality. (McFague, 1993, p.359-360)

The model of machine, or gigantic clockwork, used to be a useful model for most of the people for centuries ago. From now we need a more appropriate model that has characteristics like openness, relationship, interdependence, novelty; characteristics not found in the mechanical model. With Newtonian paradigm, the scientific method could get along with the reductionistic approach. The word 'mechanism' and 'reductionism' are interchangeable because with the mechanical worldview, we try to reduce this huge machine into smaller parts. Through the reductionistic approach, the whole nature is understood in terms of its parts. Briggs and Peat described metaphorically reductionism with a watch as follows:

> Essentially reductionism is a watchmaker's view of nature. A watch can be disassembled into its component cogs, levers, springs, and gears. It can also be assembled from the parts. Reductionism imagines nature as equally capable of being assembled and disassembled. Reductionists think of the most complex systems as made out of the atomic and subatomic equivalents of springs, cogs, and levers which have been combined by nature in countless ingenious ways. (Briggs & Peat, 1989, p.21-22)

The mechanistic view of nature seems to be very closely related to the reductionistic approach, and thus the whole nature looks like an aggregate of the parts. Then, with the mechanistic worldview, the whole is the sum of the parts. Through the Newtonian mechanical worldview, the historical development of the Western science has been founded on the basis of reductionism, in which we can understand the complicated system of the universe by studying the behavior of its component parts. The parts and the whole have no internal relationship as Briggs and Peat described above. The whole can be disassembled into parts, and the parts can be assembled to be the whole. With this reductionistic approach, most of the scientific works are based on quantification, abstraction, and analysis. The advance of scientific knowledge, then, could be considered mostly by quantitative analysis. Paul Davies identifies the word 'science' with 'analysis' which illustrates the scientist's almost unquestioning habit (Davies, 1983, p.61). The etymological meaning of the word 'analysis' derived from the Greek root 'lysis' which means 'to break up or dissolve' (Bohm, 1980, p.125). With reductionism, science can get along with deterministic causal explanation because the cosmic machine can be seen as being completely causal and determinate. But with the new scientific knowledge, we realize that the mechanistic worldview is not appropriate for our new vision of nature. The traditional reductionistic approach has been challenged by a new holistic approach which is based on some new discoveries in the early period of the twentieth century. The controversy between reductionism and holism has been put into discussion among many intellectuals, and an account of the two different approaches could be seen from a dialogue in Douglas R.Hofstadter's *Godel, Escher, Bach: An Eternal Golden Braid* as follows:

> ***Achilles:*** I will be glad to indulge both of you, if you will first oblige me, by telling me the meaning of these strange expressions, "Holism" and "Reductionism".
> ***Crab:*** Holism is the most natural thing in the world to grasp. It's simply the belief that "the whole is greater than the sum of its parts". No one in his right mind could reject holism.
> ***Anteater:*** Reductionism is the most natural thing in the world to grasp. It's simply the belief that "a whole can be understood completely if you understand its parts, and the nature of their 'sum'". No one in her left brain could re-

> ject reductionism.
> ***Crab:*** I reject reductionism. I challenge you to tell me, for instance, how to understand a brain reductionistically. Any reductionistic explanation of a brain will inevitably fall far short of explaining where the consciousness experienced by a brain arises from.
> ***Anteater:*** I reject holism. I challenge you to tell me, for instance, how a holistic description of an ant colony sheds any more light on it than is shed by a description of the ants inside it, and their roles, and their interrelationships. Any holistic explanation of an ant colony will inevitably fall far short of explaining where the consciousness experienced by an ant colony arises from. (Hofstadter, 1979, p.312)

Hofstadter ended the above dialogue with his denial of the question, "Should the world be understood via holism, or via reductionism?" He takes some ideas from Zen. He rejects the premises of the question and opens the larger context to include both holism and reductionism. Hofstadter may be right in his opening the wider context where holistic and reductionistic interplay in the complexity of nature. We ought to leave an old way of 'either/or' thinking that leads us to an extreme attitude of 'all-or-nothing'. Frederick Ferr?, in his article *Personalistic Organism: Paradox or Paradigm?*, argues as follows:

> It is not necessary to think *either* wholes *or* parts; both are important levels for understanding. The whole, seen as a system, gives context and significance to its parts. The parts, in turn, show the fine structure of the whole. Moreover, the parts, looked at closely, are themselves each system with fine structures of their own and therefore become wholes relative to their sub-parts. Equally, the larger, context-conferring system, seen in its own context, is itself part of a still more inclusive system. What we should find objectionable about analytical thinking is not that it engages in close examination of parts, or that it conceptually divides its subject matter for rigorous study, but rather that analytical thinkers have too often lost sight of (or interest in) the very contexts that give point to the analytical

> process itself. They have lost themselves in fascination with the parts. But it is not necessary to choose sides. Epistemological holism can (and in ecological science effectively does) embrace analytical thinking, enriching detailed knowledge with wider understanding even as analysis provides rigour in the appreciation of detailed relations. (Ferre, 1994, p.64-65)

We have seen the limitations of the Newtonian mechanistic worldview that reduces everything into smaller parts and separates human beings from nature. Science in the Newtonian model is often criticized as isolating man from the world and separating the subject and the object. The dichotomy between the subject and object, the observer and the observed has been challenged by quantum theory especially with Bohr's principle of complementarity in which we are both spectators and actors. By this principle, wave and particle are complementary properties of the same object of human knowledge. We cannot, simultaneously, see both waves and particles because as one property is known, it excludes knowledge of the other. Then, our knowledge limits itself depending on the choice we choose in measurement. We are not separated from what knowledge we acquire. The objectivity of scientific knowledge through Newtonian science treated knowledge as 'out there' independently and separately from our involvement. But for quantum physics we are taken into the main part of the process of acquiring knowledge. Nature is not 'out there' to be explored. According to quantum theory, the separated entities of the mechanistic worldview have to be replaced with the network of the interconnected, dynamic whole whose parts are interdependant. Bohm, in his article *Postmodern Science and A Postmodern World*, argues for the interdependence of all things in the universe as follows:

> If you bring two particles together, they will gradually modify each other and eventually become one. Consequently, this approach contradicted the assumption of separate, elementary, mechanical constituents of the universe. In doing so, it brought in a view which I call *unbroken wholeness or flowing wholeness*: it has also been called *seamless wholeness*. The universe is one seamless, unbroken whole, and all the forms we see in it are abstracted

> by our way of looking and thinking, which is convenient at times, helping us with our technology, for example. (Bohm, 1988, p.62-63)

In Bohm's idea of an unbroken wholeness, the individuality of things appears through our abstractions from the whole. At its root, there is no separation between elements, and then the world is one, unbroken wholeness. With quantum mechanics, two subatomic particles can interact locally and then move effectively at the distance, which is called the nonlocality. Einstein rejected this nonlocality until he died. But recent experiments in quantum mechanics have begun to affirm this nonlocality. Following this idea of nonlocality and Bohm's idea of unbroken wholeness, we have to accept this profound implications for our view of the universe as Davies puts it:

> The mystery is all the deeper for the fact that the separability of nature is actually only approximate. The universe is, in reality, an interconnected whole. The fall of an apple on Earth is affected by, and in turn reacts upon, the position of the moon. Atomic elements are subject to nuclear influences. In both cases, however, the effects are tiny, and can be ignored for most practical purposes. But not all systems are like this. As I have explained, some systems are chaotic, and are exquisitely sensitive to the most minute external disturbances. It is this property that makes chaotic system unpredictable. Yet, even though we live in a universe replete with chaotic systems, we are able to filter out a vast range of physical processes that are predictable and mathematically tractable. (Davies, 1992, p.157)

Davies describes the universe as an interconnected whole where the holistic approach is needed. But he still provides the place for the mechanistic approach to play. However, with this new understanding we need to expand our knowledge about parts to cover the interdependence of all things in the whole. Even though we know the technological benefits that scientific reductionism has brought human society, we should be aware of its limitations and also its negative consequences otherwise our concern will be for only human beings, not for the wider context. Briggs and Peat give a warning as follows:

> The definition of a tree as a thing or part of nature composed of roots, trunks, limbs, and leaves interchanging with the environment is useful if we want to cut trees down or plant them. In a larger context, however, this idea may be detrimental. The tree is not a part. It is impossible to say at just what point a molecule of carbon dioxide crossing the cell membrane into a leaf stops being air and becomes the tree. The tree threads out into the whole environment and eventually the whole universe. If this fact is ignored and forests are cut down, consequences will arise which affect the whole ecology. Human misapprehension about parts and whole can be not only confusing but also dangerous. (Briggs & Peat, 1984, p.104-105)

In order to know a tree, we do not reject scientific reductionism, that is to say, we can analyze tree into separate parts in order to know the details of every part. But we should not end with this, we should expand our understanding to its environment where the tree is, the atmosphere and everything else that relates to that tree. The mere analysis into parts is the narrow view of the old scientific determinism. We need to enlarge our perspective to cover the wider context, the evolutionary ecosystem of our cosmos. Eugene P. Odum, a leading ecologist as quoted by Frederick Ferre, says: "When someone is taking too narrow a view, we may remark that 'he cannot see the forests for the trees'. Perhaps a better way to illustrate the point is to say that to understand a tree, it is necessary to study both the forest of which it is a part as well as the cells and tissues that are part of the tree" (Ferr?, 1988, p.94). We need to expand our understanding from the cells to the tree, from the tree the forest, from the forest to a larger environment as much as we can. In this ecological perspective, we understand that the world is an endlessly complex network of interdependent organic systems. The mechanical worldview has the presupposition that we could understand the whole by merely abstracting the separated parts without considering their mutual connection with the whole. But we are now seeing its limitations. Nature cannot be totally reduced into separated parts, and nature itself expresses in complexity, its unity in diversity. It is an interconnected whole. And this whole is more than the sum of its parts. Whitehead comments on the reductionistic approach of modern science which attempts to discover eternal truths as follows:

> The universe is not a museum with its specimens in glass cases. Nor is the universe a perfectly drilled regiment with its ranks in step, marching forward with undisturbed poise. Such notion belongs to the fable of modern science – a very useful fable when understood for what it is. Science deals with large average effects, important within certain modes of observation. But in the history of human thought no scientific conclusion has ever survived unmodified by radical increase in our subtleties of relevant knowledge. (Whitehead, 1938, p.90)

Corresponding with Whitehead's view of the universe, Charles Birch, in his article *Processing Towards Life*, confirms the defect of scientific reductionism which overlooks the importance of the whole. He argues:

> The Whiteheadian interpretation of self-organizing entities is in contrast to the parts that make up a machine. He enunciated more clearly than anyone how creative evolution of living organisms cannot be understood if the elements composing them are conceived as individual entities that maintain exactly their identity throughout all the changes and interactions, as is the case with the parts of a machine. That is the Newtonian model of the universe. Complex living organisms can be broken down into their component parts such as their cells. How is it that the whole has properties the components do not have? It is evident that the properties of the whole are not found in the parts, except as they are organized in the whole. It is for this reason that the reductionist program of science is deficient. One response has been to say that the whole is more than the sum of its parts. There is an element of truth in this statement, but it does not go far enough. It is not just that the whole is more than the sum of its parts. It is that parts become qualitatively different by being parts of a whole. (Birch, 1998, p.286)

The radical change from reductionism to holism has been expected to develop our new understanding of the world in contrast to the Newtonian mechanistic worldview since the beginning of the twentieth century. The removal of our perspective from reductionism to holism has been accepted as the transition from the old to the new worldview in which Sanders describes about this movement in her *The New Planning Paradigm As Defined By The New Science* (Sanders, 1998, p.147).

| From | To → |
|---|---|
| **Mechanics of Parts** | **Dynamics of the Whole** |
| Linear | Nonlinear |
| Static, cause-effect view of individual factors | Dynamic, constantly changing field of interaction |
| Microscopic, local | Wide angle, global |
| Separateness | Relatedness |
| Marketplace | Environment |
| In the old paradigm, it was believe that only by understanding the parts could one make sense of the whole. It also was thought that the worldworked like a machine with clockwork relationships, precision. | In the new paradigm, the parts of a system can be understood only in relationship to the dynamics of the whole. The whole is a constantly changing field of connections, and patterns of interaction. |
| Component thinking | Seeing and thinking in wholes |
| Time cards, task analysis | Complex adaptive systems |
| Problem solving | Butterfly Effect, system feedback |
| Brainstorming | Self-organization, adaptation |
| Polarization | Environment scanning plus mapping |

According to Sanders' description of the new paradigm, we need to revise our perspective of nature. Mechanism cannot be taken to be the main part of a new vision of nature. This new vision would need to reestablish the relation of thought to nature. It cannot be based on the mechanical model alone. Even though we have criticized the Newtonian mechanical model, we do not intend to dispense with it. We just need to show its deficiencies and limitations. It cannot be merely replaced by holism. Holism also has its limitations. With a merely holistic approach, we cannot know much about nature because we never find a full set of holistic laws explaining the whole universe. Paul Davies talks about the limitations of the holistic view, "One of the major unsolved problems of modern physics is whether the holistic features of a physical system require additional holistic laws that cannot be reduced to the fundamental laws of elementary forces and particles. So far we have no evidence for truly holistic laws of physics" (Davies, 1983, p.225). Bohm also insists that the full set of laws governing the wholeness is unknown and indeed probably unknowable (Bohm, 1980, p.178). Bohm proposes the idea of "explicate" and "implicate" orders to describe nature in a manner where mechanism and holism can be viewed as co-present in the same process.

> What distinguishes the explicate order is that what is thus derived is a set of recurrent and relatively stable elements that are outside of each other. This set of elements (e.g., fields and particles) then provides the explanation of that domain of experience in which the mechanistic order yields an adequate treatment. In the prevailing mechanistic approach, however, these elements, assumed to be separately and independently existent, are taken as constituting the basic reality. The task of science is then to start from such parts and to derive all wholes through abstraction, explaining them as the results of interactions of the parts. On the contrary, where one works in terms of the implicate order, one begins with the undivided wholeness of the universe, and the task of science is to derive the parts through abstraction from the whole, explaining them as approximately separable, stable and recurrent, but externally related elements making up relatively autonomous sub-totalities, which are to be described in terms of an explicate order. (Bohm, 1980, p.178-179)

According to Bohm, the implicit and explicit orders seem to be separated, but they actually work in the same process where the explicate order is regarded as a particular case derived from the implicit order. Bohm's explicit order in implicit order can represent mechanism in holism as our new vision of nature. Briggs and Peat further explain the difference between the parts and the whole by using the analogy of music, "In the sense that parts seem autonomous, they are only 'relatively autonomous'. They are like a music lover's favorite passage in a Beethoven symphony. Take the passage out of the piece and it's possible to analyze the notes. But in the long run, the passage is meaningless without the symphony as a whole' (Briggs & Peat, 1989, p.29). We can analyze things into pieces as many as possible in order to know the details of each piece like we separate each note from symphony, but each piece or each note without symphony as the whole will be meaningless. Paul Davies, therefore, argues that the reductionistic approach is not adequate for our understanding of the world, and that we also need the holistic approach.

> In the case of living systems, nobody would deny that an organism is a collection of atoms. The mistake is to suppose that it is nothing but a collection of atoms. Such a claim is as ridiculous as asserting that a Beethoven symphony is nothing but a collection of notes or that a Dicken novel is nothing but a collection of words. The property of life, the theme of a tune or the plot of a novel are what have been called 'emergent' qualities. They only emerge at the collective level of structure, and are simply meaningless at the component level. The component description does not contradict the holistic description; the two points of view are complementary, each valid at their own level….To say that an ant colony is nothing but a collection of ants is to overlook the reality of colonial behavior. It is as absurd as saying that computer programs are not real, they are nothing but electrical pulses. Similarly, to say that a human being is nothing but a collection of cells, which are themselves nothing but bits of DNA and so forth, which in turn are nothing but strings of atoms and therefore conclude that life has no significance, is muddle-headed nonsense. Life is a holistic phenomena. (Davies, 1983, p.62-63)

Hofstadter, with this Zen answer, rejects the idea that we should use merely reductionism or holism to understand the world. We now know that both reductionism and holism can help us reach a better understanding of the world. The mechanical worldview is still a useful and fruitful model, and we need not throw it away. But we need to keep in mind its limitations when we engage in scientific reductionism. Science cannot deny reductionism. But it should not end with a reductionistic approach. Here we may paraphrase Kantian thought: reductionism without holism is blind, but holism without reductionism is confused. Consequently, science should expand to the interconnected network of relationship of all things in the world as Bohm puts it: "everything is internally related to everything through mutual enfoldment. And evidently the whole world, both society and nature, is internally related to our thinking processes through enfoldment in our consciousness" (Bohm, 1988, p.67). A new science would need to expand from analysis of the parts to a new understanding of the whole. With this new approach, we may begin to see that reductionism and holism interpenetrates our understanding of nature.

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