The Emergence of New Diseases Associated with Environmental Pollution
— Toward An Extended Synthesis of Interdisciplinary Subjects —

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Abstract: How safe is our present man-made environment? To what extent does it contribute to chronic illness? Despite the rapidly increasing knowledge of different disciplines in science and technology, we are unable, as yet, to understand a whole picture about these problems. It is just like the famous story about six blind men and the elephant. There are quite different results from the same animal such as a wall, a snake, a spear, a tree, a fan and a rope. These are all right, but all wrong, too. All these answers are the only parts of the large animal. The same is the case in attacking the huge human-and-environment problems. Humans themselves have individual life histories with a variety of genotypes. Surrounding local as well as global environment has changed so rapidly. Uncommon disorders have emerged with relatively long latent periods. The diagnosis of such emerging disorders is still under investigation. We now need to put all the information we have together, in order to most effectively understand the wholeness behind these human-and-environment problems.

The present paper describes a unifying picture based on the current knowledge of science in life, environment and toxicology. With this unifying picture, it is plausible to say that there are potential hazards of modern environmental pollution from a point of view of precaution principles.

Keywords: life theory, chronic physical and mental illnesses

Introduction

Over 40 years have passed since Rachel Carson's pioneer book *Silent Spring* (1962) and Theron G. Randolph's critical book *Human Ecology and Susceptibility to The Chemical Environment* (1962). These books declared man-made chemicals to be potentially hazardous to life itself including humans. The former book focused on the destructive effects of man-made chemicals on wild life in nature. It was the first comprehensive book that clearly mentioned the long-term biological effects of chemical pollution based on the concept of ecology. The latter described how most of us are chronically affected by environmental chemicals from a clinical view point; especially, it described how individual person adapts, fails to adapt (or mal-adapts), or even shows an addiction-like response to the circumstances of his or her existence, as does any other living thing. The term of *Human Ecology* was used to embody such complex biological phenomena of humans to environmental chemicals.

Have we learned a lot of things about environmental pollution-induced illnesses? Unfortunately, the answer is 'No'. Even now, certain common chemical exposures remain unsuspected causes of chronic physical and mental illnesses. What is worse, electromagnetic pollution has progressively occurred everywhere on Earth, despite astonishing evidences with strong cautions clearly written in Robert O. Becker's comprehensive books *The Body Electric* (1985) and *Cross Currents* (1990).

I myself did not realize how worse the environmental pollution can affect a healthy and common man until I got chemical sensitivity syndromes due to the chemical pollutants in the air of my house at November 11, 2001. Undesirable experience of my own illness, before and after the onset of my illness, must be understood in terms of the interdisciplinary subjects such as modern biology, clinical medicine, cognitive science and psychology. Of course, philosophy is also required to accomplish such a comprehensive study.

In the book *The Dynamics of Cellular Motility* (Murase, 1992), I demonstrated that there are the common mathematical features among a wide variety of biological systems such as insect flight muscle, vertebrate skeletal muscle, nervous systems, eukaryotic flagella and cilia.

Self-organization of dynamical behaviors in these biological systems such as the emergence of spatio-temporal chaos and the generation of new orders were also investigated from a point of view of nonlinear physics.

In an invited paper *Alzheimer's Disease as Subcellular 'Cancer': The Scale-Invariant Principles Underlying the Mechanisms of Aging* (Murase, 1996), I proposed a new theory of aging where aging may be regarded as intra-individual evolution under the influence of self-organization. This is the further extension of Stuart Kauffman's idea.

Actually, Stuart Kauffman published the book *The Origins of Order: Self-Organization and Selection in Evolution* (1993), in which he constructed a new theory about the origin of life. The important point of his theory is that natural selection alone, proposed by Charles Darwin's book *The Origins of Species*, does not account for the spontaneous emergence of order (or the occurrence of self-organization). Kauffman tried to combine biological concepts of natural selection and physical concepts of self-organization in order to understand the origin and evolution of life.

In my paper on Alzheimer's disease, I expanded Kauffman's idea on biological evolution to aging phenomena, as aging may be interpreted in terms of within-individual evolutionary process. The publication of my paper was just before *BSE (bovine spongiform encephalopathy)* or *mad caw disease* appeared; that is, I became aware of the importance of *prions (proteineceous infectious particles)* defined by Prusiner (1982) and pointed out that such undesirable proteins must be play an important role in constructing new biology prior to the world-wide panic about a new type of neurodegenerative disorders in humans.

Through Kyoto University Press, I published the book (written in Japanese) *Life as History: The Construction of a Theory of Self-Nonself circulation* (Murase, 2000). By this book, a comprehensive view was proposed based on opposed life phenomena such as self-organization versus self-destruction, evolution versus aging, health versus disease, and opposed theories on the same biological phenomenon such as Darwin's natural selection theory versus Lamarck's acquired inheritance theory, instructionist theory versus selectionist theory (Sporns and Tononi, 1994), and so on. In writing the book, I focused on physical (or bodily) aspects of humans. Then, I noticed that mental (or

psychological) aspects of humans can also be theorized based on my life theory, namely, the self-nonself (or endo-exo) circulation theory. Such an idea was published by a paper *Aging of Mind* (written in Japanese) in 2001. Just after appearance of my paper, I was so disappointed by myself, firstly because I got an environmental illness seriously and secondly because I did not know by any chance the progress of my illness during writing the book and paper.

As a response to my experience, I organized a series of conferences on *Electromagnetic Fields and Their Biological Effects* at Yukawa Institute for Theoretical Physics, Kyoto University, in every year since 2003. The contents and discussions were reported by the monthly journal *Bussei Kenkyu* published by Yukawa Hall (Murase, 2004; Murase, 2005; Murase, 2006). Of course, it is very difficult to get final conclusion about the cause-and-effect relationship between environmental pollution and emergent disease. Nevertheless, as I myself know how long it takes time during the development of physical and mental symptoms, I strongly have to write what is the problem and what is the plausible answer. It is very important and also satisfactory for a chronically ill person like me to know why he is sick, even though a completely satisfactory answer to his serious problem may not be available immediately.

From a point of view of precaution principles, we had better avoid any environmental pollution as much as possible, because, as Randolph (1962) clearly mentioned, the general rule still holds that finding and avoiding causes of illness is better than treating the effects of illness.

What we know determines what we see

Citing imperfect anatomic drawings of Leonardo da Vinci under the influence of distorted knowledge at his age, Alfred I. Tauber (1994) on the book *The Immune Self: Theory or Metaphor?* mentioned that 'persuasive' preconceptions can often guide cognition in a wrong direction. There seems to be a serious dilemma: without right knowledge, we can not rightly observe what is there; but without right observation, we can not get right knowledge. Even though we have right knowledge, we have another dilemma like the old story about six blind men and the elephant:

how do we get a coherent picture by combining 'conflicting' knowledge. It is such a developing and dialectical process that would operate in the interpretation of knowledge itself through the interaction between thinking subject and observed objects.

As Jean Piaget (1950) already pointed out that this developing process based on the relationship between perceiving subject and perceived objects would be strikingly similar to the adapting process based on the progressive interaction between the organism and its environment. Such a parallel relationship between development of knowledge and adaptation of life occurs because, as Konrad Lorenz (1973) on the book *Behind the Mirror: A Search for a National History of Human Knowledge* strongly emphasized, both the perceiving subject and the perceived object share the same kind of reality through evolution. In other words, humans must be regarded not only as the objective physiological processes but also as the experiencing subjective entities, leading to indiscrimination between mind and body. Knowledge itself can, therefore, be understood as a process of evolution. Inversely speaking, we can regard life as a process of learning.

Like any organism during evolution, any scientific and common knowledge must continuously challenged by new insights with emerging evidence. Otherwise, just as some species showed extinction, distorted knowledge may misguide us toward unwilling destruction. As Kitaro Nishida (1921) clearly mentioned on the book *An Inquiry into the Good* that a living thing as well as spirit contains unlimited oppositions giving rise to unlimited variation, and that if spirit is fixed in a single state and cannot switch to opposing states, it dies. Here, it seems to be a problem in attacking scientific problems.

How do we solve such a problem of problems? As Daisetz Suzuki (1949) said that it is *Zen* that proposes its solution by directly appealing to facts of personal experience and not to book-knowledge. My personal experience in suffering environmental illness, therefore, is the source of infinite knowledge. This seems to be able not only to solve the above-mentioned dilemma between knowledge and observation, but also to reconstruct my life theory including environmental pollution.

A unified view of mind and body

How do the diverse parts of the brain create a unified mind? Rene Descartes (1596-1650) was the first scholar to attack this mind-and-body problem. Descartes identified the brain as a palpable organ with length, breadth and a correct spatial locus within the body, and realized that the brain could be broken into parts. Because Descartes found that the mind could not be reduced to the material brain, he simply conducted that there were clear differences between the mind and the brain.

This distinction between mind and body turns out to be an artificial dichotomy. Thinking about a natural history of human knowledge, Lorenz (1973) proposed the strict demand that mind or cognitive functions of humans must be understood in the same way as any other phylogenetically evolved function of a physical system, which serves the purposes of survival under the continuous interaction with a physical external world. It is this unity of human as a physical entity and an experiencing subject that can attack the illusion of many philosophers who do not think in biological terms. The relationship between the identity as object and the identity as subject may be regarded as merely two sides of the same coin.

Investigating the origins of immunology, Tauber (1994) treated immunology as a philosophical subject in order to place the science explicitly in its philosophical context. The philosophy of immunology as well as developmental biology is rich sources for studying the contours of organismal identity, or more metaphorically of the self. The most important subject of immune function is to discriminate the self from the non-self. Because such self-identifying function is fundamentally cognitive, the immune function may be ultimately understood in terms of the cognitive function like the nervous system, as it discriminates the organism from its environment (Jerne, 1974). As physiological immune function of self-nonself discrimination is itself cognitive, the philosophically investigating the immune system proves another good solution to the mind-and-body problem.

A unified view of mind and body also was proposed by Gibbs in the book *Embodiment and Cognitive Science* (Gibbs, 2006). Gibbs mentioned “One of the traditional beliefs in cognitive sciences is that

intelligent behavior, including the ability to perceive, think, and use language, need not arise from any specific bodily form", and continued to mention "the traditional disembodied view of mind is mistaken, because human cognition is fundamentally shaped by embodied experience". As Gibbs suggested, bodily experience, or embodied activity, is central to mental life, leading to a unified view of embodied mind.

Actually, embodiment in the field of cognitive science puts the question: How do our bodies influence the ways we think and speak? But as Carl Gustav Jung suggested on the book *Modern Man in Search of a Soul* (Jung, 1933), this does not mean that there is a greater influence of the body over the mind than *vice versa*. It is possible to put another question: What are the bodily correlations of a given mental condition? It seems to be more difficult to answer this question even roughly rather than the former question, simply because starting from the visible or the relatively known body to the invisible or the unknown mind is easier than thinking in the opposite direction. So, as a first step toward the understanding human mind, Jung tried to derive mental correlative from a mental characteristic in proceeding from the relatively known to the unknown

Consequently, according to advancement in science of animal behavior, immunology, cognitive science and psychology, a unified view of mind and body provides an important perspective to understand human behavior and thought.

Mind as emergent phenomena from nested hierarchies of brain

It is true that the mind extends beyond or is "more than the sum of the parts" of the material brain, and thus that the mind can not be reduced to the brain. This does not, however, immediately lead to the belief of the separation of mind and brain or the belief of the separation of mind and body.

As long as the mind and the brain are viewed as a traditional type of hierarchy known as *non-nested hierarchy* like a pyramidal structure or an inverse tree-type structure with a clear-cut top and bottom as illustrated in Figure 1, the control of the hierarchy has to always come from the top,

as described by Todd E. Feinberg (2001) on the book *Altered Egos: How the Brain Creates the Self*. In other words, there must be unidirectional control from top to bottom. The term of *non-nested hierarchy* means that each level of the hierarchy is independent from all higher and lower levels, while the successive levels of the hierarchy directly interact. Based on this perspective of the non-nested hierarchy, it is necessary to consider that there is the clear separation between mind and brain.

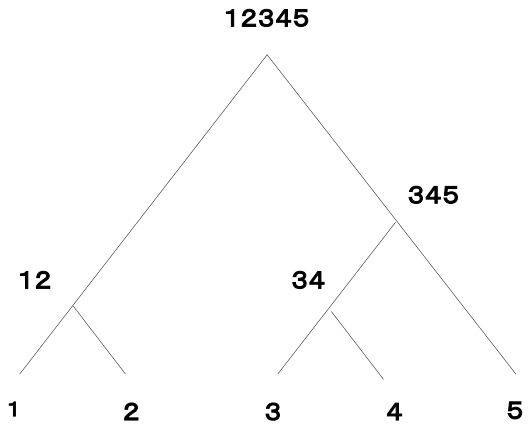

Figure 1: In this non-nested hierarchy, there are five elements (numbered from 1 to 5) at the lowest level. Four nodes assigned series of numbers indicate supra-structure of the non-nested hierarchy.

An alternative framework for viewing the mind-and-brain relationship is different type of hierarchy known as *nested hierarchy*. The term of *nested hierarchy* means that the elements composing the lower levels of the hierarchy are connected or nested within higher levels to create increasingly complex wholes. Such a nested hierarchy has no top or bottom, and as a result, the control of the hierarchy is embodied within the entire complex system.

How are nested hierarchies different from non-nested hierarchies? To answer this question, it is very useful to construct a nested hierarchy from a non-nested hierarchy. When each element (or node) has its connection with nearest neighbor at the next hierarchical level, we get simply a non-nested hierarchy.

When new connections are successively introduced among elements

and nodes at different hierarchical levels, a pyramidal structure deforms and finally a nested whole appears (Fig. 2).

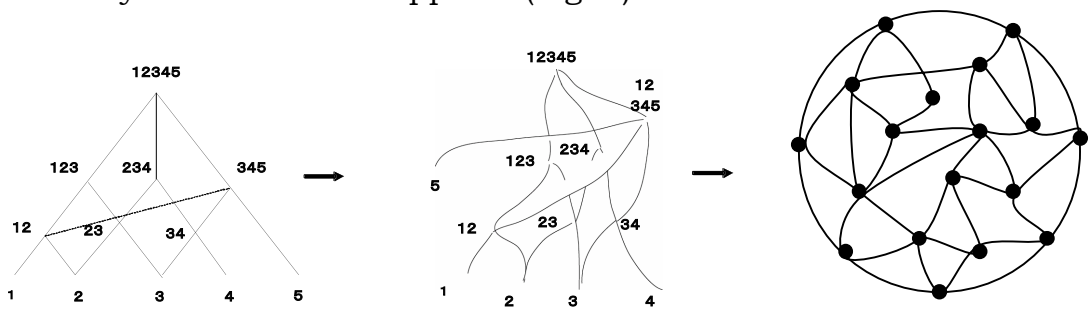

Figure 2: As the connections among elements and nodes are successively introduced at different hierarchical levels, a non-nested hierarchy turns to be a nested whole.

When the resulting nested whole is embodied within the next hierarchy (Fig. 3) and allowed to connect with other nested wholes, a complex structure with nested hierarchy can be constructed.

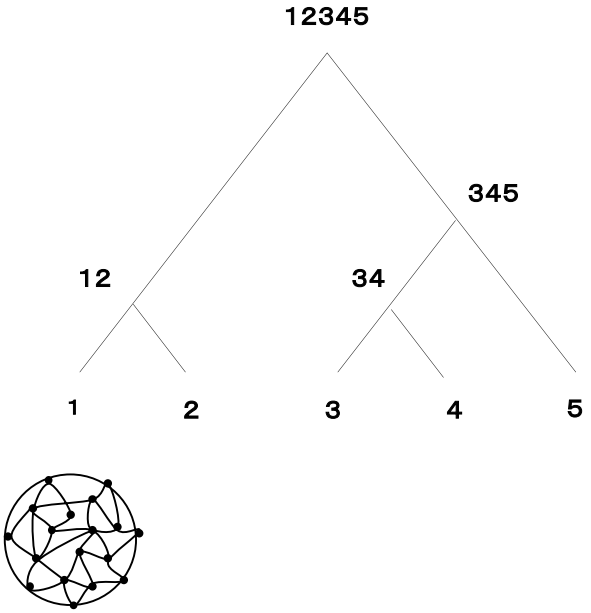

Figure 3: When a nested whole is embodied successively within the next hierarchy, a nested hierarchy is constructed. Here, a pyramidal structure of a non-nested hierarchy has to be deformed again and again like the patterns shown in Fig. 2.

While each level of a non-nested hierarchy is physically independent

from all higher and lower levels, the various levels of a nested hierarchy are composed of each other. All living things, including our brain, are nested hierarchy. Each part of the living system, as does each part of the brain, makes a contribution to its unified emergence into life or mind.

Continuing challenges to the traditional nature-nurture problems

Now, we need to reconsider the way in which we understand causes of the construction of nested hierarchies from non-nested hierarchies. It is the traditional nature-nurture problems that must be taken into account. Actually, we have been facing the traditional nature-nurture problems over and over again. Relating to the concept of 'absolutely contradictory self-identity', Nishida (1921) asked: How is a reality established despite seemingly unlimited oppositions? Discussing the characteristics of humans' types between introverted and extraverted attitude, Jung (1933) asked: How do we determine not only the style of behavior, but also the nature of subjective experience? As Piaget (1950) or Hodapp (1998) asked: How does human development occur? As Burnet (1959), Gazzaniga (1992) or Tauber (1994) asked: How does an immune system recognize any foreign substance? Concerning the endless controversy between transcendental idealists and hypothetical realists, Lorenz (1973) asked: How do we recognize the world? As Oyama (2000) asked: How does an animal exhibit the development of characteristic form? Although all these problems look quite different, the essential question is the same: What is the origin of orders?

A typical case of the traditional nature-nurture problems is found in the explanations of human development. There are two kinds of theorists: developmentalists and behaviorists. The most distinct difference between developmentalists and behaviorists concerns the role of the environment. On one hand, classical developmentalists pay relatively little attention to the environment, that is, they generally think of the environment the way most of us think about air; on the other hand, behaviorists are entranced by the environment, that is, they consider it extremely powerful, serving to strengthen or weaken behavior at every moment

The modern version of the traditional nature-nurture problems is a typical gene-centric view in genetics and molecular biology. It had been hold that an organism's genetic code is so dominant that there is little room for the environment to affect its development. Actually, explanations of how organisms grow and differentiate to develop their own characteristic forms and properties had become framed entirely in terms of "on" and "off" of gene activity. However, we now understand that the interplay between organisms and environment plays an important role in the development of organisms.

The famous chicken-egg paradox concerning the explanation of life's origin seems to be a different version of the nature-nurture problem. When RNA molecules called *ribozymes* were discovered which possess both enzymatic activities and genetic information, we expected that such a discovery solves the paradox. Despite our expectation, we are facing with further dilemma of how self-replicating ribozymes came into existence (Joyce and Orgel, 1993). Here we encounter another chicken -egg paradox: Without evolution, a self-replicating ribozyme hard to arise; but without some form of self-replication, there is no way to conduct an evolutionary ribozyme.

Usually, the emergence of new orders is thought to be creative features of organisms in biology. I had a serious question about this over-simplified view, not only because both Daisetz Suzuki's Zen belief and Kitaro Nishida's philosophy strongly emphasized the important roles of conflicts and oppositions in experiencing and thinking, but also because life phenomena seem to always contain conflicts and oppositions such as struggle between evolving cancer cells and defending host immune system, competition between preys and predators, and so on. I therefore suggest that the emergence of new orders must be understood in a framework of a double-edged sword: new emergent orders contribute not only to a creative process like evolution, but also to a destructive process like aging. Murase (1996) then developed a theory of aging based on this framework.

Reviewing these continuous challenges to the traditional nature-nurture problems, Murase (2000) further constructed the self-nonself (or endo-exo) circulation theory of life. This theory also accounts for the origin of life in the paper *The Origin and Evolution of Life*

by Means of Endo-Exo Circulation briefly written in English (Murase, pp369-376, 2000).

Figure 4 illustrates how a closed self (or endo-system) not only shows identity in contrast with the open environment (or exo-world), but also undergoes evolution through variation and weak selection in the context of a combination of elements involved. This interactive processes between endo-system and exo-world was referred as endo-exo circulation (Murase, 2000).

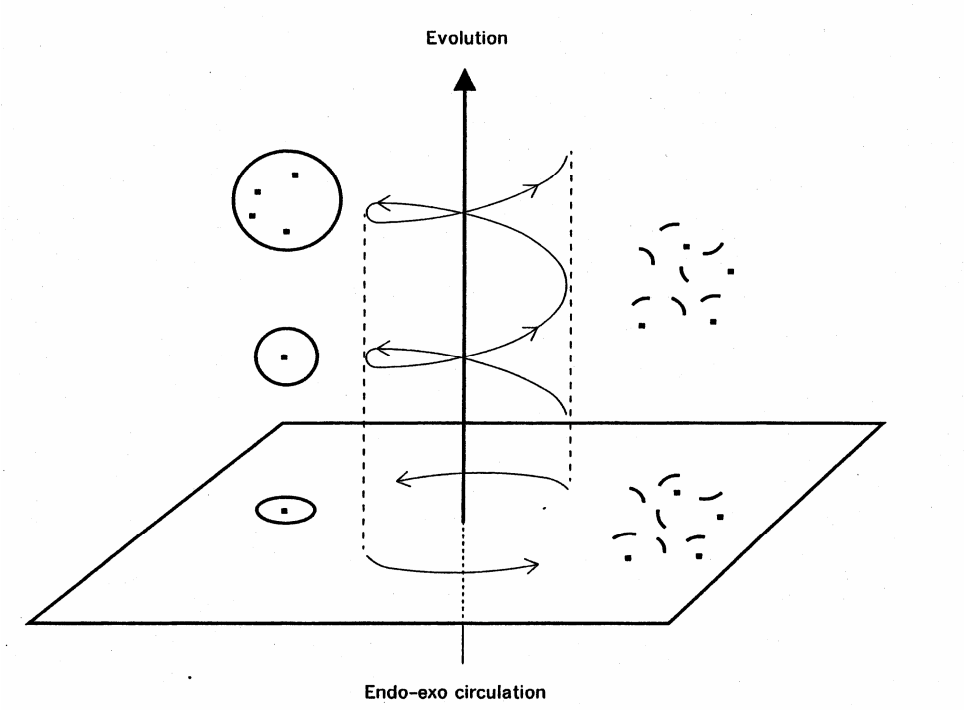

Figure 4: Evolution of a closed self (or endo-system) by means of endo-exo circulation. A closed self can keep its identity as it has the boundaries which isolate the internal materials from the exo-world. Suppose that such a closed self is subject to formation-deformation cycles as shown in the lower panel — that is, the boundaries are broken, allowing entry of new elements from the exo-world, and resealed. At each cycle, the closed endo-system could not retain the same composition as it was before, but instead evolve in a spiral way as shown in the upper panel.

Traditionally, identity and evolution have been ascribed to the same

self-replicating genetic systems, because such genetic systems maintain identity by self-replication and yet undergo Darwinian evolution through variation and natural selection. Resent studies on present-day cells, however, suggest that the membrane processes — such as the growth, budding and fusion of plasma membranes and vesicles, together with the membrane transport and membrane transduction — are not directly controlled by genetic systems, and still they are essential for adaptive behavior of cells, biogenesis of intracellular organelles and many other functions (Rothman, 1994). Actually, each endo-exo circulation can create new combinations of elements involved which might be subject to weak selection through inter-elementary interactions, and therefore, it can reach beyond the boundaries of its identity. Furthermore, the enclosed internal-environment can provide a basis for open evolution, because an almost infinite number of elements are supplied by the exo-world at every cycle. Note that the endo-exo circulation can link different levels of the hierarchy such as individual elements, linear fragments, and membranous boundaries. As a result, the endo-system can undergo continuous complexification with the emergence of new levels of the hierarchy.

Based on this paradigm of endo-exo circulation, we have to consider both nature and nurture, but not either of them. They are tied together from the beginning and inseparable through the dynamical process, say, circulation. Such endless circulation between nature and nurture — or between self (or endo) and nonself (or exo) in the terminology of Murase's theory — gives rise to the emergence of new orders. It is the new orders that account for both creative and destructive features of life.

Environmentally triggered illnesses as emergent phenomena

In this paper, I first regarded a unified view of mind and body as the important perspective to attack the complex problems of human behavior and thought. Then, introducing the new paradigm of endo-exo circulation underlying all the living systems, I discussed that we need to consider not only both nature and nurture at the same time from the beginning of development and evolution of life, but also both creative and

destructive features of life as a result of emergent phenomena. It is now time to synthesize a unified mind-and-body view and a unified nature-and-nurture view, for as William J. Rea (1992) mentioned on the book *Chemical Sensitivity Vol.1*, there must be a simple truth: man's well-being is a function of his environment and living in polluted surroundings adversely affects health.

As Randolph (1962) clearly mentioned "Most illnesses were originally thought to have arisen within the body. Only recently has this age-old concept been challenged". The importance of the outside environment as a cause of sickness was first recognized in infectious disease about one hundred years ago and to allergic disease almost seventy years ago. Despite the improvement of our knowledge of infectious disease, it has been slowly developed for medical science to investigate cause-and-effect relationships between the man-made, non-microbial environment and ill health. Besides cancer, any ill health as well as good health of living systems with nested hierarchies must be considered as emergent phenomena, as Alfred I. Tauber (1994) mentioned that identity is an evolving and dialectical process of an organism engaged in challenges from both its internal and external environments.

First, consider the origins of cancer. Some familial cancer arises inherently; while other arises externally via virus infection, or even triggered by chemicals in the environment. It is now known that cancer arises through the interplay between inherent genotypes and outside environment. In other words, cancer development must be considered as emergent phenomena.

Next, consider a role of environmental chemicals. Most chemicals are not usually avoided deliberately due to a lack of common knowledge of their potential hazards. Not being avoided, they are not usually suspected. Not being suspected, they are not usually avoided. As a result of such an endless circular causality, certain common chemicals remain unsuspected causes of chronic physical and mental illnesses (Randolph, 1962). Even though certain chemical exposures may be suspected, addiction-like responses may be involved and these exposures still continue. Thus, chronic physical and mental illnesses may be considered as emergent phenomena as a result of relative exhaustion of a long-term interplay between the patient and his or her specific

environment.

Now, let us think about consciousness or free will. Robert O. Becker (1990) challenged the traditional common knowledge of consciousness and free will on his book *Cross Currents*:

We believe that our behavior is determined solely by the way our brains integrate information and present it to our consciousness. We also believe that we have the free will to choose either to obey the dictates of our information-processing system or to take another action. In short, we believe that our behavior is internally generated by a process of conscious free will. The possibility that behavior is even in part determined by some unperceived external force — one that influences the operations of our brains without our knowledge — has been rejected, primarily on the basis that there is no known external force that could have any such effect.

Cross Currents (pp218, 1990)

In the early 1960s, after the preliminary works, Becker postulated that external magnetic fields could alter the basic operations of the brain by interfering internal electrical current system. With Dr. Howard Friedman, a psychologist at New York's Upstate Medical Center, Becker conducted experiments to explore the relationship between the occurrence of magnetic storms and the rate of admissions to psychiatric hospitals. They found, as reported by *Nature* in 1963, that there is the significant relationship between incidence of magnetic storms and increases in rates of admissions to mental hospitals.

Later, they conducted laboratory experiments in which they exposed normal human volunteers to controlled magnetic fields and measured their reaction times. They found that magnetic fields as strong as 15 gauss have no effect on reaction time, but that, when modulated at 0.1 or 0.2 Hz, significant effects are produced (Becker, pp219, 1990). These extremely low frequencies are present in the micro-pulsations of the Earth's normal geomagnetic field with the center around at 10 Hz.

Based on these different kinds of investigations at mental hospitals as well as laboratory controlled experiments, Becker concluded:

It would seem that we may not be the free agents we like to think we are.

Our thoughts and actions are, at least to some extent, determined by electromagnetic fields in the environment that we cannot sense and that we remain unaware of to our peril.

Cross Currents (pp228, 1990)

Gibbs (2006) also mentioned that we must not assume cognition to be purely internal, and that consciousness depends on the manner in which brain dynamics are embedded in the somatic and environmental context of the individual's life. Conscious cognitive actions may be, therefore, emergent phenomena through the coupled dynamics of brain, body, and environment.

Since the environmental pollution is getting worse both in chemicals and in electromagnetic fields, almost infinite combinations among such pollutant entities must be suspected as environmentally triggered illnesses. It is even worse when a patient already exposed by the environmental complex pollutions is further treated with additional chemically derived drugs or additional electromagnetic fields for medical purpose. Obviously, a chronically oriented synthesis of all the subjects is needed.

The 21st century's ever-increasing electromagnetic pollutions

Despite the pioneer works conducted by Robert O. Becker about a half century ago, we have ignored the potential health hazards of man-made electromagnetic radiations; especially, the electromagnetic fields of electric-power transmission lines at extremely low frequencies (either at 50 Hz or at 60 Hz) and microwaves at much higher frequencies (around 10^8 — 10^9 Hz).

Several reasons may be considered for our ignorance of the potential health hazards, although there have been a number of studies suggesting the potential health risks:

1). In the range of electric-power transmission frequencies, we just believed the consensus that these extremely low frequencies are benign simply because they are at the low energy levels.

Unfortunately, the first report was published about the relationship

between exposure to 60-Hz magnetic fields from electric lines and childhood cancer by Nancy Wertheimer and Ed Leeper in 1979. Following this pioneer work, the potential health hazards of electromagnetic fields have been more and more reported (Savitz et al., 1988; London et al., 1991; Feychting et al., 1993). Blank and Soo (2003) found that the Belousov-Zhabotinski chemical reaction is accelerated by the exposure of low frequency electromagnetic fields. This finding may provide new insights into electromagnetic interaction mechanisms in living systems.

2). Microwaves in higher frequency range have been used to cook foods, but recently they have also been used for communication systems such as mobile (cellular) phones in nearby frequency range Without shielding of a microwave oven, health hazards must be obvious due to tissue heating effects. So, a safety standard was adopted simply based on thermal effects of microwaves for the use of communication systems. Due to this "thermal-effects-only" concept, most scientists have ignored the new experimental data which would suggest the possibility of non-thermal or direct effects of electromagnetic fields on life.

In spite of our ignorance of the potential health hazards, Martin Blank edited the book *Electromagnetic Fields: Biological Interactions and Mechanisms*, in which non-thermal biological effects of electromagnetic fields are discussed in details. Potential health risks of mobile phone use have been successively reported (Hyland, 2000; Pomerai et al., 2000; Salford et al., 2003; Lonn et al., 2004).

3). In 1950s, the chemical-mechanistic concept of life was established, in which living things were regarded merely as the chemical-mechanistic machines. There is no room to consider the role of electricity and magnetism.

However, the paradigm based on such chemical and mechanistic concept gradually changed after the discovery of magnetotactic bacteria containing magnetic crystals (Blakemore, 1975). Joseph L. Kirschvink (1997) reviewed recent developments in studies of magnetoreception in vertebrates. Becker and Murray (1970) and Becker (1988) reviewed electrical control mechanisms in living systems and emphasized that the chemistry of life must be considered especially on the basis of the underlying forces of electricity and magnetism.

4). We have often encountered with conflicting results about the biological effects of electromagnetic fields as follows: “Several investigators have reported robust, statistically significant results that indicate that weak (about 1 μT = 10 mG) magnetic fields increase the rate of morphological abnormalities in chick embryos. However, other investigators have reported that weak magnetic fields do not appear to affect embryo morphology at all.” as typically reported in the paper by Farrell et al. (1977).

Are these conflicting results good enough to regard the biological effects of electromagnetic fields as plausible artifacts? The answer to this question is absolutely ‘No’. Consider living things and mind as the emergent phenomena driven by endo-exo circulation. As the life of every organisms is surely unique, and so is the mind. Recent book *Principles of Hormone/Behavior Relations* by Pfaff et al. (2004) clearly described that even *endogenous* hormones can both facilitate and repress behavioral responses. Similar *bipolar responses* in living systems to *exogenous* electromagnetic fields were reviewed by Liboff (2003).

The rapid growth in our use of man-made electromagnetic fields, which never before existed on Earth, has occurred with few questions being asked about the safety of living things exposed to such environmental pollution. Ironically, a relatively recent history of such ever-increasing use of the electromagnetic fields quite resembles a rather long history of still ongoing development of new chemicals for new uses. New chemicals, once developed, had to be checked by the results of acute and chronic toxicity studies in animals. Such animal toxicity studies of new chemicals were performed, not only under ‘ideal’ laboratory conditions in relation to already suspected illnesses such as cancer, but also by adopting young healthy individuals of uniform age to single chemical. The results of these animal toxicity studies are therefore not good enough to apply to a wide variety of humans who are daily subjected to complex combinations of many chemicals with little knowledge of their associated illnesses.

As mentioned earlier in this paper, it is true that without appropriate knowledge it is impossible to observe what is there. However, without right observation, it is difficult to get right knowledge. As a result, a sort of distorted knowledge would guide us in an undesirable direction. In

order to understand current human-environment problems, it is necessary to reconsider the long-standing nature-nurture problems once again from an interdisciplinary perspective.

Discussion

To change framework is in the very nature of science, because it is in the nature of science to go on adding to itself, just like history as Arnold Toynbee mentioned on the book *A Study of History* (1988). One of the striking cases was found in the paradigm shift of molecular biology from a pathway-centered view to a network oriented view. Actually, the traditional paradigm of molecular mechanisms within living cells assumed that there is a simple pathway from DAN to protein via RNA known as Crick's central dogma (Crick, 1958). It is the cause-and-effect relationship that is considered in this traditional pathway paradigm as illustrated in Figure 5.

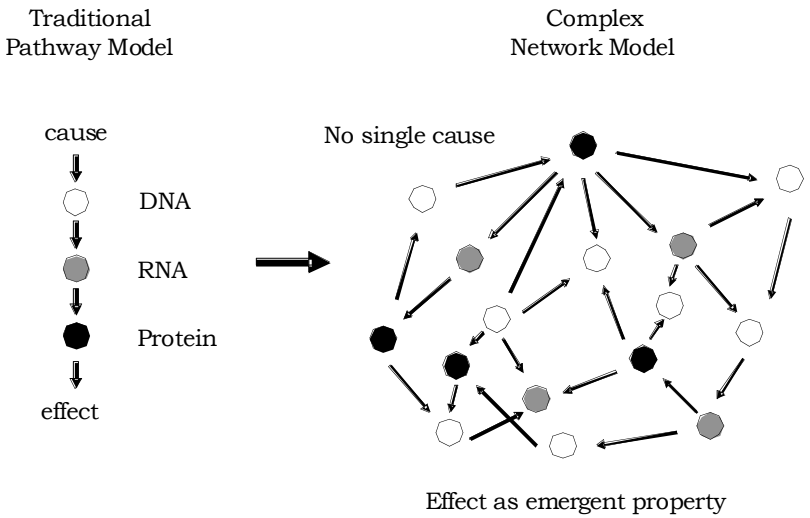

Figure 5: Traditional pathway model and complex network model.

The advanced development of molecular biology has revealed that there

is much more complex picture of the molecular machinery which mediates the cellular response to endogenous growth factors as well as exogenous environmental factors (e.g. Huang, 2002).. In this new network paradigm, it is impossible to assign which one to the cause or which one to the effect.

Here, I have to emphasize two characteristics about this network paradigm. First, without any cause the effect appears as an emergent property of the networked interactions. Second, when one molecule is activated in this networked system, it causes disparate or opposed effects on cell fate.

Consider the fact that bipolar responses in cell signaling (Liboff, 2003), as briefly mentioned earlier in this paper, often result from small changes in concentration of endogenous molecules. If some of these molecules is the target of environmental factors such as man-made chemicals or electromagnetic fields, even a small perturbation may be amplified through the networked interactions.

As illustrated in Figure 6, organism's responses to external environment factors must be studied in a wide range of frameworks.

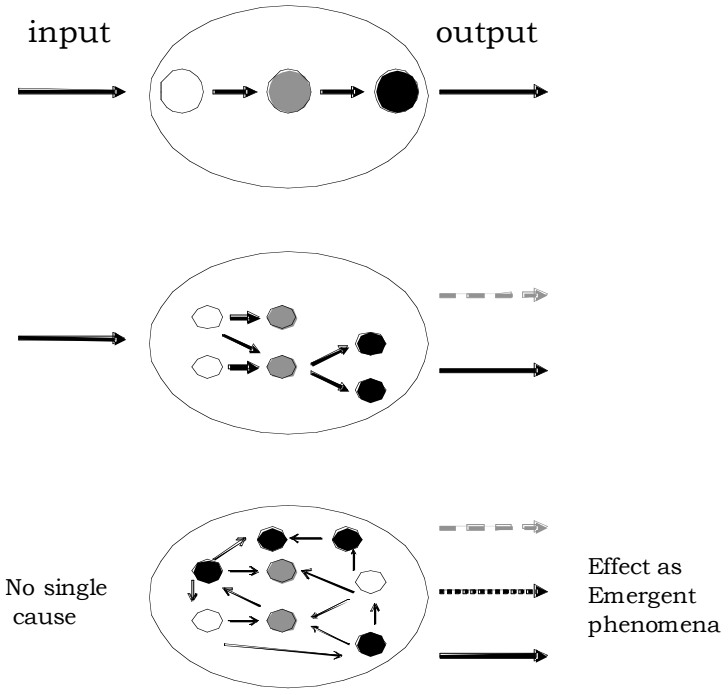

Figure 6: Complex organism's responses.

It is true that a single input signal causes an associated effect (upper

panel), as long as we believe the single cause-and-effect relationship. As molecules are found to possess multiple functions, however, even a single signal turns out to cause often diverse effects (middle panel). When molecules are regulated in a complex network, such a system may no longer require any external input: that is, cellular responses must be understood as emergent phenomena.

Let us consider a unified view of mind-body problem. The above discussion might be easily extended to the nervous system in the brain, although the complexity must be much higher than that of this simple model. The change from a simple pathway model to a complex network model via intermediate semi-network model may be viewed as the development of the nervous system in our brain. Of course, the development of this kind is observed during the ontogeny of our body. Reorganization of the nervous system or the expression of neural plasticity always occurs even in adult. The expression of neural plasticity, once again, has opposed effects: one important effect is used in learning, while the other is adverse effect leading to neurological disorders such as hyperactivity in sensory system.

Aage R. Moller (2006) clearly mentioned on the book *Neural Plasticity and Disorders of the Nervous System* as follows:

Biological systems and especially the human central nervous system are extremely complex systems and the nervous systems in different individuals have different degrees of instability and different amounts of reserves. Even two systems that normally function in exactly the same way can have different degrees of stability, and such differences may only manifest when an insult to the nervous system occurs.

(Moller, p4, 2006)

This kind of diversity must be an obstacle not only in diagnosis and treatment of disorders of the nervous system, but in evaluating the biological effects of environmental factors.

One of the most important features related to neural plasticity is *kindling phenomenon* (Goddard, 1964). Traditionally, the mature nervous system was regarded as relatively stable, except for changes that are related to aging. This traditional concept now turned out to be wrong.

Goddard (1964) conducted the following experiment in which very weak electrical stimulation upon a laboratory animal. Such a weak stimulation has at first no discernible effect on the animal's behavior or on the pattern of electrical activity in the brain. As this weak stimulation continues once a day for several weeks, it begins to produce dramatic change in behavior and in nerve excitation pattern typical of seizures. This kindling phenomenon is essentially permanent even after an interval of a whole year: that is, the same weak stimulus will again trigger a full-blown seizure.

Such a sequence of different degrees of animal's responses to external stimulus may be interpreted in terms of the tree successive panels in Figure 6. Here, the outputs of the first two panels must not be drawn, and the bottom panel must be slightly arranged such that a little input causes an enormous effect as emergent phenomenon.

Since learning of human beings and adaptation of living organisms obey the same principle of endo-exo circulation, our ways of thinking represent the same patterns as illustrated in Figure 7.

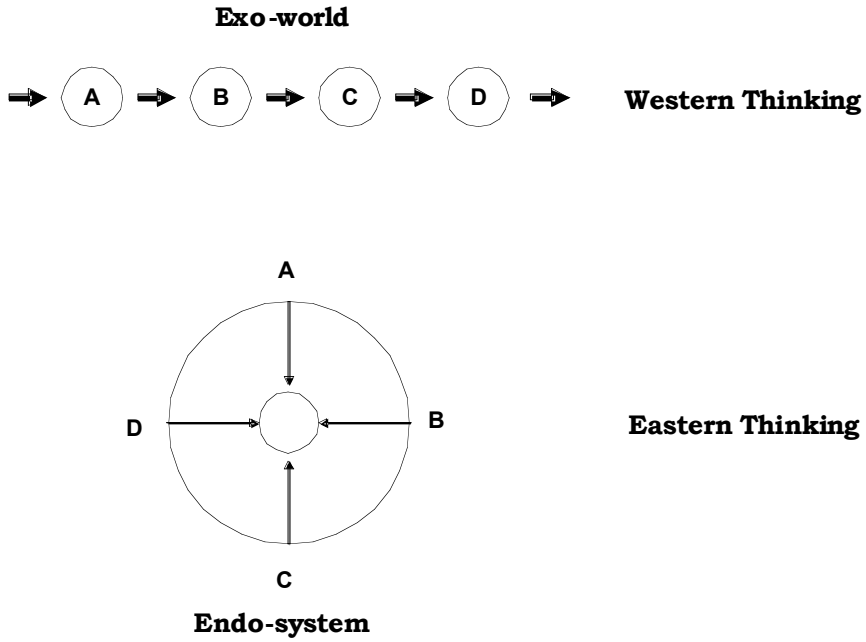

Figure 7: Western thinking and Eastern thinking.

It is well known that there are two kinds of thinking patterns (Jung,

1950; Nisbett, 2003; Gieser, 2005). It is typically Western to think in terms of cause and effect, whereas thinking in simultaneities is said to be typically Eastern. To the Westerner, it is an important question to ask 'what came first, the chicken or the egg', and it is very natural to think in the form of a time lapse, where cause precedes effect. When a current state of affairs is derived from a preceding cause, it is considered that an explanation is now obtained satisfactorily. In contrast, Eastern thinking stands on a comprehensive or a filed-like view rather than a cause-and-effect or an arrow-like view.

As Nisbett (2003) emphasized, both Western thinking and Eastern thinking are equally important in our life. The same is true in our science. Despite the rapid development in our technology and science, we have more and more problems than answers. It is now time to reconsider the Arnold Toynbee's belief that the very process by which growth is sustained is inherently risky (Toynbee, 1988).

In conclusion, the endo-exo circulation can cover both Western thinking and Eastern thinking, as it can bridge between them. Furthermore, the endo-exo circulation can develop nested hierarchies from non-nested hierarchies. The resulting complex systems exhibit opposed phenomena, sometimes observed as conflicting results. But such opposed phenomena are merely the two sides of the double-edged sword. To attack the human-environment problem, we have to have an interdisciplinary perspective.

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