Environmental pollution and health: an interdisciplinary study of the bioeffects of electromagnetic fields

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Abstract: As levels of environmental pollution continue to rise, we are confronted by an important question: how does our degraded environment affect our health? This is no easy question to answer: conflicting results of scientific studies and the fact that environmental change is occurring at an unprecedented rate make it very difficult to correlate suspected environmental causes and probable biological effects. This paper attempts to explore the relationship between today's polluted environment and human health by applying holistic, interdisciplinary and Eastern philosophical perspectives to a comprehensive study of the possible bioeffects of electromagnetic fields.

Keywords: environment and human health, endo-exo circulation, complementarity, electromagnetic pollution, window effects

1. Introduction

More than 45 years have passed since two groundbreaking works alerted humankind to the potential hazards of artificial chemicals in our natural and human environment: Rachel Carson's *Silent Spring* (1962) and Theron G. Randolph's *Human Ecology and Susceptibility to the Chemical Environment* (1962). Carson focused on the destructive effects of artificial chemicals on wildlife, outlining for the first time in any comprehensive form the long-term biological effects of chemical pollution on the natural environment. She argued that even if we human beings could not directly perceive the effects of chemical pollution over a short period of time, ecological changes were evidence of pollution's deadly bioeffects. Randolph focused on how most of us are affected chronically by environmental chemicals from a clinical viewpoint. He looked at how humans adapt, fail to adapt, mal-adapt or become addicted to the chemically polluted circumstances of their existence. Randolph used the term "human ecology" to embody the complex biological relationship between humans and their surrounding environment.

The decades since then have confronted us with a plethora of environment-induced diseases: different forms of lung cancer associated with smoking tobacco and breathing asbestos; asthma from breathing the air in our increasingly polluted cities; and Creutzfeldt-Jakob disease, the human form of bovine spongiform encephalopathy (BSE), a prion disease caused by eating the meat and bonemeal of contaminated cattle. In many cases, we have successfully identified the specific environmental factors inducing these diseases where causal factors are restricted to the local area around the patients — despite the fact that many of today's emerging health disorders have a relatively long latency period of several decades which constantly challenges efforts to identify them.

Is it, therefore, fair to say that we have learned a lot about environmental pollution-induced illnesses? Unfortunately, no. Indeed, human ecology problems remain difficult to identify for a number of reasons, seven of which are listed below.

(1) We tend to deny or ignore environmental changes that cannot be detected by our senses as plausible factors for human diseases. One example would be the increase in artificial electromagnetic fields caused by modern communications networks: being unable to see or otherwise detect them, we are more likely to dismiss their possible adverse effects on our health. In the majority of cases, when diseases arise with no obvious cause — sporadically or over a time frame that distances their occurrence from the cause — we are apt to search for their causes in the wrong places.

(2) We remain trapped by the traditional cause-effect notion that there is a typical cause for an associated effect, such as the relationship between smoking and lung cancer. There are, however, different possibilities, as follows:

  (i) A combination of benign causes can trigger serious effects, though each benign cause induces no effect by itself.

  (ii) Living organisms do not always obey the rules of cause and effect. Two examples are associative learning, where an initially meaningless or unrecognised stimulus becomes recognised and evokes a strong response (think of Pavlov's dog learning to link the smell of meat with the ringing of a bell), and adaptation, where organisms initially sensitive to a stimulus become almost insensitive to it. In the case of associative learning, the effect is amplified with the organism becoming sensitive; under the conditions of adaptation, the effect is almost completely suppressed or the organism shows

fatigue. In each case, the traditional correlation between cause and effect becomes unclear.

(3) Even though certain environmental factors are recognised directly by our senses or indirectly by monitoring equipment, we have almost no way of knowing what kind of latent symptoms may appear, or after how long. New diseases may thus pass completely unnoticed until their symptoms are displayed by a significant portion of the population.

(4) Comparative epidemiological studies cannot effectively be made between affected and unaffected people because rapid, global environmental changes result in there being no 'ideal' unaffected samples to be used as a benchmark. Our whole planet as such becomes a sort of 'disordered laboratory', where experiments on environmental pollution are conducted without any standard for reference.

(5) Most biologists have taken traditionally a nativist position that prioritises nature over nurture. This position holds that we are born with certain qualities and defects dictated by our genes, and disregards the role of environment on the developmental process. More recent emphasis on the role of environment as a potential cause of disease is, as yet, only beginning to challenge the conventional nativist position.

(6) We are familiar with the dichotomy of 'yes' *or* 'no' with regard to any given statement but not the complementary relationship of 'yes' *and* 'no'. An understanding of complementarity enables us to see that seemingly irreconcilable views in general need not be contradictory. This provides a good guiding principle for addressing complex problems for which dichotomous answers of 'yes' ,'no', 'true' or 'false' do not apply.

(7) All complex life is continually subject to intrinsic variability at any level and scale. Life shows transient behaviors, regardless of whether the external environment remains constant. We cannot, therefore, always expect that a given living organism will respond automatically in the same way to the same stimuli, even under the same external conditions. This defies the scientific principle of reproducibility, which states that events occur in the same way under the same conditions, and leaves us with a problem: we can not always identify the internal conditions of complex living organisms correctly. Notwithstanding, so long as we are concerned with the principle of reproducibility from an external viewpoint only, we will fail to understand the real responses to environmental changes. (Note that the processes of associated learning and adaptation described above both violate the reproducibility principle).

The kind of reasoning shown above greatly impedes our understanding of how our polluted environment affects human health and ensures that exposures to environmental pollution remain the unsuspected causes of chronic physical and mental illnesses (see Rea 1992). The same reasoning holds back debate even where suspicion exists. We see this today in the case of electromagnetic pollution, which is increasing rapidly all over the globe because of the growth of electric power and communication systems such as cellular telephones, despite the publication of scientifically backed calls for caution such as *The Body Electric* (Becker and Selden 1985) and *Cross Currents* (Becker 1990). Becker blames a chemical-mechanistic paradigm that dates back to the 1950s for a concept of life that perceives living things as machines, whose functional capabilities are dependent on chemical reactions. Under this paradigm, there is no place for any other factors, such as forces of electricity and magnetism to influence life for good or ill.

The existence of magnetic materials in microorganisms and more complex organisms, such as bees and pigeons, was first reported in the 1970s (Blakemore 1975; Gould et al. 1978; Walcott et al. 1979). Further research revealed the presence of magnetic materials in humans in the 1990s (Kobayashi and Kirshvink 1995; Kirshivink 1997). It was reported that our bodies and brains generate electromagnetic fields within and around us (Cohen 1972; Becker 1985, 1990) and that a variety of tissues in the body are capable of conducting an electrical current (Becker 1985; 1990). All of these findings suggest that naturally occurring as well as man-made external electromagnetic fields may have an effect on human biological processes, triggering concern that some of the effects may be detrimental to human health. Electrical devices such as pacemakers, computers and even satellites have been known to malfunction as a result of external electromagnetic fields. How prudent is it, then, to continue to ignore the possible influence of external electrical and magnetic fields on our bodies?

In Sections 2 to 6 of this paper, I present approaches, taken from a wide number of disciplines, with a view to suggesting a more holistic way for us to understand our relationship with our degraded living environment — one that affords us the wider perspective we need to comprehend fundamental scientific problems and the complex problems of environmental health that we face today. Sections 7 to 8 present a detailed discussion of the hazards posed to human health by electromagnetic pollution (see also Murase 2004, 2005, 2006). My conclusion sets out to synthesise the perspectives presented in this paper into a more coherent and holistic approach that may serve us whenever we confront disorders caused by the bioeffects of environmental pollution, be these electromagnetic, chemical or from some other, perhaps yet to be discovered, source.

2. Health, disease and environment for the evolving organism

Before approaching in more detail the question of how environmental pollution affects human health, it might be pertinent to consider what we are and what makes us what we are. In the following, I focus first on body and then mind in setting out to establish some of the basic principles underlying complex life phenomena. We begin with the classic scientific question: how do new species of living organisms originate?

2.1 Darwin's natural selection theory on the origin of species (1859)

The evolution of life on earth is the result of endless competition among a variety of organisms under varying environmental conditions. No organism is unchanging: all evolve through adaptation. We have learned this from Charles Darwin, whose theory of evolution is summarised in the phylogenetic tree diagram pictured in Figure 1.

Darwin's thesis was simple, albeit revolutionary. The phylogenetic tree depicts time as linear, proceeding from the bottom to the top. Preexisting variable organisms are denoted by *A, B, C, D* and *E*, respectively. When preexisting variable organisms encounter a particular environment, the organism best equipped for survival, in this case, organism *A*, is selected. The selected organism then proliferates to build up a new species as time proceeds, one generation succeeding the next, each generation marked by change.

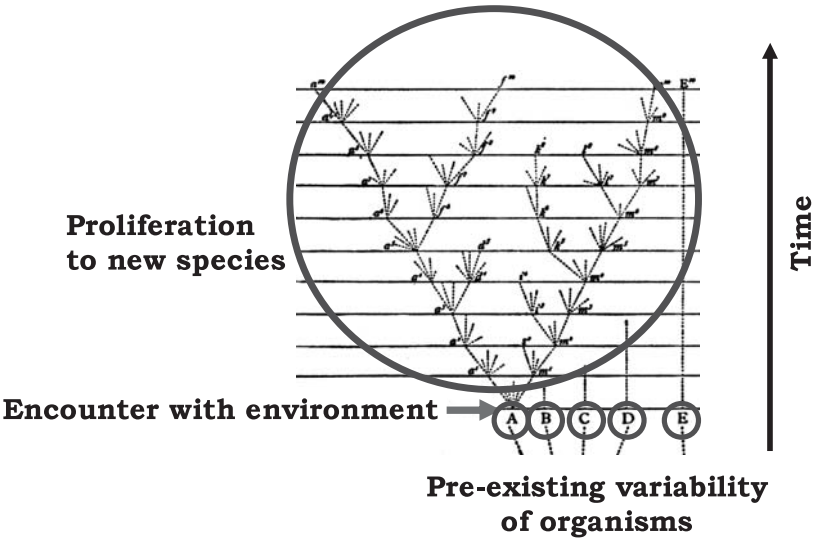

Fig. 1 Darwin's phylogenetic tree (modified by Murase)

Darwin's natural selection theory rests on three conditions, which must be met for natural selection to occur.

(1) A large repertoire of heritable variability must be generated and preexist at the level of individual organisms. Non-heritable variations do not play a part in the evolutionary process because they cannot be transmitted to later generations.
(2) Each organism encounters the environment that dictates the criteria for selection.
(3) The selected or adapted organism produces offspring.

For Darwin, writing in 1859, new species originated from adapted organisms interacting with a certain environment. Exactly 100 years later, Frank Macfarlane Burnet applied Darwin's theory within the context of immunology, in doing so, breathing new life into a fascinating question: how does our immune system discriminate the self from the non-self? What, indeed, is the self?

2.2 Burnet's clonal selection theory of acquired immunity (1959)

The human body is composed of two different classes of cells: dividing, inter-differentiated cells, such as immune and liver cells; and non-dividing, post-differentiated cells, such as nerve and muscle cells. Both dividing and non-dividing cells are subject to change in different ways as we see in Sections 2.3 and 2.4. Where Darwin considered the ecological system as a society of descendants of proliferating organisms, Burnet depicted our immune system as a society of clones of dividing cells. Because variations and heritability are held in the cell lineages within the immune system, the general principles of natural selection known to govern the adaptive evolution of organisms in an animal society are also capable of governing the adaptive behaviour of dividing cells as members of a cellular society.

As long as dividing cells exist, the body is inevitably exposed to different clones of variant cells through successive rounds of genetic mutations and natural selection. Our immune system takes advantage of this preexisting pool of variant immune cells, allowing natural selection — or clonal selection — to immunise the self against non-self factors such as invading antigens from the external environment.

Figure 2 — a summary of Burnet's clonal selection theory — shows the cell lineages within the immune system. Like Darwin's natural selection theory, Burnet's clonal selection theory stands on three conditions:

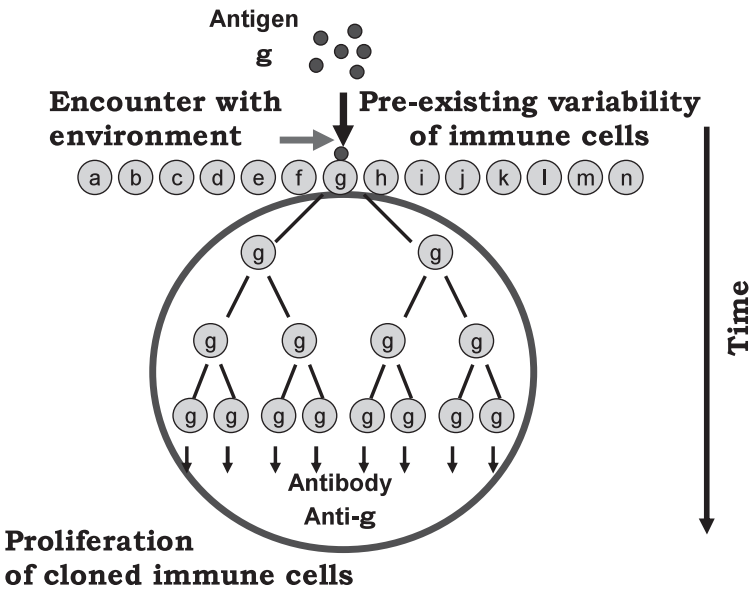

Fig. 2 Burnet's clonal selection theory

(1) A large repertoire of variable immune cells must be generated and pre-exist. These are denoted *a* to *n* in the figure.

(2) Pre-existing variable cells encounter new environmental conditions in the form of an antigen, which dictates the criteria for selection. In the figure, cell *g* is selected since it has a receptor — an antibody — that can attach specifically to the antigen g.

(3) The selected immune cell *g* responds to the given antigen g by producing clones. A large amount of the antibodies — anti-g — are produced when the clones start to proliferate.

Although the scale of this immune system is quite different from that of the ecological system, the underlying principles are the same.

2.3 Clonal evolution theory and the origins of malignancy

Clonal selection theory presents us with a serious dilemma. The same principles of natural selection that make dividing cells essential to the body's immune system, can also allow any dividing cell to be malignant within the same body. Clonal evolution theory explains how cancer cells develop in accordance with the principles of Darwin's natural selection, applied at the cellular level (Cairns 1975; Nowell 1976).

This can be seen in Figure 3, in which time's progression is shown from left to right, and the development of malignant cells is depicted as a micro evolution-

ary process. In the figure, a large repertoire of newly emerging variable cells denoted by *a, b, c, d, e* and *f* occur as a result of heritable mutations. One of these cells — *d* in the figure — clones itself by cell division when it comes into contact with endogenous factor *x*. Further rounds of mutation and selection result in the development of different kinds of cells, denoted by *d, f, g, h, i* and *j*. When the latter encounter an environment, denoted by exogenous factor *y*, a selected cell — *f* in the figure — clones itself through cell division. Through successive rounds of heritable mutation and selection, originally benign cells may in this way become increasingly malignant under the varying environment.

It is essential here to observe the role played by environment — the internal environment of the body itself, as well as the external environment in which the body lives. Cancerous cells can occur as a response to endogenous factors such as hormones, as well as exogenous factors like environmental chemicals and, ironically, anti-cancer drugs. In each case, environment plays a crucial role and the principle of natural selection is revealed as a double-edged sword that can work both for and against the body. Here we see two opposing evolutionary processes, both conducted by the clonal selection process written into the immune system. The same mechanism that promotes health may also end in disease, in this case cancer. From a hierarchical point of view, these evolutionary processes occur within the still-evolving organism. The organism's identity is challenged by both its 'internal' and 'external' environments, and the unity or

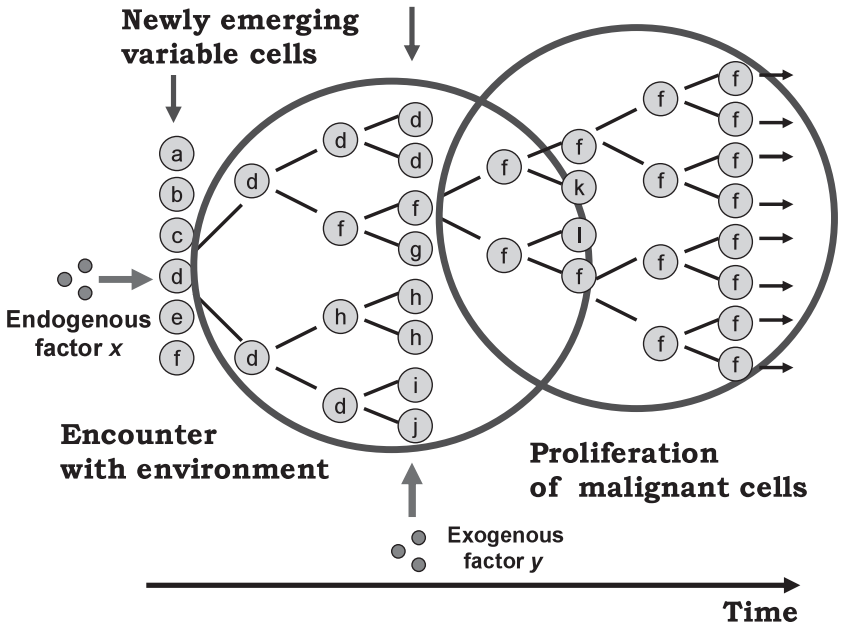

Fig. 3 Clonal evolution theory and cancer development

coherence of the self is seen to depend on the delicate balance negotiated by within-body competition in the face of environmental variation.

So far, we have learned two ways in which dividing cells may behave. What can we learn with regard to non-dividing cells?

2.4 Neurodegenerative disorders as intracellular 'cancer'

The above section identified cancer in terms of the micro-evolutionary process of dividing cells within our body. In this section, we look at the origins of neurodegenerative disorders such as Alzheimer's and prion diseases, both of which are caused by the selective cell death of non-dividing neurons in the brain. In 1996, I proposed a theory of aging that explored the origins and causes of neurodegenerative disorders and suggested that the self-aggregation of abnormal molecules responsible for neuronal cell death resembles, in many respects, the development of malignant cells. Although neurodegenerative disorders and cancers differ in pathology, they nevertheless obey the same principles of natural selection regardless of the level and scale of their biological organisation.

We can begin by considering how natural selection operates at the level of molecules within a single non-dividing cell. A 'normal' intracellular environment is shown in Figure 4 (a). Here, a number of different circles are used to denote a

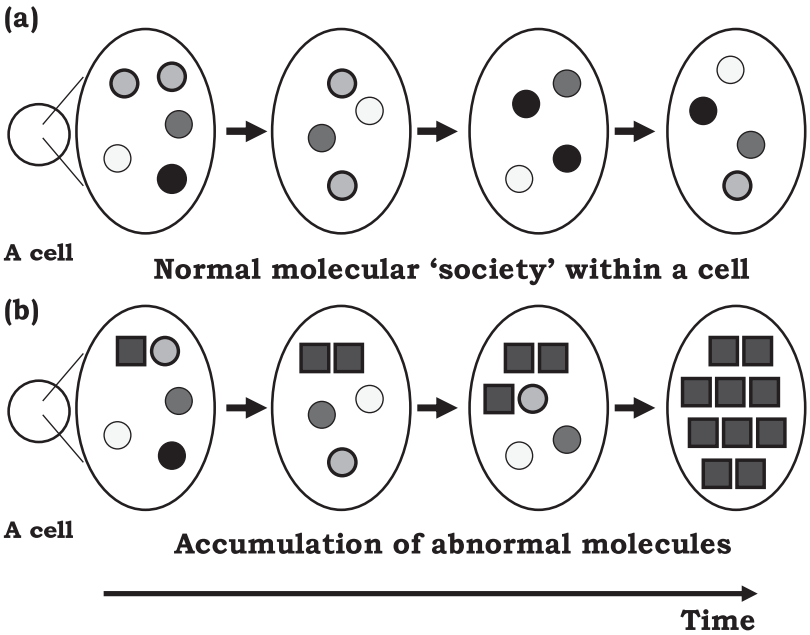

Fig. 4 Molecular society within a single non-dividing cell in (a) normal and (b) abnormal cases. ○ and ■ denote normal and abnormal molecules, respectively

variety of molecules in different states of synthesis and degeneration. Together, they form a dynamic stable-state. All cell molecules in a dynamic intracellular environment are possible targets of variation and natural selection. Targeted molecules, which have become non-degenerative in nature, may begin to accumulate within the cell. This situation can be seen in Figure 4 (b), which starts with a single molecule that has deformed from ○ to ■ through mutation or external influences. The resultant deformed molecule causes nearby normal molecules to become abnormal and, in doing so, acts very much like a kind of intracellular cancer. Eventually, the accumulation of abnormal molecules destroys the cell. This process is the origin of all neurodegenerative disorders.

We have now seen that all the cells have the potential for variation and selection, regardless of whether they are dividing or non-dividing. Health and disease, or life and death, are conducted under the same principles, although different processes occur at different levels and scales of biological organisation.

3. What we know determines what we see

We perceive objects through our senses and conceive their image as reality. What happens, though, when our senses deceive us with illusions, or when what we know — or what we think we know — determines what we see? How do we gain a faithful picture of the world when we cannot be sure that what we see is really there?

3.1 'Right' knowledge versus Heisenberg's uncertainty principle

Referring to the imperfect anatomic drawings of Leonardo da Vinci, Alfred I. Tauber shows in *The Immune Self: Theory or Metaphor?* (1994) how 'persuasive' or distorted preconceptions of what is true or right in a particular historical period can often guide cognition in the wrong direction. Scientific progress for this reason depends upon revolution: a new theory must destroy an old one for cognition to move in a new direction. That said, most of the so-called revolutionary concepts in science refine, extend or generalise upon old systems of thought. This makes scientific development intrinsically *evolutionary*. Indeed, in much the same way as any organism undergoing the evolutionary process, scientific and common knowledge evolves through a process of interaction with environment: in this case, an environment made up of new insights and emerging evidence. Just as some species face extinction on account of maladaption, distorted knowledge may lead us unwittingly to our destruction.

We face a serious dilemma: without the right knowledge, we cannot rightly observe what is there; but without the right observation, we cannot attain the

right knowledge. Modern physics may help us understand this dilemma somewhat: Heisenberg's uncertainty principle (see Schrödinger 1958) notes that observing a particle alters its normal or regular state or path. As a result, there is always uncertainty about the state of the particle. The outcome of experiments can only be understood statistically because there is no way to describe the state of the particle precisely. For objects, as for particles, we are all both actors and spectators. Consequently, our knowledge, resulting from perceiving the external world, can never be final or complete. We must always be ready to change our notions of reality by combining different knowledge of different subjects.

3.2 'Conflicting' knowledge versus Bohr's complementarity principle

Let us consider for a moment the famous story about six blind men and their encounter with an elephant, illustrated in Figure 5. Led to the elephant and asked to describe what they are touching, they give six very different answers: a wall, a snake, a spear, a tree, a fan and a rope. Each man's answer is right — all six speak from personal experience and knowledge. Yet all six men are also wrong. The moral of this story is that there is no right or wrong answer. There are just different ways of perceiving the same reality.

The story of the six blind men alerts us to a second dilemma that affects us all. How do we build a coherent picture of a given reality when our only tool is conflicting knowledge? Niels Bohr's complementarity principle in modern physics may be instructive here (Kothari 1985: 325–331). Bohr observed that elementary particles at the atomic level exhibit a wave aspect as well as a particle aspect. These two aspects are contradictory and mutually exclusive in the everyday world. In the microscopic world of elementary particles, however, they may be considered as complementary, not contradictory.

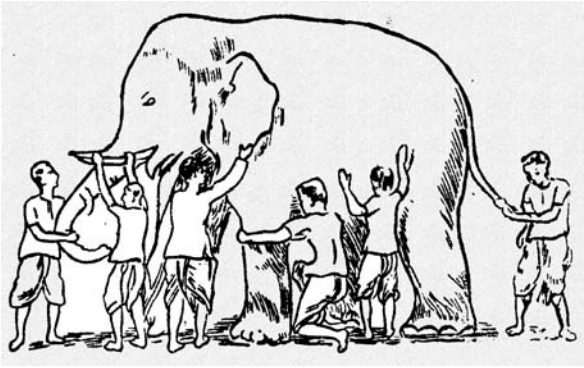

Fig. 5 Six blind men and an elephant
(Source: http: //www.jainworld.com/education/stories 25.asp)

To consider opposites as complementary seems to require a paradigm shift in how we think about reality. Does it, though? Many of the deep insights in the classical texts of Eastern philosophy, such as the *Upanishads* and Buddhist texts, readily apply the complementarity idea to questions of life and existence and voice a denial of absolutism in any of its forms (Schrödinger 1958). So could the complementarity principle work for us now, in guiding us through problems not only of life but also science?

3.3 From dichotomy to dynamic circulation: the evolution of subject and object

Based as it is on ancient Greek thought, present scientific thinking is often described as 'Western'. A clear distinction between subject and object is central to the so-called Western scientific paradigm. It is believed that we obtain knowledge about a given natural object in strict isolation from other objects and from ourselves as perceiving subjects. Such is our inherited scientific world picture. How accurate a world picture does this present?

Schrödinger offers us a good summary of our present situation:

> What is new in the present setting is this: that not only would the impressions we get from our environment largely depend on the nature and the contingent state of our sensorium, but inversely the very environment that we wish to take in is modified by us, notably by the devices we set up in nature to observe it. (Schrödinger 1958: 126)

We would be wise, therefore, to reassess our relationship as subjects with the objects around us, perhaps bearing in mind the dictum: "There is nothing either good or bad: thinking makes it so." By moving away from the traditional scientific world picture, we take part in an evolving and dynamic process in which knowledge is produced through the interaction between thinking subject and observed objects. The dialectical process that results is common both to the history of scientific evolution and the history of development in an individual's life cycle.

Jean Piaget (1950) noted the striking similarity between these two processes: first, the developmental process of knowledge arising from the interaction of perceiving subject with perceived objects; and second, the evolutionary process of their structure and function arising from the interaction of organisms with their environment. The parallel relationship between the development of knowledge and adaptation of life occurs because both the perceiving subject and the perceived object share the same kind of reality through evolution (see Lorenz

1973). In other words, humans are at once objective physiological entities and experiencing subjective entities: this dual capacity leads to the blurring of boundaries between mind and body.

4. A unified view of mind and body

In the previous section, I focused on the complementarity approach to advance our knowledge about the 'outside' world. Let us now consider the 'inside' world: the internal relationship between mind and body. What guidance might the complementarity approach provide in deconstructing the traditional mind-body dichotomy that has dominated the histories of Western philosophy and science?

4.1 Descartes and the dichotomy of mind and body

René Descartes (1596–1650) was influential in identifying and propounding the dichotomy of mind and body. He identified the brain as a palpable organ with length, breadth and a correct spatial locus within the body and observed that the brain could be broken into various parts, each performing a unique function. Unable to locate the 'spiritual' mind in the 'material' brain, Descartes simply concluded that there were clear differences between mind and matter.

Cogito ergo sum (I think, therefore I am): Descartes' famous dictum evokes a subjective-idealist position that suggests all we know about objective reality in the 'outside' world is defined by the internal experience of the subject. Damasio (1994) summarises the impact of Cartesian thought on Western medical and neuro-scientific perceptions of body and mind as follows:

(1) The mind can be fully explained solely in terms of brain events.
(2) There is no need to consider the rest of the organism and the surrounding physical and social environment.
(3) Part of the environment is itself a product of the organism's preceding actions.
(4) Diseases that affect the body do not have any psychological consequences.
(5) Mental illnesses do not cause bodily effects.

Objectivation tries to exclude all the subjects from the world, though our bodies are always part of the world. Yet science is itself a function of the subjective mind, in which all knowledge is rooted. Here we are faced with the relationship between subjective mind and objective body. We now know that the mind-body dichotomy originated from the subject-object dichotomy. What will happen now

to the mind-body dichotomy, given that the distinction between subject and object has been proved false?

4.2 Embodied mind

Let us think more about the disintegrating boundary between subject and object, given what we now know about cognitive function. Over the course of evolution, single cells without neurons became huge multi-cellular organisms that, in time, acquired a complex nervous system and cognitive function. Evolution in this sense inverts Descartes: I am, therefore I think. Putting together a history of human knowledge, Lorenz (1973) proposed that mind or human cognitive function must be understood in the same way as any other phylogenetically evolved function of a physical system, which survives through a process of continuous interaction with a physical 'external' world. Lorenz's supposition may be supported by Varela et al., who propose in *The Embodied Mind* (1991) that our bodies must be considered both as physical outer structures and experiential inner structures. These two sides of embodiment are not opposed; instead we continuously move back and forth between them. Here, the body serves not only as the context of cognition but also as a living experiential entity.

Gibbs joins the debate for a unified view of mind and body by arguing strenuously against the disembodied view of mind. Beginning "one of the traditional beliefs in cognitive sciences is that intelligent behaviour, including the ability to perceive, think and use language, need not arise from any specific bodily form" (Gibbs 2006: 2), he argues that the contrary is the case: "human cognition is fundamentally shaped by embodied experience" (Ibid: 3). Bodily experience is central to mental life: embodied activity and embodied mind must be considered in terms of unity and not separation.

4.3 Another aspect of embodied mind

The concept of embodiment in the field of cognitive science poses a question: how much do our bodies influence the way we think and speak? As Carl Gustav Jung warns in *Modern Man in Search of a Soul* (Jung 1933), there is no reason to assume that the body exerts a greater influence over the mind than vice versa. The opposite question is therefore equally valid: what are the bodily correlations of a given mental condition? Answering the latter is perhaps harder even than addressing the former, given that starting from the visible or relatively known body in our attempts to understand the invisible or unknown mind is conceivably easier than thinking in the opposite direction. Difficult or not, Jung encourages us not to shrink from the tight relationship between mind and bodily behaviour. His attempt to identify different psychological types in close correspondence

with bodily attitudes is just one of the ways in which he explores the influence of mind on physical behaviour.

An investigation by Tauber (1994) of the origins of immunology lends weight to Jung's conclusions. Both immunology and developmental biology provide rich sources with which to explore the contours of identity and 'self' for living organisms. In the case of immunology, for example, the most important purpose of immune function is to discriminate the self from the non-self. This self-identifying function is fundamentally *cognitive:* it therefore follows that the immune system may be understood ultimately in terms of the cognitive function like the nervous system (cf. Jerne 1974). Physiological immune function of self-non-self discrimination is cognitive: here, yet again, we glimpse a unified view from which to address problems of mind and body.

Section 4 borrowed from the fields of immunology, cognitive science and psychology to create a synthesised view of mind and body that offers an important perspective on the understanding of human behaviour and thought. How might this perspective be used to understand the emergence of physical and mental diseases associated with environmental pollution addressed in Sections 7 to 9 of this paper?

5. Brain, mind and the constitution principle

5.1 From sequential information processing to context dependence: the visual pathways of the brain

It was believed as recently as the 1970s that the brain processed information sequentially by following a chain of command. The traditional way in which the visual pathways of the brain were considered is depicted in Figure 6 (a). Here, the optic nerve connects the eyes to a region in the thalamus called the lateral geniculate nucleus, before connecting to other regions of the brain via the visual cortex. Visual information enters through the eyes and is relayed sequentially via the thalamus to the visual cortex. The information in the visual cortex is then sent to other parts of the cortex for higher-order processing in the brain.

Varela et al. (1991) have described animal experiments revealing that neurons in the visual cortex respond to specific visual stimuli. A simple stimulus-response relationship occurred when an animal was anesthetised in a highly controlled 'internal' and 'external' environment. The animal was next studied without the use of an anesthetic, under rather more natural conditions. This time, when the animal was awake and able to move, the same visual stimulation gave rise to different neural responses in the primary visual cortex. The change in response to the same stimulus occurred because a small change in animal's posture took

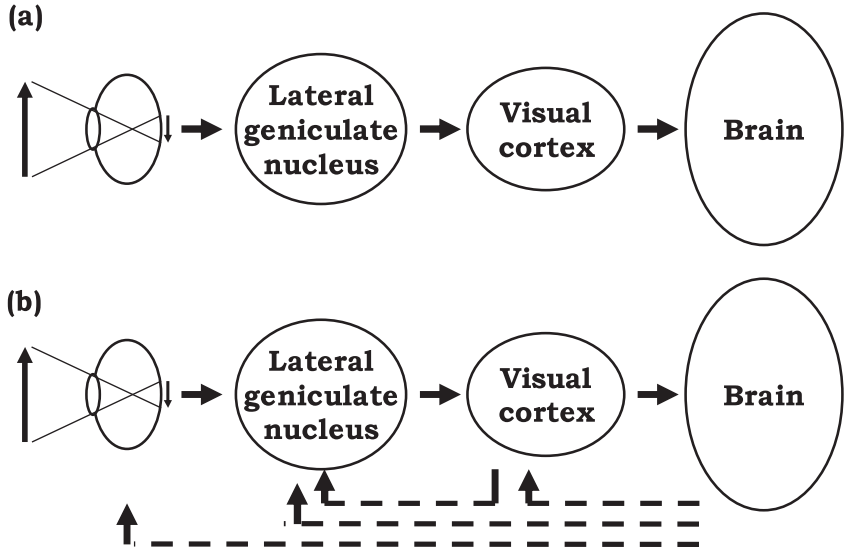

Fig. 6 Connections in the visual pathway of the brain: (a) traditional pathway; (b) interactive pathway

place. In other words, the animal's responses were highly context-dependent. This experiment demonstrates that seemingly remote motion is in resonance with sensation. This revises our understanding of the traditional pathways of the brain, and suggests, once again, that mind and body are a unified part of the same highly cooperative system.

Figure 6 (b) depicts the visual pathways of the brain as they are understood today. The lateral geniculate nucleus is shown embedded within the brain network, receiving information not only from the eyes but also from the visual cortex and other parts of the cortex, as indicated by broken lines. This interactive pathway model offers a better description of reality than the sequential information-processing model on which the brain was originally thought to function. Here, the complex networks in the brain seem to obey the *constitution* principle: if a region A connects to B, then B connects reciprocally back to A. This principle holds not only for the subsystems of the brain but also at the level of connections among those subsystems. The resulting dense interconnections among various components in the brain engineer both coherence and cooperation within the system: what a local component within a given subsystem does depends on what all the other components of all the subsystems are doing.

Knowledge of these interconnections transforms traditional perceptions of the brain as a highly hierarchical structure. What implications does our new understanding of the brain as a series of interconnected subsystems have for our understanding of 'mind', which extends beyond — and is more than the sum of

the parts — of the material brain?

5.2 From non-nested to nested hierarchy

Figure 7, a pyramidal or inverse tree-type structure with a clear-cut top and bottom, represents a typical non-nested hierarchy: the two ends of the hierarchical spectrum remain independent while the neighboring levels of the hierarchy interact directly. Five elements from 1 to 5 appear at its lowest level and four nodes are assigned a series of numbers, denoted by 12, 34, 345 and 12345. Together they indicate the supra-structure of the non-nested hierarchy.

Viewing the mind and brain as a traditional type of hierarchy obliges us to perceive them as separate, because the various levels of a non-nested hierarchy are not composed of each other. In addition, we put them in a hierarchical relationship within which control must always come uni-directionally, from the top to the bottom (see Feinberg 2001). We have already seen one good example of a non-nested hierarchy: the traditional pathway diagram depicted in Figure 6 (a).

An alternative framework for viewing the mind-brain relationship is offered by the nested hierarchy model. How do nested and non-nested hierarchies differ? Figure 8 helps us answer this question by constructing a nested hierarchy from a non-nested hierarchy. On the left, we begin with the simple non-nested hierarchy depicted in Figure 7, where each element (or node) ordinarily connects with its nearest neighbour *only* at the next hierarchical level. If, however, an intra-level connection takes place — as is implied, for example, by the broken line connecting node 12 and node 345 — the structure begins to transform as it becomes deformed. This state is indicated by the middle panel of the figure, where the number of connections among the elements increases and the pyramidal structure starts to collapse. The completion of this process is presented on the right of

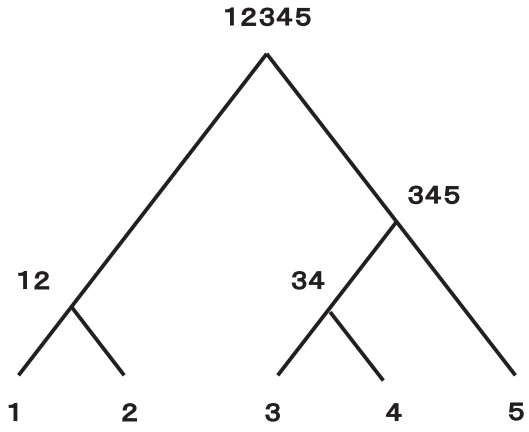

Fig. 7 The non-nested hierarchical model

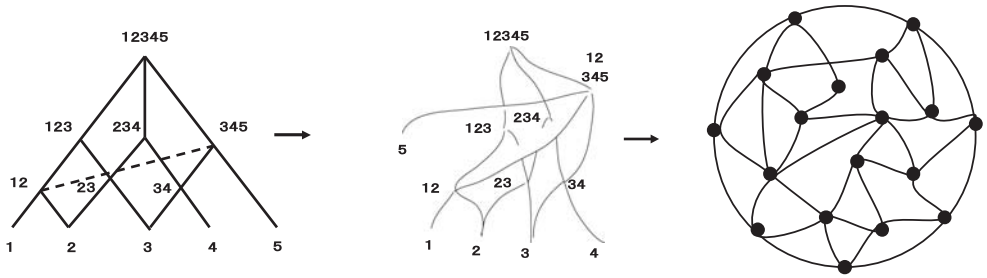

Fig. 8　A non-nested hierarchy（left）becomes a nested whole（right）

Figure 8. Here, the elements composing the lower levels of the original hierarchy are connected or nested within higher levels. An increasingly complex whole is created, with no top or bottom or clear-cut direction for command. Control within this now-nested whole is instead embodied within the entire complex system.

It is pertinent to remember the constitution principle at this point. If A connects to B, and B connects reciprocally back to A, as we saw in Figure 6 (b), we might expect each component of our nested whole to connect not only with neighboring components but also to the different components of different subsystems. Nested whole connects with other nested whole through repeated cycles of connection and collapse, resulting at last in the construction of a complex nested hierarchy.

What are the consequences of this process of transformation from non-nested hierarchy to nested whole to nested hierarchy? Clearly, while each level of a non-nested hierarchy is physically independent from all higher and lower levels and the control of the hierarchy comes from the top, the various levels of a nested hierarchy are composed of each other and the control of the hierarchy is embodied within the entire hierarchical system (see Feinberg 2001). Any living organism is a nested hierarchy within which every part of its system is connected and interdependent.

The brain, we may extrapolate from this, connects with the mind, while both connect with everything that makes up life. The mind cannot be reduced to the physical, material brain, just as life can not be reduced to mere physical and material substances. In the nested hierarchy of mind and body, the immaterial mind can cause material events to happen in the brain and body while the opposite is also true: bodily events can influence was goes on in the mind. There is, in short, no clear distinction between mind and body. Mind and matter are one and the same.

6. Separation and merging as the same action of a wholeness

The tendency to distinguish between the interior and exterior may be considered intrinsic to Western thought (cf. Atmanspacher and Dalenoort 1994). Dialectical oppositions based on the interior and exterior are found everywhere in Western cultural, philosophical and scientific thought: in the distinctions between subject and object; in the dichotomy of mind and body; in the strict dialectics of yes and no, positive and negative. Last but not least, they are found in the distinction between nature and nurture.

6.1 Nature versus nurture

The practice of dichotomising nature and nurture persisted well into the 20th century, fuelled largely by arguments from the fields of psychoanalysis and human development. Developmentalists and behaviourists lead the debate, divided principally by the significance each allows to the role played by environment. Classical developmentalists emphasise genetics and disregard environment for the most part. In contrast, behaviourists believe environment exerts a powerful influence on human actions, regardless of, or in addition to, genetic makeup.

These modern battle lines in the traditional nature-nurture debate were first built on early discoveries in genetics and molecular biology. For decades it was held that an organism's genetic code is so dominant that there is little room for the environment to affect its development. Explanations of how organisms grow and differentiate to develop their own characteristic forms and properties have therefore been framed almost entirely in terms of 'on' and 'off' gene activity. More recently it is understood that the interplay between organisms and environment plays an important role in how organisms develop. Let us consider the origins of cancer in this context. While inherited genetic factors may make certain individuals particularly vulnerable to developing cancer, it may also be triggered by external factors such as viral infection or exposure to chemical pollutants in the environment. As such, cancer is a product of the interplay between inherent genotypes and the outside environment.

It is essential to note that not all humans will evince any or the same symptoms under the same polluted, 'external' environment. Some fortunate individuals (think here of heavy smokers who do not develop lung cancer) sail through life free of disease, seemingly protected by their genetic makeup or such aspects as lifestyle or life history. Nature and nurture work in tandem here, neither one more important than the other.

6.2 An end to nature and nurture: the self-nonself (or endo-exo) circulation theory of life

Troublesome dichotomies of nature and nurture would not worry a Zen master, for the simple reason that he would not believe them to exist. The interior and the exterior, nature and nurture: these things are at once separate from and merged into one another, just as separation and merging are one and the same action of the originally undivided 'Something' (Izutsu 1975). The complementarity of Eastern religious and philosophical thought offers us one way to overcome the dichotomy inherent in Western concepts of nature and nurture.

In Figure 9, I offer my personal solution to the impasse created by conventional dichotomies of nature and nurture. The diagram illustrates how a closed self (endo-system) establishes identity in contrast with the open environment (exo-world). While evolving through processes of variation and selection triggered by interaction with its environment, the system maintains its identity by means of the boundaries that isolate its internal materials from the exo-world. Let us suppose that this closed self is subject to the kind of connection and collapse cycles we observed when looking at how nested hierarchies grow out of non-nested hierarchy. In this case, boundaries are broken, allowing entry of new elements from the exo-world before being resealed. With each successive cycle, the composition of the closed endo-system will change, evolving in a spiral. I describe this interactive process between an endo-system and the exo-world as a

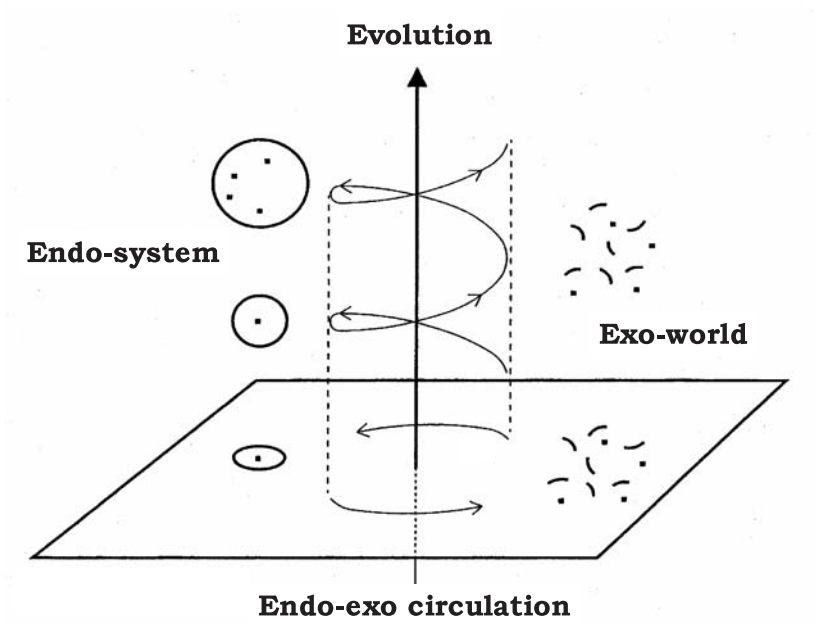

Fig. 9 Evolution of a closed self (or endo-system) by means of endo-exo circulation

self-non-self (endo-exo) circulation theory of life (Murase 2000: 369–376).

The paradigm of endo-exo circulation suggests that, while nature and nurture may be taken together, they may not be considered in isolation. Each is tied to the other, inseparable within a dynamic circulatory process. This endless circulation between nature (self or endo-) and nurture (non-self or exo-) makes the emergence of new health disorders inevitable whenever our environment changes for the worse.

7. Environmentally triggered illnesses as emergent phenomena

Sections 2 to 6 of this paper suggest that a holistic synthesis of mind and body is necessary if we are to approach complex problems of human health, behaviour and thought. The following sections posit a simple question: what are the costs to human health of living in polluted surroundings?

7.1 The problem of common sense

As Randolph (1962: preface, page v) has noted: "Most illnesses were originally thought to have arisen within the body. Only recently has this age-old concept been challenged." The outside environment was first identified as an important cause of sickness in the early 1900s, in relation to infectious diseases, and again in the 1930s, in relation to allergic reactions. Even so, the medical establishment remains slow to investigate cause-and-effect relationships between the manmade environment and ill health. The general public, meanwhile, is dependent upon the scientific community for its cue.

Attitudes to environmental chemicals are a good case in point in this context. There remains a lack of common knowledge of the potential hazards of many of the chemicals in common use today, despite past and present efforts on the part of some concerned scientists and individuals to broadcast findings on the hazardous effects of chemicals released into the environment. As a result, certain common chemicals remain the largely unsuspected causes of chronic physical and mental illnesses. Common sense offers the public little protection here. Orthodoxy suggests that lower concentrations of chemicals produce smaller biological effects, yet this is not the case. Endocrine disrupting chemicals, for example, obey a bell-shaped dose-response curve like the one illustrated in Figure 10, in that their largest bioeffects may occur even where they are low in concentration (Colborn et al. 1996). The existence of a 'window' indicates that specific responses are inhibited at the higher and lower ends of a given spectrum whereas responses occur strongly in between. Similar window effects occur in the case of electromagnetic fields, which obey their own bell-shaped dose-response curve as

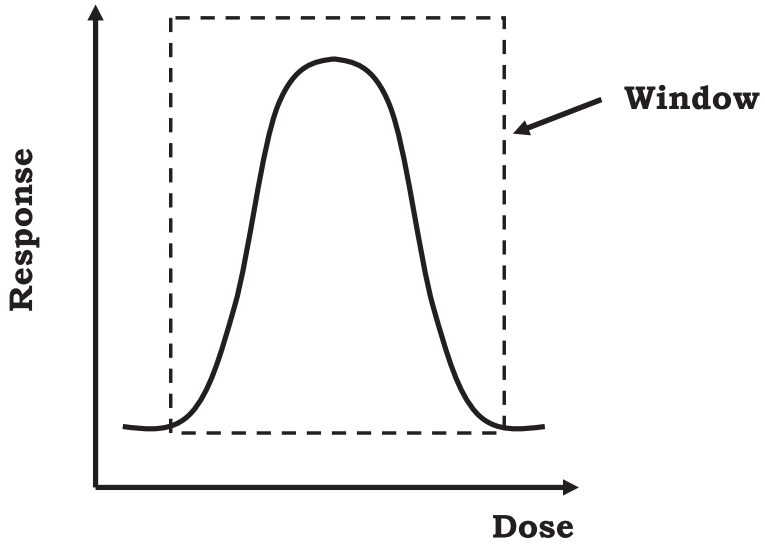

Fig. 10 The bell-shaped dose-response curve as determined by a 'window' effect. Note that windowed responses appear only in a certain range of doses

we will see in Section 8.2.

Let us look more closely at the problem of electromagnetic pollution, which has yet to be understood widely within the public domain. Figure 11 shows two electromagnetic field spectrums, the frequency of which are measured in cycles per second, shown in hertz (Hz) along the horizontal line scale at the bottom of the figure. Panel (a) shows the earth's natural electromagnetic field spectrum. It begins with the earth's magnetic fields at 0 Hz and extremely low frequency (ELF) electromagnetic fields between 0 and about 30 Hz. Lightning flashes produce fields in the frequency range of 10–20 KHz, and visible light produces fields ranging in a narrow band around 10^{15} Hz. ELF and visible light are denoted by broken circles in the figure. Both can penetrate deeply into the sea, where the origin of life and evolution is assumed to have taken place several billion years ago (Fernald 1997). This strongly suggests that living organisms are potentially sensitive to extremely low frequency electromagnetic fields: a supposition supported, perhaps, by the fact that the frequencies found in the earth's natural geomagnetic fields (from 0 Hz to 30 Hz) closely correlate with those found in human brain waves.

Panel (b) shows the spectrum of electromagnetic fields created artificially over the past 100 years. It will be immediately evident that the spectrum of artificial electromagnetic fields shown in the panel looks very different from that of the earth's natural spectrum. Here, almost all the regions of the spectrum are

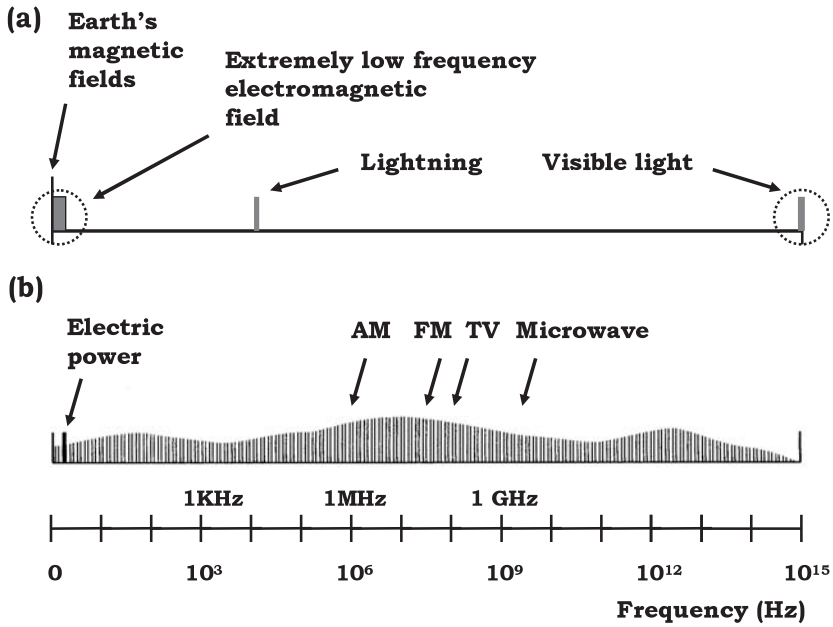

Fig. 11 Spectrums for (a) the earth's natural electromagnetic fields and (b) artificial electromagnetic fields. Modified from Becker (1990: 188–189) and Levitt (1995: 67)

completely filled with man-made electromagnetic fields. The two panels show that there has been a drastic increase in the range of electromagnetic fields to which human beings are exposed over the course of the past century. How is it that so many of us remain unaware of not only of this fact but of its consequences?

7.2 The question of consciousness

Robert O. Becker (1990) argues that an inherent belief in freewill makes it easy for us to remain in a comfortable state of denial.

> We believe that our behaviour 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 behaviour is internally generated by a process of conscious free will. The possibility that behaviour 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. (Becker 1990: 218)

Becker postulated that external magnetic fields could alter the basic operations of the brain by interfering with its internal electrical current system. He teamed up with Dr. Howard Friedman, a psychologist at New York's Upstate Medical Centre, to investigate the relationship between the occurrence of magnetic storms (which disturb the earth's magnetic fields) and the rate of admissions to psychiatric hospitals. Their findings, reported in the scientific journal *Nature* in 1963, noted a significant relationship between the incidence of magnetic storms and increases in rates of admissions to mental hospitals.

Experiments conducted on blindfolded volunteers yielded yet more evidence of the effects of even weak electromagnetic fields on human subjects (Becker 1990: 105–106). In the experiment, two electromagnetic fields were generated by two sources, each pulsing at a slightly different frequency and directed in order to intersect at the head of the subject. Nothing happened when each field — the first with a frequency of 100 KHz and the second with a frequency of 99.99 KHz — was generated in isolation. However, when both beams were generated in tandem and intersected at the subject's head, a third frequency was generated: a *beat* frequency, with a frequency of 0.01 KHz (10 Hz). At this point, the blindfolded subject began to 'see' simple patterns such as circles, ellipses or triangles.

Cognition, it would appear, is far from an internal matter. As Gibbs (2006) has shown, consciousness depends on the manner in which brain dynamics are embedded in the somatic and environmental context of an individual's life and conscious cognitive action arises from the coupled dynamics of brain, body and environment. Becker's conclusions to his investigations were dark:

> 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. (Becker 1990: 228)

There is a stark warning in here for us all. Let us consider the situation of electromagnetic pollution today, in which crisscrossing signals beam forth across space and time like a latticework, beat frequencies arising at their intersections. Multiple in source and limitless in possible combinations, how can we even begin to quantify their potential threat? Perhaps more importantly for each and every one of us, how can we begin to understand their effects?

8. Why do we ignore the potential health hazards of man-made electromagnetic fields?

For all Becker's warnings, society continues to ignore the potential health hazards of man-made electromagnetic radiation. As suggested in Section 3, the danger lies less in what we do or do not know, but more in what we think we know.

8.1 Supposition, science and electromagnetic pollution in the public domain

Let us begin with general attitudes to the electromagnetic fields of two potential health hazards very much in our midst: first, electric-power transmission lines with extremely low frequencies (either at 50 Hz or at 60 Hz) and, second, microwaves used in various technologies at much higher frequencies (around 10^8–10^9 Hz). What is it that we think we know, that helps us to feel safe?

Let us start with the simple supposition that anything low in something is unlikely to be *too* bad for the health. Cholesterol, salt, calories and energy: all these things are believed to be better for us in low rather than high doses. Small wonder, then, that consensus dictates that the extremely low frequencies emitted by electric-power transmission lines must be benign simply because the energy levels they emit are low.

Unfortunately, the consensus would appear to be wrong in this case. In 1979, Nancy Wertheimer and Ed Leeper published persuasive evidence on a causal link between exposure to 60 Hz magnetic fields from electric power transmission lines and childhood cancer. Their research, carried out in Denver, USA, has been followed by a mass of epidemiological studies into the potential hazards of electromagnetic fields published by scientists all over the world: Savitz et al. (1988), also working from Denver; London et al. in Los Angeles in 1991; Feychting and Ahlbom in Sweden in 1993; and Kabuto in Japan in 2004.

Consensus also contends that tested technologies are likely to be safe technologies. But are they? Let us take the example of microwaves in higher frequency ranges, used in cooking for some decades. Microwave frequencies are modulated for use in communication systems such as mobile (cellular) phones. Any device using microwave technology potentially bears the risk of tissue-heating effects. In ovens, these effects are barred by a simple shielding mechanism. Applying a similar safety standard to protect against the thermal effects of microwaves has therefore been deemed to make mobile phone communication systems 'safe'. Recent studies suggest, however, that the technology is less safe than we would imagine: Hyland (2000), de Pomerai et al. (2000), Salford et al. (2003), Lonn et al. (2004), Blank (1995) and Salford et al. (2008) have all suggested the

possibility of non-thermal bioeffects of electromagnetic fields on living organisms. (These are described in more detail in Section 8.2.)

With so much evidence in the scientific domain, why are these messages not getting through to the public? Sometimes, the barriers to understanding are culturally created: one remembers, here, the chemical-mechanistic concept of life established in the 1950s, in which living things were regarded merely as chemical-mechanistic machines. Other barriers might be constructed deliberately by strategic marketing campaigns, intent on selling new technologies as long as the dangers to public health are not evident. Perhaps the greatest problem is that the messages, while many, are mixed. The following statement with regards to the biological effects of electromagnetic fields offers a good case in point:

> Several investigators have reported robust, statistically significant results that indicate that weak magnetic fields increase the rate of morphological abnormalities in chick embryos. *However* [my emphasis], other investigators have reported that weak magnetic fields do not appear to affect embryo morphology at all. (Farrell et al. 1977)

Section 3.1 of this paper described how it is impossible to observe what is there without appropriate knowledge and it is difficult to get right knowledge without right observation. One might query how conflicting results such as those reported by Farrell are ever to lead us to the right knowledge. Fortunately, hope is at hand, if we can just learn to take Farrell's 'however' out of the equation. Instead of thinking that conflicting results are mutually contradictory, we need only to consider them as complementary parts of a larger picture.

8.2 Towards right knowledge (1): the window effects of electromagnetic pollution

It is scientifically proven that lower frequency electromagnetic fields produce fewer bioeffects and lower strength microwaves produce smaller heating effects that result in fewer bioeffects. Yet science also suggests that non-thermal bioeffects arise where living organisms are exposed to electromagnetic fields and microwaves at certain frequencies, for a certain duration and at a certain intensity. The parameters under which bioeffects occur in these cases are governed by three sets of window effects: a frequency window, a time window and an intensity window. This section focuses on frequency window effects in order to build up a more detailed picture of how bioeffects may arise.

We begin by considering the effects of visible light on the human subject. Figure 12 illustrates how a light flashing at about 10–15 Hz can induce seizures in

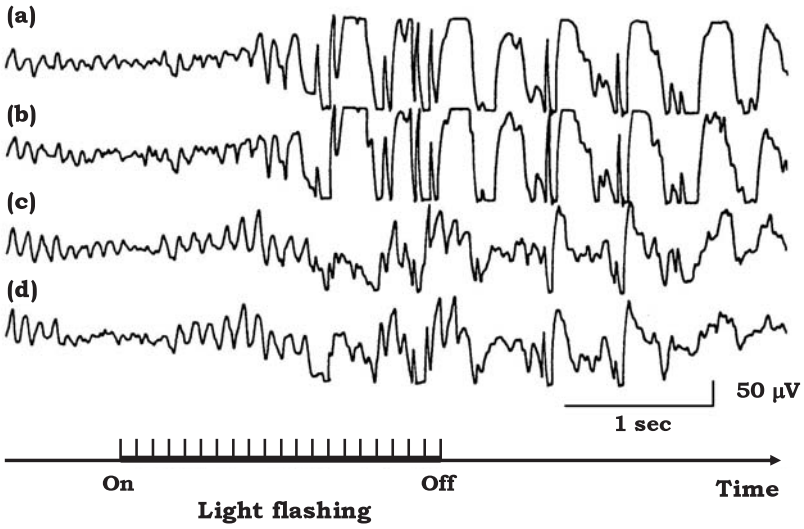

Fig. 12 Electroencephalogram (EEG) record of the brainwave activity of a human subject before and after the onset of a seizure. Activity is recorded in the (a) left central, (b) right central, (c) left occipital, (d) right occipital parts of the brain. Light is flashed at a frequency of 10 Hz for a period of two seconds. Adopted from Konagaya (1996: 70)

people with photosensitive epilepsy. Seizures may continue even when the stimulus is switched off, as indicated by the synchronous brainwave patterns registered for all four parts of the brain in the figure. Photosensitive epilepsy is a good example of how human beings may respond to a non-thermal, electromagnetic influence. In this case, it is not the amount of energy absorbed from the light that causes the seizures. Visible light alone does not cause photosensitive epilepsy, after all. Instead, the seizure arises because the information transmitted is at a frequency that is very close to the frequency used by the brain itself. There is some oscillatory similitude or some sort of resonance between the pulses of light and the human subject's brainwaves (see Becker 1990; Hyland 2000) and this can trigger seizures in some individuals.

Let us next compare the non-thermal bioeffects of microwaves and low frequency electromagnetic fields on the cells in living nerve tissue. Figure 13 illustrates the results of experiments in which samples of living nerve tissue were irradiated and the bioeffects of radiation monitored (Adey 1981, 1983). The figure consists of two panels. The upper panel depicts 147 MHz microwaves modulated at various frequencies shown by the numbers along the abscissa, and the lower panel shows electric fields at low frequencies, again shown along the abscissa. Changes in the levels of calcium efflux and influx taking place in the cells of nerve tissue were monitored in order to determine the contrasting biological

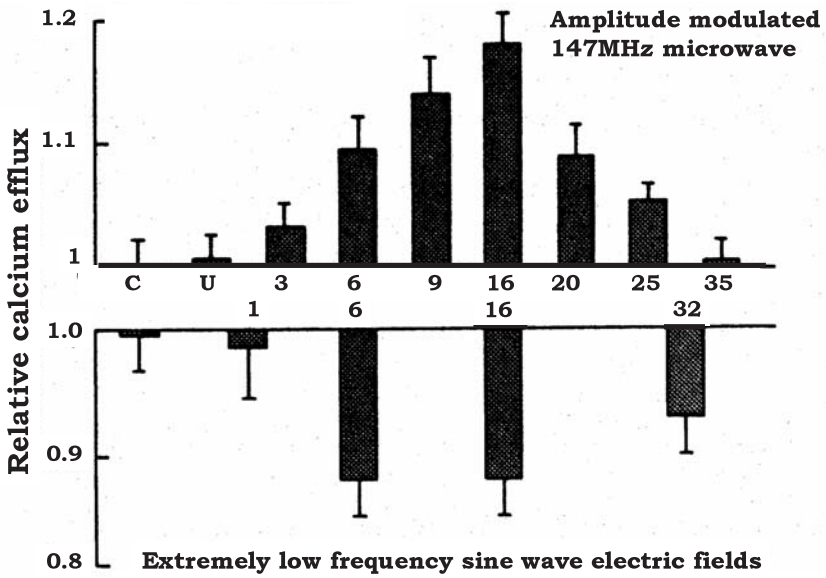

Fig. 13 Calcium efflux from living nerve tissue samples exposed to (1) a weak radiofrequency field of 147 MHz, amplitude modulated at extremely low frequencies (upper panel), and (2) extremely low frequency electric fields only (lower panel)
NB: Frequencies are denoted by the numbers along the abscissa. Unmodulated carrier wave U causes no effect, as compared with control C. Adopted from Adey (1981)

effects of the microwaves and low frequency electric fields.

The upper panel indicates that exposure to 147 MHz microwaves with amplitude modulation at low frequencies caused a significant increase in calcium ion efflux. A progressive increase in calcium efflux occurred as frequency modulations were amplified from 3 to 6 Hz, through 9 Hz, 11 Hz and finally, 16 Hz. The response decreased progressively at higher modulation frequencies of 20 to 35 Hz.

The lower panel shows that electric fields of extremely low frequencies alone, such as 1, 6, 16 and 32 Hz, produce a virtual mirror image of the upper panel. The peak magnitude of variation in efflux levels is similar for the two panels but opposite in direction. This probably occurs because the applied field strength for each frequency is much weaker than that of the upper panel. Both the upper and lower panels show a bell-shaped response curve determined by frequency window effects. The levels of calcium efflux that occur in particular at about 16 Hz are in this sense, significant bioeffects.

Adey (1981, 1983, 1988), Blank (1995) and Liboff (2003) have demonstrated that while modulation frequencies prove to be essential parameters in experiments similar to the one described above, intensity and irradiation time provide

additional parameters for the window effects observed. All three parameters are thus exerting a combined influence on the levels of calcium efflux and influx in the nerve tissue cells exposed to radiation in the experiments. Their bioeffect is problematic because the maintenance of steady-state concentration of calcium ions at extremely low levels is essential to the health of all living cells. Calcium ions play an essential role in cell biology: they are used as 'messengers' for cell reactions such as secretion, contraction, enzymatic reactions and motility. Even a slight change in local levels of calcium ion can trigger significant effects in the physiological state of individual cells. Calcium efflux or influx from the cells of living tissue is in this context a powerful indicator that physiological change can be driven by 'external' electromagnetic fields.

Let us consider the bioeffects of electromagnetic pollution around us in light of our knowledge of window effects. While microwaves can have very high frequencies, up to several million cycles per second, the microwaves used for mobile telephony are modulated at very low frequencies, such as about 2 and 8 Hz (Hyland 2000). These low frequency components correspond to the frequencies of electrical oscillations found in the human brain, especially the delta and alpha brainwaves. Non-thermal biological effects may occur when there is oscillatory similitude between waves of radiation and brainwaves in the living organism. The living organism 'recognises' certain frequency characteristics of the 'external' radiation based on any 'intrinsic' or 'endogenous' activities that take place within a similar range of frequencies. This evidence points to a simple, if somewhat alarming, conclusion: that electromagnetic fields at certain frequencies, for a certain duration with certain intensities, may have bioeffects no less dangerous to human health than the endocrine disrupting bioeffects of manmade chemicals.

8.3 Towards right knowledge (2): neural plasticity as a 'learning' mechanism

The previous section shows how window effects are created by parameters such as the frequency, intensity and duration of exposure to radiation. Whether bioeffects appear or not depends, however, not only on external parameters, and how these change, but also on the internal conditions within a living organism and how these also change. Even under the same external conditions, living organisms show a wide range of behaviours.

Figure 14 presents three models representing the relationship between inputs and outputs for a living organism. For the simple linear internal signaling pathway shown in the upper panel of the figure, any input will cause an associated predictable effect. The middle panel shows what happens when the internal simple pathway branches: in this scenario, the same input may cause different outputs. When the internal pathway becomes much more complex, as is

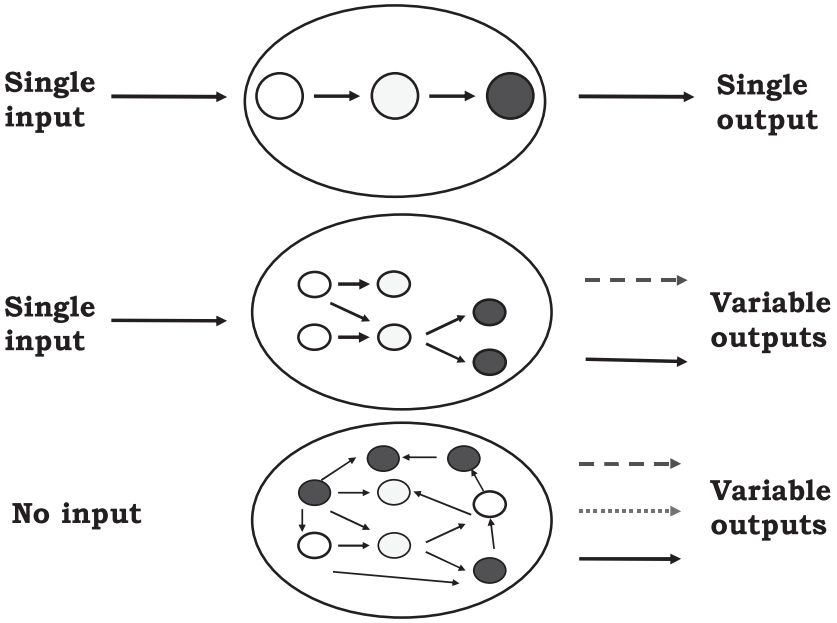

Fig. 14 Three input/output scenarios for a complex living organism

seen in the bottom panel, different kinds of outputs may emerge even without an input signal.

This bottom panel may help us to understand the nervous system in the brain, which is, of course, far more complex than any of the scenarios represented in the figure. Even mature nervous systems — held in the past to be in a relatively stable state, with the exception of changes related to aging — are in a state of continuous change. This is because the brain is a highly responsive organ: neural networks — even the neural networks of adult organisms — can reorganise themselves in accordance with changes in stimulation created by internal and external factors. This so-called 'neural plasticity' can make the brain respond in far from predictable ways — ways that are sometimes injurious to the health of the organism in question.

Experiments carried out by Goddard (1964) highlight just how endangering the brain's responses can be by observing it 'learning' to respond in new ways to a given stimulus. Goddard's findings were based on the results of repeated applications of very weak electrical stimulation on a laboratory animal. These produced at first no discernible effect on the animal's behaviour or on the patterns of electrical activity observed in its brain. However, this situation changed as weak stimulation continued once a day for several weeks: the animal learned to respond to the stimulation and began to show nerve excitation patterns typical of seizures.

This process — described by Goddard as a kindling phenomenon — is a good example of neural plasticity. Neural plasticity is commonly considered an important mechanism of learning. But as the results of Goddard's experiments show, learned responsiveness can lead to neurological disorders in some situations (see also Møller 2008). These disorders, once 'learned', can be permanently debilitating. Goddard's experiments showed that even after an interval of a whole year, a single application of the same weak stimulus proved capable of triggering a full-blown seizure in his animal subject. Evidently, a particular response, once learned, is not easily forgotten.

What are the implications of Goddard's experiments for the human subject? Møller writes persuasively on the dangers presented by neural plasticity in terms of disorders of the nervous system:

> 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. (Møller 2006: 4)

Individuals, it would appear, suffer disorders in very individual ways. We all have different levels of stability inherent within our nervous systems, and these levels are subject to change at any time, under changing conditions. This difference and diversity presents the primary obstacle, perhaps, to the diagnosis and treatment of biological health disorders in living organisms caused by environmental factors.

9. Discussion

Environmental skeptics may demur, but most of us would agree that environmental pollution — be it chemical, electromagnetic or atmospheric — is on the increase. Yet we remain largely oblivious to the potential hazards to human health of the pollutants contaminating our environment. It is, as we have seen, our customary way of thinking that keeps us in ignorance of the dangers in our midst.

Jung (1933), Nisbett (2003) and Gieser (2005) argue that most of us think in one of two patterns — Western or Eastern. Both are illustrated in Figure 15. The Western mindset thinks in terms of a linear progression, starting at A and

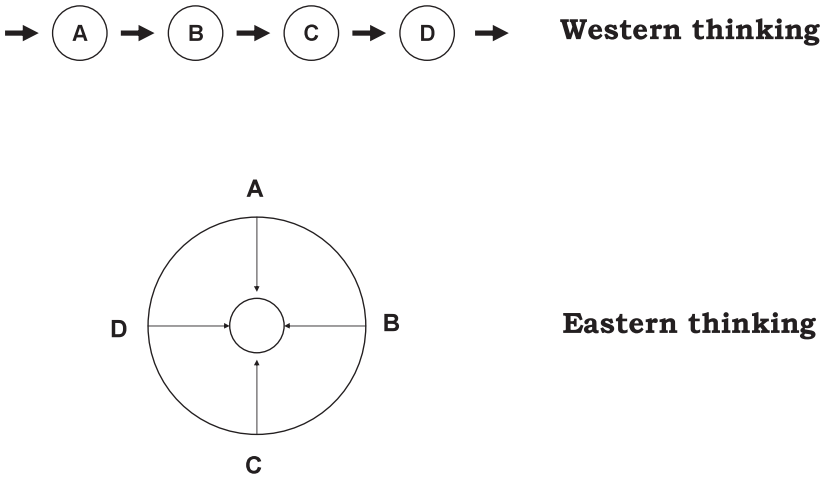

Fig. 15 Western and Eastern ways of thinking

working through B to C and, finally, to D. It will always be important to ask: 'What came first, the chicken or the egg?', to answer firmly yes or no, to establish cause and, most of all, to trace the effect that must always follow — never precede — a given cause. This way of thinking is compelled to view conflicting results as mutually exclusive or even contradictory. By contrast, the Eastern mindset is able to think in simultaneities, allowing for the coexistence of A, B, C and D at any one time. This mindset views conflicting results and ideas as complementary rather than oppositional. Nisbett (2003) has emphasised that both Western and Eastern thinking have an important role to play in all our lives. The same, I would argue, is true of our science, for which a complementary approach is required for an improved understanding of the complex problems of human health caused by environmental factors in today's world.

Alfred I. Tauber (1994) described identity as the evolving and dialectical process whereby an organism engages in challenges posed by both its internal and external environments. Section 8 showed the brain's response to two such challenges: plastic neural responses to challenges from the internal environment on the one hand, and reactions to the external environment modulated through window effects on the other. In both these cases, nature (endo-) and nurture (exo-) factors act together on and in the organism in ways that are not always immediately explicable. Endo-exo circulation is a paradigm that overcomes the need for endless oppositions. Instead, it provides a new synthesis of Western and Eastern thought through which the potential hazards of environmental pollution on human health may at last be understood.

Acknowledgements

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