



The Natural Sciences, Classical Chinese Philosophy, Process Thinking, and Brain Lateralization

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ABSTRACT: In this essay my focus will be on three propositions. Arguments in support of these propositions are presented in the first four parts of this paper. A conclusion follows in the fifth part.

(1) The modern natural sciences, classical Chinese thinking, and the philosophy of Whitehead can all be characterized as examples of process thought. Change is more important than stability. Process thinking is superior when compared to mechanistic materialism or logical positivism.

(2) A satisfactory image of the structure and dynamics of our surrounding world requires, in addition to a physical basis, also a scientific-metaphysical basis of our thinking. The three realms of the natural sciences, i.e., the very small (the microworld), the very big (cosmology) and the very complex (life processes) evoke questions that cannot be solved solely in terms of scientific approaches. Process metaphysics, with its foundation in the modern natural sciences, suggests answers to an important set of fundamental questions.

(3) In the final part it is proposed that the “cultural differences” between the modern natural sciences, classical Chinese thinking, and Whitehead’s process philosophy can be related to recent insights into lateralization of the human brain.

INTRODUCTION

According to the philosopher and psychologist George Herbert Mead (1863-1931), the nature of humans is to be transformed and to be transformative—evolving from, reflecting upon, and creating the culture in which human beings are living. Such ideas about social behavior have an early analogy in traditional Chinese thinking. Kongzi (or Confucius, 551-479 BCE) believed that the essential qualities of the ideal human self (Ren) emerge from, are nurtured by, and in turn affect social institutions (Keith).

In the present essay, I will first briefly review some highlights of Western and Eastern thinking as laid down in the natural sciences, in classical Chinese philosophy, and in the philosophy of Alfred North Whitehead. It will be argued that these lines of thought, although originating from periods more than 2000 years apart, can be characterized as *process thinking*. The guiding idea is that natural existence consists in and is best understood in terms of *processes* rather than *things*—of modes of change rather than fixed stabilities. In fact, change of every sort: physical, organic, and psychological is the pervasive and predominant feature of the real (Rescher). Process thinking has a long tradition: In the East it is found in (Theravada) Buddhism, in the Yi Jing, in a variety of classical Chinese philosophical schools, and is most clearly developed in Neo-Confucianism. The Western tradition comprises much work in the natural sciences, and philosophers like Heraclitus, Leibniz, Hegel, Peirce, James, Bergson, Dewey, and Sheldon. But the most important process philosopher in the West is Alfred North Whitehead.

All these systems of thought have emerged from the human brain, the most complex entity known in our cosmic epoch. During recent decades, brain research has now made it possible to define general features of brain activity. Among these are *brain asymmetry* or *brain lateralization*, involving the notion that the right and left brain hemispheres are controlling human behavior and thinking in different ways. It has been suggested that these differences have been important in determining the large variety of cultures as they evolved over the ages.

The available knowledge about brain asymmetry allows us to conclude that the left hemisphere, primarily specialized in step-by-step logical and mathematical analysis, is dominantly associated with the natural sciences. By contrast, classical Chinese philosophy, stressing the unity of nature

and the human being, is largely intuitive and associated with the right hemisphere. This significant difference can occur despite the fact that both lines of thought involve process thinking. Interestingly, the foundations of Whitehead's process thinking have their basic roots in *both* physics and metaphysics and can be best understood in terms of a continuous communication between, and a mutual modification of, both hemispheres primarily via the corpus callosum, a thick string of nerve fibers. The experience of this deep connection between the physical and metaphysical realms stimulates and guides our understanding of the dynamics and mechanisms operating in our world, but it also enhances our perception of the beauty and greatness of the universe to which we belong.

THE HUMAN BRAIN

The most important components of our brain are neurons, nerve cell bodies. In the adult brain there are 10^{10} - 10^{11} neurons. Axons are nerve fibers, able to conduct outgoing impulses. Dendrites are shorter than axons and receive nerve impulses. Nerves are orderly arrangements of axonal and dendritic processes. Ganglia are clusters of neurons which support brain action but also transmit information. About 90% of the cells in the brain are not neurons, but support cells (glial cells) which give physical support for the dendritic and axonal processes. They also provide nutritional support for the neurons.

Synapses are terminals of the axons that form junctions with other neurons. Nerve impulses are small "spikes" of electricity, travelling through a neuron. There are about 1,000-10,000 synapses in a neuron. The membrane surface area of 10^{11} neurons is ca. 25,000 m², equivalent to about 4 soccer fields! The amount of information that can be stored in the human brain is $10^{10} - 10^{11}$ bits. About 1-10 % of the brain's cells are firing at any one time at a rate of ca. 100 hertz. Those processes include the absorption of data, the synthesis of data, the discernment of patterns, the retention of both data and their synthesis into generalizations, and the expulsion or loss of data. There is no steady state in the brain. As a consequence, process thought is relevant for understanding the functioning of the brain.

At birth, the weight of the human brain is 350 g, after one year 1000 g, during puberty 1300 g, whereas the weight of the adult brain is about 1500 g. During prenatal life, $2.5 \cdot 10^6$ neurons are generated per minute. The bad news is that at an age above 20 years, ca. 70,000 neurons are lost every

day. It should be noted that the growth of the brain is not the exclusive product of the genetic code: there are just not enough genes to account for the bewildering complexity of the brain. It is believed that the development of mature neurons takes place by two sets of influences. First, by specific subsets of genes for turning the nervous system into ordered and temporally timed sequences. And second, by environmental stimuli from within and outside the organism. External environmental factors include nutrition, sensory experience, social interaction, and learning. All are essential for a proper differentiation of individual neurons and for fine-tuning the details of synaptic connections. Continuous stimulation over an entire lifetime is required for sustaining optimal functional activity.

The importance of sleep can hardly be overestimated. The vital function of sleep is bound up with learning and memory. Sleep plays a critical role in flagging and storing memories and in seeing subtle connections invisible during waking, i.e., regulation of neuronal networks and connections. It also restores energy requirements, particularly glycogen, a readily mobilized storage form of glucose. During sleep, the brain works actively on learned information and bundles it in readable chunks. The various stages of sleep seem to be specialized to handle specific types of information. In fact, the human brain has three stages of activity during our life: (a) to be awake, (b) non-rapid-eye-movement sleep (NREM sleep), and (c) rapid-eye-movement sleep (REM sleep). It always participates in a process.

Consciousness, with emotions, sensations, thoughts, and perceptions as its most basic forms (Carter), can be associated with a definite level of brain organization, i.e., highly transient groupings of neurons that are in a dynamic process of change (Greenfield). These dynamic neuron assemblies can accommodate varying degrees of subjective, vanescent consciousness. The depth of consciousness depends on the size of the neuronal networks. At least four types of factors are important here: (1) the number of already existing neuronal networks, (2) functioning neurotransmitters, like (pro)hormones and peptides, (3) the degree of stimulation, and (4) the speed of neuron recruitment by rival assemblies, determining the time available for realization of the full potential of consciousness.

The human brain can be viewed as a system of networks of neurons, largely formed after birth and reflecting individual experiences. This is the most plausible physical basis for personalizing the brain into an idiosyncratic conglomeration of experiences, generalizations, prejudices, and propensities (Weber). All the time experiences leave their mark and

in turn determine how we interpret new experiences. It has been argued that persistent activity in the prefrontal cortex and basal ganglia is crucial for learning correct actions through experience (Greenfield; Carter). An issue that has received recent attention is the “default state” (“resting state”) of the human brain (Raichle). This is the state of the brain of an individual lacking attention or intention, eventually with the eyes closed. Under these conditions in some parts of the brain substantial amounts of energy are consumed, and these energy requirements decrease when attention is given to a particular issue with a concomitant use of energy in those parts of the brain. It has been suggested that these default areas are the core of our conscious experience, since under conditions of sleep or of coma the brain activity in the default areas is very low. During our whole life the mind takes shape and the individual mind will color the way one feels at varying times. The mind evolves rather slowly over long time frames (Greenfield).

A concept that has received much recent attention is brain asymmetry. Brain lateralization involves differentiation of sensory information between the right (RH) and left hemisphere (LH) of the brain, thereby controlling human behavior in different ways. The hemispheres exhibit important and consistent differences. The RH is longer, broader, and usually bigger and more heavy than the LH. Still more interesting, both hemispheres possess different “personalities.” The RH, strongly focused on experiences of the environment, can in its functioning be compared with a parallel processor and is handling fast, intuitive notions, feelings of empathy (via mirror neurons; see Iacoboni), and emotional experiences. It allows an associative, pattern-oriented experience of the world. The LH can be better viewed as a serial processor, specialized in linear and methodic thinking, and controlling language. It deals specifically with isolated pieces of experience or information. Both hemispheres communicate with each other via a thick string of nerves, known as the corpus callosum, containing more than 200 million nerve fibres. Two much smaller bundles of nerve fibers (the commissural anterior and the commissural hypocampii) serve the subcortical interactive process. The RH is particularly involved in transmission of information across parts of the brain, whereas the LH is primarily focussed on local communication, i.e., transmission of information within parts of the brain. In all human brain activities both hemispheres are actively involved, but not necessarily with equal effectiveness.

Cultural differences may find their origin in specific, culture-associated patterns of brain activation, predominantly dominated by either the RH or the LH.

Harvard psychologists (Spelke) argue that during the evolution of the brain, humans have been endowed with a small number of separable systems of *core knowledge*. These include (1) object representation, centered on cohesion (objects move as connected wholes), continuity (objects move on connected, unobstructed paths), and contact (objects do not interact at a distance); (2) agents and their actions (goal-directedness, efficiency, contingency, reciprocity, and gaze direction); (3) number representations; (4) recognition of space; and (5) identifying and reasoning about potential social partners and social group members.

From this core knowledge, imprinted into our neuronal networks, common sense notions have been developed. In practice, no notion that denies one of more of them can be deemed adequate. They are permanently present in the depth of our experience. According to Griffin (*Reenchantment*), deep common sense involves at least eight different notions: the notion that we experience the external world, the notion of truth as correspondence to this world beyond our immediate experience, the reality of the past, causation by way of real influence, freedom as choice among alternative possibilities, normative values (“better and worse possibilities”), genuine evil (involving the realization of less than optimal possibilities), and the notion of an ultimate reality bringing into existence our type of cosmic epoch. Deep common sense tells us that at the most basic level of our experience we have to do with an objective world (Hosinski).

THE NATURAL SCIENCES

Introduction

In the next section, important aspects of the natural sciences will be summarized, and it will be argued that process thought is the most appropriate mental construct for understanding the physical, chemical, and biological aspects of the world that surrounds us. However, it should be taken into account that the natural sciences embody implicit ontological schemes. These are often not completely justifiable on purely empirical grounds. The links between theory and reality are always mediated by a model. And any theoretical model is built in term of the contextual scheme of the theory (Labarca). In fact, the model can be viewed as the vehicle to cut the corresponding ontology out of the independent reality.

Cosmology, physics, chemistry, and biology are the major natural scientific disciplines, describing phenomena as they appear to us. They operate on their own ontologically equivalent levels of reality. Often physical processes that occur on immeasurably small scales are ignored, or averaged over, in formulating theories. Indeed, selecting relevant information and suppressing details is the usual pragmatic approach. Thoughts are automatically parcelled in categories of interest. And categories are usually organized in terms of relevant distances or energies to produce an effective theory (Randall).

Logic was forced on us by the physical world and is therefore consistent with it. Mathematics derives from logic. This is why mathematics is consistent with the physical world. Livio has suggested that physicists have been able to find mathematical tools that not only explain the existing experience and observational results, but which can also lead to novel predictions. However, there are numerous mathematical theories of the world and great care and expertise is required in selecting the most realistic one. As stressed by Whitehead: "philosophy has been misled by the example of mathematics" (*PR* 8).

My purpose in this section will be to explore two major points. First, that reality can be best viewed as a complex combination of interdependent energy events, birthing and then rapidly fading away. Reality is a dynamic process. And second, as already pointed out, the laws of physics and cosmology suggest that the existence of life on this planet is delicate and requires exceptional, finely tuned conditions.

Of course, within the space limits of this essay, no attempt can be made to give a comprehensive summary of the natural sciences. Some specific topics will be selected which demonstrate and illuminate these two major points. Three great frontiers in the natural sciences will be briefly considered: (1) the very small (molecules, atoms, elementary particles, and the forces among them), (2) the very big (cosmology, the universe), and (3) the very complex (the brain, life processes, evolutionary processes).

The natural sciences and metaphysics

It will be shown that the laws of physics and cosmology suggest that the existence of life on this planet is rather delicate and appears to require exceptional conditions. Physical theories cannot explain this situation: there appears to be no *ultimate* theory. In fact, there are numerous issues in our life experiences that put the sciences more or less in the shadow.

I refer to David Griffin (“Lecture”), who has formulated a starting point for dealing with this problem: “the quest for a comprehensive philosophical or metaphysical framework and the quest for adequate scientific theories that are testable by empirical data are on equal footing.” Metaphysics is speculative and aimed at the philosophical investigation of the nature, constitution, and structure of the reality that we experience. It is nothing but the description of the generalities which apply to all the details of practice.

At least three types of metaphysics can be distinguished. First, *plain metaphysics*, which does not use science as a helping tool. Second, *exact metaphysics*, built up with the help of logic. And finally there is *scientific metaphysics*, which takes full consideration of the results of modern science.

Metaphysics in general considers questions that cannot be answered by the natural sciences. In my view, it is crucial that these answers should not be at odds with the scientific insights based upon experimental observations. There is a definite need for a *scientific metaphysics* creating a worldview that is congruent with our best scientific knowledge and which fits also with our actual experience (see Cobb and Griffin). In my discussion of the natural sciences I will only consider this type of metaphysics.

The purpose of a metaphysical theory is to provide a speculative scheme that has a wider scope than the sciences. In the most general sense, metaphysics has the fundamental and dual tasks of: (1) integrating into a coherent and comprehensive whole the truths of diverse disciplines, and (2) opening new vistas of inquiry and illumination by provoking more profound journeys of human curiosity. Attempts to express the matter of immediate experience leads us beyond itself to its contemporaries, to its past, to its future, and to the universals in terms of which its definiteness is exhibited. In the words of Whitehead: “the primary method of mathematics is deduction; the primary method of philosophy is descriptive generalization” (*PR* 10)

Three types of statements are involved. The first are pre-systematic statements: statements of facts to take account of and do justice to the speculative construction. Then we have systematic statements: analytical statements of relationships within the scheme which has been constructed and which are used to interpret non-systematic statements. Finally we have post-systematic statements in which facts and principles of various sorts are interpreted in terms of the metaphysical scheme. The truthfulness of

a post-systematic statement presupposes the truth of some pre-systematic statements (Christian). Such a metaphysical scheme enables us to express in a coherent way the concrete perceptual experiences from which the sciences abstract. These include also our moral, aesthetic, and religious intuitions as embodied in practical activity, works of art, and religious experiences (Engberts, "Earth").

The very small

In the first part of the last century completely novel insights were obtained regarding the structure and behavior of the smallest constituents of matter. A whole group of scientists, including M. Planck, A. Einstein, N. Bohr, P. Dirac, W. Heisenberg, W. Pauli, E. Schrödinger and L. De Broglie, revolutionized and radically revised our understanding and description of the physics and chemistry of molecules, atoms, and elementary particles. Newtonian physics was found to be inadequate for studying the microworld composed of very small particles. An early finding was the necessity of bundling elementary physical characteristics (both particles and waves) into discrete small energy packets, called quanta (with an energy E equal to $h\nu$, with h ($6.626 \cdot 10^{-34}$ Joule.sec) being Planck's constant and ν the frequency of the wave). The idea had emerged that both matter and radiation exhibit a simultaneous wave-like and particle-like behavior. This new type of physics, *quantum mechanics or quantum physics*, describes the state of a system by a complex wave function $\psi(r,t)$. This theory allows one to compute the *probability* of finding an electron in a particular region (r) around the nucleus of an atom at a particular time ($P = \psi(r,t)^2$). The basic issue involves the fact that both the place and velocity of a particle at a particular time cannot be concurrently determined with very high precision. This is the famous Heisenberg indeterminacy principle, in mathematical form $\Delta x \cdot \Delta p_x \geq \frac{1}{2} \cdot h / (2\pi)$, where x is position and p is impuls. A similar uncertainty occurs for energy/time. It has to be noted, however, that while Heisenberg's uncertainty principle is widely accepted, some theorists, Einstein included, find this ontological indeterminism to be unsatisfactory. In fact, some physicists have suggested that quantum mechanics has for a long time been wandering in a philosophical wilderness (Folger).

The popular "Copenhagen interpretation" assumes that, when no observer is present, any given particle can exist everywhere, dispersed like a wave. If an observer measures the wave, there occurs a collapse of the wave function ("quantum leap") into a single particle. Thus the act of

measurement is associated with a particle to assume a single and definite position. Apparently physics does not tell us how things are, but it tells us how human beings perceive and measure things. There are, however, different views. Pioneered by de Broglie, and further developed by Bohm and Valentini, it has been proposed that the wave equation is just a mathematical abstraction and that waves are real. They are called pilot waves and particles do not exist in more than one place at the same time. The pilot waves, to be viewed as a new kind of physical entity, are guiding particles along their trajectories and there is, in fact, no collapse of the wave function triggered by the measurement. The collapse is just “apparent.” In this theory, particles can interact faster than the speed of light, in fact, they can interact instantaneously. This leads to the notion of a universal time, in contrast with the time interpreted by Einstein’s relativity theory. The Valentini theory is being further developed and might substantially change our views about quantum mechanics.

Perhaps the most useful and plausible interpretation of quantum mechanics is the Heisenberg/Dirac ontology. In the words of Stapp, the wave-like aspect of nature is called the state of the universe, i.e., every wave-like feature of nature is embedded in Heisenberg’s state. An actual event, an observable activity in some large physical system, originates from a quantum jump in the Heisenberg state of the universe. The old state jumps to a new state, which specifies the tendencies for the next actual event, and so on (Stapp). In sum, the states account for the wave-like aspects of nature, which describe tendencies for events. The events account for the particle-like aspects which are localized in a particular physical system.

It is worth mentioning here that the Heisenberg/Dirac ontology appears to have an immediate relevance for a better understanding of consciousness and, in fact, human consciousness is supposed to possess a place in the quantum universe. The human being is an integral part of the global, integrating process that gives form to the universe. Quantum theory is pertinent to brain dynamics. Stapp developed an, in part speculative, theory implying that the extreme smallness in the ion channels in human brain nerve terminals has profound quantum mechanical importance. It leads to spreading of the calcium-ion wave packet and an uncertainty in the release of the neurotransmitter contents from the vesicles induced by the calcium ions. This makes it necessary that the brain has to monitor what is actually happening in order to allow the

selection of a particular plan of action. This is made possible by selecting a particular course of physical events from the smeared out mass of possibilities inherent in the quantum state of the vesicles containing the release sites for neurotransmitter molecules. A “choice” has to be made, not determined by orthodox laws of physics. Research in this area is now under active development, but the present state of knowledge looks consistent with Whitehead’s thoughts about the mind/body unity and the emergence of actual entities (see section below: “Process Thought of Alfred North Whitehead.”)

There is abundant experimental evidence for the adequacy of quantitative aspects of quantum mechanics. For atoms and molecules it has been shown that electrons reside in orbitals of different quantized energies. The maximum number of electrons in an orbital is two. This is a result of the Pauli exclusion principle that states that no more than one particle of a particular kind and spin is permitted in a single quantum state. So the atoms of matter consist of positively charged nuclei with negatively charged electrons in their orbitals (many of them of different energies) circulating around these nuclei. This makes an atom a highly dynamic system, with quantum mechanics only offering the possibility to calculate the probability of finding an electron at a certain position within the atom.

Initially, for many people, quantum mechanics looked rather bizarre. But it should be recognized that we just are not physiologically equipped to perceive the quantum nature of matter and light. We experience and see only huge aggregates of atoms and molecules, so many of them that classical physics overwhelms quantum effects. Generally, we also perceive only many quanta of light (Randall). Therefore, in the words of Stapp, the basic problem in the interpretation of quantum mechanics is to reconcile the quantum features of mathematics with the fact that our perceptual experiences are described in the language of classical physics.

In later decades it was found that the interactions among all particles in our universe are governed by *four forces*. In our daily life we experience, apart from gravitation, only directly a single type of force: the electromagnetic force (EM). This is long range and responsible for binding electrons to the atomic nucleus. Particles of opposite charge attract each other, those of the same charge repel each other. All binding interactions of atoms in molecules and the interactions among all types of matter are caused by these interactions. These are the forces that we feel in our daily lives. Quantum

electrodynamics (Feynman) is the quantitatively accurate theory that covers all chemistry and biology. It starts from two ideas: (1) that nature consists of matter, space, and time, and (2) that the carriers of forces are the massless photons, the quanta of light. When an electron emits a photon which is then absorbed (at a vertex point) by another electron, there is an interaction between both electrons, depending on specific quantum rules. In sum, interactions are due to the exchange of energy and impulse moment, which is transmitted by virtual particles. These virtual particles do not show up in the initial and final stage of the process, and do not need to possess a physical mass. The theory of virtual particles employs the so-called Feynman diagrams and has been developed in great detail.

The other three types of forces are: (1) the strong force (SF, short range, they keep the quarks in atomic nuclei together), (2) the weak force (WF, short range, important for nuclear reactions), and (3) the gravitational force (GF).

The relative strengths of these forces are SF (1), EF (10^{-2}), WF (10^{-5}), and GF (10^{-39}). This makes it clear that the GF plays no significant role in interactions within atoms and between atoms. Does an ultimate theory exist encompassing all four types of interactions? Furthermore, is such a “unification of forces” even philosophically required?

Einstein and many other leading physicists have tried to find such an “ultimate theory,” that is, a theory that offers the possibility to provide an explanation for all phenomena that we experience. In a lecture given on March 8, 2009, Stephen Hawking (University of Cambridge) has made some remarkable statements. While general relativity (pioneered by Einstein) describes the cosmos at large, and quantum mechanics makes precision statements about phenomena on subatomic length scales, a mathematically consistent and experimentally tested theory that combines these two great pillars of twentieth-century science has yet to be achieved. Hawking argues that such a theory is expected to be self-referencing. One might expect it to be inconsistent or incomplete. We and our models are both part of the universe we are describing.

Hawking concludes that there is not such an ultimate theory that can be formulated as a finite number of principles. Therefore, our search for understanding will never come to an end. In his most recent book, however, Hawking (with his co-author Mlodinow) says that M-theory is the only candidate for a complete theory of the universe.

This theory induces supersymmetry between the forces of nature and the matter on which they act. He claims that the grand design may have been found, thereby eliminating both philosophical discussion and the concept of God.

But there appear to be other striking new developments. In a very recent paper, Verlinde argues that gravity is an “emergent” interaction, which can be explained as an entropic force caused by changes in the information associated with the position of material bodies. So it may well be that we are left with only *three* fundamental forces!

My own conclusion at the moment is that the most thorough understanding of the world around us should be couched in a marriage of physics and metaphysics. Although I will come back to this issue, there is another reason for this conclusion. Let me briefly summarize the highly successful and reliable Standard Model of Elementary-Particle Physics (Weinberg). It describes two types of elementary particles (often more basically treated as fields): leptons (six types), elementary particles not made of quarks, including electrons and neutrinos, and secondly, quarks (six kinds) which are the constituents of protons and neutrons and confined within the nucleon that they constitute. These particles interact via the four (or three, *vide supra*) fundamental forces. The basic physics of these twelve particles and the forces is comprehensively and accurately described by the Standard Model. There is, however, at least one big problem. It is a fundamental one. The issue is that there are about twenty *adjustable* constants necessary for quantitative application of the theory and which have to be determined by experiment. These constants appear to be “chosen” in nature. We just do not know the physical reasons or mechanisms responsible for setting these constants to their observed values. Consider just one example. In a fundamental analysis (Hogan) it is argued that nuclear physics would change dramatically when there would be a change of only a few percent in the mass of two quarks (m_u and m_d). The “given” values of the mass of these elementary particles allow a world of stable protons (hydrogen nuclei) and permit the formation of carbon and oxygen. These elements are essential for the rich interactive chemistry in our world. Again, it can be held that a blending of physics and metaphysics could bring us a step further in our attempts to understand the mysteries of our surrounding world.

I finish this section with a few notes about “empty space” or “nothingness” (Close). First, there is the rather unexpected feature of matter, namely that it is *almost completely empty space*. It is well-established that atomic

mass is for 99.9% in the nuclei of the atoms. Following the reasoning of J.A.Jungerman, I note that these nuclei consist of quarks, with a radius of $< 10^{-17}$ cm. Atomic diameters are about 10^{-8} cm. Therefore, the ratio of the diameters of a quark and that of an atom equals to $10^{-17}/10^{-8} = 10^{-9}$. As a result, the fraction of the atomic volume in which the atomic mass is located is smaller than $(10^{-9})^3$ which is 10^{-27} of the atomic volume itself! Is this really empty space? Modern physics has shown that the answer is no. The real situation is, that "empty space" is filled with complex energy events, a field of incessant activity. The vacuum should be viewed as a reservoir of energy, it contains "vacuum energy." Pairs of virtual particles (e.g., electrons and positrons with opposite charges) emerge spontaneously from the vacuum, temporarily borrowing some of its energy. But these virtual particles only exist fleetingly and disappear back into the vacuum, taking with them the energy they borrowed. This birth and death of virtual particles also takes place in the space between atoms. Without going into further physical detail, it should be said that the formation of these very short-lived particles is a consequence of Heisenberg's uncertainty principle. If there are no particles (matter and mass) in a finite volume of space, this implies that energy cannot also be zero. Thus "empty space" is filled with energy. For macroscopic volumes these effects are not directly observable, but for very small volumes energy fluctuations are very significant and have been experimentally measured in 1996 in terms of the Casimir effect (Close).

These insights are of great importance, since indirect interactions, involving virtual particles, play a significant role in communicating forces. Their effects depend on the distance over which the force is communicated. In sum, there is no stable, unchanging vacuum! Even "empty space" has to be viewed as a *process*, in full accord with process thinking. In fact, the whole spatial universe is a field of force, i.e., a field of incessant activity. Fields are the fundamental objects that live in empty space, in space in which there are no particles (Alexander). An event can best be understood as a concretization of a field, an actualization of space-time parameters.

The very big

Cosmology is the study of the universe in its totality. During the past decades there has been an enormous progress in our understanding of the structure and dynamics of our expanding universe. There is only one universe to be observed and it contains everything there is, at all times. If the universe, however, is either temporally or spatially infinite, as some

physicists and philosophers hypothesize (Phipps), it cannot all be observed and human hubris has its boundaries.

The visible universe is characterized by three spatial dimensions, one time dimension and four forces. The horizon of the visible universe is now at a distance of about fifteen billion light years. But we should take into account that the universe is not the same as the visible universe. It is now almost generally assumed that the age of our universe is about 14 billion years. A popular but not universally accepted (Phipps) theory states that the universe originates from the Big Bang, involving matter bounded by a space-time singularity of infinite density, thereby creating in a quantum fluctuation, as some argue, not only matter and energy, but also space and time. The first atoms were probably created 380,000 years later, the first stars following after some 20,000 years.

In this brief section I will concentrate my attention on only two major problems in modern cosmology that have remained unsolved. The first is the uncertainty about the composition of the major part of our universe. As far as we know now, only 4% consists of matter of known composition, i.e., the chemical elements we are familiar with. The remaining part has an unknown identity: 23% is dark matter (exhibiting gravitational attraction) that cannot participate in nuclear reactions, while 73% is dark energy. This dark energy is supposed to exert gravitational repulsion on itself and on all other forms of matter (Alexander). There is much research going on to clarify the composition of these forms of matter. This is a major challenge and a prerequisite for understanding crucial issues underpinning the behavior of our cosmic epoch.

I now come to the cosmological evolution, as discussed in a book by Martin Rees, called *Just Six Numbers* (1999). Rees, the Astronomer Royal at the University of Cambridge, has illuminated a fundamental issue, namely that there are *six fundamental constants* that “constitute” the “recipe” for our universe. At present, these numbers appear to be independent. Every one of them plays a crucial and distinctive role. These six numbers are in an extremely delicate, finely tuned interaction and determine how the universe evolves and what its internal potentialities are. If any of them would be “untuned,” there would be no stars and no life. I will now briefly consider these numbers one by one.

First there are two numbers (N and ϵ) that determine the basic forces in our universe:

- (1) $N = 10^{36}$. This number measures the strength of the electrical forces that hold atoms together, divided by the strength of the gravitational forces between them. It shows that gravity is extremely feeble compared to the other forces affecting atoms. Chemists can safely ignore gravitation in their studies of atomic binding in molecules. If N would be smaller, let us say 10^{30} , gravitation would be much more important, leading, via the force of gravity, to many more close encounters of stars, galaxies and plasmas, which would make many life forms just impossible. Only a short-lived miniature universe could exist. Biological evolution would be practically impossible.
- (2) $\varepsilon = 0.007$. Atomic nuclei consist of protons and neutrons. The binding of these subatomic particles depend in essence on one number: ε . This number directly determines how long stars can live, by determining how much of the mass of the hydrogen gas in the core of the Sun is converted into energy when it fuses into helium. In the event that ε would be 0.006, protons would not bind to neutrons, thereby making the formation of deuterium impossible, and also making helium formation impossible. Similarly, if ε would be somewhat larger, say 0.009, two protons would have been able to bind to each other, no hydrogen would be available as fuel for the stars, and the formation of water could not have occurred. It is clear that these deviant ε values would impede the creation of our universe with a complex chemistry required for the evolution of life processes.

The second two numbers (Ω and λ) constitute the size and texture of our universe:

- (3) $\Omega = 0.04$. This is the cosmic number which measures the amount of matter in our universe, i.e., galaxies, diffuse gas, dark matter. It amounts to the actual density divided by the critical density. The actual density is 0.2 atoms per m^3 . The critical density is 5 atoms per m^3 , needed for gravity to bring cosmic expansion to a complete stop. If Ω is too high, the universe would have collapsed long ago. If Ω is too low, no galaxies or stars would have formed.

(4) λ , small and positive. The cosmological constant λ determines the weakest force in the universe and measures the energy content of empty space. This cosmic “antigravity” (dark energy) controls the accelerating expansion of the universe. The effect of the hypothesized cosmic repulsion force of antigravity is only significant on the immense distance scales of the universe and stabilizes the cosmos (Close). Since λ has a small *positive* value, galaxies and stars have not been stopped from forming and cosmic evolution has been made possible.

The final two numbers (Q and D) constitute the properties of space:

(5) Q (ca. 10^{-5}). Q measures the energy to break up and disperse stars and galaxies as a proportion of their total “rest-mass energy” (mc^2). If Q were smaller, the universe would be inert and structureless. In case Q were larger, the universe would be highly violent, no stars or solar systems could survive and many black holes would exist.

(6) D = 3. This is the number of spational dimensions. For D = 2 or 4 no life could exist (Whitrow). In recent speculative theories it has been claimed that close to the Big Bang D might have been much larger: 10 or even 13 (“superstrings”).

Apart from an impressive list of other fundamental questions (for example, about the nature of dark matter and dark energy and about the relevance of string theory), we are left with these six numbers for which the natural sciences provide no explanation. We cannot predict the value of any one of them from the values of the others nor form any higher level theory of the structure of the cosmos.. This situation is rather similar to that for the about twenty constants in the Standard Model (section 3.3).

The very complex

Although modern chemistry is often confronted with highly complex molecular systems, these complexities are usually not comparable with those encountered in living systems, studied in the biological sciences. Definitions of life are notoriously difficult. Davies) argued that three properties stand out: (1) life processes are a product of the evolutionary principle of replication, including variation and selection; (2) they have an autonomy in that living organisms have a life of their own and are able to carry out an agenda; and (3) they have a special way to handle meaningful information.

A genome or a brain provides a blueprint or algorithm for carrying out a project, such as making a protein or copying a molecule.

It has been estimated that the human body consists of 10^{13} cells. Recently many researchers are trying to bridge the gap between biology and chemistry. Perhaps the greatest unanswered question is the transition from molecules to biological cells. Despite progress in this challenging area of science, some characteristics of the evolution of animate systems are still difficult to explain in chemical terms (Noble, "Music"). Three important examples have recently been summarized by Pross ("Seeking"):

- The highly organized complexity expressing functional design in even the simplest life forms;
- The homeostatic nature, an ability to maintain a dynamic far-from-equilibrium steady-state through a complex network of control and feed-back mechanisms;
- The metabolic capability (in the sense of energy gathering) that enables living systems to tap into an external source of energy for maintaining that far-from-equilibrium steady-state.

Pross ("Driving," "Emergence") went further and made a comparison between the regular (nonliving) world and the replicative (living) world. Stability in the regular world is primarily *thermodynamic*, aimed at the lowest Gibbs energy. By contrast, stability in the living world derives from the nature of the replicating processes. The dream of every cell is to become two cells (Jacob, cited in Monod), or, if this is not possible, as in nerve cells, at least to stay in a homeostatic state. Replicating systems reflect a stability that is *kinetic* in nature, in fact a *dynamic kinetic stability* of the kind that we find in a flowing river or in a water fountain. What characterizes the replication process and makes it unique is its exponential character, rather than the rate of replication itself. It is the balance between rate of replication and rate of decay that generates the steady-state population and thereby determines the stability (Pross, "Driving"). All living systems are kinetic aggregates, kinetic states of matter to be viewed as processes rather than as stable particles. Life is not a collection of reactions, but a network of reactions (Whitesides). Darwinian fitness, translated in chemical terms, is just dynamic kinetic stability; survival of the fittest is the drive toward greater kinetic stability, and natural selection is just kinetic selection. Biology is an extension of chemistry: it is replicative chemistry (Pross, "Seeking").

What is the drive of replicating systems towards greater dynamic kinetic stability? This has been defined as teleonomic, goal-oriented purpose (Monod). The evolutionary history of life seems to indicate that value and the aim at value is present in all living things. There is an urge, an aim at greater intensities of experience and higher modes of subjective satisfaction. A scientific metaphysics can be helpful here. Kauffman alerts us to the fact that living systems are autonomous in that, in a way, they act on their own behalf. This is a delicate situation, probably not fully accessible by the natural sciences. Dennis Noble expressed this carefully: “there is much more to be discovered, a genuine ‘theory of biology’ does not yet exist” (“Claude”).

Finally, it should be noted in this section that we cannot imagine life processes in the absence of *water*. The very small water molecules that make up the liquid form an extended, *highly dynamic*, three-dimensional hydrogen-bond network, not corresponding with the closest packing of individual molecules. A little more detail might be interesting here. One mole of water (18 g, one sip of water) consists of $6 \cdot 10^{23}$ molecules (Avogadro’s number). This is six times a one with 23 zeros. How can we get a feeling for this large number? Let us estimate the total number of sand grains in all beaches of the world (Jungerman). There are about 100,000 km of beaches in our world. We first consider a beach, 1 km long, 100 m wide and 1 m deep. A reasonable assumption is that there are 10,000 grains of sand in 1 cm^3 of sand. Then 1 m^3 contains $10^2 \cdot 10^2 \cdot 10^2 \cdot 10^4 = 10^{10}$ grains. Now, all beaches of the world, as defined above, amount to $[10^5 \cdot 10^3][10^2][1] = 10^{10} \text{ m}^3$. In this large volume of sand are $10^{10} \cdot 10^{10} = 10^{20}$ grains. So the amazing result is that in 18 g of water the total number of water molecules is 1,000 times the total number of sand grains in all beaches of the world! These molecules are in constant rapid motion relative to each other and are permanently interacting with each other. It is clear that the sip of water should be viewed as a *process*.

Water has a dominating effect on the structure and function of the biomolecules of life processes (proteins, DNA, carbohydrates, etc.). In fact, water bound to biomolecules can be considered as an integral part of the biomolecules themselves (Ball). It is not surprising that water has been a frequently used metaphor in process thinking (Engberts, “Water”).

THE PHILOSOPHY OF PROCESS

Introduction

During the past centuries the dominant metaphysics of the West entailed a mechanistic or scientific *materialism*, implying that matter (or mass) is fundamental in reality. It is assumed that there is a linear notion of cause and effect as a fixed universal law of the universe acting on inert matter. The authority of the natural sciences is recognized. Every particular is physical.

Descartes defined matter as that which is spatially extended. It moves, but it has no principle of motion in itself. Changes in motion are due to external forces.

Human beings are viewed as being fully included in the physical world, thereby providing a basis for the evolutionary theory. It is assumed that there is a complete bifurcation of the material and mental realms. Minds are not extended in space and are distinct from physical substance.

This worldview, inspired by empirism and verificationism, encouraged the development of logical positivism. It has ruled out whole areas of philosophy, such as metaphysics and ethics, as nonsense instead of reconstituting those areas as valid fields of inquiry (Phipps). Moreover, it is associated with a number of problems. It can give no satisfactory explanation for the basic orderliness of the world. There is no explanation for the six cosmic numbers, for the about twenty constants in the Standard Model and for the teleonomic drive in evolutionary processes. Other unexplainable notions on the basis of this worldview include the novelty and upward trend that appears in evolution, the objectivity of normative ideals, such as those of mathematics and logic, and the human experience of the world's value and beauty.

The cosmic numbers and the constants in the Standard Model have been recognized as crucial for the existence of our universe and for allowing life processes on our planet. Some tentative rationalizations have occasionally been given. The most facile one is pure chance. Our universe just happens to permit life. There are no links between life, mind, and cosmos. A more intriguing one is the multiverse theory (Linde) that claims that a large number of universes were created out of nothing, just arising from physical laws originating from a quantum event. Although there is an enormous multiplicity of cosmic domains, we are privileged to live in one that allows life processes. A third idea is that of Barrow and Tipler,

who have put much emphasis on the anthropic principle. Intelligent information processing must come into existence in the universe. Once it comes into existence, it will never die out. And finally we have intelligent design: the traditional monotheistic religious view. None of these world views is based on proper experimental evidence, a requirement for theories originating from the natural sciences.

I will now turn to the philosophy of process, showing that this way of thought is much more capable of dealing with the essential questions of the natural sciences than mechanistic materialism. It also provides a scientific metaphysics that can deal with issues outside the realm of the natural sciences. A start will be made with a brief summary of process thinking in ancient China. The underlying metaphysics is, of course, not scientific, but the intuitive metaphysical concepts illustrate deep wisdom and are still inspiring because of the intuitive understanding of the dynamics of our world processes. Aspects of Chinese process philosophy will then be compared with the philosophical ideas of Alfred North Whitehead. It is to be hoped that R.L.Greenwood was right when he said: "The future, if there is to be one, lies in the East and the West, jointly fertilizing one another's cultures."

Process philosophy in ancient China

THE YI JING (易经BOOK OF CHANGES)

Some four to three thousand years ago, the Chinese already cherished a worldview that emphasized the position of a human being within its surrounding natural environment. The frequent large-scale disasters, such as awesome floods and earthquakes that cost many lives and destroyed the harvests, made it very clear that human beings, in particular farmers, and their environment constituted an unbreakable unity. This led to the very ancient concept in Chinese thinking that the human has to adapt him(her)self to the dynamics and cosmic rhythm of the universe, a necessity for survival. This conviction was later extended to social life and has been laid down in a famous classic, the Yi Jing (易经, *Book of Changes*). This book contains the very foundation of Chinese culture. The first version, attributed to Fu Xi (伏羲born in present day Tianshui天水, ca. 8000-6000 BCE) contained eight trigrams, composed of three lines, either solid (yang) or broken (yin). They comprise the most elemental experiences that as human beings we have of nature, or heaven and earth, and which contain the patterns of change and transformation (Cheng).

Originally yang (阳) is the sunny side of a mountain, yin (阴) the shadow side, yang is male, yin is female, the sun is yang, the moon is yin, the mountain is yang, the river is yin, fire is yang, water is yin, warm is yang, yin is cold, yang is dominating, strong, active, yin is docile, passive, tender. Yin and yang are viewed as competitive and complementary forces or streams of energy in the world (Liu, *Introduction*) and can be described as paired, complementary aspects of any configuration in space or process in time. The trigrams represent heaven, earth, water, fire, wind, thunder, mountain, or lake. They stand for the basic natural phenomena, but also for other relations in a metaphorical sense, and depict the continual process of change in the cosmos. They are symbols for changing transitional stages involving dynamic potentials for change. If yang is growing, yin becomes smaller; if yin is growing, yang becomes smaller. Nothing is completely yin or completely yang. Yin and yang are symbolic representations of yin and yang characteristics, functioning as a cosmic hierarchy. Time makes actual what was potential.

The second version of the Yi Jing, attributed to king Wen (ca. 1150 BCE), contained 64 hexagrams with six lines and in which each component line was either yin or yang. Each hexagram signifies a moral situation in life being yin or yang and represents actual conditions in the world. Human judgments do not define what is “good,” in that “good” is what is manifested in nature. For humans to show moral behavior means that they possess goodness within themselves. The emphasis remains on change, viewed as alteration between yin and yang. A proper understanding of the symbolic meaning of the hexagrams is a starting point for right and creative, i.e., human, behavior in line with the cosmic order, both for the ruler and for the individual.

A final word here on the two traditional modes of study of the Yi Jing. The previous remarks are illustrative of the Meaning and Principle (Yili, 义理) school of study, rooted in the actual text of the Yi Jing. The Image and Number (Xiangshu, 象数) school, by contrast, focusses its attention on the images and properties of the symbols themselves (Schöter). In recent times, the structural properties of the symbols of the Yi Jing have been analyzed using tools of modern algebra (Nielsen).

The cosmology of the Yi Jing had a dominating influence on Chinese culture, extending to the present day. But also in the West there is abundant interest in the Yi Jing and in analogies between the Yi Jing and modern science and philosophy. An example is a recent study of

chemical self-assembly systems as viewed in the light of basic notions embodied in the Yi Jing (Pandoli).

CONFUCIANISM

The first important thinker is Kongzi (孔子, Confucius, 551-479 BCE), who laid down the fundamentals of a great moralistic and political philosophy. This school of thought had the greatest influence on the well-being of the Chinese people and on the continuity of Chinese culture. Most attention is given to human behavior that should lead to peace, harmony, happiness, and joy. In fact, the philosophy of the Yi Jing becomes strongly moralized in Confucianism (Cheng). The main Confucian issues are the problems of human nature, personal cultivation, and the place of human beings in the universe. Knowledge is associated with wisdom.

The concept of *Dao* (道), the Way, plays an important role, which is conceived as the dynamics as experienced in the smallest and biggest events in the universe (“all under heaven”). In Confucianism the concept of Dao and the yin/yang dynamics are focussed on compassion and goodness, as incorporated in the concept of *Ren* (仁). It has, apart from being the principle of humanity and care, also the dynamic quality of life-giving creativity. Identification with Ren leads to a feeling of oneness with “all under heaven.” Important aspects of Ren are Xiao (孝, love and respect for our parents), Yi (义, justice), Li (礼, ritual, the right behavior at the right moment), Zhong (忠, loyalty), and Xin (信, mutual respect).

Another great thinker is Mengzi (孟子, Mencius), who stressed that human beings are essentially good. He tells us: “human nature is just good just as water seeks low ground. There is no man who is not good; there is no water that does not flow downwards” (Gardner).

PHILOSOPHICAL DAOISM

In this school of thought, Dao also plays a major role. The most well-known classic is the Daodejing (道德经), attributed to Laozi (老子). It describes the behaviour of the Daoist saint who knows Dao intuitively and who lives and acts according to the Dao. Dao is essentially a process, the dynamics involved in “everything under heaven.” The Dao of the saint is not what he is, but what he does. In the words of Ames and Hall: “process is privileged over substance, continuity over discreteness” (67). Dao comprises an unfolding process. Therefore it is proposed to translate Dao as Way-making. A second important concept is *De* (德), virtue or force. De is the general virtue inherent in the wisdom of nature, which

puts us in a synchronistic relation with the course of the natural events in the world.

Another great thinker and writer of Daoism is Zhuangzi (庄子, 369-286 BCE). In his famous and much-admired classic he emphasizes the unity of nature and of the human being and explains in beautiful prose how our knowledge of Dao, the all-embracing ultimate principle, directly determines our moral behavior, spontaneous and free.

Neo-Daoism, a later development, particularly stresses the role of the human being in his (her) society. The flux of being is the main topic of attention in this school of thought.

BUDDHISM IN CHINA

Buddhism was first introduced in China in the first century CE. It was the learned monk Xuan Zang (玄奘), who travelled to India in 628 CE to collect the main Buddhist texts. He returned in 645 CE and settled in Chang'an (长安, present day Xi'an), where the texts were translated into Chinese and stored in the Big Wild Goose Pagoda in the Ci'en monastery.

Buddhism was well-received in China and flourished particularly during the Tang dynasty (618-906). Several Zong-pai (宗派, branches) were established, including the Chan-zong (禅宗, Zen) and the Jingtzu-zong (净土宗), which have a clear affinity with Daoism. Their metaphysics stresses "no-self," that is no continuity, no integrity, in line with process thinking. It is assumed that reality consists of ultimate entities or dhar-mas, arising and ceasing in irreducible moments in time. A poem that I found in the Big Wild Goose Pagoda (Engberts, "Water") expresses the Buddhist view of permanence and flux:

My permanent home is in
the ancient pagoda,
where every puff of existence
is tenderly renewed at dawn
in the glorious sunshine.

An important concept is the "void" (not corresponding to nonexistence), that can be related to the Daoist "non-being" (无, wu). The void is not a negative nor a nihilistic concept, but points to a new state of consciousness of complete fullness, but which is nevertheless in complete rest. A quote from the "Verses on the Faith Mind," written by the third Zen patriarch Seng-ts'an, illustrates the views of Chang Buddhism: "To live in the Great Way is neither easy nor difficult, but those with limited

views and fearful and irresolute: the faster they hurry, the slower they go, and clinging (attachment) cannot be limited; even to be attached to the idea of enlightenment is to go astray. Just let things be in their own way and there will be neither coming nor going” (Seng-ts’an).

Chinese Buddhism also developed ideas that were quite close to those of Confucianism. For example, the emphasis on the importance of compassion can be compared with the central Confucian notion of Ren.

The dialogue between Daoism, Confucianism, and Buddhism had a strong influence on the Chinese mind and culture, and stimulated novel metaphysical notions, which will be described in the next section. This intensive dialogue illustrates the remarkable tolerance that is characteristic of the philosophies of the East.

NEO-CONFUCIANISM

The introduction of Buddhism in China initiated a gradually increasing interest in a stronger metaphysical foundation, especially in Confucianism. Fundamentals were laid down by Zhou Dunyi (周敦颐, 1017-73) and by the Cheng brothers (Cheng Hao, 1032-85; Cheng Yi, 1033-1107). A novel philosophical school was created, Daoxue (道学, “School of Dao”), later better known as Neo-Confucianism. Its ideas dominated social and cultural life until the establishment of the Chinese republic in 1912.

Zhu Xi (朱熹) was the most important philosopher in this school of thought. He wrote a number of books, among them the *Jinsi Lu* (“Reflections on Things at Hand,” translated by Chan 1967). It has been called the most influential philosophical writing of the East in the second millennium.

Zhu Xi postulated that from the indeterminate Wu-Ji (无极) emerges Tai-Ji (太极), the great ultimate, which is the principle of creativity, unity, and oneness. The Tai-Ji governs the world through two fundamental concepts: *Li* (理), the heavenly principle (Tian-li), and *Qi* (气), the material principle. Li brings multiplicity into unity, allows permanence amid flux. Li is the ideal pole “above shapes,” the mind of the myriad creatures (wan-wu). The consequent nature of Li becomes immanent in each individual actual entity through Qi. Therefore Li and Qi need each other. Li becomes manifest through Qi, and is involved in change and becoming through the two modes yin and yang. The great ultimate is order and principle (Li) as well as creativity and plurality (Qi), but also mind (hsin) and humanity (Ren, love). Ren is the life-giving principle, a metaphysical elaboration of human love (Ching). Completely in the

Confucian tradition, the concepts of Li and Qi are heavily focused on human behavior.

Qi is the vital force, the dynamic principle of change and multiplicity, giving shape and actuality to Li. Qi is the real pole, “within shape,” which causes creativity to be immersed in the process of concreteness. The universe is viewed as the totality of Qi in perpetual motion and constant alteration (Li). The interaction of yin (quiescence) and yang (activity) with the five phases (fire, water, wood, metal, and earth) brings the myriad creatures into existence (Ching; Liu, *Introduction*).

Interestingly, two other Neo-Confucian thinkers, Zhang Zai (1020-77) and Wang Fuzhi (1619-93) had different views concerning the Li/Qi concepts. According to them, Li is not a “precondition” for existence, but is simply the law of nature. Li is seen in the necessary tendencies of the Qi itself. Qi has an internal order, that can be regarded as Li (Liu, “Cosmic”).

In the sixteenth century lived another great Neo-Confucian thinker: Wang Yang-ming (王阳明, 1472-1529). Some of his ideas are rather different from those of Zhu Xi and are summarized in his collected works (王文成公全书, *Wang Wen Cheng Gong Quan Shu*). He proposed to replace learning via (mainly) historical studies by learning via direct experiences. This should be done through development of *liang-zhi* (良知), a knowledge of the good given to human beings by nature. In the older literature, although with much less emphasis, there was *ko-wu*, the direct observation of Li in all things and beings, leading to openness and impartiality, unbiased observation. Via *liang-chih*, a human is aware, by intuition, of the moral excellence of “all under heaven.” This explains why a human being is able to differentiate between bad and good.

A final note. Chinese thinking is not just philosophy in that it also encompasses literature, poetry, the sciences, and the arts. Philosophy, poetry, and painting melted together in China into a unity of wisdom experience, unique in the history of the world. The human being is seen as part of the universe and, in fact, no entity can be conceived in complete abstraction from “all under heaven.” In all Chinese schools of thought there is a strong emphasis on unity. For example, the unity of nature and humanity, of substance and function, of knowledge and action, of virtue and truth.

The three great poets of the Tang dynasty, Li Bai (李白, 701-62), Du Fu (杜甫, 712-770) and Wang Wei (王维, 701-61) expressed in a sublime manner the worldviews of Daoism, Confucianism, and Buddhism

(Cai). In landscape painting, highly valued in China, the painter puts the human in the middle of nature, of the universe. Often we see mountains and water, permanence and flux, yang and yin. The paintings reflect the harmony and complementarity of flux, yang and yin, and the coherence of the cosmos.

Process thought of Alfred North Whitehead

Alfred North Whitehead (1861-1947) was a mathematician and philosopher with extraordinarily broad interests. He started with a position in mathematics at the University of Cambridge in the UK. He then moved to London in 1910 where he was appointed professor of applied mathematics at the Imperial College of Science and Technology. In 1924 he was appointed as professor of philosophy at Harvard University in the USA.

He has written a whole series of important books and articles that were well received. The topics include the mathematical concepts of materials, dynamics within viscous liquids, symbolic logic, relativity, and geometric concepts. It seems clear that in the period of his life in the UK his professional interests were largely focused upon scientific concerns, with a strong preference for logical and scientific thinking. His first masterpiece is *Principia Mathematica* (three volumes, 1910-13, written in cooperation with Bertrand Russell). It has been called the most famous and seminal book ever written on the foundations of mathematics. It is claimed that mathematics is a development of symbolic logic. All the fundamental propositions of logic and mathematics are deduced from logical premisses and primitive ideas.

His prime interests changed substantially over time; there might have been a relation with the tragic death of his son in the first world war. Whitehead switched to philosophy, and, coping with mandatory retirement in England, he accepted a position as a professor of philosophy at Harvard in 1924. There he founded the most comprehensive process philosophy as laid down in a second masterpiece *Process and Reality* (1929). His earlier work in mathematics gave him an ideal preparation for constructing a really new philosophy. He was saved from being ensnared, as many professional philosophers are, by current philosophical language (Lowe).

An attempt will be made to summarize briefly some of the most significant tenets of Whitehead's scientific metaphysics, which are useful for the sake of comparison with the natural sciences and classical Chinese thinking.

Whitehead holds that the ultimate metaphysical principle is *creativity*. Creativity is that eternal aspect of the universe by reason of which there is an endless becoming and perishing of actual entities, i.e., drops (quanta) of experience, complex and interdependent. The actual world thereby provides the determinate data existing in the creative process (Stapp). Space, time, and matter are derivative concepts of process. This has even been verified in modern physics for “empty space” is filled with an endless birth and death of virtual particles. It generates the transition of events through time and the extensive relationships of time. It manifests itself in the becoming (“conrescence”) of all actual entities, the “atomic” facts of life. Creativity is the ultimate principle by which the many, which are the universe disjunctively, become the one actual occasion, which is the universe conjunctively. This ultimate notion of creativity is inexplicable in terms of higher universals. Based on this notion of creativity, five derivative concepts can be formulated (*PR*):

- Process is metaphysically prior to substance.
- All processes are in a grip of the metaphysical ultimate, creativity, that involves a creative advance into novelty.
- Everyday experiences are valued as concrete intuitions of the universe. The universe is to be conceived as being made up of occasions of experience. An experiencing subject is one occasion of sensitive reaction to its actual world from that subject’s unique perspective within space-time.
- The final facts, of which the world is made up, are all alike, actual entities, to be considered as energy events (which may originate from quantum leaps, discontinuous jumps from one actual occasion to the other—see Stapp).
- There is an ultimate reality which (1) bestows an orderly character on creativity so that the becoming of actual entities is not purely chaotic, and (2) functions in the selection of repeatable patterns (“eternal objects,” pure potentials of the universe) that are enacted in the world. Our universe exhibits some general systematic and rational metaphysical character.

Let us look in somewhat more detail at eternal objects. These represent the modes of definiteness, such as specific mass, shape, size, or change, which ingress in the non-recurring events constituent of reality. Modes of definiteness in their capacity as pure possibilities neither dictate nor

preclude where, when, or how often they ingress into the temporal flux of the cosmos.

To define the orderliness of the universe, one should understand the evolution of any finite system or aggregate of events. For this purpose, it is essential to have a grip on the characteristics and causal potentialities inherent within that system, its internal dynamics, and its causal interactions with the surroundings and the spatio-temporally contiguous communities of events. This principle is valid for both micro and macro communities of events.

Actual entities or actual occasions are the most concrete facts, unique and particular, and they are connected with all other actual occasions. They are essentially occasions of experience, embodied in “atomic” extended events. Although Whitehead has characterized actual entities as atomic, this concept contrasts with the original Greek notion of atomicity, which means indivisible rather than very small. They are not instantaneous facts because instantaneous facts cannot have an immediate successor. Actual entities are perpetually perishing and perpetually arising. The ontological principle states that actual entities are the only reasons, so that search for a reason is to search for one or more actual entities.

All existents are involved in causal relationships. Supervening and constituent processes are ordering a natural hierarchy. A balanced level of connectedness, in which change can occur within appropriate constraints, is necessary for stability in systems. The essence of actual entities is becoming, incapable of recurrence, perpetually perishing, extended, atomic, and exhibiting a *physical* and *mental* pole. An actual entity is a process and is not describable in terms of the morphology of a substance. Actual entities are realized in a concrescence and reflect (1) the past through physical and conceptual prehensions, (2) their own self-determination, and (3) their initial aims originating from the primordial aims of the ultimate reality. Creative experience has a bias towards greater complexity, novelty, beauty, and value through a desire to be in harmony with the ultimate in the nature of actual events. Life might be seen as wedding of fact to value. Metaphors such as this provide a way for a deeper understanding of the world’s nature.

As noted above, every actual entity has a physical and a mental pole. Reality is *not* bifurcated into separate material and mental realms. Both poles are in a causal, dynamic interaction with each other. The physical pole is the aspect in which creativity is revealed in its extensive and material

character. The mental pole is the source of all creative advance and includes an aim at an aesthetically and morally harmonious nature as the result of the self-creation of the actual occasion. This aim is called the subjective aim and it is the source of the atomicity of the actual occasion.

An actual occasion is usually a member of some aggregate of actual occasions, called a nexus. There is a physical adjustment between the members of the nexus such that the nexus itself is made a systematic, albeit composite, unity.

How are actual entities connected to each other? Whitehead asserts that other entities can be included in the constitution of a particular actuality because those entities are being *prehended* by the actuality in question. The physical fact at each region of space-time is a composition of what the physical entities throughout the universe mean for that region (*AI*). An actual entity is a process of prehensions and displays itself as a concrescence of prehensions. Every prehension consists of three factors: (1) the actual entity in which the prehension is a concrete element, (2) the datum which is prehended, and (3) the subjective aim, which is *how* that subject prehends the datum.

Two types of prehensions should be distinguished. First, there are physical prehensions, which are prehensions of other actual entities. And second, there are conceptual prehensions, which are prehensions of eternal objects.

A feeling is defined as a prehension, a prehension is not defined as a feeling. One cannot attribute aesthetic experience to stones or individual molecules. Prehensions describe the way one actual occasion participates in the constitution of another. There is, however, one kind of prehension that is not a feeling: a negative prehension. This is the exclusion of something from playing a role in the constitution of an actual entity. It is worth adding here that the theory of prehensions is only one half of the relational story of the real. Whitehead's theory of extension is an important adjunct to Whitehead's metaphysics, but this theory will not be discussed here.

The unity of an actual occasion is constituted in a perception-like responsiveness to the universe that, though usually lacking consciousness or apprehension, is an appropriation to and for itself of the whole. Human experience is a special case of prehension, but mind-body dualism is rejected. Thus, Whitehead maintains that prehensions fill the universe. And let it be clear: *comprehension* and *consciousness* are reserved for entities with highly evolved central nervous systems.

Finally, some comments are needed regarding a necessary part of Whitehead's metaphysics, which gives the system its coherence. When observing in our everyday lives an ever-increasing complexity of our environment, we can only conclude that changes are not random, but occur with an orderliness and lawfulness. At any moment we experience a lure to actualize novel possibilities for the future. The flux of time is not conceivable as a continuation of a changeless world. Therefore, there must be an actual source for these future possibilities, defined in terms of eternal objects which reflect the actual world. This nontemporal actual entity does not have absolute power, but provides a lure for novelty, value, and beauty and hence in a way is responsible for the orderliness of the universe. This orderliness, it should be noted, is the basis for an efficacious teleology within the flux of life. This divine actual entity is metaphysically necessary for creativity. One can see divinity as a total field which sets the goals of the cosmic process and continuously influences events towards their goals. Whitehead has called this divine actual entity God, but it is clear that his naturalistic theism is very different from the concepts of God in monotheistic religions that are embedded in rigid orthodoxies. In such monistic schemes, God is allowed a final, "eminent" reality, beyond that ascribed to any of its accidents. One interpretation is to see God as a temporally ordered series of divine occasions of experience, rather than as a single actual entity that transcends time and the temporal flux.

The nature of divinity is dipolar: (1) it has a primordial nature, the mental pole involving an unlimited conceptual realization of the absolute wealth of potentiality. This ordered realm of potentials has causal efficacy. It is not before all creation, but within all creation and represents the source of the evolutionary process of the universe. (2) It has a consequent nature, the physical pole, not separable from the primordial nature and evolving in its compassionate relationship to the changing world. The consequent nature of the divine represents its physical prehension of actual occasions.

One has to consider the possibility that the "six numbers," the constants in the Standard Model and the teleonomy in life processes, as discussed above, are specific orderings in the sphere of potentials, "cosmic decisions" in terms of purposeful choices. Nobel prize winner Steven Weinberg expressed this as follows: "whatever one's religion or lack of it, it is an irresistible metaphor to speak of the final laws of nature in terms of the mind of God" (242). Many of history's great physicists, including

Newton and Einstein, saw, within the contingent ordering of the most fundamental laws of nature, the hand of God. According to Whitehead, divinity and the world are one, both are in the grip of creative advance into novelty. The consequent nature of God is the weaving of physical feelings with primordial concepts.

BRAIN ASYMMETRY UNDERLYING CULTURAL DIFFERENCES IN PROCESS PHILOSOPHY

Introduction

I would now like to defend three claims based upon the material summarized in the previous sections:

- (a) The modern natural sciences, classical Chinese philosophy, and the thought of Alfred North Whitehead are all based on *process thinking*. The natural sciences claim that reality can be best viewed as a complex combination of interdependent energy events. Matter seems solid to us, but this is due to a limitation of our senses. Solid matter is space filled with an unimaginable number of events—not only those from spontaneous particle pairs—but also from the virtual photons, gluons, and bosons that are the force carriers of interactions (Jungerman). These notions substantiate the fallacy of “substrate thinking.”

In classical Chinese philosophy the world is viewed as arising from eternal changes originating from compatible and complementary forces (yin/yang, li/qi). In Whitehead’s philosophy the ultimate metaphysical principle is creativity, the endless becoming of actual entities, a stream of drops of experience in an endless process of birthing and perishing. Permanence itself is derivative from the recurrence of qualitative identity among sequences of arising and perishing events. The unavoidable conclusion is that process thinking is philosophically superior to mechanistic materialism as well as to logical positivism.

These considerations make it possible to characterize these three ways of thought as process philosophy.

- (b) For a satisfactory understanding of our experiences of the world, there is a definite need to include metaphysics in our reflections. If we divide the natural sciences into three areas, the very small (the microworld), the very big (cosmology), and

the very complex (life processes), we find that in each of these realms there are fundamental questions that cannot be solved by solely using the tools of these sciences. Scientific metaphysical considerations can bring us some steps further in our desire to get the best understanding of our world.

- (c) Taking into account our modern insights into the functioning of the human brain, and particularly the unequal localization of specific brain functions in the left and right hemispheres (LH and RH), one is led to some tentative suggestions regarding some important issues. The major one is, how it is possible that process thinking can be identified in three different modes of thought which evolved under such different circumstances and in very different historical periods? Somehow these three modes of thought arising and maturing in such different historic and cultural epochs must have their fingers upon the pulse of the universe.

In the final section an attempt will be made to relate the bispheric structure of the brain with the three different types of process thinking. The conclusions will be in part speculative and tentative, but they are made with the hope of bringing philosophical reflections and brain activities somewhat closer together.

Brain lateralization in process philosophy

The natural sciences are among the most important contributions to Western culture. Exceptionally deep insights have been obtained into the behavior of matter, in the microworld, the macroworld, and in the highly complex life processes. It appears clear (but often not recognized) that process thinking is the ultimate basis of scientific thinking.

Fundamental results have largely been obtained by *step-by-step discoveries*, with a focus on causal relationships, and on logical and mathematic analysis. Metaphysics is disclaimed and considered to be unnecessary if not nonsense. The conclusion is that in the natural sciences brain activities are dominated by the *left hemisphere*. This should not be misunderstood. No doubt, intuitive thinking, involving the right hemisphere, is occasionally important in the natural sciences, but the final criteria for adequate results are judged on the basis of logic and step-wise analysis.

Now turning to ancient Chinese philosophy, we have a different situation. Daoism, Confucianism, Chinese Buddhism, and particularly

Neo-Confucianism rest on the *intuitive* notion that a human being and all natural phenomena participate in the same continual process of change manifested within the whole cosmos. The Chinese mind considers human life and the world at large as a challenge in harmonization of the micro (human) and macro (heaven) realms of existence. It should be noted here that the Chinese written language has retained a closer relation between observed reality and written signs than the phonetic Western languages. The Chinese characters have originally been directly derived from drawings of natural objects and these characteristics can still be noted, even in the modern, simplified written characters. And let us not forget, language is an important instrument of thought. Not only is language able to express thoughts, language is also shaping them.

Human endeavor can be viewed as situated within the larger framework of cosmic energies. This worldview has been called immanent transcendence (Inada), which is a vision of experiences that transcends our direct empirical and rational understanding of occurrences around us. The Chinese philosophical schools all possess a similar cosmological foundation as first layed down in the *Yi Jing*.

It is also worth mentioning that the typical Chinese cultural tradition to value social relations, respect for rules, ritual, and symbolism, can be related to a dominance of the right hemisphere. The right hemisphere senses better how one has to adjust his or her conduct in a particular social-emotional context. This is what psychologists today call emotional intelligence. Mirror neurons (Iacoboni) are probably important in the development of social behavior. There have been some interesting studies that suggest how cultural differences play a vital role in the development of the two hemispheres and the predominance of one hemisphere over the other. Children from Asian backgrounds were shown the same phenomena as children from Western backgrounds. They tended to perceive in a more synthetic and relational manner than the Western children, who abstract the dominant and aggressive elements from what they consider to be the background. This represents a tendency toward more holistic and creative understanding of experiences as opposed to a more rigorous analytic abstraction of parts (Masuda). It should also be noted here that reading Chinese words aloud activates far more widespread networks of neurons of the right hemisphere than English. This is probably a consequence of the subtlety of both visual and tonal demands by the Chinese language (McGilchrist; Tan).

I conclude that the basic brain activities associated with classical Chinese thought are dominated by the *right brain hemisphere*. Here it should also be stressed that it is just a dominance. Logic can also play a significant role, as, for example, in the Image and Number school of the Yi Jing tradition. A rather similar conclusion has been drawn by McGilchrist, who suggests that the East Asian cultures use strategies of both hemispheres more evenly, while Western strategies are steeply skewed towards the left hemisphere.

The final system of thought that has been considered is Whitehead's process thinking. Whitehead looks at nature as a system of factors apprehended in sense-awareness and it presents itself as essentially a becoming. This scheme of thought takes full account of the insights offered by the natural sciences. Science and metaphysics are now fused in a single rational scheme of thought, in which conceptual and emotional experiences are carefully united. His thought illustrates the integration of controlled and factual observation with an intuitive approach. This idea is further supported by the fact that Whitehead, in his extensive discussions of education and teaching (Lowe), has put so much emphasis on evoking and stimulating *curiosity* in the minds of his students. Curiosity has been called by the Harvard biologist E.O. Wilson "the greatest of all human virtues." Wondering about an unexpected pattern of experience, is primarily arising in the right hemisphere, whereas further thinking and analysis of these experiences is primarily located in the left hemisphere of the brain.

Whitehead's thought embodies a mature metaphysics, which is still in a process of further development. In his own words: "in philosophical discussions the merest hint of dogmatic certainty as to the finality of statement is an exhibition of folly" (*PR* xiv). Important concepts show a remarkable resemblance with basic ideas encountered in classical Chinese thought. But now the whole scheme of thought takes account of modern physical insights and is *systematically* developed in Whitehead's magnum opus *Process and Reality*. This worldview, based both upon adequate scientific and metaphysical schemes, promotes the most general systematization of civilized thought.

It is suggested that here brain activities involve *equally important contributions from brain activities localized in both the right and left hemispheres*. Both hemispheres communicate intensively with each other, either stimulating or inhibiting each other, thereby leading to modern

discoveries in the natural sciences, a coherent combination of creative intuitions and profound wisdom.

In sum, the ultimate appeal of human thought is to the general consciousness of what in practice we experience. Indeed, the vitality of thought is an adventure!

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