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Mind in Nature: the Interface of Science and Philosophy by John B. and David R. Griffin Cobb, Jr.

John B. Cobb, Jr. is Professor of Theology at the School of Theology at Claremont, Avery professor of Religion at Claremont Graduate School, and Director of the Center for Process Studies. David Ray Griffin teaches Philosophy of religion at the School of theology at Claremont and Claremont Graduate School and is Executive Director of the Center for Process Studies. Published by University Press of America, 1977. This book was prepared for Religion Online by Ted and Winnie Brock.

(ENTIRE BOOK) A collection of essays by prominent physicists, biologists, geneticists, zoologists, philosophers and other thinkers about the relationship between science and philosophy, particularly the teleological versus the mechanistic explanation of the universe. Special emphasis is given to the writings of Alfred North Whitehead and Process Theology. Contributors include John Cobb, Jr., Theodosius Dobzhansky, Charles Hartshorne, and Arthur Koestler.

Preface

These papers come from a conference held in Bellagio, Italy in June, 1974. The hope underlying the conference was that, if aspects of Whitehead's form of process philosophy were effectively communicated to scientists who in turn could help philosophers understand the nature of their current problems, both philosophers and scientists would benefit. Although communication between the two communities is far from easy, this volume suggests that it is possible and that, when it occurs, it is mutually fructifying.

Part 1: The Evolution of Mind

Chapter 1: The Frontiers of Biology -- Does Process Thought Help? by W. H. Thorpe and Response by Bernhard Rensch.

The reduction of chemistry to physics, of biology to chemistry, of animal conscious or subconscious experience to biology, and of consciousness itself and the creativeness of the human mind to animal experience, are all problems that are unlikely if not impossible to succeed.

Chapter 2: Can Evolution be Accounted for Solely in Terms of

Part 2: Mind and Order

The author uses an analyses of quantum theory and how it needs a fundamentally new notion of order to show a development that is capable of making full contact with modern science, yet assimilates common experience, to give a single, whole, unfragmented world view.

Chapter 2: Three Counter Strategies to Reductionism in Science by Francis Zucker

Three research programs that are motivated by opposition to physical reductionism.

Chapter 3: Temporal Order and Spatial Order: Their Differences and Relations by Milic Capek

Our instinctive tendency is to believe that the relations of succession can be adequately symbolized by geometrical relations. The persistence of this belief has had disastrous influence through the centuries on philosophical and theological thought, and upon physical theories as well.

Chapter 4: Free Will in a Hierarchic Context by Arthur Koestler, Responses by Charles Hartshorne and Bernhard Rensch

The degrees of freedom in the hierarchy increase with ascending order, and each upward shift of attention to higher levels, each handing over of decision to higher echelons, is accompanied by the experience of free choice. But is it merely a subjective experience? The author thinks not, since freedom cannot be defined in absolute, only in relative, terms, as freedom *from* some specific constraint.

Chapter 5: Some Whiteheadian Comments by John B. Cobb, Jr.

Reductive determinism mistakenly holds the view that when prediction of behavior and thought is not possible, this is because of the complexity of the determining factors rather than because of indeterminacy or freedom.

Part 3: The Primacy of Mind

Chapter 1: Arguments for Panpsychistic Identism by Bernhard Rensch and Response by Charles Hartshorne

All psychic phenomena (sensations, mental images, feelings, thoughts and processes of volition) are merged in our stream of consciousness. All psychic experience is therefore part of a *process.* Many considerations speak in favor of this "panpsychistic identism."

Chapter 2. Panpsychism and Science by Sewall Wright

In addition to the necessarily deterministic and probabilistic interpretations of the material world of science, there is the primary but private knowledge which each of us has of his own stream of consciousness, more or less continually directed toward the finding of an acceptable course through the difficulties of the external world by means of voluntary actions.

Chapter 3: Physics and Psychics: The Place of Mind in Nature by Charles Hartshorne

Since physics and chemistry have demonstrated how limited in penetration our mere sense perceptions are, how radically they fail to disclose what is really there in nature, it follows that the entire traditional foundation for both materialism and dualism has been destroyed by the advance of knowledge. All concrete or physical things (a) are minds of some high or low kind, or (b) are composed of minds. However, only active singulars are individually sentient.

Chapter 4: Some Whiteheadian Comments by David Ray Griffin

The author discusses the similarities and differences between the insights of Bernhard Rensch, Sewall Wright, and Charles Hartshorne, from a Whiteheadian point of view.

Part 4: Mind and Organism

Chapter 1: Some Main Philosophical Issues in Contemporary Scientific Thought by Ivor Leclerc

Previously, biology was conceived as reductive to chemistry and chemistry as reductive to physics. But today these sciences have distinct features. Biology, as an example, by virtue of its structure, makes possible the requisite degree of conceptual origination, having the characteristic of "life," which is not true of chemistry or physics.

Chapter 2: Whitehead and the Philosophy of Science by Ann Plamondon and Response by Bernard Rensch

Metaphysics has an essential role in the philosophy of science -- that of the understanding and the grounding of scientific concepts and methodology. That is, the fundamental concepts of a metaphysical system should give an analysis of the foundational concepts of the sciences in such a way that these concepts themselves provide a grounding -- a general logic -- of the methodology of the sciences.

Chapter 3: Whitehead’s Philosophy and Some General Notions of Physics and Biology by David R. Griffin

A discussion of Whitehead’s understanding of: 1) metaphysics and it’s relation to science; 2) the fundamental categories to all of reality; 3) the implications in his understanding of fundamental categories in the objects of physics; and 4) non-reductionistic biology which avoids dualism, including vitalism.

Chapter 4: Can Whitehead Help Us Learn What We're Talking About? by Richard H. Overman

The proper interpretation of Lamarckian notions in genetics depends fully on knowing 'what' we are talking about. All new patterns of efficient causation in animal bodies can be traced to *some* occasions' subjective aims.

Chapter 5: Whitehead and Modern Science by C. H. Waddington

If we approach science from the Whiteheadian point of view, the fortress which the anti-scientists will have to attack is not what they think it is, and may be capable of mounting a rather devastating counter-attack.

Chapter 6: Concluding Editorial Comments by John B. Cobb, Jr.

From the sixteenth through the eighteenth century, philosophy and science developed in close connection. During the nineteenth and twentieth centuries they have become quite separate. The disciplines of cosmology and philosophy of nature have fallen between the stools. Alfred North Whitehead is the major twentieth-century exception to this breakdown of an ancient and fruitful relation. C.H. Waddington believes that scientific thought is "just about now beginning to catch up with the first phase of Whitehead's thought," and that science will proceed in the general direction Whitehead moved in his later work. The editors believe that the advance of science can be facilitated by an ongoing discussion with Whitehead's philosophy of nature, and hope that more philosophers and scientists will join in the discussion.

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Preface

Students of living things have long been in a quandary. On the one hand, progress in understanding follows when they treat their objects like complicated machines, composed purely of matter. On the other hand, it is clear to many of them that living organisms, and especially self-conscious human living organisms, are something quite different from what their explanatory categories allow. Explaining in this conventional way is too much like explaining away.

Many working biologists are content to add to the corpus of biological knowledge without troubling themselves about these issues. Some strongly insist that reductionistic explanations are fully adequate. But others continue to seek ways of thinking that explain without explaining away. The conferences and volumes for which C. H. Waddington has been responsible have pressed toward new conceptualization; and Arthur Koestler and 1. R. Smythies have edited essays developed from a conference on "Beyond Reductionism."

Neo-Darwinism has played a prominent role in expanding the power of reductionistic modes of thought in evolutionary theory. It has been an effective force in weakening older forms of vitalism and teleological thinking. Yet some of its chief architects do not themselves draw reductionistic or materialistic implications from their theories. Sewall Wright sees biological science as treating the externals of living things with deterministic and statistical laws, but he believes the creatures themselves have internality and freedom. Theodosius Dobzhansky stresses the miracle of the emergence of humanity in its radical discontinuity with the rest of the world. C. H. Waddington sees an interaction between the purposive behavior of animals and their environment that was inadequately recognized in more reductionistic interpretations of neo-Darwinism.

Topics of this sort have not been in the center of philosophical attention in the past generation. Neither existentialists nor language analysts undertook to explain life. But there has been a tradition of philosophical naturalism in this century, stressing organic and processive categories, which seems to have the potential for fruitful interaction with the work of reflective biologists. Bergson and Teilhard de Chardin in France have obvious relevance, as do James, Peirce, and Dewey in the United States, and Tennant and Alexander in England.

A small but growing number of philosophers have been particularly impressed by the potential fruitfulness of the conceptuality of Alfred North Whitehead. Whitehead called his position the ‘philosophy of organism.’ He held that, while biology studies the larger organisms, physics studies the smaller ones. Much scope for ‘reduction’ of biological phenomena to physical ones remains, but when that to which reduction occurs is not matter in motion but organisms in environments, the meaning of ‘reduction’ is changed. Furthermore, organisms of organisms can be understood as transcending their organic parts in ways that the most complex machines do not.

In June, 1974, a meeting was held at the Rockefeller Foundation’s Study and Conference Center at the Villa Serbelloni in Bellaglo, Italy, to consider whether and how process philosophy in general, and Whitehead’s conceptuality in particular, might help those who are seeking new, nonmaterialistic or nonreductionistic ways of understanding biology. Whitehead’s fully developed system in *Process and Reality* is of such complexity as to have been largely inaccessible to scientists, and the developments in science are so rapid and technical as to bewilder philosophers. The hope underlying the conference was that, if aspects of Whitehead’s form of process philosophy were effectively communicated to scientists who in turn could help philosophers understand the nature of their current problems, both philosophers and scientists would benefit. Although communication between the two communities is far from easy, this volume suggests that it is possible and that, when it occurs, it is mutually fructifying.

The use of the term ‘mind’ in the title of the book may be misleading; for the noun suggests that a substantial entity is in view. Process thought, on the contrary, understands mind as mental activity or functioning, especially purposive action. ‘Nature’ is similarly understood by most participants as occurrence or event.

The papers in Part One, "The Evolution of Mind," describes the mystery of the rise of self conscious, human, purposive action out of a flux in which it has been customary to find no grounds for such an emergence. Thorpe formulates the problem as a challenge to process philosophy and, after papers by Birch, Dobzhansky, and Waddington, and comments by Cobb on the potential contribution of Whitehead, Thorpe shares his concluding reflections. The issues are: What kind of continuity and what kind of discontinuity are to be found in the evolutionary process? And can process philosophy help biologists to understand their data?

Part Two, "Mind and Order," treats the broader question of what is meant by ‘order’ and how order is related to the human experience of purposive freedom. Several strategies for overcoming reductionism are distinguished and defended. The discussion is chiefly between physicists and philosophers, although the relation to biology is always especially in view.

Part Three, "The Primacy of Mind," opens up the specifically ontological question of how the ultimate entities of the universe are to be conceived. Two biologists and one philosopher argue that the psychical, or mental, or subjective elements in reality are more fundamental than the physical, material, or objective elements.

Part Four, "Mind and Organism," consists of papers that deal specifically with Whitehead. They include expositions of his philosophy of nature and his philosophy of science as well as more topical and critical treatments. The final essay (apart from the concluding editorial comments) is an account by Waddington of how his own work as a biologist has been influenced by Whitehead’s philosophy.

A collection of essays of this sort does not reach a unified conclusion.

Yet the editors find themselves confirmed in the beliefs (1) that the philosophy of nature is an important and fruitful area for continuing exploration, especially if scientists and philosophers can learn to work together, and (2) that for the time being Whitehead's rigorously articulated vision provides the most promising basis for further reflection in this area.

This book is published under the auspices of the Center for Process Studies. The conference out of which this book arose was sponsored by the Center with support from the Rockefeller Foundation. Public thanks are herewith given to the Rockefeller Foundation, with special thanks to the directors of the study and conference program.

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Part 1: The Evolution of Mind

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Chapter 1: The Frontiers of Biology -- Does Process Thought Help? by W. H. Thorpe and Response by Bernhard Rensch.

W. H. Thorpe is Director of the Sub-Department of Animal Behavior, Department of Zoology, at the University of Cambridge.

At the very start of my work in biological research I was much inspired and stimulated by the writings of Whitehead. I expressed this in the first chapter of my book (Thorpe 1951, 1963). He seemed to me one of the very few philosophers who showed a real understanding of biology; its nature and its problems. I still regard him as one of the most profound minds of his time and still find refreshment and stimulation in his writings on an extraordinary variety of topics.

But over the years I have found him less of a support in biological research than I had at one time hoped and expected. So I will try to single out one or two recent biological developments to illustrate this and at the same time mention some which seem more compatible with the Whiteheadian view.

The two main frontiers of biological thought at present are (1) the living/non-living frontier (and included in this the tremendous problem of the origin of the ‘primitive’ cell) and (2) the mind/life frontier. Both these frontiers seem today as impassable as ever they did; and indeed the first seems to have been rendered (contrary to popular belief) even more impregnable, as a result of the unraveling of the genetic code, than it was before.

The First Frontier

Ever since Victorian times it has been the changes in physics and in astronomy which have in fact seemed so appalling and disconcerting to many thoughtful persons. Many of our most cherished beliefs have gone by the board. Atoms were thought to be permanent, unchanging elements of nature. Now, far from remaining unaltered, they appear to be created, destroyed, and transmuted. What do remain enduring are certain abstract attributes of particles, of which the electric charge and the wave aspects of elementary physical particles are the most familiar. Edmund Whittaker (1949) has described what he calls *postulates of impotence*, but which Bronowski (1969) has cleverly entitled *the laws of the impossible*, a break-up of which is particularly disturbing. Thus a great part of mechanics can be derived from the single assertion that perpetual motion is impossible. In special relativity it is impossible to detect one’s motion if it is steady, even by measuring the speed of light. In general relativity it is impossible to tell a gravitational field from a field set up by one’s own motion. In quantum physics there are several laws of the impossible which are not quite equivalent: *the principle of uncertainty* is one, another is that *it is impossible to identify the same electron in successive observations.* At bottom all the quantum principles assert that there are no devices by which we can wholly control what state of a system we will observe next. Bronowski translates that into the statement, "It is impossible to ensure that we shall copy a specified object perfectly."

One of the most striking differences between physics and biology arises in just this context. I think one can say that in biology there are no *genuinely biological* postulates of impotence *except* that spontaneous generation is impossible. Any other postulates of impotence which may appear to be part of biology are in the end, I think, reducible to physics, and it is from that discipline that they really come.

But there is another side to all this. There are assumptions which we cannot do without, even though all seems to be dissolving. One of these is that there is a *real world which we in some measure apprehend by our senses: that is to say that knowledge is possible.* And (as Bronowski [1969] points out) in the field of science this means that it is *rational.* But this is not to imply that nature is necessarily therefore all machine-like. And this idea of a great machine is one of the great misconceptions of our age, haunting the biologist now as it haunted the thinkers of the nineteenth century when Tennyson wrote, "The stars, she whispers, blindly run." But let us come back to biology, and particularly to the ideas of modem biology as affecting man’s views of nature and his own place in it.

In 1944 Professor Schroedinger wrote a little book entitled *What is Life?* This treatise of less than a hundred small pages has perhaps had more influence on recent thinking on this topic, among both physicists and biologists, than almost any other recent study. Schroedinger points out that when a piece of matter is said to be alive it is because it goes on ‘doing something’ -- moving, exchanging material with its environment, and so on. Moreover, it goes on doing this for a much longer period than we would expect an inanimate piece of matter to ‘keep going’ under similar circumstances. A system that is not alive, if isolated or placed in a uniform environment, usually ceases all motion very quickly as a result of various kinds of friction. Temperature becomes uniform by heat conduction and after that the whole system fades away into a dead, inert ‘lump of matter.’ A permanent state has been reached in which no *macroscopically* observable events occur, a state which the physicist speaks of as thermodynamical equilibrium or ‘maximum entropy.’ During a continued stretch of existence, it is by avoiding rapid decay into the inert state of equilibrium that an organism appears so enigmatic; so much so that from the earliest stages of human thought some special non-physical or supernatural force was claimed to be operative in the organism.

Pantin, in discussing such statements, points out that almost everything that Schroedinger has said about life could at least in some measure be said about a thunderstorm. A thunderstorm goes on doing something, moving, exchanging material with the environment, and so forth; and that for a much longer period than we would expect of an inanimate system of comparable size and complexity. It is by avoiding the rapid decay into an inert system of equilibrium that a thunderstorm appears so extraordinary. But the parallels between living organisms and thunderstorms, and indeed some other meteorological phenomena, are remarkable. It is true that thunderstorms arise by spontaneous generation, and since they are incapable of sexual reproduction, natural selection can only act upon them by selecting individuals and not by acting upon the whole species. Like living organisms, they require matter and energy for their maintenance. This is supplied by the situation of a cold air-stream overlying warm, moist air. This situation is unstable and at a number of places vertical up-currents occur. Once these have developed they are maintained, at least for a while, through the liberation of heat consequent upon the formation of rain as the warm damp air rises. Each up-current ‘feeds’ upon the warm and damp air in its neighborhood and is thus in competition with and can suppress its neighbors. A storm is in fact parasitic on the increase of entropy which would result from the mixing of warm moist and cold air to form a uniform mass. Moreover, the storm itself has a well-defined anatomy of what can almost be called functional parts.

But although certain non-living systems, of which the thunderstorm is such a striking example, do show what we can call ‘organismal characters,’ this property is nowhere found in so high a degree as it is in living organisms. Woodger (1960) pointed to the importance of the fact that living things have parts which stand in a relation of existential dependence to one another, e.g., limbs, digestive organs, circulatory systems and brains. And even in a single cell we find organelles, micro-organs so to speak, all of which seem to constitute some essential part of the cell’s machinery. So we can ask of the structures in a living organism, just as we can ask of the structures in a man-made machine, "What is this for?" We can often give fairly exact and plausible answers. It has been argued, I think convincingly, that we cannot sensibly ask that kind of question of natural non-living systems. It is surely nonsense to ask of a solar system or its parts, or of a nebula or an atomic structure, or of the parts of a mineral, "What is this for?" Any answer which we think we can give is an answer of an entirely different kind from that which we can give in the case of a man-made machine or the parts of a living organism. Another distinction, of course, concerns reproduction. If we compare this in living and non-living systems we find that in non-living systems (e.g., thunderstorms or vortex rings), new examples are generated but the new ones do not exactly reduplicate the old. In the reproduction of living organisms, however, reproduction is essentially reduplication of all the essential features of the design (Pantin, p. 75). It is the fact that the organization of living creatures, whether great or small, is determined by a molecular and therefore precisely repeatable template that makes biological reproduction possible.

So we can say: (a) What organisms *do* is different from what *happens* to stones. (b) The parts of organisms are functional and are inter-related one with another to form a system which is working in a particular way or appears to be designed for a particular direction of activity. In other words the system is directive, or if we like to use the word in a very wide and loose sense, 'purposive.' (c) The material substances of organisms, on the one hand, and inorganic materials, on the other, are in general very different. And there is still another difference which seems to me of great importance, and that is (d) that organisms absorb and store information, change their behavior as a result of that information, and all but the very lowest forms of animals (and perhaps these too) have special organs for detecting, sorting and organizing this information -- namely the sense organs and specialized parts of the central nervous system. I shall return to this very important aspect later.

First we must make it clear, as of course Michael Polanyi has done, that we adhere to the basic assumption that all local structural or physiological organizations and events inside the living being occur according to a local biochemical determinism. That is to say that there is no firm evidence whatever against, and an immense amount of evidence for, the view that the 'ordinary' laws of physics and chemistry hold within the organism just as they do within a man-made machine. The problem is how to explain the stability and reproduction of even the simplest organism in space and time in terms of the organization of the structure itself.

It is a claim of molecular biologists, a claim with which we can in general agree, that they have made very large steps towards reducing the problem of the organization of the living being (including even the problem of its hereditary processes) to physical laws. Some indeed would claim to have accomplished the whole task already. We shall come back to the question of the hereditary organization later. Here we can say that what the molecular biologists have done is to develop a model of the cell which behaves very much like a classical man-made machine, or an automaton, but one in which the 'secret of heredity' is found in the normal chemistry of nucleic acids and enzymes. The implication of this is that parts functioning like a machine can be described as a machine even though these parts may be single molecules; and machines are understood in terms of elementary physical laws. This is an attractive analogy and is indeed one which we have all been using for a long time. As has been explained above, we repeatedly and successfully ask the question, "What is this for?" when considering the different structures in living organisms -- quite as successfully and legitimately as we can ask this of a piston, a lever, or an electric circuit in any machine designed by man.

The Nature of the Organization Shown by Living Beings

But we can easily be trapped by this useful analogy into losing sight of two basic aspects of living beings which are clearly evident to the physicist but, curiously enough, overlooked by the biologist. It is, of course, no satisfactory answer to respond to the question, "How does a man-made machine or living machine work?" by saying that it obeys the laws of physics and chemistry. As Pattee (1971) points out, if we ask, "What is the secret of a computing machine?" no physicist would consider it in any sense an answer to say, what he already knows perfectly well, that the computer obeys all the laws of mechanics and electricity. If there is any problem in the organization of a computer, it is the unlikely constraints which, so to speak, harness these laws to perform highly specific and directive functions which have of course been built into the machine by the expertise of the designer. So of course the real problem of life is not that all the structures and molecules in the cell appear to comply with the known laws of physics and chemistry. The real mystery is the origin of the highly improbable constraints which harness these laws to fulfil particular functions. This is in fact the problem of hierarchical control. And any claim that life has been reduced to physics and chemistry must in these days, if it is to carry conviction, be accompanied by an account of the dynamics and statistics and the operating reliability of enzymes ultimately in terms of present-day groundwork of physics, namely quantum mechanical concepts. So we have two questions, "How does it work?" and "How does it arise?" The second question has in fact two facets: (a) how does it arise in the development of the individual organism during the process of growth from the moment of fertilization of the egg; and (b) how does the egg itself come to get that way -- that is to say, how can we conceive of evolution as having ‘designed’ the cell?

The Idea of Hierarchy

It is the necessary concept of hierarchy in biology which pinpoints the problem. And the problem is one of hierarchical interfaces. In common language, a hierarchy is an organization of individuals with levels of authority -- usually with one level subordinate to the next one above and ruling over the next one below. For an admirable account of this, see Koestler and Smythies (1969). So any general theory of biology (which must include the concept of hierarchy) must thereby explain the origin, operation, reliability and persistence of these constraints which harness matter to perform coherent functions according to a hierarchical plan. Pattee (1970,1971) says:

> It is the central problem of the origin of life, when aggregations of matter obeying only elementary physical laws first began to constrain individual molecules to a functional, collective behavior. It is the central problem of development where collections of cells control the growth or genetic expression of individual cells. It is the central problem of biological evolution in which groups of cells form larger and larger organizations by generating hierarchical constraints on subgroups. It is the central problem of the brain where there appears to be an unlimited possibility for new hierarchical levels of description. These are all problems of hierarchical organization. Theoretical biology must face this problem as fundamental, since hierarchical control is the essential and distinguishing characteristic of life (1970, p. 120).

He goes on to point out that a simpler set of descriptions at each level will not suffice. Biology must include a theory of the levels themselves.

I have said above that even the simplest biological mechanism is to a superlative degree more complex than the most complex of humanly constructed machines. It is perhaps instructive to consider this complexity as it appears when we look at the human body and brain. Professor Paul Weiss (1969) has put this very dramatically by pointing out that the average cell in our bodies contains about 10^5 macromolecules. The brain alone contains 10^{10} cells, hence about 10^{15} macromolecules. To get these figures themselves into perspective, it is worth remembering that the age of the galaxy in which our solar system resides is estimated at 10^{15} sec! This is to say each of us has in our brains about as many macromolecules as there have been seconds since our part of the cosmos began to assume its present form.

This is just another way of putting the problem that Schroedinger poses in his book, *What is Life?* The problem is mainly that of the contrast between the degree of potential freedom, on the one hand, and, on the other hand, the perseverance and the essentially invariant pattern of the functions of such systems. (By ‘degrees of freedom’ we mean simply the number of variables necessary to describe or predict what is going on. Thus there is a potential freedom amongst trillions of molecules making up the brain, or for that matter the whole body.)

Consider this for our nervous system, and following this our thoughts, our ideas, our memories. Schroedinger was forced to the conclusion that, as he put it, "I. . . that is to say, every conscious mind that has ever said or felt I. . . am the person, if any, who controls ‘the motion of the atoms’ according to the laws of nature." This puts the problem of the boundary conditions, which have to be maintained all the time in both simple and complex examples of biological mechanisms, as it appeared to one of the most able physicists of his time who had given particular thought to these problems. Polanyi, as we have seen, assumes that all molecules work according to natural laws, but concludes that, since no one has accounted for hierarchical organization by these laws, there must be principles of organization which will in due course be found not to be reducible to the laws of physics and chemistry. Many others would be rather more cautious. Thus the physicist Pattee (1970) expresses himself as neither satisfied with the claim that physics explains how life *works* nor the claim that physics cannot explain how life *arose.* In his view (i) the concept of autonomous hierarchy involves collections of elements which are responsible for producing their own rules as contrasted with collections which are designed by an external authority to have hierarchical behavior. He then (ii) assumes, of course, that they are part of the physical world and that all the elements obey the laws of physics. He limits his definition of hierarchical control (iii) *to those rules or constraints which arise within such a collection of elements but which affect individual elements of the collection.* Finally, and perhaps most important, he points out (iv) that collective restraints which affect individual elements always appear to produce some integrated function of the collection. In common language this is to say that such hierarchical constraints produce specific actions or are ‘designed for’ some purpose.

It is in considering the third of the above four statements, in relation to classical mechanics, that the difficulties are seen to be at their greatest.

Classical physics appears to provide no way in which an explanation can be reached because it requires a 'collection' of particles which constrains individual particles in a manner not deducible from their individual behavior. However, it has been pointed out that in quantum mechanics the concept of the particle is changed and the fundamental idea of a continuous wave description of motion produces the stationary state or local time-independent collection of atoms and molecules. So it seems to be not impossible that hierarchical structures could be reducible to quantum mechanics, although, as we shall see later, the whole scheme of quantum mechanics is now in such confusion that, to the outsider, it seems far from clear to what extent they will be able to help. But even if structural hierarchies can be explained ultimately in this way, there is still something missing when we come to biological systems. Complexities of physical structure seldom if ever, by themselves, provide any feature which seriously suggests to biologists that such structures are in any sense alive. As has been said above, what organisms do is different from what happens to stones. The piece missing in the hierarchies of the non-biological world is, once again, function. What is so exceptional about enzymes and what creates their hierarchical significance is the simplicity of their collective function which results from their very detailed complexity. This is the core of what is meant by integrated behavior.

Self-programming

We are generally content with the view that a physical system, at least a macrophysical system, may appear completely deterministic. But the attempt to reduce living systems to such, that is to say *formal reductionism,* fails in part because the number of possible combinations or classifications is generally immensely larger than the number of degrees of freedom. And then, as we have seen, living systems are *self-programming;* this means that the particles of which they are composed form an internal simplification, or *self-representation,* and these systems of self-representation which assume control of the whole seem utterly baffling in many cases because they appear to originate spontaneously. Again this means that the organism is self-programming. This concept of living organisms being uniquely different from non-living systems in having an internal self-representation raises a point of profound importance. It is difficult to know where in the animal kingdom one has the need to postulate 'self-consciousness,' 'self-awareness' or, to use Eccles' phrase, 'the experiencing self.' We come to the conclusion that as we proceed from man downwards through the animal series, the lower we go the less useful (as predictive of animal behavior and as leading to an understanding of animal nature) the concept becomes. Until with the lowest animals and with the plants the usefulness of the idea becomes vanishingly small. But if it be true that all living organisms have internal self-representation, does this not amount to saying that the seeds of self-consciousness are present in all living creatures -- from the virus and bacterium upwards?

Another theoretical physicist, Walter M. Elsasser (1966), has approached some of these problems in an original manner by considering the number of internal configurations in which a complex system may exist in theory. Astronomers assume the existing finite total of atomic nuclei is of the order 10^{80} but, as we have seen, the lifetime of our galaxy is assumed to be no more than 10^{18} sec. Elsasser argues that the number of distinguishable events which can occur in a finite universe is correspondingly limited. In considering these systems of increasing complexity we must soon reach a point where a number of internal configurations in which the system may exist will vastly exceed the number of actual examples of any one given class that can possibly be collected in our universe. It follows that, if the discrepancy between the number of possible states and the number of possible samples is large enough, we can assert without fear of contradiction that no two members of a class, e.g., no two members of an animal or plant species, not even two bacteria, can *ever* be in the same internal state.

This leads Elsasser to suggest another characteristic of living organisms as distinct from non-living. He says that in physics the classes of things, e.g., atoms, protons, electrons, etc., are very homogeneous. It is a fundamental assumption that all the helium atoms in the universe are identical; though when we come to larger aggregations, however fully homogeneous the class, the objects would have to be not only chemically equivalent but also in the same quantum state. That is to say, for complete homogeneity all the members of a class have to be at the absolute zero point of the temperature scale so that their molecules are in the ground state. But the point is that in principle we do have, and can work with, the ideal of homogeneous classes in physics. And all fundamental questions of theory may be evaluated in terms of these. This can never be the case in biology, even in principle, as the number of individuals in any class in existence at one time is far too small to allow statistical prediction to have any physical significance. The resulting conclusion is that while *physics is a science dealing with essentially homogeneous systems and classes, biology is a science of* *inhomogeneous systems and classes.* In physical terms one may say that an organism must be a system that is endlessly engaged in producing, regenerating, or increasing inhomogeneity, and thereby the phenomenon of individuality, at all levels of its functioning.

Polanyi seems so convinced of the impossibility of the physical explanation of these biological constraints that he often appears to be speaking as a vitalist. That is to say, he is coming near to returning to the original idea of an indwelling vital principle guiding the organism in some manner completely independent of its physical nature. Elsasser does not go as far as this, and he suggests that there is room for (and we must assume the existence of) separate laws -- biotonic laws, as he calls them -- which are compatible with the quantum laws but not deducible in principle from them. Two other physicists have considered this matter carefully, E. H. Kerner (in Waddington 1970), and D. Bohm (in Bastin 1971). Bohm indeed appears to find not only room for, but, even within physics itself, a necessity for ‘hidden variables,’ which the usual scheme of quantum theory has ruled out as a matter of principle. Kerner, considering this, hesitates as yet to espouse either biotonic law or the incompleteness of quantal law, for he feels that no clear set of observations seems thus far to compel either. And we must not forget that a quantum-mechanical calculation even on one particular bacterial cell would be incorrect for every other cell, even of the same species -- a point clearly made by Elsasser in his conclusions about the heterogeneity of the material with which the biologist has to deal. Finally one must here bring in again the most important biological discovery of recent years, and this is the discovery that the processes of life are directed by programs -- which, besides manifesting activity, also in some extraordinary way produce their own programs. Professor Longuet-Higgins (in Waddington 1970) sums this up from the biological point of view by showing that it results in the biological concept of the program being something different from the purely physical idea of the program. And we can now point to an actual program tape in the heart of the cell, namely the DNA molecule. Even more remarkable is that programmed activity which we find in living nature will not merely determine the way in which the organism reacts to its environment; it actually controls the structure of the organism and its replication, including the replication of the programs themselves. This is what we mean by saying once again (a statement that can hardly be reiterated too often) that life is not merely programmed activity but self-programmed activity.

Monod (1970, 1971) has suggested that the combination of processes which must have occurred to produce life from inanimate matter are so extremely improbable that their occurrence may indeed have been a unique event (an event of zero probability). Monod also rightly points out that the uniqueness of the genetic code could be the result of natural selection. But even if we assume this, the extraordinary problem remains that the genetic code is without any biological function unless and until it is translated, that is, unless it leads to the synthesis of the proteins whose structure is laid down by the code. Now Monod shows that the machinery by which the cell (Or at least the non-primitive cell, which is the only one we know) translates the codes "consists of at least fifty macromolecular components which are themselves coded in DNA." Hence the code cannot be translated except by using certain products of its translation. As Sir Karl Popper comments (1972, 1974), "this constitutes a really baffling circle: a vicious circle, it seems, for any attempt to form a model or a theory, of the genesis of the genetic code." In fact this undreamed of breakthrough of molecular biology, far from solving the problem of the origin of life, has made it, in Sir Karl Popper's opinion, a greater riddle than it was before. Thus we may be faced with a possibility that the origin of life, like the origin of the universe, becomes an impenetrable barrier to science and a block which resists all attempts to reduce biology to chemistry and physics.

The Second Frontier

We come now to the question: How far does the existence of conscious awareness, as we ourselves experience it, constitute a new domain over and above that established by the phenomena of the lower ranges of the biological world?

But first we must consider for a moment what exactly we imply by the term, for it has many overtones of meaning. But we can at least say that it involves three basic components: *First,* an inward awareness or sensibility -- what might be described as 'having an internal perception.' *Second,* an awareness of self, of one's own existence. *Third,* the idea of consciousness includes that of unity, implying, in some rather vague sense, the fusion of the totality of the impressions, thoughts and feelings, which make up a person's conscious being, into a single whole. As Lashley put it, the process of awareness implies a belief in an internal perceiving agent, an 'I' or 'self' which does the perceiving. This in its turn implies that the agent selects and unifies elements into a unique field of consciousness. Next, it follows again, that this perceiving self (a) transcends time and space, bringing into immediate relation events remote from one another in these dimensions, and (b) makes possible in man the creation of aesthetic and ethical values held to be absolute.

There are four main attitudes of mind open to those who consider these problems. They are as follows: (I) We may accept the Cartesian dichotomy as essentially valid, which of course commits us to Dualism. This may be of two types or intensities: (a) one that allows a two-way causal interaction between mental and physical events, which we may call the strong form of dualism; or (b) the weak form (epiphenomenalism) which allows mental events to be effects but never causes. (II) We may accept Berkeley’s position and regard mental entities as real and the idea of material entities as at best a convenient abstraction. (III) We may acknowledge material entities as real but dismiss the idea of mental entities as an abstraction. Finally (IV) we may assert that certain events are at one and the same time both mental and material -- the mental, so to speak, being the interior view of that which has a physical exterior. This is usually known as the ‘Double Aspect Theory’ or ‘Identity Hypothesis.’

Of the above I, for the moment, rule out (II) as being, for most scientists and many philosophers, regarded as verging on the absurd. Similarly (III) can be eliminated as clearly false since it negates the whole of experience (though quite a number of physiologists and a vast number of scientists who have not thought deeply on the matter are attracted to it as being superficially convenient and ‘tidy’). So we are left with (I) and (IV), both of which involve us in some form of ‘dualist’ commitment. In fact a great many biologists and physicists of great reputation -- Paul Weiss, Polanyi, Elsasser, Eccles and Sherrington (to mention only a few) are presumably dualists, of one type and degree or another. And this leads us to the views of philosophers and to the central and ever-present problem of reductionism.

Amongst philosophers and logicians, particularly amongst those who have given special attention to scientific problems, many names could be mentioned, including that great thinker, L. T. Hobhouse, whom I like to mention first because I owe so much to his writings. When Hobhouse speaks of what he calls "the correlation of governing principles" -- a concept which involves the recognition of abstract moral law and eternal values which are good in themselves -- he has surely passed far beyond the possibility of any form of scientific reductionism. Again the views of Sir Karl Popper and the logician William Kneale are, in some sense at least, unashamedly dualist. The former indeed sees no future at all for philosophical reductionism. To these I might have added the name of Professor Stephan Koerner, and finally that bright comet in the present-day firmament which, according to certain observers, comes trailing dazzling clouds of uncertain composition, namely Dr. Noam Chomsky.

Whitehead came to a position of what could be called ‘panpsychism.’ Philosophically this is of course eminently respectable and indeed most attractive. As a biologist I have long been immensely impressed by and beholden to Whitehead’s philosophy of organism (*Process and Reality*), in that it seems to me that he is the first great philosopher who really took trouble to comprehend the biological developments of his time. My trouble with panpsychism, as advanced by Whitehead and, for instance, Charles Hartshorne, is that I see no conceivable scientific possibility of investigating its significance. It is easy enough to assume some sort of psychic element in the ultimate physical particles; indeed Eddington himself toyed with that idea. It may be that, as Carl von Weiszaecker (1968) has boldly suggested, since the concept of a particle itself is just the description of a connection which exists between phenomena, there may, if we are prepared to jump into strict metaphysical language, be no reason why what we call ‘matter’ should not in fact be ‘spirit.’ This I think amounts to saying that not only physical theories but biological theories portray not nature itself but our knowledge of nature. Again the trouble here is that I see no conceivable scientific possibility of confirmation.

Nor does the combination of physical units, in so far as modern physics reveals them, suggest to us how, or by what laws, psychic units could similarly combine and so produce what we recognize as the mental. Moreover there is a lack of parallelism between the laws of the combination of the physical units and those governing the development of mind. We can indeed assume with panpsychism that the mental, spiritual, artistic and ethical values which we experience really are in some sense one with the electrons and other primary components of which the world is made. But yet it does not *appear* to be so. Consequently a great leap of faith is required to believe it -- a leap without, so it seems to me, any scientific evidence. Yet reductionism requires a much greater faith. In the former case we are required to believe something which is eminently sensible but which cannot be scientifically confirmed; in the second we are required to believe in a source of value added to or injected into a natural process as complexity develops, which we are unable to understand -- either this, or we have to regard values as pure epiphenomena.

One might choose many different examples to illustrate the basic problem of reductionism and its refutation. However, I think that, rather than coming at once to biology, one secures a better perspective by starting with physics. First, we must say that, as a working hypothesis, reductionism is the major basic tool found to be in use among the great majority of active experimental scientists. And with good reason: for when and where it is successful, it achieves the most impressive of all scientific advances. In fact as a working tool it is indispensable, and all of us use it all the time. But many scientists go on from there to accept it without question, not merely as a tool, but as a philosophy. That is, they assume that all the activities of our minds and bodies, all the changes and complexities shown in the study of animate or inanimate matter, are controlled by the same set of fundamental laws.

To the ordinary working scientist there is an obvious course of action, perhaps one should call it a temptation. Having first assumed that there is a basic set of fundamental laws, the temptation is to proceed from there to what seems an obvious corollary, that everything obeys the same fundamental laws. Then the only scientists who are studying anything really fundamental are those who are working on these laws. A physicist colleague of mine to whom I am much indebted (Anderson 1972) has pointed out, in a discussion of the topic "More is Different," that if this were so, then the only scientists who would certainly be regarded as carrying out ‘fundamental’ work would be some astrophysicists, some elementary particle physicists, some logicians and other mathematicians, and a few more. This reductionist point of view, which seeks knowledge by analysis, almost inevitably leads its proponents to assume, quite unwarrantably, that all that is then required is to work out the consequences of these laws by the prosecution of what is called ‘extensive science,’ whereupon all truth will be revealed! But there is a tremendous fallacy here. For even the apparent success of the reductionist hypothesis in certain areas does not by any means imply the practicability of a ‘constructionist’ one -- to reduce everything to simple fundamental laws does not imply the ability to start from those laws and reconstruct the universe. In fact, "the more the elementary particle physicists tell us about the nature of the fundamental laws, the less relevance they seem to have to the very real problems of the rest of science, much less of society."

Actually it is a mistake to be too analytical in one's approach and to assume that all new and fundamental laws come from logical analysis. They do not. Take the arguments for the building of a thousand billion electron volt accelerator. We often hear it argued that, in short, intensive research goes for the fundamental laws, extensive research for the explanation of phenomena in terms of known fundamental laws. It is often assumed to follow that, once new fundamental laws are discovered, a large and ever increasing activity begins in order to apply the discoveries to hitherto unexplained phenomena. Thus the frontiers of science extend all along a long line from the newest and most modern intensive research, over the extensive research recently spawned by the intensive research of yesterday, to the broad and well developed web of extensive research activities based on intensive research of past decades. Hence, on this view, ordinary physicists are applied particle physicists, chemists are applied physicists, biologists are applied chemists, psychologists applied biologists, social scientists applied psychologists, etc. Anderson states, "I believe this is emphatically not true: I believe that at each level of organization, or of scale, types of behavior open up which are entirely new, and basically unpredictable from a concentration on the more and more detailed analysis of the entities which make up the objects of these higher level studies." True, to understand worms we need to understand cells and macromolecules, but not mesons and nucleons. And even the comprehension of cells and macromolecules can never tell us all the important things that need to be known about worms. At each level in fact there are fundamental problems requiring intensive research which cannot, be solved by further microscopic analysis but need, as Anderson says, *some combination of inspiration, analysis and synthesis."*

Popper, in a recently published consideration of the problem of scientific reductionism, commences by asking three questions: (1) Can we reduce or hope to reduce biology to physics or to physics and chemistry? (2) Can we reduce to biology or hope to reduce to biology those subjective conscious experiences which we may ascribe to animals, and, if question (1) is answered in the affirmative, can we reduce them further to physics and chemistry? (2) Can we reduce, or hope to reduce, the consciousness of self and the creativeness of the human mind to animal experience, and thus, if questions (1) and (2) are answered in the affirmative, to physics and chemistry?

Before proceeding to answer these questions, Popper makes the following points: First, he suggests that scientists have to be reductionists in the sense that nothing is as great a success in science as successful reduction. Indeed it is perhaps the most successful form conceivable of all scientific explanations, since it results in the identification of the unknown with the known. Second, Popper suggests that scientists have to be reductionists in their methods, either naive or else more or less critical reductionists, and sometimes desperate critical reductionists, since, as he points out, hardly any major reduction in science has ever been completely successful. There is almost always an unresolved residue left by even the most successful attempts at reduction. Third, Popper contends that there do not seem to be any reasons in favor of philosophical reductionism. But nevertheless the working scientists should continue to attempt reductions for the reason that we can learn an immense amount even from unsuccessful attempts at reduction, and that problems left open in this way belong to the most valuable intellectual possessions of science. In other words, emphasis on our scientific failures can do us a lot of good.

Popper proceeds to discuss some of the classical examples of reductionism. Einstein wrote in 1920: "According to our present conceptions the elementary particles (that is, electrons and protons) are *nothing else* than condensations of the electromagnetic field. . . . our view of the universe presents two realities . . . namely, gravitational ether and electromagnetic field or -- as they might also be called -- space and matter." By using the term *nothing else* here, Einstein implied that this was an example of complete reduction -- as Popper remarks, "reduction in the grand style." Einstein was not the only one and by 1932 almost all leading physicists -- Eddington, Dirac, Einstein, Bohr, de Brogue, Schroedinger, Heisenberg, Born and Pauli -- accepted uncompromisingly the reductionist view. Popper gives a quotation from R. A. Millikan (1932) in which this physicist says that nothing more beautifully simplifying has ever happened in the history of science than the whole series of discoveries culminating about 1914, which finally brought about practically universal acceptance of the theory that the material world contains but two fundamental entities, namely, positive and negative electrons.

But, as Popper points out, this reductionist passage was written in the very nick of time, for it was in the same year that Chadwick announced his discovery of the neutron and Anderson (1933) first discovered the positron. Nevertheless, many of the greatest physicists, such as Eddington (1936), continued to believe that with the advent of quantum mechanics the electromagnetic theory of matter had entered into its final state and that all matter consisted of electrons and protons. Popper (1972) points out that, though we still believe in the repulsive forces as being electromagnetic and still hold Bohr's theory of the periodic system of elements in a modified form, everything else in this beautiful reduction of the universe to an electromagnetic universe with two particles of stable building blocks has by now disintegrated. An immense number of important new facts has been learnt, but the simplicity of the reduction has disappeared. This refutation of the reductionist position started with the discovery of neutrons and positrons and continued with the discovery of new elementary particles ever since. But particle theory is not even the main difficulty. "The real disruption is due to the discovery of new kinds of forces, especially of nuclear forces irreducible to electromagnetic and gravitational forces." So now we have at least four very different and still irreducible kinds of forces in physics: gravitation, weak decay interactions, electromagnetic forces and nuclear forces.

In discussing Pauling's work (1959) on the nature of the chemical bond, Popper further asks: even supposing that we have a fully satisfactory theory of nuclear forces, of the periodic system of the elements and their isotopes, and especially of the stability and instability of the heavier nuclei, have we thereby a fully satisfactory reduction of chemistry to physics? The answer is 'No.' For, an entirely new idea had to be brought in, an idea which is somewhat foreign to physical theory -- the idea of evolution, of the history of our universe, of cosmogeny. This is so because the present theory of the periodic system explains the heavier nuclei as being composed of lighter ones, ultimately as being composed of hydrogen nuclei (protons) and neutrons (which might in turn be regarded as a kind of composition of protons and electrons). This theory assumes that the heavier elements have properties which can only actually result from a very rare process in the universe which makes several hydrogen nuclei fuse into heavier ones. These heavier elements are at present regarded as products of super-novae explosions. The present estimate is that, since hydrogen forms 25% of all matter by mass and helium 75% of all matter by mass, all the heavier nuclei appear to be extremely rare -- not more than 1 or 2% by mass. Hence the earth and presumably the other planets are made of extremely rare materials. The present most widely accepted theory of the origin of the universe -- that of the hot big bang -- claims that most of the helium is the product of the big bang itself and occurred within the very first minute of the existence of the expanding universe, and that the background radiation which is now being studied so intensively provides some evidence of the date of this initial explosion. Moreover it is only under the circumstances of the intense gravitational contraction, which leads to super-novae outbursts, that the heavier elements have been formed. Two things of great interest emerged from these considerations. First, in the conditions of the once supposed universally distributed primeval nebula, existence of gravitational forces could never have been envisaged and consequently the existence of heavy elements could never have been envisaged. These can thus be regarded as genuine emergents in the strict sense. In so far as chemistry has been reduced, it has not been reduced to physics but to cosmology (or as Popper says, even to cosmogeny). And present views seem to imply that the possibility of ever reducing chemistry to physics are remote indeed.

Popper points out that nuclear forces are thus potentialities and become operative only under conditions which are extremely rare, namely tremendous temperatures and pressures. He goes on to suggest that this comes very close to a theory of essential properties which have the characteristics of predestination or pre-established harmony. At any rate "a solar system like ours depends, according to present theories, on their pre-existence." The same close approach to the idea of pre-established harmony applies to the production of heavy metals by gravitational forces and, if this is the best that can be done, then any philosophy of pre-established harmony is an admission of the failure of the method of reducing one thing to another. "Thus the reduction of chemistry to physics is far from complete even if we admit unrealistically favorable assumptions. Rather, this reduction assumes a theory of cosmic evolution or cosmogeny and in addition two kinds of pre-established harmony in order to allow sleeping potentialities, or relative propensities of low probability built into the hydrogen atom to become activated. Thus we are operating with *emergent properties."* In fact the so called reduction of chemistry is to a physics that assumes evolution, cosmology, cosmogeny and the existence of emergent properties.

Karl Popper also develops the thesis that the idea of problem-solving is quite foreign to the subject matter of non-biological sciences but seems to have emerged together with life. Even though there is something like natural selection at work prior to the origin of life, we cannot say that for atomic nuclei survival is a ‘problem’ in any sense of the term. Nor can we say that crystals have problems of growth or propagation or survival. But life, as Popper says, is faced with the problem of survival from the very beginning, indeed we can describe life if we like as problem-solving, and living organisms as the only problem-solving complexes in the universe. This, of course, does not mean that we have to suppose that all life has a consciousness of the problems that have to be solved. This is obvious nonsense. Popper agrees that there can be little doubt that many animals possess consciousness and can be, at times, even conscious of a problem. But, he says: *"The emergence of consciousness in the animal kingdom is perhaps as great a mystery as the origin of life itself"* He will, however, agree that there can be little doubt that consciousness in animals has some function and can be looked at as if it were a bodily organ. We have therefore to assume, "difficult as this may be, that it is a product of evolution, of natural selection." Of course, for the behaviorists, who tend to deny the existence of consciousness altogether (a position quite fashionable at present), there is no problem. But, as Popper says, "a theory of the non-existence of consciousness cannot be taken any more seriously than a theory of the non-existence of matter." These theories, he says, solve the problem of the relationship between body and mind by a radical simplification. It is the denial either of body or of mind. But, as Popper says, "in my opinion it is too cheap." In fact there seems to be no prospect whatsoever of reducing the human consciousness of self and the creativeness of the human mind to any other explanatory level. Here Jacques Monod (1971) would appear to agree with Popper in that he calls the problem of the human central nervous system 'the second frontier,' comparing its difficulty with the 'first frontier,' the problem of the origin of life itself. Popper indeed believes that the reduction of chemistry to physics, of biology to chemistry, of animal conscious or subconscious experience to biology, and of consciousness itself and the creativeness of the human mind to animal experience, are all problems the complete success of which seems most unlikely if not impossible.

So, after this very rambling discussion, I end with the query included in my title: Faced with this extraordinary impasse (or rather not one but a whole series of them), Does Process Thought Help?

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RESPONSE TO THORPE'S PAPER

By Bernhard Rensch
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You mentioned that there seems to be no prospect of reducing *the human consciousness* of self to any other explanatory level. In my opinion we can do this by analysing the ontogenetical development of this concept in a young child. In my paper I point out that the concept of one's own self becomes gradually developed in early youth. The child soon learns to distinguish his own body from the environment, because reciprocal feelings only arise when he touches a spot of his own body, and when strong feelings, particularly pain, arise in his body. In this way the child begins to distinguish two kinds of psychic phenomena: those which indicate his own body and those which have to do with the environment. Later on the concept of one's own self becomes enhanced by remembering personal experiences, knowing one's own name and so on. At last also concepts of extramental 'things' originate.

The basic facts, which I mentioned, are also experienced by higher animals. We can therefore assume that they have at least prestages of such self-consciousness. Social animals can therefore learn to act according to their rank in the society. And apes surely have a concept of their own self. This could for instance be proved by experiments with a mirror. As soon as they begin to recognize themselves in a mirror, they begin to took to the mirror when they clean or touch a spot of color which the experimenter had put on their front, or when they clean their teeth or try to inspect their backside. (Gallup 1968; Lethmate and Duecker 1923 [references given at close of Rensch's essay]).

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Mind in Nature: the Interface of Science and Philosophy by John B. and David R. Griffin Cobb, Jr.

Part 1: The Evolution of Mind

John B. Cobb, Jr. is Professor of Theology at the School of Theology at Claremont, Avery professor of Religion at Claremont Graduate School, and Director of the Center for Process Studies. David Ray Griffin teaches Philosophy of religion at the School of theology at Claremont and Claremont Graduate School and is Executive Director of the Center for Process Studies. Published by University Press of America, 1977. This book was prepared for Religion Online by Ted and Winnie Brock.

Chapter 2: Can Evolution be Accounted for Solely in Terms of Mechanical Causation? by L. Charles Birch

L. Charles Birch is Challis Professor of Biology at the University of Sydney.

What happened to evolution? The happenings we know a lot about, thanks to evolutionary biology, particularly of the last four decades, are the roles of mutation, recombination of genes in sexual reproduction resulting in a great diversity of gene arrangements, and natural selection. These are the main mechanisms of the so-called Neo-Darwinian theory of evolution. There are of course many mechanisms that are involved in these concepts, such for example as genetic assimilation established by Waddington (1957), but they may all be regarded as aspects, albeit subtle ones, of the three main mechanisms mentioned. The sum total of them presents a mechanistic world picture of the evolutionary process. It has been eminently successful in explaining transformation phenomena, although less successful in prediction. A brief but cogent account of the modern view is given by Waddington (1969).

What these mechanisms help us to understand is the way in which organisms are transformed in time, genetically, anatomically, physiologically and behaviorally in adaptation to environment. At that level the theory seems to be remarkably successful. One of the great achievements of modern evolutionary theory has been the quantification of many of these processes. The theoretical model of Neo-Darwinism is a quantitative model. It rests on well-attested concepts and has great explanatory value.

The terms ‘mechanism’ and ‘Mechanistic world picture’ may be regarded as the conception according to which the universe is seen as a machine or contrivance and all that is in it as smaller machines or contrivances which, once set in motion, perform as they do, by virtue of their construction (Dijksterhuis 1961, p. 495). Having originated in the physical sciences, the mechanical analogy was taken over by the biological sciences as they became established as sciences in their own right. As a result it is true to say now, as Whitehead (1926, p. 128) said decades ago, that "It is orthodox to hold that there is nothing in biology but what is physical mechanism under somewhat complex circumstances . . . the appeal to mechanism on behalf of biology was in its origin an appeal to the well-attested self-consistent physical concepts as expressing the basis of all natural phenomena. But at present there is no such system of concepts." To this latter claim I shall return later. The main point of Whitehead’s remark is that biology has an orthodoxy; it is mechanism based on physics.

There are, however, outstanding problems in evolution that remain unaccounted for when we come to look at evolution in a comprehensive way. In particular, there is a qualitative side to evolution which escapes interpretation that is solely concerned with mechanical causes. Evolutionary biologists, with some notable exceptions, such as Dobzhansky (1967), Wright (1969), Waddington (1961) Rensch (1961), and Thorpe (1965), scarcely seem to recognize that this is a problem requiring interpretation. Where the problem is recognized it is usually in relation to two ‘events’ in evolutionary history: the emergence of life and the emergence of *mind.* ‘Livingness’ and mentality I take to have qualitative as well as quantitative aspects.

The Concept of Emergence

Dobzhansky (1967, p. 32) has said that "the origin of life and the origin of man were evolutionary crises, turning points, actualizations of novel forms of being. These radical innovations can be described as emergences, or transcendences, in the evolutionary process." In the sentence that immediately follows this quotation, which is about the human mind, Dobzhansky says that evolution is a source of novelty, of forms becoming what did not occur at all in the ancestral state. It is this new aspect which leads him to use the words ‘emergence’ or ‘transcendence.’ C. Lloyd Morgan, in his book *Emergent Evolution* (1923), wrote of the emergence of life and mind as ‘miracles’ in the sense of something that is not understood. He with other ‘emergent evolutionists’ such as J. C. Smuts believed that these emergent properties could not be understood in terms of the laws of physics and chemistry, but that some new laws come into existence with the new qualities. Morgan considered there to be different laws at the level of the inorganic, the organic, and the human (Lloyd Morgan 1923, p. 43). By contrast, Dobzhansky clearly considers that the emergence of life and mind are to be understood according to the same evolutionary principles as are applied to anatomical or physiological characters.

The term ‘emergence,’ however, does not explain any problems. It is not a solution to a problem. As Leclerc (this book) says, "rather the term emergence signifies a problem requiring solution."

The qualities that ‘emerge’ in evolution are not, of course, just livingness and mentality. To discuss the issue as if they were is to discuss evolution as though it were punctuated with discontinuities. Modern biology has demonstrated the continuity of the evolutionary process in the sense that what has evolved constitutes a continuum without any sharp dividing lines, even between non-living and living. While the words ‘life’ and ‘mind’ refer to aspects of such great significance in the whole process that we might wish to attach special terms such as transcendence or emergence to them, we must recognize that the qualitative side of evolution, like the material side, is a continuum. The manifestation of life in an amoeba is different from that in a bacterium, and so on. I am not implying that the word ‘life’ refers simply to the qualitative, but it does include the qualitative when we recognize responsiveness and perception as evidence that living organisms are subjects for themselves and in themselves as well as objects that we observe. The problem that calls for explanation is the qualitative so far as it is evident in the whole gamut of evolutionary history.

The tradition of science since Descartes has been to start with the physicist's atoms and molecules and attempt to account for the whole complexity of the universe, including life and mind, this way. That is the aim of molecular biology. It is the faith of mechanical determinism. The trouble is that it does not work, because there is nothing ultimate about the physicist's atoms and molecules. It incorporates two attitudes which are radically inconsistent. As Whitehead (1926, p. 94) remarked, "A scientific realism, based on mechanism, is conjoined with an unwavering belief in the world of men and of higher animals as being composed of self-determining organisms." How you get one from another is the problem (Overman 1967, p. 166). I think it is because of this problem that Whitehead (1926, p. 157) further remarked, "a thoroughgoing evolutionary philosophy is inconsistent with materialism. The aboriginal stuff, or material, from which a materialistic philosophy starts is incapable of evolution." If we are to understand why Whitehead thought this way we need first to examine the alternative he proposed.

Whitehead reversed the situation of the mechanists (Waddington 1961, p. 19). We do not start with knowing all about atoms and molecules and then seem to understand the phenomena of biology. It is from observed phenomena in biology that we have to start, with "occasions of experience" (Whitehead 1933, p. 196). It is from these we work back to construct models of similar entities. But these models take account of the phenomena observed at the more complex levels. To use an example of Waddington (1961, p. 20), sodium chloride molecules exhibit properties which we cannot observe by studying sodium and chlorine atoms in isolation. When the compound sodium chloride is formed, it is not that something entirely new is added to sodium and chlorine atoms, but rather we now know something more about the nature of sodium and chlorine atoms then we did before. Similarly with phenomena of life. When certain arrangements of atoms of carbon, nitrogen, hydrogen, oxygen and so on exhibit properties which we recognize by the name enzymes, or other combinations are able to conduct electrical impulses as in nerve cells, it is not that something new has been added to these atoms. We have discovered something about the nature of these atoms that we did not know before. We discover that when atoms are organized in particular ways they reveal aspects of their nature not revealed in isolation. Atoms and molecules organized in brains reveal the potentiality of atoms organized in particular ways to give rise to entities with subjective experience to which we give the name mind or consciousness. Atoms that can give rise to brains that think must be different from hypothetical atoms that could under no circumstances have done this.

Evolution of the Subjective

This is the crux of our problem. Evolution has given rise to ourselves who know the existence of a subjective aspect of life in our own lives. The subjective aspect of life for us is a central fact of our existence. The conduct of human affairs is entirely determined by our recognition of foresight determining purposes which we pursue consciously. This conscious pursuit of purpose issues in conduct determined by the purpose. There is of course a whole set of mechanisms, physiological and biochemical, associated with these subjective experiences, but these are not that experience *per se.* A feeling is a feeling, period. Consciousness is *sui generis* an aspect of existence. What then is the origin of the subjective we know in our own lives?

Where in evolution did the subjective start if it started anywhere? We cannot of course be sure that anyone besides ourselves has a subjective side to life. We cannot have another’s experience. But most of us do not deny that other human beings must be like ourselves in this respect. Many of us too will be inclined to attribute feelings of pleasure and pain to the animals we know well, such as our domestic cats and dogs. We may be less willing to attribute a subjective side to organisms lower down the evolutionary scale. But that is an arbitrary decision based perhaps on their lack of a complex nervous system. It seems to me less arbitrary and more logical to go along with Jennings (quoted by Agar 1943, p. 153), who wrote after years of study on the behavior of amoebae: "I am thoroughly convinced, after long study of the behavior of this organism, that if Amoeba were a large animal, so as to come within the every day experience of human beings, its behavior would at once call forth the attribution to it of states of pleasure and pain, of hunger, desire, and the like, on precisely the same basis as we attribute these things to the dog."

It is of course commonplace that perception does not reveal to us the intrinsic nature of things, but only the way in which they act, and are acted upon by other things. The object as constructed by us in perception differs from the real object in the same way as another person’s sensory perception of myself differs from the real me. I am an experiencing subject and no one else can experience my experiencing.

The position is the same in our perception of living organisms other than man and in our perception of non-living objects.

Although we cannot know another organism's subjective experience, it is reasonable to posit that variations will depend upon the sort of nervous system and sensory system the organism has. A person deprived of eyes or of the region of the brain where vision is involved must have a subjective experience that differs from the person equipped with these organs. Animals that are color blind have a different subjective experience than those that respond to color. Furthermore, there is no logical reason to restrict the subjective to organisms with a nervous system. Plenty of organisms without nervous systems have sense organs. Even an individual cell in our bodies is a responsive entity whose behavior can be studied in tissue culture. It has no nervous system though it has other means of communication within the cell. It 'takes account of' other entities in its environment, including other cells. It may move toward some things and move away from others. These are the sort of criteria we use to infer subjectivity in organisms like ourselves. But why limit subjectivity to just those complex organisms? If we do that, then we imply that subjectivity 'emerged' out of objectivity, that there was a stage in the evolutionary sequence when from zero subjectivity there came subjectivity, or that a combination of non-mental things could produce mind. This is to imply a discontinuity in the evolution of subjectivity; from no subjectivity came subjectivity.

This argument is applied to evolution even by those who do not apply it to their own existence, which is a contradiction. We have an insider's view of our own 'taking account of,' and even then only of its conscious aspects. If we admit the existence of this aspect of our existence, then we admit that our lives cannot be reduced to the status of objective entities alone. Is it not then inconsistent to suppose that, in the evolutionary process, from objectivity alone there evolved subjectivity? Since in the rest of the world besides ourselves processes of 'taking account of' are going on, be it in electrons or atoms or cells, then it is logical to suppose that this subject-object relationship involves subjectivity for these other entities. This is Whitehead's proposition that you have either got to have subjectivity everywhere or nowhere. Since it is obviously in us, then it must be everywhere. Just as the discovery that sodium chloride has properties not exhibited by sodium and chlorine in isolation tells us something about the nature of sodium and chlorine which we could not otherwise know, so too the existence of subjectivity in combinations of atoms that make human brains tells us something about the nature of those atoms that make those brains. To say that is not to imply some sort of preformation theory in which the experience of brains is wrapped up in atoms before there were any brains. It is to say that in those atoms there is the germ of subjectivity and not just zero subjectivity. The germ provides the possibility or potentiality of what can exist at more complex levels of organization. The evolving architecture of matter provides the necessary processes for the evolution of subjectivity, which is an aspect of the qualitative side of the process.

If we accept this argument so far, then does it not follow that there is an activity in evolving entities (their subjective aspect) which is not described in terms of mutation and selection and all other mechanical causes of the evolutionary process? Speculation on the nature of this activity is the subject of much of process thought. It is the point at which the concept of final causation becomes relevant.

A Role for Final Causation

Final causation is a potent causal agent in our conscious lives. What we do and are is very much dependent upon our imagined future or goals. Anticipation of the future influences our present existence and activity. It is the causal agent in so-called ‘cultural evolution’ which made the difference between cave man and modern man, and will make the difference between modem men and men of the future. Is there anything at all analogous to this in pre-human evolution? That is the critical question. It is a question that raises unwelcome spectres in the minds of most biologists. It resurrects for them concepts now discarded by science as a result above all of the work of Charles Darwin -- concepts of design according to a preordained plan of a designer, or primitive transformist concepts of fishes willing to become Amphibia, or Bernard Shaw’s man willing to become superman. But none of these concepts correspond to the sense in which Whitehead and other process thinkers see the role of final causation in the world.

Final causation is concerned with one aspect of the subjective side of entities, be they humans or electrons. It is that aspect which Whitehead (1934, p. 134) called ‘subjective aim.’ Subjective aim is analogous to purpose at the human level. It is the anticipation of the future and in this sense the influence of the future on the present. It is the nisus towards completion of an event. It is the element of creativity in every event, for it involves the selection of possibilities. Each occasion of experience is in touch with possibilities from which it selects a goal regarding its ‘self-fulfillment.' Unless there were some selection of possibilities there would be no reason for including the conception of subjective aim. It would be enough to describe an event as an effect of preceding events which automatically become the cause of other events. The selection of possibilities is the element of freedom which may, indeed, be infinitesimally small in the electronic event but substantial in a conscious mental event in human experience.

What we call 'things' are really not things but events. Reality is process. An entity as it is to itself is a subject, but then as it appears to another subject it is an object.

We may hardly quibble at the existence of subjective aim at the human level, but why postulate its existence in non-human entities? There seem to me to be two reasons. Firstly, it is postulated in response to the question of how it is possible to get freedom, responsiveness and purpose at the human level out of a determined, non-responsive and feelingless world of physical particles. No one has shown how that is possible. If science or the process of knowing cannot deal with purpose, then so much the worse for science and knowing. If final causation is to have a place anywhere, we must be sympathetic to a philosophy which finds it in principle everywhere, as we find mechanical causation everywhere. Secondly -- and here we enter upon a difficult argument -- subjective aim is postulated because, without it, no entity could exist. All entities are processes. "There is *no thing* in the universe" (Bohm 1969, p.42). When you come to analyze the nature of these processes, it is seen that they include this sort of relation to an immediate future state. As Whitehead has said somewhere, "the present is the fringe of memory tinged with anticipation." It is not within my competence to elaborate this argument in the way in which Whitehead has pursued it. Suffice it to say that the attempt to penetrate this difficult area of thought on the fuzzy boundaries of knowledge is more commendable than either erecting impenetrable walls around knowledge or supposing that knowledge has clear-cut boundaries.

Whereas subjective aim has no semblance to the role given to final causation in much pre-scientific thinking, and whereas it was science itself which eliminated the role given to final causation in the pre-scientific world, we nevertheless need to be circumspect lest we throw the baby out with the bath water. Indeed, modern physics seems to indicate a much greater awareness of this danger than modern biology. It has moved away from the mechanistic view of its fundamental particles and is finding the need for concepts that go beyond mechanism. The nature of the order of the physical world is not as simply mechanistic as biologists tend to believe. Bohm (1969, p. 18) has said that our physical theories are at present in a state of flux, that may lead to radical changes in them, such that current fundamental ideas, based on measure and metric, may also have to be replaced by new ideas, based on order." These new ideas, he suggests, will have to involve the notion of order in a way that is more fundamental than that in which order now exists in the theories of physics.

The conclusions of a reductionist mechanistic biology are dependent upon the assumption that the ultimate particles are exclusively mechanical in their properties. "Therefore," says Bohm (1969, p. 29), "the question of whether the basic laws of physics are in fact mechanical or not is of the utmost potential significance in biology." I have argued that a comprehensive evaluation of the phenomena of life leads to notions of the physical particles that are not exclusively mechanical. Now we find the physicist arguing on his own grounds that if physics comes to such a view of its subject matter this will be of the utmost significance for biology. "It does seem odd therefore," says Bohm (1969, p. 34), "that just when physics is thus moving away from mechanism, biology and psychology are moving closer to it. If this trend continues, it may well be that scientists will be regarding living and intelligent beings as mechanical, while they suppose that inanimate matter is too complex and subtle to fit into the limited categories of mechanism." But, as Bohm points out, such a position cannot stand up to critical analysis, for the molecules studied by biologists in living organisms are constituted of electrons, protons and other such particles, from which it must follow that they too are capable of behaving in ways that cannot be described in terms of mechanical concepts. There is in this view a thoroughgoing unification of nature from electronic-type events to events in the mind of man.

There are then arguments both from biology and from physics that lend credence to a view of the ultimate particles as having a subjective aspect as well as a mechanical aspect. It is within this subjective aspect that we have looked for final causation.

So far I have referred to the role of subjective aim as necessary to the constitution of the entity as it is in itself and, secondly, as being an aspect of the subjective side of existence, be it of an electron or a man. But the universe and organisms that are in it are more than a multitude of entities with subjective aims. In what way, if any, does the concept of subjective aim help us to understand the organization of organisms as we find them today and their evolution in time? Two questions call for comment.

1. How is it that subjective aims of a multitude of cells in a living organism relate to the subjective aim of the whole organism? The same question can of course be asked concerning the organization of fundamental particles into atoms and of atoms into molecules. It is by virtue of their physical properties that electrons and other particles combine in different ways to produce atoms, and so it is with atoms that find themselves in juxtaposition and then combine to produce molecules. The atom does not have a subjective aim to become anything that it is not. But when it combines with another atom by virtue of its physical properties, a new entity is formed and this new entity has its appropriate subjective aim. There is no sense in which atoms aim to become molecules or molecules to become cells. By their physical nature there is a great variety of possible architecture of arrangement of the fundamental building blocks. Of the many possible sorts of arrangements, no doubt some are too unstable to survive. Survival depends upon suitable environment. The concept of natural selection is appropriate both at the inorganic and organic levels.

At the cellular level, cells are subjects and the multicellular organism to which they belong is also a subject. The cell and the multi-cellular organism act causally as units and so as subjects have subjective aim. Tissues are nexus of cells; i.e., a tissue is a nexus of subjects but hardly a subject as such. What makes a nexus of cells into a subject in the higher multicellular organism is the centrally coordinating activity of the central nervous system or other centrally coordinating systems. It is such physiological mechanisms which turn nexus of cells into subjects as a whole. Natural selection determines that only those collections of animal cells that are organized into subjects survive. The plant is less coordinated as a subject than an animal and is more like a democracy of cells in which no particular group of cells has a central control. Nevertheless, there is coordination of function in plants despite the absence of a coordinating center.

2. Is there any sense in which the subjective aims of entities that exist at one stage of evolutionary history are directed toward some later stage of evolutionary history? For example, we might ask the question in this form: Once the cell had come into existence, was it destined to evolve

men? Or, even more boldly, one could ask if there is any sense in which the universe and all that is in it have some movement toward "that far off divine event to which the whole creation moves," to use Tennyson’s phrase. The implication of these questions is that there is a terminus and that it is determined. There is, however, nothing to suggest that either concept applies to this universe (Whitehead 1934, p. 169). There is no single stream in evolution leading to *Homo sapiens*. There are two factors which give the question some metaphorical meaning. First, the possibilities of the future, though no doubt infinitely great, are yet limited. Second, these possibilities or potentialities exist within the foundation of the universe. That something is possible for this universe says something about the nature of this universe. But there is no implication that what is possible is inevitable. A third factor relevant to these questions might be that subjective aim applied to distant events. However, the concept of subjective aim in subjects below the human level is that of an anticipatory relationship to the immediate future, not to the distant future. It is possible that a wasp may have subjective aim to stock the nest with food before it lays its eggs. A consequence of this behavior is the survival of the species. But it would be ridiculous to postulate that the subjective aim of the wasp was the survival of the species. Natural selection sees to it that those wasps with appropriate subjective aims survive to reproduce.

What then is the role of subjective aim in evolution? Is it to be regarded as another force in addition to mutation and selection? The answer must surely be no. Mutation and selection are mechanical causes that tell us something of the way in which new organisms come into existence. The theory of subjective aim tells us that, unless subjective aim existed in entities, no organisms could come into existence. Organisms are entities that have subjective aim. The theory is saying that the only sort of universe in which evolution of organisms can occur is one in which the entities have subjective aim, and that there is an evolution of subjective aim alongside physical evolution. That is, it becomes more complex. It becomes conscious in man and, in so far as man can have long-range plans which he can execute, his conscious subjective aims or purposes can control the future direction of evolution. A second point the theory of subjective aim is making in relation to evolution is that the potentialities of the future are an aspect of existence that should be acknowledged as such, though a potential entity is a different sort of entity than one that is concretely realized. The potentialities of this universe are a property of this universe and make this a different sort of universe from some hypothetical universe without these potentialities. It seems to me, therefore, that the metaphysical background of process thought is far more germane to the evolutionary picture provided by biology than is the mechanistic philosophy, implicit or explicit, that so often accompanies evolutionary theory. I leave it as an open question whether this perspective is suggestive of new hypotheses that might be tested and whether such a view implies any change in the way in which biologists do biology and formulate theories.

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Mind in Nature: the Interface of Science and Philosophy by John B. and David R. Griffin Cobb, Jr.

Part 1: The Evolution of Mind

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Chapter 3: From Potentiality to Realization in Evolutiony by Theodosius Dobzhansky

Theodosius Dobzhansky, after teaching for many years at Columbia University, finished his career by teaching in the Department of Genetics at the University of California at Davis. He died in 1975.

The universe is the product of the evolutionary process. All that was, is, and will be has evolved, is evolving, and will evolve. The inorganic and human evolutions are parts of a single process. Ultimately all evolution is one. It is reasonable to assume that the past evolution has brought about the present, and the present will lay the foundation for the realization of future evolution. If so, the potentialities of the future must have been present in the past. The Big Bang, or whatever it was that launched the development of the Cosmos, contained the potentiality of life, and hence of the biological evolution. The primordial life had the potentiality of evolving mankind, as well as every one of the several million existing and extinct species. Mankind, the human species, is unique in several ways. It has rationality, self-awareness, and death awareness. These and other unique properties of the human species must have been among the potentialities of the primordial life and the primordial cosmic substratum.

The statement that the potentiality of man was contained in the primeval living monad and in the primordial cosmic stuff may seem inordinately audacious. More careful consideration shows that it is really trite. It means no more and no less than that the process of evolution has in fact generated life and engendered man; these are patently true but trivial affirmations! It does not necessarily follow from these affirmations that all matter or all energy have in them some bits of life or protolife, or that the primordial amoeba or the primordial virus possessed some rudiments of human consciousness or some embryonic minds. To have a potentiality to become something does not mean possession of a snippet of that something. Between potentiality and realization there intervenes a process of development or evolution. It is worthwhile to consider at this point some biological illustrations. Animals evolved quite different kinds of organs of respiration -- lungs, gills, tracheae, etc. The ancestral unicellular and primitive multicellular organisms respire through the entire body surface. It is gratuitous to ascribe to them proto-lungs, proto-gills, and proto-treachae. Mammals and birds arose from reptiles, reptiles from amphibians, amphibians from fish. Yet there is no trace of communication by learned symbolic languages among reptiles, of hair or feathers among amphibians, of the auditory apparatus of land vertebrates, or of legs or wings, among the fish. A zoologist can, to be sure, identify the body parts in the ancestral groups that gave rise to new organs and functions in the derived classes. However, it scarcely makes sense to say that certain bones of a fish skull are incipient ears, or that two pairs of fins in fish have concealed in them the five-fingered appendages of the higher vertebrates. Biological and human evolution are creative processes. This means that they at least occasionally engender novelties. How do novelties arise?

Preformation, Epigenesis, and Creativity

In classical biological terminology, a development may be preformistic or epigenetic. Preformation postulates that the germ has in it a miniature copy of the new organism, or at least of its main. components. Preformistic development is essentially growth. A human sex cell was imagined to contain a miniature homunculus, which increases in size until it becomes an embryo, an infant, and eventually an adult woman or man. Evolution may conceivably also be preformed. Etymologically, evolution means unfolding or unrolling something that had been present in the ancestral forms or substances. Organisms that evolved were latent but somehow prefigured in ancestral organisms. Evolution was, then, no more than gradual removal of masks and camouflages; a homunculus was hidden in the ancestral amoeba, and then it gradually became open to view.

Epigenesis means the development of something that did not exist previously. Epigenetic evolution is a creative process. To my taste, preformation is less interesting, and I am tempted to say less inspiring, than epigenesis. Being interesting and inspiring is however not a criterion of validity of a scientific or philosophical theory. The theories of preformation and epigenesis must be examined further. First of all, epigenesis does not mean creation *ex nihilo.* A fertilized human egg cell does not contain a homunculus, but neither is it a structureless drop of viscous liquid. It contains, in addition to nutrient materials, a developmental program encoded in the DNA of the chromosomes. The outcome of the development is, in a given environment, predetermined by this program.

Did the primordial life contain a program of evolutionary developments? Some philosophers and some biologists thought that it did. This led to evolutionary theories called orthogenesis, nomogenesis, finalism, etc. These theories, now mostly abandoned, postulated that the ancestral organisms were programmed to evolve into everything into which they did evolve. But this is failing to perceive the basic difference between the individual and the evolutionary developments (ontogeny vs. phylogeny). The ontogeny is so programmed that it either yields an individual of a certain species or nothing. Even so, the programming is not absolutely rigid; in different environments the development proceeds in more or less subtle or even clearly diverse ways. Thus, the human development depends, to use somewhat antiquated words, both on nature and on nurture. Evolution is not programmed in the same way as is ontogeny; in fact it lacks a program. This does not mean that the phylogeny is wholly unconstrained or wholly at the mercy of the environments. A mouse is unlikely to evolve into a species of elephants, or an elephant into a mouse. Their organizations are so radically distinct that they could hardly be reconstructed in such ways, even if this were advantageous in some environments. On the other hand, an environmental challenge may be answered by an adaptive modification. ‘May’ rather than ‘must,’ because this depends on many factors, such as the availability of genetic variance on which natural selection can work. Biological and human evolutions come neither from within the organism nor from the environment. They involve creative syntheses of internal and external causes.

Determinism or Freedom?

How much determinism or indeterminism is there in evolution? Was evolution fated from the beginning to produce mankind and every other species? Does evolution sometimes involve origination of radical novelties? Much confusion has entangled these problems, and I can hardly hope to disentangle them all here. The physicist and cosmologist Laplace believed that to an all-knowing intelligence "nothing would be uncertain, the future as well as the past would be present to its eyes." The Laplacean 'hard' determinism is now out of fashion even in physics. The universe is one, and it has evolved only once. Evolution is a unique event, or rather a unique concatenation of events. Since evolution is not acausal, the meaning of Laplacean determinism is at most that what happened was bound to happen. Even this is questioned by process philosophers. Anywhy, it does not follow that if the evolution were to start again it would go exactly as it did before.

The problem of evolutionary determinism is often brought up in relation to the hypothetical extraterrestrial life on hypothetical planets in other solar systems. The problem is not meaningless, but inferences that one may put forward are not at present verifiable or falsifiable. The crucial consideration is that if the hypothetical planets actually exist, none of them can be at any single moment identical in the states of every component with the earth as it was at any point of its history. The Laplacean determinism is therefore beside the point, and the problem is shifted back from astronomy and chemistry to evolutionary biology. The question to be asked is this: is the evolutionary process at all likely to be repeated even in its most general features on planets with similar, though not identical, environments? Those who ventured to speculate about these matters came to diverse decisions. A majority, composed mainly of cosmologists, physicists, chemists, and a few biologists, surmised that the extraterrestrial evolutions should proceed as the earthly one did, including the production of 'humanoids,' i.e., of rational beings. Projects are discussed in all seriousness of establishing radio communications with these 'humanoids' in other solar systems and even other galaxies. Such projects fit the needs for romance and fancy, felt by many millions of people who are bored with everyday drudgery.

A minority of skeptics, most of them biologists, see themselves obliged to deflate the romantic bubble. Assume for the sake of argument that extraterrestrial life exists, and that it is based on proteins and DNA like the life on earth with which we are familiar. Even so, that extraterrestrial life would evolve in some ways quite dissimilar to the earthly one. The probability of repetition of terrestrial evolution is zero. The same holds for the possibility that, if most life on earth were destroyed, the evolution would start anew from some few primitive survivors. That evolution would be most unlikely to give rise to new man-like beings. I want to make it perfectly clear that the un-repeatability of evolution does not mean that evolution is acausal. Nor is evolution, as sometimes alleged, due to 'pure chance.' Evolution, at least on the biological and the human levels, is neither rigidly predestined nor completely indeterminate. Viewed in the perspective of time, evolution is a creative process. It has so multiple a causation that its outcomes are unlikely to be repetitious. Each evolutionary event is conditioned by the whole preceding history of the species, by the environment in which it occurs, and possibly, in higher organisms with developed nervous systems, by the behavioral reactions of these organisms.

Emergence of Novelty

We have postulated that the potentiality of every evolutionary event was present in the primordial life and the primordial cosmic stuff. The problem then turns out to be what is involved in the realization of potentialities. According to the preformation model, evolution is mostly growth or unwrapping. The primordial life carried rudiments of every basic structure and function that appeared later. It may have had protopsychism, and protovoluntarism, and protogood, and protoevil. Metaphysics of panpsychism or panvitalism are attractive perhaps for the same reasons which make all preformistic notions attractive to many. Everything is in existence from eternity, albeit only in hidden states, which need germinate, sprout and grow. Old-fashioned vitalists supposed that the origin of life involved the addition of a vital force, which came from some unspecified place, or perhaps from God. Panvitalism avoids this problem by postulating that life was also preformed in lifeless matter. Panvitalism and panpsychism make it unnecessary to assume that a vital force need be added from somewhere. It was invisibly present everywhere before there was life.

Some of the process philosophers have, to my surprise, rejected the identification of panvitalism and panpsychism with preformation doctrines. Yet to a biologist, preformation is a perfectly respectable biological and evolutionary view, even though it is at present a minority view among embryologists and evolutionists. If you postulate that life and mind were brand new principles which began to appear at some time and were not at all present earlier, you have an epigenetic evolutionary view; if, by contrast, you find the rudiments present in all nature universally, this is a preformistic view. It must be admitted that epigenetic models lead to difficulties, because they postulate the emergence of qualities, such as life and mind, in evolving systems which did not possess them at all. Origination of novelty is harder to envisage than mere growth.

Epigenesis does not assume anything arising *ex nihilo.* My body is composed of atoms of the same chemical elements which are found in inorganic matter. But in my body these atoms are components of many kinds of molecules which are formed chiefly or only in organisms. Moreover these molecules are not mixed uniformly in a solution -- they are arranged in unbelievably complex patterns known as cells. And the cells, in turn, are ordered in an even more complex pattern, which is my body. Other, rather similar but not identical patterns are individuals of the species *Homo sapiens,* a great multitude of less similar patterns are representatives of other animal and plant species. Evolution is emergence of new patterns, particularly on the cellular and organismic levels. Living beings as we observe them now are patterns of inorganic and organic constituents. These patterns emerged and were gradually perfected during at least three billion years of biological evolution on earth. We should never forget about these billions of years of evolution. A sudden appearance of life from no life, and of mind from no mind, would be, in the words of Sewall Wright, ‘sheer magic.’ The billions of years of evolution have made this ‘magic’ everyday occurrence. Indeed, the kindling of new life in the process of reproduction of organisms would be awe-inspiring, if it were not so commonplace that it is taken for granted.

Molecular constituents of all organisms are far more similar than the organisms themselves. It is remarkable that the same four kinds of nucleotides compose the DNA’s of all organisms. Equally remarkable is that the same twenty kinds of amino acids make up most proteins, in organisms all the way from bacteria and viruses to man. Evolution was the emergence of patterns more often than invention of new chemical components. Life and mind did not arise *ex nihilo.* They appeared in the process of evolution as novel patterns, and patterns of patterns, of organic functions. Evolution involved what one may refer to as emergence or transcendence. These words nettle many scientific puritans. The dictionary definition of ‘transcendence’ is, however, simple: "going beyond ordinary limits, surpassing, exceeding." There is no doubt that this happened in evolution -- cosmic evolution transcended itself producing life, and biological evolution did so when there emerged mind.

Realized and Unrealized Evolutionary Potentialities

At the present state of our knowledge, it seems most probable that all life on earth was monophyletic at its origin, i.e., derived from a single kind of primordial life. If this is true, the primeval life had potentialities of originating every one of the existing and fossil species of organisms. It seems to me that this makes the preformationist model unlikely. Far too many things would have to be preformed! As already pointed out above, organic evolution is not what the etymology of the word ‘evolution’ suggests, i.e., not unfoldment of what was there hidden to begin with. Evolution has involved multiple branching and divergence of countless evolutionary lines. The old idea of the ‘great chain of being’ implied that all organisms can be ordered in a single sequence, from primitive to complex. This idea was important in the history of biology, since it suggested the idea of evolution. But as far as I know, the ‘great chain’ idea has no adherents at present. Instead of a single chain, evolution proceeded along innumerable branching lines, most of them ending blindly in extinction. Starting from a single original source, the evolutionary lines have branched and rebranched, and this branching has led to increasing structural and functional complexity. Evolutionary progress, no matter how the concept of progress may be defined (and no generally accepted definition has yet appeared), has undoubtedly occurred in some lines, but in other lines there has been stasis or even partial regression.

Potentialities of all biological evolution were present in the primordial life. This must now be supplemented by the assertion that, in addition to all the potentialities that became realized, the living world had, and doubtless still has, countless unrealized potentialities. The foundations on which this assertion rests are really very simple. So great is the efficiency of the Mendelian mechanism of gene recombination that only a minuscule fraction of the potentially possible gene combinations can ever be realized. This was pointed out by Sewall Wright already in 1932. Supposing that a species has only 1000 genes each in ten different allelic forms (both figures are overly conservative estimates), 10^{1000} gene combinations are potentially possible. The number of subatomic particles in the Universe is estimated by physicists to be of the order of only 10^{78}. Even if most of the possible gene combinations are poorly viable, or inviable, a stupendous majority of the genetic potentialities of the living world have never appeared, and never will be realized and tried out by natural selection.

There is no way of telling what sorts of organisms evolution could have produced but did not in fact produce. There is plenty of evidence that the availability of an opportunity for a certain way of life does not by any means guarantee that species of organism exploiting that opportunity will evolve. This is interesting to philosophers who wish to discover the degree of determinism in evolution. Biologists have, since pre-evolutionary days, been fascinated by instances of structural parallelisms in not closely related animals and plants that exploit similar environments in similar ways. Whales and dolphins resemble fishes in body shape, though not in internal anatomy and physiology. Cacti in the deserts of the New World are mimicked by euphorbias in African deserts, although they are botanically not closely related. Marsupials have evolved in Australia several forms which occupy ecological niches held on other continents by placental mammals -- wolf-like, squirrel-like, mole-like, woodchuck-like, etc.

Biologists have paid much less attention to the equally significant but opposite phenomena -- absence of evolutionary parallelisms where they could, by analogy, be expected. Thus, there are no horse-like, deer-like, or antelope-like marsupials in Australia. The large herbivores in Australia are instead kangaroos, which are obviously quite different from horses or antelopes. And yet in South America there developed in Miocene times horse-like and camel-like animals; these belonged to the extinct order of mammals, *Litopterna*, and were not closely related to the real horses and camels. One of the most widespread and ecologically obviously successful groups of ants in the American tropics are the fungus-growing *Atta.* These agriculturalists of the insect world feed exclusively on certain kinds of fungi which they cultivate in subterranean ‘gardens’ on especially collected pieces of leaves and other plant parts. Yet such agriculturalist ants are wholly missing in the Old World tropics. Their ecological success and diversity in the New World virtually insures that they could flourish in the Old World as well if they evolved or were introduced there. The absence in the Old World of humming birds is a further example of lack of evolutionary parallelism where it could well be expected.

The Uniqueness of Mind

The possession of human mind makes our species a unique product of an evolutionary transcendence. The capacities for abstract reasoning, symbolic language, self- and death-awareness set mankind apart from the rest of the biological world. Was a man-like ‘rational’ species predetermined to appear in the course of evolution? Some philosophers and biologists thought so; in fact, the so-called finalists contended that organic evolution as a whole was designed to bring man into existence. Or was the origin of man a matter of chance alone, a haphazard outcome of the operation of the evolutionary roulette? This view also has its exponents, among whom perhaps the most recent and distinguished is Jacques Monod. His statement is crystal clear: "man knows at last that he is alone in the universe’s unfeeling immensity, out of which he emerged only by chance." I believe that the emergence of mankind, and for that matter of any other form of life, was neither foreordained nor due to random chance. Mankind is a masterpiece of creative evolution. Like the creativity of a human artist, evolutionary creativity is a synthesis of environmental challenges with the available biological (or intellectual) means to respond to these challenges.

Julian Huxley defined evolution as a process which generates, among other things " . . . more complex organizations, higher levels of awareness, and increasingly conscious mental activity." Teilhard de Chardin postulated the so-called law of complexity-consciousness, according to which mind must inevitably emerge when a certain level of structural and functional complexity is reached. As a definition of evolution, that given by Huxley is certainly invalid, since increasing complexity, awareness, and mental activity occur by no means in all, not even in a majority, of evolutionary lineages. In many lineages the opposite has occurred, and the self-awareness and ‘mental activity’ appeared in only a single species, among two or more millions that now exist. We need not take a stand here on the problem whether some rudiments of mind, or self-awareness, or conscious mental activity, are present in animals other than man. Most of the observations bearing on this problem come from introspection rather than from controlled experiments. As a result, competent students of the issue hold quite different opinions, none of which is demonstrably right or wrong. An evolutionist is not surprised if he finds component parts or precursors of organs or functions fully developed in more complex organisms in their less complex relatives. Human mental abilities must have emerged in evolution from raw materials that were present on prehuman levels. Anyway, the human psyche is unique in the living world. This uniqueness does not force us to return to the Cartesian body-soul dualism. It does however illustrate that evolution can produce radical novelties.

There is no reason to think that, given some millions or tens of millions of years to evolve further, other animal species will evolve humanoid minds. Nor is it likely that if mankind were to become extinct it would be replaced by another ‘rational’ or ‘humanoid’ species. The fact that mind has emerged only once in the whole known course of evolution does not, in my opinion, bear out the view that rudiments of mind, or some kind of protominds, are omnipresent or even widespread in the living world. One can see that certain conditions are necessary, but evidently not sufficient, for the appearance of a psyche capable of self-awareness. A highly developed nervous system and a capacious brain appear to be indispensable for the emergence of anything like human mind. Jelly-fishes, ants, termites, and even birds have not evolved nervous systems that could sustain humanoid performance. As stated above, there is no assurance, and even not much likelihood, that given some more millions of years to evolve, any of them would reach a level of brain development at which the emergence of mind would be a possibility. This may seem, particularly to non-biologists, excessive skepticism; at least a brief explanation of my reasons for this stand seems in order.

Any biologist, at any rate any not exclusively laboratory biologist, knows that organisms that inhabit a given geographic area exploit its resources in many different ways. Yet all of them possess adaptedness to their environments and their ways of life, for otherwise they would have died out. Already Darwin had to rebut the objection to his theory that the coexistence at our time level of high and low, primitive and advanced organisms contradicts the doctrine of evolution. If, for example, mammals are more advanced than amoebae, and flowering plants more than bacteria, why then are amoebae, bacteria, and a host of other ‘primitive’ organisms still with us? Why have they not evolved to more advanced grades? The answer is that bacteria and amoebae exploit different environments or sub-environments, or exploit them in ways different from, for example, insects or birds or mammals. There is no 'law' that would make all organisms evolve just for the sake of evolving. Evolution propelled by natural selection is sometimes progressive, but not always and not necessarily so. Evolution is thoroughly opportunistic. Bacteria and amoebae seem to be doing as well in their ecological niches as insects and vertebrates in theirs.

Conclusion

Life appeared in the universe some billions of years after its origin in the hypothetical 'Big Bang.' Furthermore, it appeared, as far as anybody knows for certain, on just one of the myriad of celestial bodies, the earth. Before that event, the universe was lifeless, and most of it is still lifeless. Some three billion years after the origin of life on earth, there appeared man. During these billions of years life existed without man, and could continue to exist without him, in some ways even better than with him, since man is a pitiless destroyer of many animal and plant species. Yet man did arise and develop a completely novel and hitherto unprecedented way of life.

Mankind adapts its environments to its genes more often than it changes its genes to fit its environments. The rationality, or mind, or symbolic communication, or self-awareness -- call the evolutionary uniqueness of man by whatever name you prefer -- has made him by far the most successful biological species. His arrogance makes him sometimes call himself the Lord of Creation. The origin of man was neither predestined nor was it an evolutionary accident. Mankind's novel and unique psychic capabilities came about as a result of a long travail of evolutionary creation. The successful outcome of this travail was not guaranteed. There were two species of *Australopithecus* living in late Pliocene and early Pleistocene periods -- *A. africanus* and *A. robustus. The A. africanus* was apparently our ancestor; it did evolve the biologically unique human qualities, and its descendants gradually became human. The *A. robustus* did not so evolve, and eventually became extinct. Now both species must have descended from some common, but as yet unknown, ancestral species. This ancestor must have had potentialities of becoming humanized. The potentialities became realized in one species derived from it, but not in the other species.

Life at its origin was a radical novelty in the formerly lifeless world. Human mind was another radical novelty. Man, a species endowed with mind, or consciousness, or self-awareness -- call this unique property by whatever name you choose -- arose from ancestors not endowed with this property. To some philosophers the origin of such novelties is as unbelievable as magic. I can offer two considerations which will make this ‘magic’ perhaps less magical. In the first place, the evolutionary transcendence from the non-living to the living did not require anything like old-fashioned ‘vital force’ suddenly implanted by the Creator. Nor was the transcendence from the non-human due to implantation of a ‘soul.’ Both transcendences were basically like other evolutionary transformations, albeit more radical ones.

In the second place, the transcendences should not be imagined to have been sudden. They took probably millions of years. The transitions from no life to life, and from no mind to mind, were gradual. Our scientific knowledge is, of course, quite insufficient to give anything like satisfactory accounts of these transitions. Biologists as basically different in their philosophical and biological views as W. H. Thorpe and Jacques Monod agree that the origin of life is a difficult, and thus far intractable and unsolved, problem. I concur. However, probably thousands of biologists and biochemists all over the world are now working on this problem. Their working hypothesis is that life arose epigenetically in a lifeless world. Assuming that life always existed is a simplification, but not a helpful simplification.

The origins of life and mind are indeed miraculous. Do not forget, however, that many other biological phenomena also strike us as wondrous and awesome. Consider the origin and development of mind in a human child. A miracle indeed! But no more miraculous than the origin of mind in human evolution. A newborn infant has a potentiality of developing mind, and self-awareness, but this potentiality can be realized only by way of a slow and gradual process of maturation. As pointed out above, a potentiality of mind must have been present in all ancestors of the human species, down to the primordial life. The analogy between the evolutionary origin and the maturation of mind in a growing child must not, to be sure, be pushed too far. Ontogenetic and phylogenetic potentialities are fundamentally different. Ontogeny is a product of phylogeny, not vice versa, as some people wrongly assumed. The alternative to realization of many ontogenetic potentialities is death; a child either grows up or dies. Not so with phylogenetic potentialities. In the first place, these potentialities are innumerable. Secondly, a great majority of the potentialities are never realized. Novelty may emerge or not emerge. This is not due to some intrinsic biological indeterminacy, but rather to an overwhelming complexity of very numerous interacting causal chains. You may see here a precursor of freedom on the human level.

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Mind in Nature: the Interface of Science and Philosophy by John B. and David R. Griffin Cobb, Jr.

Part 1: The Evolution of Mind

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Chapter 4: Emergence in Evolution: (Response to Birch and Dobzhansky) by Ann Plamondon

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Charles Birch has explained Whitehead's remark that

> a thoroughgoing evolutionary philosophy is inconsistent with materialism. The aboriginal stuff, or material, from which a materialistic philosophy starts is incapable of evolution. . . (Whitehead 1925, p. 151)

as expressing the inconsistency of high-level orders such as self-determining organisms (possessing life and mentality) emerging from low-level orders of mechanically determined particles. I think that Birch's setting of the problem is essentially correct and that his solution in terms of attributing subjectivity to all entities, even particles, does show a necessary condition for emergence in evolution. This comment, therefore, should be viewed as an addition to, rather than as a criticism of, Birch's paper. The suggestion that I wish to add is that another metaphysical presupposition is necessary for emergence in evolution -- that of internal relations. It seems to me that understanding the role of this principle in emergence is extremely important for two reasons. First, to approach a more complete listing of the metaphysical presuppositions for such emergence. Second, to clarify an apparent disagreement between Birch and Dobzhansky with respect to the nature of emergence.

I

Whitehead maintained the necessity of a doctrine of internal relations for evolution in the continuation of the passage quoted by Birch:

> This material is in itself the ultimate substance. Evolution, on the materialistic theory, is reduced to the role of being another word for the description of the changes of the external relations between portions of matter. There is nothing to evolve, because one set of external relations is as good as any other set of external relations. There can merely be change, purposeless and unprogressive. But the whole point of the modem doctrine is the evolution of the complex organisms from antecedent states of less complex organisms. The doctrine thus cries aloud for a conception of organism as fundamental for nature. It also requires an underlying activity -- a substantial activity -- expressing itself in achievements of organism (Whitehead 1925, pp. 151-152).

The full passage shows that Whitehead is basing his claim about the inconsistency of materialism and evolution on the grounds that materialism presupposes a doctrine of external relations and that this doctrine is inadequate to the development of more from less complex organisms. Consider the relationship of materialism and external relatedness. Materialism entails that what a thing (bit of material) is does not depend on its relationships to other things (bits of material); the relationships of a thing are not constitutive of it. (This is the doctrine of 'simple location'; Whitehead 1925, pp. 69-70). The application of this doctrine to the formation of higher levels of order out of lower levels results in an aggregate view of the higher order. This means that when higher levels are formed out of lower levels of order there is no modification of the lower level to a pattern of the higher level. There is no modification of this kind because such modification requires that the relationships of the lower orders be constitutive of them. Materialism rules out the possibility of such internal relatedness. Yet increase in complexity depends upon such a modification. This is because there can be no real increase in complexity unless there is a new order brought about at the higher level. There can be no new order if what the lower orders are is independent of the relationships into which they enter. The formation of the higher order by their relationships does not bring about a new and independent order at all. The 'higher order' is, in a sense, a misnomer. It is an aggregate, and it cannot be said to be of greater complexity than its constituents.

The point I am attempting to make is that a necessary condition for evolution at all is an increase in complexity which cannot be accounted for on a materialistic view. This is an addition to the claim made by Birch (above, p. 14). I am claiming that the difficulty with most neo-Darwinian discussions of evolution is not merely that its mechanisms are inadequate to account for evolution's 'qualitative side' but that these mechanisms will be inadequate so long as they are attached *(ad hoc)* to a materialistic philosophy. They will be inadequate because the meaning of evolution and the meaning of materialism are incompatible. That is, the difficulty to which I am referring is that the neo-Darwinian theory of evolution, on the whole, has not disassociated itself from *materialism.*

II

The addition of the doctrine of internal relations as a necessary condition for evolution can clarify three arguments used by Birch to support his claim that low levels of order, such as particles, must have a subjective as well as a mechanical aspect. Consider the following restatements of these arguments in general terms.

1. If an explanation is to be given of actualized subjectivity in higher orders, then subjectivity must be potentially in the lower level constituents.

2. When higher levels of order exhibit properties not belonging to their lower-level constituents, the correct inference is not that something has been added to the lower-level constituents but, rather, that they exhibit different properties when they organize the higher-level order. We know

more about the lower-level orders in the sense that we know more about their possibilities for *modification* when they are situated in different higher orders.

3. ‘Taking account’ belongs to all orders which exhibit such modification. Since this is the principal criterion for subjectivity in highly developed organisms, there is no warrant for refusing to attribute some sense of subjectivity to lower organisms, including the constituent particles.

It seems to me that when the arguments are expressed in this way they provide the core of an answer to Dobzhansky’s question as to the process involved in the realization of potentiality in evolutionary development. At the same time, they avoid the ‘snippet’ fallacy which Dobzhansky seems to accuse Birch of committing. They avoid this fallacy because emergence in evolution is put in the context of *acting* and not of containing.

These arguments refer to the modification of lower levels of order to the pattern of the higher level which they organize. Because there is an internal relatedness of the higher-level order and the constituent orders, there can be an emergence of new properties. The emergence arises in the act of modification. There is no question of ‘snippets.’ It is not the case with respect to a particular property of the higher-level order that it must have been contained in some sense in the lower-level constituent(s). Rather the property comes about in the act of relating in that particular situation.

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Chapter 5: The Process Theory of Evolution and Notes on The Evolution Of Mind by C. H. Waddington

C. H. Waddington taught and did research at the Department of Genetics in the University of Edinburgh. He died in 1975.

The Theory of Evolution has undergone rapid changes during this century. Some of these changes seem to me to be drastic enough to qualify as alterations of paradigm in the sense of Kuhn. Certainly the change at the beginning of the century was of that nature. Previous to that time any theories of heredity which existed -- there was nothing very highly developed -- were in terms of statistical aggregates. For instance, Pearson and Galton had some sort of theories based on the resemblances and differences between collections of individuals standing in different relations to one another, as sibs, cousins and so on. The introduction of Mendelism changed the emphasis entirely from a consideration of populations in statistical terms to a consideration of the offspring resulting from individual crosses between identified individual parents. It was by experiments of this kind that genes were identified and the process of gene mutation discovered. Evolution was not of major interest to most of these biologists, but insofar as they had a theory of it, it was a theory in terms of mutations of individual genes, carried by individual organisms and submitted to natural selection. It was not until some two decades later that the people started seriously to consider evolution, when of course it became clear that they had to think in terms of populations of individuals. However, the first workers in this field, such as Haldane and Fisher from the theoretical point of view, and biologists such as Timofeef-Ressovsky, Dubinin and others, in practical field investigations, were still thinking mainly in terms of individual genes. This was the phase of evolutionary thinking about which the term neo-Darwinist was first used. However, this first phase fairly rapidly was superseded by a second, in which Sewall Wright and Theodosius Dobzhansky were the two key figures, both of them insisting on the importance of thinking of populations of many genes, as well as populations of many individuals. This can properly be called neo-Darwinism of the second and fully developed kind.

A characteristic of all this neo-Darwinist thinking is that it effectively did not pay any attention to the phenotype. In its mathematics, the selection coefficients are attached to genes or genotypes. Now, selection of course does not act directly on genes or genotypes, but on phenotypes, and in the formation of these phenotypes environmental factors have an influence as well as genetic ones. I have for many years been trying to introduce a new paradigm which takes the phenotype seriously. Charles Birch seems to think this can also be lumped in together with neo-Darwinism, and speaks of it as part of the orthodox modem theory of evolution. I should like to see it accepted as orthodox, but I do not believe it as yet. Very few other authors, with the exception perhaps of Schmalhausen and a few of his students, have done anything more than pay the merest lip-service to the idea that selection operates on phenotypes. The conventional view surely still is that ‘acquired characters,’ since they are not inherited by individuals, have nothing to do with evolution. Anyone who suggests anything else is dismissed by many leading biologists, such as Monod and Luria, as a Lamarckist if not a Lysenkoist.

This rejection persists because people persist in thinking in terms of individuals rather than of populations. If an individual acquires a character during its lifetime, that does not increase the probability that its offspring will exhibit the character; but if the development of some members of a population are affected by the environment in ways which improve their chance of leaving offspring, this will obviously increase their contribution to later generations, that is to say, their natural selective value; and the frequency of that character in later generations will be increased, not by any physiological or genetical change, but by the operation of selection. In fact we can say that natural selection will favour organisms which acquire useful characteristics.

Now, if one combines this simple fact with a well-known but rather more unexpected one, namely that developmental processes are difficult to alter, one finishes up with a very powerful evolutionary mechanism. Say we have a population of animals which has to meet some new challenge offered to it by an altered environment; there may be some individuals in the population whose development is changed by the environment in a way which makes them better able to deal with the challenge -- they show a capacity for adaptive modification. They will, therefore, be favoured by natural selection. After this selection has gone on for some considerable number of generations, the new pathways of development will have gradually acquired a more pronounced chreodic character, which can itself be difficult to modify. In fact, should the environment now revert to what it was before the whole process started, the organism may well go on developing in the way in which it adapted to the changing environment. This process, which I have called genetic assimilation, gives exactly the same end-result as the theory proposed by Lamarck, at one time espoused by Darwin but rejected by modern biology, of the direct inheritance of acquired characters.

The fact that, by a slightly more sophisticated development of modern biology, we have come across an evolutionary mechanism which can produce the same effect is, I think, not without importance in relation to mind. It shows how a behavioural pattern, which in an earlier evolutionary stage emerged only in the actual presence of a certain environmental situation, might, if it was selected as useful over many generations, become habituated to a chreodic developmental pathway which would operate even in the absence of that environmental situation. It is because of the existence of this mechanism that I am not alarmed by the suggestions, of people like Chomsky, that man has an ‘innate’ capacity for the use of language. If at an early stage in his evolution it was useful for an individual to be able to adapt to a language-using community, i.e., to learn language as fast as possible, selection for this capacity might well have brought about a genetic assimilation of at least the bases for what had originally been only a learned adaptive response.

Another great oversimplification of the neo-Darwinist statement of evolution implies that the thing that is being selected (genotype according to the conventional statement, phenotype as I suggest) finds itself inevitably subjected to certain selective pressures arising from 'its environment.' In fact most higher organisms select their environment before they allow the environment to select them. Release a hare and a rabbit in the middle of a field; the rabbit will run off to the hedge and live its life there, while the hare will be content to live its life in the open field. Even plants, in a more rudimentary way, make some sort of selection of the circumstances in which they will develop. If a seed falls on stony ground in the desert, it simply refuses to germinate until the next shower of rain comes along and gives it an environment at least somewhat appropriate to its needs. However, there can be no doubt that this reciprocal relationship of mutual feedback, between an organism which selects an environment and an environment which then selects the most efficient organisms, assumes greater importance as we go higher up the evolutionary scale.

In particular, I think it must be of crucial importance in the evolution of behavioural patterns and of anything which we might call a mind. For instance, at some point in their evolutionary history, the ancestors of horses began to eat primarily the grasses of open plains, and not for instance the leaves of shrubs. They then had to deal with the possibility of being attacked by carnivores, and they came to deal with this threat by running away rather than by standing on their hind legs and trying to fight off the attack with their front feet, as giraffes do, for instance. One might somewhat figuratively say that they had 'chosen' to inhabit one type of environment rather than the other, and to adopt one type of strategy against predators rather than another. But, of course, that mode of expression should not be taken to imply a conscious process of choice. However, once evolution had started to go in those directions, this defined the character of the natural selection that would be exerted, and evolutionary changes went on in the same direction for a very long period. The mind of the horse has evolved into that of a plains-dwelling fleet-footed animal, which runs away from its enemies. The mind of the buffalo, on the other hand, is that of a plains-dweller which faces its enemies and charges them.

Such types of animal minds, evolved in relation to a reciprocal interaction between the selection of environment by animal and of animal by environment, are what we refer to rather crudely as instincts. An instinct is a pattern of behaviour which is to a major extent dependent on the hereditary constitution of the animal. It is a mistake, however, to think that it is in all cases wholly dependent on the genetic constitution and that the environment plays no role in shaping the behaviour. I will mention only one example which illustrates two ways in which the environment is important in the development of instinct. Weaver birds build elaborate nests consisting of a completely enclosed nest chamber, approached through a tubular entrance. Each species of weaver birds builds nests of a different shape. I do not know why different species should adopt differently shaped homes, but the fact that they do shows that there is a very strong hereditary element in their behaviour. However, birds build a better finished, and more competently constructed, nest in their second year than they do in their first. There is, therefore, an element of learning involved. Consider the problem of a bird approaching a half-finished nest. It has got to decide just how to weave the piece of straw in its beak in amongst the other pieces of straw. It has been found that there are certain kinds of weaving stitches which it can do, but it never, for instance, ties a proper knot. However, it has always to discover some way of adapting the particular types of weaving process at its command to the particular circumstances which confront it. This involves highly adaptive behaviour -- much more adaptive to the environment than one might imagine if one simply wrote the instincts down as hereditary.

We may say that instinctive behaviour is behaviour related to a rather well-defined goal, but often demanding a more flexible adaptive type of behaviour, including the possibility of learning from experience, in deciding exactly how that goal shall be reached. I myself should not refuse to use the word *mind* in connection with organisms which showed this type of behaviour. The main point I should like to emphasize is that, in such cases, the goal towards which the instinct drives has certainly not been decided by any conscious choice of the organism, but by this subtle evolutionary process of natural selection within a framework which has been set by the previously existing instinctive behaviour.

But if an animal behaves in accordance with one definite unalterable goal, how much of a mind would we be inclined to attribute to it? Surely, we would not think it was being very clever. In fact, we might be tempted to say it was indulging in ‘mindless repetition.’ We would be much more tempted to think the animal had a worthwhile mind if it had at least two goals, and followed one or the other in appropriate circumstances.

Thus the evolution of the mind must involve not only the formation of a goal, but also the development of alternative goals, and the ability to pick the appropriate goal under particular circumstances.

The problem of mind -- being intelligent -- at this level is not only to find new ways of attaining already accepted goals, but puts a premium on the still greater flexibility of discovering new goals.

I will tell the tale of the evolutionary origin of the birds -- or rather, one of the more plausible tales, because the experts have not yet quite decided exactly how it did happen. But one of the ways it may have happened concerns a group of little reptiles, rather like lizards, which had larger hind legs than forelegs, and which normally ran about on these back legs. Suppose they started using their forelegs to work up speed when they were running away from a nasty bigger reptile who was trying to catch them. And suppose the scales on the arms grew longer, into something a bit like feathers, to help them get the benefit of beating the air effectively to push them along. And natural selection pushed this development further until, one day, some of them found themselves taking off and becoming airborne. It must have been very disconcerting; they probably ran the risk of crashing in considerable disorder, and getting gobbled up. But a really clever little lizard, full of mind, must have said "Hey, we’ve got something here," and set about finding how to fly. To attain this brand new goal, he may have had to change quite a lot of his previous routines; for instance, beating his arm-wings in unison instead of one after the other in time with his legs. In order that such an evolution could be possible, his mind had to be able to do two things. It had to be able to reorganize itself around a new sub-goal, to fly, within its old main goal, to escape; and it had to be able to re-arrange its detailed activities so as to achieve this new sub-goal, to change the timing of its arm movements, for example.

Finally, one might ask the question, out of what kind of stuff is mind constructed? Recently, even those who accept physico-chemical entities as a basis of all scientific knowledge have realized that something more may be involved in them than the properties of mass, energy, etc., attributed to them in classical theory. This further component might be referred to as ‘specificity’ of spatio-temporal configuration. In the last twenty years or so, mathematicians and engineers have attempted to replace the rather undefined term ‘specificity,’ which had been much used by biologists earlier, with a more precisely defined notion of ‘information.’ Unfortunately, in order to achieve a precise definition capable of being utilized in a mathematical logical system, they have ‘purified’ the notion until it has become almost useless in connections with biology, or indeed in almost all contexts except that of messages -- which was the main business of the Bell Telephone laboratories in which the originator of the theory, Claude Shannon, was employed. ‘Information,’ as it emerged into the world of mathematics, is a measure of the degree of selection which has been employed in choosing some particular configuration out of a closed universe of possible configurations. It is concerned only with the specificity within a particular universe of possible specificities. For instance, the amount of ‘information’ contained in the letter A is less if it is chosen out of the English alphabet of 26 characters than if it is chosen out of the Russian alphabet with 29. Moreover, the amount of ‘information,’ in this sense, has nothing whatever to do with bringing about any action outside the closed universe; that is to say, it has nothing to do with ‘meaning,’ in any sense of that term. The information content of a message written in English words is just the specificity of the string of letters in which the words are spelt. Consider the two messages:

MEET HIGH MARKET TWELVE TEN
MEAT HIGH MARKET TWELVE TON

The differences in ‘information’ are simply that the third letter from the beginning is an E in one and an A in the other, and the penultimate letter is E in one and O in the second. ‘Information’ Theory has nothing whatever to say about the fact that the first is obviously about an appointment to meet at the corner of High Street and Market Street, and the second is a message from a wholesaler that the stocks are going off and had better be got rid of as quickly as possible.

This limitation in the meaning of ‘information’ made it possible to develop a mathematical theory which is very useful in connection with transmission of messages along channels, but effectively mined it as a word which is useful to apply in wider contexts. Rather unfortunately, the mathematical theory assigned, to the measure of ‘quantity of information,’ a formula which was identical to algebraic form with one of the most famous formulae of thermo-dynamics, namely that for entropy. This at first led Shannon to identify the amount of information given out by a source with its entropy. Later Warren Weaver developed an alternative interpretation, that the quantity of information contained in a message is the negative of its entropy. It was Weaver's rather than Shannon's interpretation which became fashionable, and the new word 'negentropy' was invented to mean 'quantity of information or negative entropy.'

The relevance of all this is that there is no doubt that reactions in living systems are very much concerned with the specificity rather than the mass or energy of the components. It is the specific arrangement of nucleotides along the chain of DNA which determines what that gene will do; it is the specific shape in three dimensions of a protein molecule which determines what sort of enzyme activity it will exhibit, and there are many other examples. For a time it became fashionable to discuss this sort of specificity in terms of negentrophy, and some of the most penetrating minds, when they turned from physics to biology, were deceived for a time. Thus Schroedinger, in his elegant essay, *What is Life?* in 1944, indulged in aphorisms such as 'life feeds on negentrophy.' However, he soon came to realize that this is an inadequate way of looking at the situation, and he withdrew or at least greatly qualified the remark in the later editions of his book.

The main point is that the specificity with which biology is so deeply concerned is not a static specificity, with no meaning outside itself. It is rather the possibility of bringing about, or tending to bring about, a certain type of activity in appropriate things which react with it. It is, in fact, a specificity of instruction, the imparting of one particular program, or algorithm. Several authors, including, for instance, H. C. Longuet-Higgins, insist that language has basically to do with programs or instructions, rather than with imparting descriptions from which nothing follows.

Of course, the word 'information,' as it is used in ordinary speech, often has some implication that the information will be useful as a guide to action. But it is pretty ambiguous in this context. In fact, during World War II, there was a useful distinction made in the slang of the RAF, which distinguished the 'info,' a lot of boring rigmarole about useless facts, from the 'gen,' the real stuff you needed to know to tell you how to operate. When we say that biological systems work by means of the programs or instructions incorporated in their components, this is a long-winded way of saying that it's the gen, not the info, that matters for them. It is not negentropy they feed on, but it might have made some sort of sense to call it gentrophy, if I may coin an unnecessary word.

It is not only biological systems that feed on gen. There are some physico-chemical systems, which no one would dream of calling living, which very clearly do so too (possibly they all do, but I will not pursue this point here). Consider the minerals making up that, at first sight, boring material, clay. They have been discussed in some detail from this point of view by Cairns Smith in his book, *The Life Puzzle.* Clay minerals consist of crystals in which atoms of silicon, oxygen and a number of metals, such as aluminum, iron and various rarer and less frequent ones, are arranged in a three-dimensional lattice. The lattice is such that at any given time in the growth of the crystal its boundary is a flat two-dimensional plan, with a particular arrangement of these atoms at certain points on it. Now, the forces at work are not terribly choosy about which particular atom goes into which place. At one particular point on the surface there might be an atom of aluminum or alternatively there might be an atom of iron, or some other substance. "Ha!" the information theorists will say, "This surface can encode a great deal of ‘information’." So it can, but the point is that this is not mere info, it is gen. If there is iron instead of aluminium at point X, and the crystal is in a solution which allows it to grow by the deposition of a new layer of atoms on top of the old one, it is much more likely that another iron atom will take this place in the lattice of the next layer. The presence of iron at X is an instruction for building the next layer.

Whatever we imagine the first living systems to have been like, they must have been even more deeply involved in a traffic of instructions. Any type of hereditary material, be it DNA or anything else, which can be transmitted from one ancestral system to two or more daughter systems, must in effect contain instructions for its own copying. Moreover, in all the living things as they are on this earth, the copying system is carried out by mechanisms, such as enzymes, which operate by means of instructions built into them. Finally, systems which we consider worthy candidates to be granted the name ‘living’ differ from things like clay minerals in that they contain instructions, not only for copying, but for the elaboration of structures which can actively Operate on surrounding materials. These new embodiments are what geneticists speak of as the phenotype. The crucial role of instruction-generated phenotypes as a fundamental aspect of living systems has been a dominant theme in recent discussions of the theory of general biology (see the four volumes entitled *Towards* a *Theoretical Biology*, edited by C. H. Waddington, Edinburgh University Press).

The early stages in the evolution of life, therefore, involve not only physico-chemical mass, energy, atoms and so on, but also specific instructions. We find the firmest evidence of mind when we look at the other end of evolution, as in our ‘occasions of experience,’ and we are again, of course, fundamentally involved in a traffic of instructions. A knower does not merely sit down before the known and observe it without consent or response. On the contrary, he brings to it certain predispositions, or interests, and observes certain characteristics more than others. The content he finds in the occasion demands a response. As Popper has put it, the ‘prior knowledge’ with which he comes to the occasion is such that what he receives from it is not mere information but instructions or challenges.

In the light of this discussion, the evolution of mind appears as a transition from the instructional traffic involved in the very simplest living things, or even in the pre-biotic systems such as clays, to the much more complex traffic of instructions involved in our own occasions of experience. We can see two ends of the evolutionary range in similar terms. We have evaded the dilemma of considering the beginning of the evolutionary process as depending on nothing but atoms, forces and physicochemical factors, and the other end as involving something of a totally different character we call ‘mind.’ One recent author who has advanced a similar view is Stephen Black. In his book, *The Nature of Life*, he also draws attention to the importance of instructional traffic in all the processes of life (unfortunately he has not escaped from the fashionable convention of speaking of information when what he really means is instructions). His next step, however, is to expand the use of the word ‘mind’ to cover the whole range of situations involving instructional traffic from the very simplest to the most complex. This is hardly satisfactory, since, as we have seen, the simplest such situations occur in things like clay minerals, and it is hardly illuminating to speak of them having minds. When God fashioned us out of clay, he may have picked the right material to start from, but there was still a lot to do. I have briefly discussed earlier in this paper the nature of the evolutionary processes which have led from the simpler situations to the more complex ones.

Note:

The editors asked me to provide some account of points made during discussions about evolution and mind. Since pressure of other work has prevented my writing a special essay on this, I have put together the gist of what I said by taking extracts from my contributions to the Gifford Lectures at Edinburgh University in 1971/2 and 1972/3 *(The Nature of Mind and The Development of Mind* by A. J. P. Kenny, H. C. Longuet-Higgins, J. R. Lucas and C. H. Waddington; Edinburgh University Press, 1972 and 1973).

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Mind in Nature: the Interface of Science and Philosophy by John B. and David R. Griffin Cobb, Jr.

Part 1: The Evolution of Mind

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Chapter 6: Some Whiteheadian Comments by John Cobb, and Response by W. H. Thorpe

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Thorpe raises the question whether process thought can illumine the mystery of life and consciousness as evolutionary emergents. Dobzhansky stresses that with human self-consciousness we are dealing with something that is radically new. Both oppose the reductionistic interpretation of these emergent novelties as merely unfolding of pregiven necessities. Both encourage us to view what has happened with wonder.

Birch, without opposing the sense of wonder, holds that evolutionary development must be seen as embodying a fundamental continuity. This means that what is manifest in higher stages must be continuous with what is present at earlier stages. This does not mean that something very like self-conscious human purpose is to be found in amoebae, but it does mean that there must be some continuity between an amoeba’s response to its environment and the response of higher organisms (including human ones) to theirs. Waddington shows how his revisions of Neo-Darwinian Theory clarify the nature of this continuity by focusing on the interactive relating of phenotype and environment.

Both positions reject mechanism or reductionism as an ultimate truth. Both affirm emergence. One stresses the radical mystery of particular emergents. Birch’s Whiteheadian view stresses the continuity underlying all emergence. The difference in emphasis need not amount to systematic opposition, but it can easily be hardened into it. This hardening occurs to the extent that particular gaps, such as that between self-conscious human experience and that of animals, is asserted to be fundamentally different from all the other gaps to be found in reality. Such judgments seem to demand an ontological dualism of the human and the natural that is incompatible with Whiteheadian process philosophy. Short of this extreme, as the gap is seen as one gap among others, in a process of emergence, the extent and importance of the gap is a matter of factual investigation. That is, as long as ontological dualism is avoided, the extent of the difference between human activity, subjectivity, and purpose and those of other animals is a subject for detailed investigation to which process philosophy is entirely open.

If those who fear the stress on continuity wish to make a case against it, they need to define more precisely where that gap occurs which they regard as inexplicable in terms of continuities. Thorpe’s paper is instructive in this regard in that it repeatedly witnesses to the variety of places where significant emergence is found. Although he stresses gaps, and focuses on two, he also testifies to continuities and refers to many gaps. In this respect his paper is highly congenial to the process perspective.

If process thought is to help, it must clarify both what the continuities are and what novelties are introduced through emergence. Whitehead’s suggestion is that all entities whatsoever are understood better as organisms interacting with their environments (composed of other organisms) than as self-enclosed entities passively shaped by external forces. All organisms both take account of their environments and act upon their environments. The taking account involves an element of receptive subjectivity. The action involves aim at some immediate attainment and at altering the situation in some way. Hence subjectivity and purpose in rudimentary and unconscious forms are characteristics of nature generally. The evolutionary process is one in which new forms of order make possible more complex organisms in which both receptivity and action are enlarged in scope.

Whitehead's theory of consciousness illustrates the way in which he conceives of fundamental emergents, or threshold crossings, in a process that also has a basic continuity. As Birch notes, what is required physiologically for consciousness to emerge is a specialization of cells leading to a central nervous system with sense organs oriented to messages from the external world. Whitehead adds that what this form of bodily organization makes possible is the concentration of complex and novel information in one portion of the body, namely, within the brain. Where complex features of the environment are thus internalized and these internalizations are brought into intense interactions, a series of events becomes possible that integrates selected aspects of this material at a new level. These events Whitehead calls 'the final percipient occasions' or 'the dominant occasions.' It is these occasions of which we have immediate knowledge; or more accurately, the experiences we speak of as ours (both conscious and unconscious) *are* these occasions. The basic structure that makes these dominant occasions possible emerged with the development of the central nervous system in animals, and where this structure is present, it is reasonable, as Thorpe does, to posit consciousness as present to some degree.

Consciousness is an aspect of feelings belonging to the dominant occasions in animals with nervous systems of some order of complexity. In all probability consciousness is lacking to all other feelings. Philosophical explanation calls for a more precise statement of the feature of feeling that allows for the emergence of consciousness. Whitehead's answer to this question is technically developed in terms of 'propositional feelings' and 'intellectual feelings.' I shall offer a non-technical account that may prove suggestive.

Whitehead believes that consciousness is a feature of feelings which contrast what is felt with what might have been felt. We are not conscious of feelings that are constant unless by an unusual imaginative leap we are able to consider the possibility of their absence. This is why metaphysics is so difficult. It consists in an account of what is always and everywhere necessarily occurrent, whereas all our ordinary attention is directed to what differentiates one situation from another. Similarly, if our visual experience were completely homogeneous in terms of color, we would not be conscious of that color. As it is, if we were on some occasion exposed only to a particular shade of red, we would still be conscious of it, because we would compare what we saw with other colors we had seen in the past. Whitehead thinks that even low grades of conscious feeling require this contrast of what is felt with what is not felt, or better, of what is with what might be.

The note of possibility is thus indispensable to consciousness. Only subjects capable of bringing contrasting possibilities of some sort to bear upon present perception are conscious. That requires that there be not only a concentration of information of the sort the nervous system offers in the brain but also memory. The qualities given in past experience must be contrasted with those given in the present. The introduction of memory brings us one step further into the analysis, but we will have to back up a bit to grasp what is distinctive of memory.

The ordinary way in which nature achieves order through time is by means of repetition or re-enactment. The characteristics of one event are inherited by its successor which in turn transmits them very little changed. A route of such occasions is in Whitehead's language an 'enduring object,' and the ordinary physical objects of the world are built up of such enduring objects. These provide for order and predictability, but the occasions in non-living enduring objects cannot achieve much value or intensity. They have to trivialize almost all of the potential offered by the past in order to maintain intact one route of dominant inheritance.

There are, however, occasions that, instead of almost totally repeating past characteristics, achieve significant novelty. They respond to their data in such a way that they can incorporate more complex elements and still achieve the unity needed for actuality of any sort. These are living occasions. The novelty they incorporate provides for this inclusion of more variegated elements, but it also tends to disrupt the continuities and orderliness that are equally needed for further achievements.

In the dominant occasions, Whitehead believes, novelty and order reach a new synthesis. For, they are living occasions and yet they can be ordered to a greater or lesser degree into enduring objects. Hence, each of these occasions receives data not only from the events transpiring outside the body through the nervous system but also from preceding dominant occasions. A succession of these occasions emerges with a definite pattern of relatedness. However, unlike ordinary enduring objects the succession is not primarily a matter of repetition of qualities in one occasion after another through long stretches of time. Instead, the successor also remembers or prehends what was novel and creative in its predecessor, and what is novel and creative in its own feelings is transmitted to its successor.

It seems likely that only occasions of considerable complexity and vitality could profit from the novelties in their antecedents in this way. Once this becomes possible then a rich storehouse of memories is available to bring into comparison with present perceptions. (E.g., the scent of a predator is noticed by its contrast with preceding olfactory experience in which that scent was lacking. The animal is conscious of the new scent.) The point being stressed here is that conscious experience is a radically new emergent in the evolutionary process, and required and still requires an extremely complex, even awe-inspiring set of conditions; and yet it emerged and still emerges out of entities which are not totally different in kind. Lower grade events or ‘occasions’ constituting the life of a cell illustrate the same characteristics as conscious events or occasions, but in a radically lesser degree.

This account of the physiological-psychological grounds of consciousness deals only with one of the many astounding stages of evolutionary development. Beyond it is the human self-consciousness to which Dobzhansky especially calls our attention. But, in Whiteheadian perspective, the explanatory description of each stage prepares the way for the understanding of the subsequent stage without in any way showing that the subsequent stage is necessitated by its antecedents. The wonder remains, but the novel emergence at each level is seen as made possible by and as continuous with the many earlier stages of emergence. (For a speculative account of a variety of emergent stages in human pre-history and history among which the rise of modern self-consciousness is one, see my *The Structure of Christian Existence*, Westminster Press, 1967.)

One of the great gaps often noted between the human species and other animals is that human purpose is a factor in shaping events on the planet, whereas pre-human evolution is interpreted without reference to purpose. This seems to justify a dualism that is antithetical to process thought. The duality can be somewhat reduced by considering how blind are many of the processes that shape human history, but it is not the intention of process philosophy to deny human purposes an important role. The question is instead whether evolutionary theory has been correct in excluding animal purpose altogether from the explanation of biological evolution generally. Is it not rather the case, as Teilhard pointed out, that "what we call evolution develops only in virtue of a certain internal preference for survival?" (*Science and Christ*, Harper, 1968, p.212.)

Waddington’s paper illustrates how a Whiteheadian vision of organisms interacting with environments takes account of a purposive element throughout the evolutionary process. This is not, of course, a purpose for the process as a whole or even for any long-range goals at all. The ability to act in terms of far-reaching goals appears flickeringly among human beings and, so far as we know, nowhere else. But animals act intelligently in their quest for food and, in doing so, modify their environments. Evolutionary theory needs to take account of the interaction between short-term purposive behavior on the part of animals and the survival value of particular characteristics.

Whitehead in this respect as in others provides a rigorous ontological grounding at the microcosmic level for the macrocosmic phenomena studied by biologists. This will appear more fully in the papers by Griffin and Overman in Part Four. However, it can be noted briefly and less technically here.

In the past, when purpose has been introduced as a category into evolutionary thinking, it has been attributed to animals as complex organisms enduring through time. Even in the understanding of human ethical behavior this kind of view has proved unsatisfactory. To describe any complex event or pattern of behavior as guided by a single purpose is always to abstract radically from the concrete course of events. The novelist more accurately shows us through a detailed account of the succession of occurrences how the result came about in a way that no one had purposed. But this does not mean that purposes were not factors in the events. As attention is focused on more and more limited sub-events, one finds it possible to see why, in just that situation, a person acted as he or she did. The action makes sense, that is, it conforms to the actual felt need of the moment. To explain it is to show how the agent concretely experienced the situation rather than to show what, from a more objective vantage point, the situation actually was. How the agent experienced the situation can be explained causally in terms of antecedent events. But the action is directly determined not by these antecedent events as such but by the aim, in the situation so perceived, to achieve something. Otherwise it is not an action at all.

There are many factors present in the perception of a situation by a human being that cannot be attributed even to the higher animals. Also, a larger part of animal behavior may rightly be interpreted as reflex action. But despite these important differences, the situation is often similar. Animals act in any moment in terms of how they perceive the situation. This perception characterizes the final percipient or dominant occasion. Why they perceive the situation as they do can be explained largely in terms of efficient causes or antecedent events. But the action that responds to that perceived situation is not determined by those conditions but by the purpose or aim to which the perception gives rise. Through the bodily action precipitated by the purposes of the momentary dominant occasions within the organism, the actual situation is changed as well as the perceived situation for subsequent dominant occasions. Thus purposive animal behavior alters the situation to which future animal behavior must be adapted. This also alters, as Waddington shows, the evolutionary selection of phenotypes and, indirectly, the genetic factors that prove most adaptive. Hence, the many purposes of individual events, if not some encompassing purpose, do constitute a factor in evolutionary development.

RESPONSE TO COBB’S COMMENTS

By W. H. Thorpe

I feel that the comments by Cobb are lucid and helpful. But there are one or two points concerning which it seems needful to argue further here.

The first of these concerns Cobb’s question "whether evolutionary theory has been correct in excluding animal purposes altogether from the explanations of the biological situation generally." To this I would reply that for a long time now many biologists have readily accepted the possibility, if not the virtual certainty, that purposes in the form of the making of choices between alternative situations may indeed have played an important function as canalising in certain directions the selective forces acting on the stock in question.

I myself discussed this in 1951 in the first chapter of my book, *Learning and Instinct in Animals*, and in a number of writings since. More recently Sir Alister Hardy has put forward such ideas very cogently (1965). Much of Waddington's writing also impinges very significantly on this topic.

But it seems to me essential to be as precise as possible as to the evidence of purpose.

While the evolutionary biologist might agree that no purpose can be discerned in the physical universe prior to the state at which evolution in the biological sense commenced (that is to say, where entities which are born, reproduce and die and in so doing are subject to natural selection), yet he might argue that evolution by natural selection automatically provides the 'purpose.' That is to say, he might argue that natural selection inevitably injects something into the cosmos which appears to us as purpose. In other words, once you have a selective mechanism which ensures that forms which produce more offspring and tend to last longer become more numerous, then you have the directiveness which is characteristic of biological and ultimately of man-made mechanisms. Thus it is meaningless to ask the question: What is a physical system such as a nebula, an atom or a solar system for? On the contrary, it is always meaningful to ask of a mechanism, whether a biological mechanism or a man-made mechanism, "What is this for?" The evolutionary biologist might cite the view of Bertalanffy (1952) that organisms are open systems which display equifinality. By this is meant that organisms are systems which (exchanging materials from the environment) attain a steady state, which is then independent of the initial conditions. "The directiveness which is so characteristic of life processes that it was considered the very essence of life, explicable only in vitalistic terms, is a necessary result of the peculiar system-rate of living organisms, namely that they are open systems." And today, twenty years later, we can be more precise and say that living organisms accumulate, store, and process information. They are thus not merely internally programmed but, having internal self-representation (as in the DNA of the nucleus), are *self-programming*. (For recent further discussion see Thorpe 1974, Chapter 1.)

From the philosophical point of view, the central problem of ethology is the relation between purposiveness ('purpose' here has the usual meaning -- a striving after a future goal retained as some kind of an image or idea) and directiveness. All biologists agree that the behavior of organisms as a whole is directive, in the sense that in the course of evolution some at least of it has been modified by selection so as to lead with greater or less certainty towards states which favour the survival and reproduction of the individual. All machines are also directive in the sense that their parts have been designed or selected so as to behave in a particular way whenever activated by an external source of power. But not even the most elaborate machine, such as a computer, is purposive. So for the ethologist the question is, "How much, if any, of the animal's behavior is purposive and what is the relation of this behavior to the rest?"

In human perception, as H. H. Price (1932) has shown, the very idea of a material object is dependent upon an element of anticipation. He says, "every perceptual act anticipates its own confirmation by subsequent acts." A. N. Whitehead (1929) considers the act of perception as the establishment by the subject of its causal relation with its own external world at a particular moment. Whitehead argues that every vital event, in fact, involves a process of the type which, when we are distinguishing between mental and material, we describe as mental -- the act of perception. A very strong case is made by W. E. Agar (1943) for the theory that a living organism is essentially something which perceives. Therefore some element of anticipation and memory, in other words, *some essential ability to deal with events in time as in space is, by definition, to be expected throughout the world of living things.*

All this, so far as it goes, fits in well with modern Whiteheadian conceptions; as I should be the first to agree. But I still feel doubtful as to the general value of Whiteheadian theory as a guide for the research biologist, except insofar as it encourages him to doubt the reliability of Lloyd Morgan's 'canon' as the sole guide to research at the present day. This is, admittedly, a very important matter and my own desire to investigate the 'higher' and more complex aspects of animal behaviour, and not to rest content with Lloyd Morgan's injunction, may well have been due to my early reading of Whitehead. Lloyd Morgan's insistence on never adopting a complex theory or formulation for a given behaviour when a 'simpler' (usually a more 'mechanical' or more physiological one) would suffice was a most valuable warning at a time when, following Romanes and other naturalists of the period, strongly anthropocentric attitudes were so absurdly rampant. Nowadays the study of perceptual synthesis, of memory, of ideation, of insightful problem-solving and of the complexities of motivation in animals, has reached a point at which the exact opposite of Morgan's strategy often seems more promising.

For myself I nevertheless find the discontinuities in nature so great and so obvious that I stick to the dualist position as an essential attitude of mind -- I am, so to speak, a pragmatic dualist. But I can say with certainty that if I ever become a monist it will be a monist of the Whiteheadian type!

I will end by quoting a characteristic remark by a very great zoologist. D'Arcy Thompson, in the introduction to his great work, *On Growth and Form,* has much to say on this and kindred subjects, which biologists, psychologists and philosophers would do well to read and to re-read. One sentence runs: "Still, all the while like warp and woof, mechanism and teleology are interwoven together, and we must not cleave to the one nor despise the other; for their union is rooted in the very nature of totality."

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Mind in Nature: the Interface of Science and Philosophy by John B. and David R. Griffin Cobb, Jr.

Part 2: Mind and Order

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Chapter 1: The Implicate or Enfolded Order: A New Order for Physics by David Bohm

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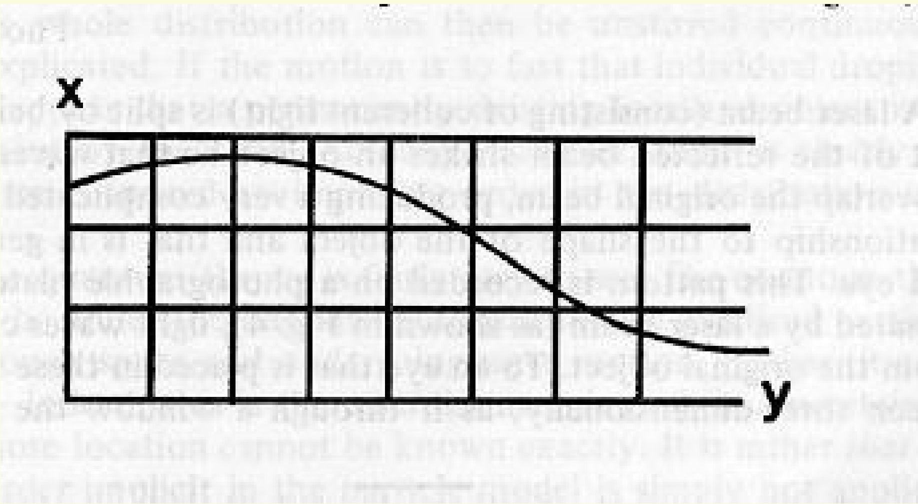
The quantum theory is, without doubt, the most revolutionary development in modern physics. Unfortunately, a large part of its potential impact on our overall world view has been lost sight of, because it is generally treated as being nothing more than a *calculus,* for which no general imaginative conception is thought to be possible. The main emphasis in working with this theory has therefore been on the development of a mathematical formalism that can predict the widest possible range of experimental results. In this talk I shall, however, describe in general terms how the quantum theory, understood somewhat more imaginatively than is usually done, can point to a new order in physics, which I call the *enfolded order,* or the *implicate order*.

I shall begin by sketching briefly a few salient historical features in the development of our modern notions of order in physics. Now, the ancient Greeks thought in terms of an essential order of aesthetic and moral perfection, which is least on the surface of the Earth and increases progressively toward the Heavens. And so, they were led to suppose that Heavenly bodies should express the perfection of their nature by moving in what they thought to be the most perfect of geometrical figures -- the circle. When observations failed to disclose such circular orbits, they retained their notions of essential order by supposing that the movements could be analyzed in terms of the Ptolemaic epicycles, i.e., circles on top of circles. In more modern times, as is well known, this view was overturned by the Copernican idea that the Sun is at the centre (and ultimately that there is no determinate centre at all). This idea led to the development of an entirely new notion of essential order, which was expressed in terms of a detailed description of the mechanical motions of bodies through space. This order was first given a precise mathematical form by Descartes, through his invention of *co-ordinates.* The co-ordinates are pictured with the aid of a grid (as shown in Fig. 1).

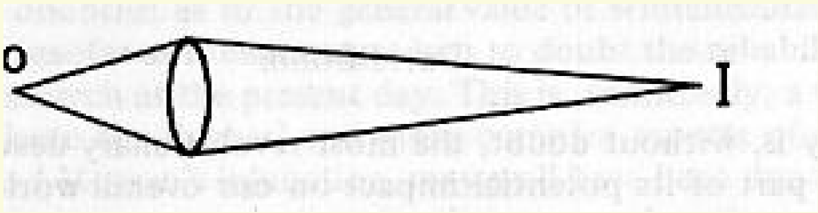


The orbit of a body is described by a curve, given algebraically by an equation determining a ‘coordination’ between two orders, that of the position, x, and that of the time, t.

Clearly, the Cartesian co-ordinates constitute a way of thinking of order that is radically different from that of the ancient Greeks. These co-ordinates have entered the whole of physics and are by now pervasively present in almost all that physicists do. In fact, it can safely be said that, while almost all the detailed content of physical thinking has changed fundamentally in the past few hundred years, the idea of co-ordinates is the one thing that has remained essentially constant. And this need not be felt to be surprising, if one takes into account that basic notions of order tend to be among the most strongly retained features of our thinking.

What I want to suggest here is that the quantum theory, understood imaginatively, gives a clear indication that we now need yet further new notions of order, as different perhaps from those of Descartes as these latter are from those prevailing in ancient Greece. I can give here only a brief description indicating certain essential features of my proposals concerning these new notions of order (which have been discussed in more detail elsewhere). In doing this, I shall use the hologram as an illustrative example, with the aid of which we can consider these notions not only mathematically, but also imaginatively.

Now, traditionally, the world was thought to be constituted of points. This view was given a great deal of support through the use of the *lens,* which provides in principle (as shown in Fig. 2) a point-to-point correspondence between object, O, and Image, I. By creating such a correspondence, the



lens brings the concept of point out in our minds in sharp relief, and encourages us to suppose that ultimately the whole of reality can be analyzed in terms of points which are to be regarded as, in some basic sense, separately existent.

The hologram, however, works in a very different way. To show this difference, we consider the

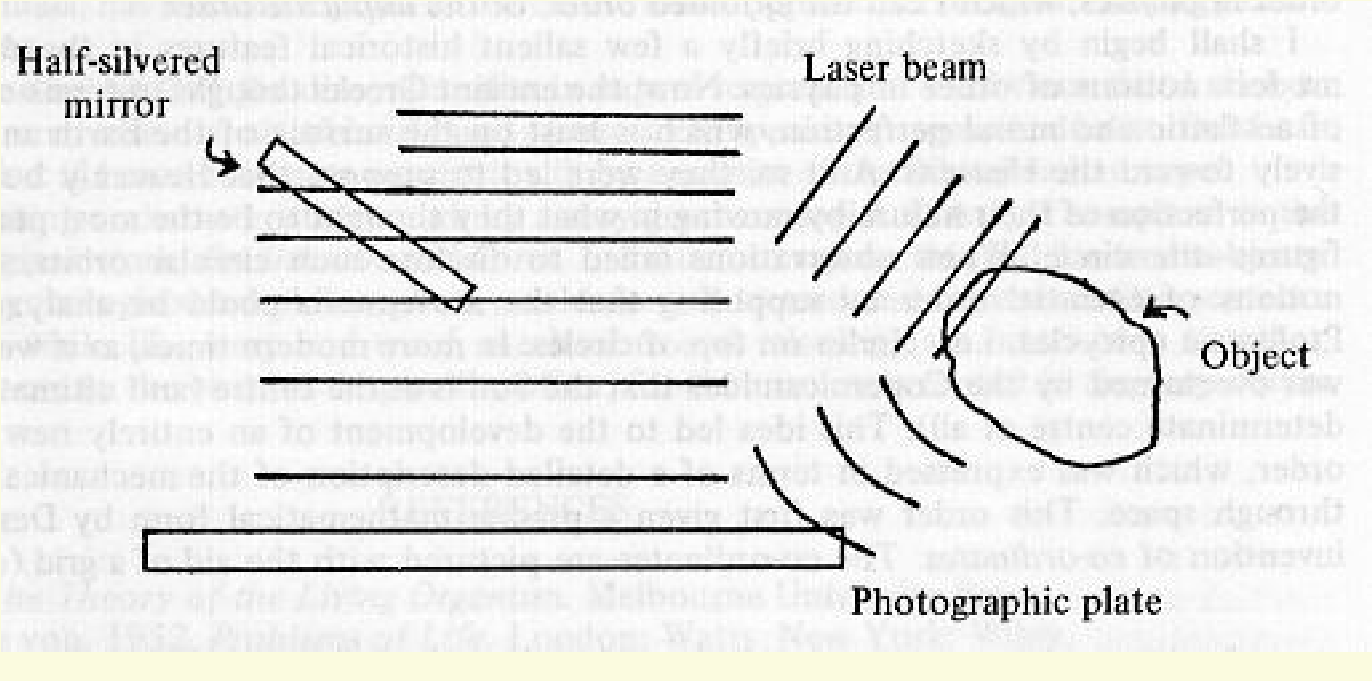
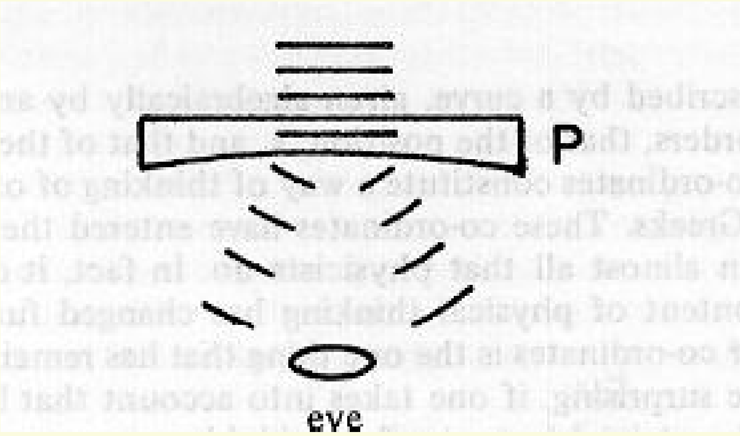


diagram in Fig. 3. A laser beam (consisting of coherent light) is split by being passed through a half silvered mirror. Part of the reflected beam strikes an object, so that waves from this object diffract and come back to overlap the original beam, producing a very complicated interference pattern that has no obvious relationship to the shape of the object and that is in general too fine even to be visible to the naked eye. This pattern is recorded on a photographic plate. When a section of this same plate is illuminated by a laser beam (as shown in Fig. 4), light waves come out which are similar to those coming from the original object. To an eye that is placed in these waves, it appears that the original object is seen three-dimensionally, as if through a window the size of a beam. What is



important here, however, is not this three-dimensionality but rather that, in some sense, *each part of the hologram contains the whole object.*

This example indicates a new order not hitherto given serious attention in physics. Actually, of course, the photographic plate is merely a convenient way of recording this order. Primarily, however, the order *is in the movement of the light whose intensity is recorded.* What is characteristic of this order is that a whole is *enfolded* in the movement in each region of space. This movement may appear at first sight to be more or less random, but evidently it has a complex order within it. This we call the *implicate order*.

Cartesian co-ordinates, then, express the *unfolded* or *explicate* order, in which the analysis of everything into separate points has been the general means of understanding the world. In physics, the explicate order has until now been considered to be fundamental for expressing the laws of nature. Thus, Newton's laws of motion are a relationship determining an unfolded order of successive positions occupied by an object at a series of successive times. What I am proposing here, however, is that the quantum theory indicates the need to take the implicate order as fundamental. In other words, the essential order of movement is not that of an object translating itself from one place to another, but rather, it is a folding and unfolding, in which the object is continually being created again, in a form generally similar to what it was, though different in detail. The explicate order of movement of the object is thus not independent, substantial, and self-existent. We suggest instead that it is an appearance, abstracted from the implicate order, on which it depends and from which it derives its whole form and set of characteristic relationships.

The above notion can be brought out by considering an example, in which an insoluble ink droplet is placed inside a viscous fluid, such as glycerine. If the fluid is stirred slowly by a mechanical device (so that there is no diffusion) the droplet is eventually drawn into a fine thread that is distributed throughout the whole system in such a way that it is no longer even visible to the eye. If the mechanical device is then reversed, the thread will slowly gather together until it suddenly coalesces once again into a visible droplet.

Now, before this coalescence took place, the droplet could be said to be ‘folded into’ the viscous fluid, while afterwards it is unfolded again. So we have an example of a movement in which an explicate order is implicated and then explicated.

We may further develop this example by considering a case in which a droplet is first put into the fluid, after which the system is stirred n times. Another droplet is then placed in the fluid at a slightly different position and the system is once again stirred n times. If this operation is given an m-fold repetition, we will end up with a distribution in which the last droplet has been stirred n times. The whole distribution can then be unstirred continuously and one droplet after another will be explicated. If the motion is so fast that individual droplets are not resolved in our perception, it will appear that a permanently existing localized object is continuously moving across the space occupied by the fluid. Actually, however, there is clearly no such object. What underlies this appearance is indeed an implicated order in the distribution of ink throughout the whole system.

The analogy with the quantum theory is fairly easy to see. The quantum theory indicates that at a deep level matter can be understood neither as constituted of localized particles nor as constituted of fields extended through space and undergoing wave motion. Rather, it seems to have some of the attributes of *both.* Indeed, this is the essential meaning of the uncertainty principle. It is not that particles exist, whose location cannot be known exactly. It is rather *that there are no particles,* in the sense that the order implicit in the particle model is simply not applicable at this level. But likewise, *there are no fields,* in the sense that the order implicit in the continuous field model is also not applicable. Some fundamentally new notion of order is therefore needed.

What I am suggesting here is that the notion of implicate order imaginatively captures the essence of this new situation in physics and that it may perhaps serve as a germ for further development of ideas in this domain. Thus, in the example of a series of ink droplets folded into a viscous fluid, we have a movement in which the results visible in certain regions (e.g., ink droplets) originate in and depend on the whole fluid in an inseparable way. The particle-like aspect is evidently implicit or enfolded in this whole. Likewise, this whole has enfolded within it a certain field-like aspect, as demonstrated by the fact that the order of appearance of the enfolded ink droplets may be radically altered by changing the general conditions throughout the whole fluid, e.g., by introducing structures of slits and obstacles within it. (The analogy with the quantum-mechanical inseparability of the results of observation from the overall experimental arrangement is evident here.)

Of course, in the above example one may, if one wishes, explain the implicate order as the result of a distribution of the particles of ink, which can ultimately be understood in terms of the ordinary explicate order of space and time. So, this example, like all analogies, can be used only in some limited sense, as a pointer. We have, therefore, now to return to the hologram, for which no such ultimate analysis in terms of a distribution of localized particles of matter is possible.

Now, with the hologram, light is taken as the particular movement that is involved in the folding and unfolding of a certain structure (e.g., an object). But more generally, it may be sound, electron beams, or any other movement, which like light is able to carry a whole content in each region or part. The totality of all such possibilities, known and unknown, I shall call the *holomovement.*

The holomovement is to be understood as necessarily and essentially undivided. Since it has no divisions, there can be no explicit way to describe or specify it. It can be known only implicitly, through particular manifestations (such as light, sound, electrons, etc.). Such manifestations have a certain relative *autonomy,* i.e., self-rule, in their order of movement, and this permits them to be studied in themselves, at least up to a point. But ultimately this autonomy is limited, because the fundamental order is *holonomy,* i.e., the law of the whole. This law of the whole is, however, just such as to provide for the above described relative and limited autonomy of the partial aspects. This provision for such relative and limited autonomy is indeed a key requirement in any theory which takes the whole as primary, since without it there is no way to understand or even account for the fact that partial aspects can be found which may serve as points of departure in the development of knowledge.

What we are suggesting then is that all matter is to be understood as a relatively autonomous and constant set of forms built on and carried by the universal and indivisible flux of the holomovement. Such material forms have a certain *subsistence,* in the sense that under appropriate conditions they can continue with a certain limited possibility for stable existence. However, they are not to be regarded as *substances,* which would be completely stable, permanent and not dependent on something deeper for their continued existence. So the flux of the holomovement, with its implicate order, is the primary reality, while the explicate order of relatively constant material forms is secondary.

It is important to emphasize here that what counts in any theory that is developed along such lines is *relative degree of implication.* For example, if we take our own order of perceptual experience as explicate, then the electron's order is implicate. But we might equally well take the electron's order as explicate, in which case our own experiential order will be implicate. In other words, the laws of nature will be invariant, in the sense that their content will be the same, regardless of which order is taken as explicate. This brings out in another way how the explicate order is an abstraction from the implicate, having no independence or substantiality of existence.

This means, however, that 'localization' cannot be a fundamental notion. What is 'local' in one order is enfolded throughout the whole of space (and time) in another order. And as pointed out above, any one order is no more fundamental than any other. Space and time are thus an abstraction from the universal flux of process.

This abstraction has ultimately to be expressed precisely in some mathematical form that will give us a new description of implicate order, which is as systematic and coherent as that given in classical physics by the Cartesian co-ordinates.

With the aid of such a mathematical development we then have, of course, to understand the overall situation in physics in a way that is free of current contradictions and confusions (e.g., the infinities of quantum field theory). Work on this is now going on and some progress has been made which will be reported later.

It is also necessary, however, to go much deeper and to explore what the implicate order means with regard to our common-sense notions based on general experience, as well as with regard to our basic philosophical ideas. In short, we have to come to a new general world view, or metaphysics, in which the implicate order is primary, while the explicate order is secondary or derivative.

In developing such a view, we cannot stop with the attempt to understand matter alone through the implicate order. For we ourselves, along with electrons, protons, rocks, planets, galaxies, etc. are only relatively stable forms in the holomovement. It is necessary, moreover, to include not only our bodies, with their brains and nervous systems, but also our thoughts, feelings, urges, will and desire, which are inseparable from the functions of these brains and nervous systems. If the ultimate ground of all matter is in the implicate order, as contained in the holomovement, it thus seems inevitable that what has generally been called ‘mind’ must also have the same ultimate ground.

What we are proposing then is that what can be touched, seen, handled by scientific instruments, etc. is an explicate abstraction from the real implicate totality of the holomovement. Likewise, in physics, the modern quantum mechanical field theory regards ‘particles,’ along with all structures constituted out of them (i.e., material bodies), as small modifications of the ‘vacuum’ (which is, in effect, being treated as an unknown and only implicitly specifiable movement that is the ground of the whole of reality).

Similarly, when we look into the depths of the clear sky, what we actually see is an unspecifiable total ground of movement, from which objects emerge. Particular ideas or thoughts coming to the mind may similarly be perceived as being like particular objects that arise from an unspecifiable ground of deeper movement. What we call ‘mind’ may be this deeper ground of movement, but if we think of the particular thoughts as the basic reality, we miss this.

Such a way of looking at everything fits in rather well with our general experience. Thus, while any statement may give an explicit expression to our thoughts and feelings, the meaning or significance of this statement is in a vast and unspecifiable *implicit* background of response. Unless we share most of this implicit background, the explicit statement will communicate little or nothing. So one may propose that, also in the mind, the explicate order arises out of the implicate, and that the basic movement is one in which the content of each of these continually passes into the other.

What all this means is that the flux of the holomovement is the implicate source of all forms, both physical and mental. That is to say, the whole of existence, including inanimate matter, living organisms, and 'mind,' arises in a single ground, in which these are all enfolded, or contained implicitly. Inanimate matter is characterized by a relatively autonomous mechanical order of behaviour (i.e., a dominant tendency to recurrence, repetition, relatively fixed and stable patterns of movement, etc.). This order is inherited mainly from the past. On the other hand, what is essential to mind is the possibility of a fresh creative act of intelligent perception, which can assimilate knowledge from the past, but which is not dominated by this knowledge. Of course, inanimate matter has certain creative possibilities also, but these evolve relatively slowly. And while mind too can function mechanically and repetitively, this is not its essential quality. Mind, which is deeply creative and new in its essential mode of operation, cannot then be explained in terms of any mechanical abstraction of the properties of inanimate matter. Rather, it is being proposed here that its operation originates in implicate depths of the holomovement beyond those needed for understanding the ordinary mechanical qualities of matter.

It is clear that, in this view, living organisms are to be regarded as particular manifestations of what is ultimately enfolded in the inward depths of the holomovement. We are suggesting here that a living organism has a more direct contact with what is thus enfolded in the holomovement than does inanimate matter. When such an organism dies, this relatively direct contact ceases to operate, so that the body of the organism reverts back to the more mechanical order of inanimate matter. So, in a certain sense, we could say that the energy of life more typically reveals the innermost order of the holomovement than does inanimate matter. For this reason, one can appropriately call the holomovement *the life energy*, which is the ground that ultimately creates and sustains all matter and all mind, as two relatively autonomous and independent streams that may move in parallel.

This view does not deny the importance of the mechanical abstraction of the structure of the living organism. But it denies that the abstraction of mechanism comprehends the ultimate ground of life, and indeed it denies also that such an abstraction comprehends the ultimate ground of inanimate matter. Nor are we saying (e.g., with Descartes) that mind and matter are to be considered as two independently existent substances. Rather, the universal life energy *is* what operates in the role that has generally been attributed to the one self-existent substance, which is the implicate ground of every form that comes to explicate manifestation.

The view outlined above is evidently close, in important respects, to that of Spinoza. The main difference is perhaps that the notion of implicate order may be more suitable for accomplishing what Spinoza intended, than was the logical geometrical form that he used. For example, the modes and aspects that he introduced to describe the activity of substance can be understood as relatively autonomous orders of movement. A key point introduced by the notion of implicate order is that it is not possible in general for all such modes to be explicate together. Rather (as indicated by the fact that different quantum mechanical 'observables' cannot generally be defined simultaneously), when one mode is explicate, others will have to be implicate.

One can in this general way regard the implicate order as a further development of what is already present in Spinoza, as well as in Heraclitus, Cusano, Leibniz, Whitehead and others, a development that is capable of making full contact with modern science, and yet opens up a way to assimilate common experience and general philosophical reflections on this experience, to give a single, whole, unfragmented world view.

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Mind in Nature: the Interface of Science and Philosophy by John B. and David R. Griffin Cobb, Jr.

Part 2: Mind and Order

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Chapter 2: Three Counter Strategies to Reductionism in Science by Francis Zucker

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Reductionism and its Counter-Strategies

I will briefly describe three research programs in this essay that are motivated by opposition to physical reductionism.

All scientific analysis seeks to isolate elements which, in suitable combination, account for the appearances and events in some domain of nature; and this enterprise, carried to completion, necessarily lands one with the basic entities of physics. Thus physical reductionism is rightly called the methodological ‘superparadigm’ of modern science, and it seems odd indeed to look for research programs in opposition to it.

To be sure, the physical reductionism I have in mind is ontological, not methodological: it is the position that the universe 'consists of' the basic entities disclosed by physics, which are, in their diverse arrangements, all there 'really is' in the world -- all else, including the subject himself and his perceptions, being reduced to the derivative status of 'epiphenomena,' which H. Jonas defines as the powerless byplays of physical happenings that follow their own rules entirely (Jonas 1966, p. 88). But can methodological reductionism be so easily separated from this ontology? Do we not, as scientists, insist on passing beyond method to existence? If we acknowledge scientific truth to be the most certain we possess, then surely its objective correlatives can be no *mere* 'thought economies' (Mach) or 'tools for manipulating nature' (instrumentalism), but they must in some sense be 'real.' Once the physical constituents are granted an independent existence, though, they appear to usurp the whole: gathered together in systems of arbitrary complexity, but all conforming to their inherent laws of combination, they now become coextensive with the universe they so fully explain -- including, therefore, the reflecting subject, which is capable of juxtaposing itself to the rest of the world, and of enunciating the theory of the very entities that constitute both. Though this feat demands a greater faith in the miraculous than we may wish to muster -- and prompts some of us to dismiss such an ontology at the instant -- it yet appears no mere trivial matter to disentangle the two phases of reductionism and thus avoid pouring out the baby with the bath.

The task would perhaps be simpler were it not bedeviled by the heritage of Cartesian dualism, which I think still serves most of us in the West as the point of departure in our ontological deliberations. When in the seventeenth century a reality split into an 'extended' and a 'thinking' substance (*res extrensa and res cogitans*) replaced the hierarchically structured, divinely governed universe of Antiquity and the Middle Ages, it did provide modern science with an ontological frame more congenial to its rise. But this frame, which had to encompass so radically fragmented a universe, struck some minds almost immediately, and ever since, as being unequal to its task. Ontological unity was thereupon sought by opting for a monist solution: for idealism (the monism of the *res cogitans*), or materialism (that of the *res extensa*), or for the hoped-for middle ground of phenomenalism. Materialism, which pictured the basic entities in mechanical terms (with billiard ball-like atoms), represents physical reductionism in its classic form.[1] Today's physics, having turned progressively more abstract and rejecting thing-like models for its elementary particles, may puzzle the old-style materialist in its apparent break with the *res extensa*, but does not in itself challenge his monist claim.

If we reject the idealist and phenomenalist monisms for the reason cited (the *reality* claim of scientific analysis), we can only hope for an escape from ontological reductionism by outflanking dualism itself. Both Whitehead and his contemporary, Husserl, held that dualism could indeed be overcome philosophically, by seeking the fundamental unity in a domain of reality that lies *anterior*, in some sense, to the sharp subject-object split, justified though that split be in certain contexts. ‘Process’ is Whitehead’s label for that domain, the ‘pre-predicative’ and the ‘life world’ are Husserl’s. In their attempts at clarifying the two-faced reductionism issue, there seem to me to be important differences between the two philosophers,[2] but these need not concern us here so long as we have license to believe that disentanglement is philosophically possible at all, that anti-reductionism can mean opposition to the *misplacement of ontological unity*, and not to the scientific enterprise as such.[3]

Philosophical consideration may thus help clear the air, but I believe that only in conjunction with the development of science itself can it lead to the construction of an ontology of nature, i.e., of a ‘body-social of scientific knowledge’ that is neither a hangover from the old hierarchical order nor captive to a monist pseudo-unity. If you have no clear vision of the perfect society, Marcuse says, register your protest against what hurts most in the old; the new will supposedly emerge in the sequel. While this attempt at emancipation through negation may not lead far with respect to the body-social, I will try it here in describing the three research programs in terms of the ‘No’ each of them says to one of the basic strands of the reductionism syndrome: to the dualism that spawned it, to the ‘nothing-but’ of its monism, and to the fragmenting sort of mathematical conceptualization it one-sidedly encourages.

The first strategy tries to explode the ontological claim of physical reductionism from within, so to speak. It takes a leaf from the tremendous changes within physics between the nineteenth and the twentieth century, and decides to continue riding the tiger. *‘Think physics to the end’* is C. F. von Weizsaecker’s way of putting it: since physics itself, as the development of quantum mechanics shows overcame the fragmentation of *physical* reality into building stone-like basic entities, so it might also, as it approaches its final, ‘unitary’ form (von Weizsaecker’s term for the still unknown theory that subsumes the currently known theories plus the long searched-for elementary theory in one system), overcome the fragmentation of the *whole* of reality into distinct domains of the physical and the mental. Indeed, von Weizsaecker’s researches suggest that the axioms of unitary physics are precisely the formal expression of the preconditions of (conceptualizable) experience; that the subject as *knower*, in other words, is encountered at the very base of physics, as Kant had (in a slightly different manner) already surmised. Thus physics itself, for whose sake Descartes had so radically separated the ‘extended substance’ from total reality, may be able to subvert the ontological reductionism which was an offspring of that separation.

To explain the second strategy, let us recall the display of the reductionist order of the sciences along the ‘Comtean ladder,’ which arranges the forms of life and the corresponding specialized disciplines in an ascending series of rungs starting with physics at the base, followed by chemistry, biology, psychology, sociology and, depending on one’s inclination, history and religion. The ‘simples’ of each rung, i.e., the basic conceptions of that discipline, are ‘nothing but’ a complicated structure composed of the simples of the rung beneath it. If human behavior, for example, is conceived as made up of a network of pre-programmed responses (psychology), these can be reduced, say, to conditional reflexes (biology), which are in turn nothing but complicated physical chemistry. Anti-reductionism, in the common understanding, here argues for the *irreducibility,* in some sense, of the higher forms of reality to the lower -- of biology to physics, or of religion to sociology -- and this the second strategy attempts to do. To this end, it accents the relative autonomy of each rung by formulating the simples appropriate to it, i.e., by conceptually ‘assimilating’ (to use Bohm’s term [Bohm, 1974, p. 58]) each type of fact into its own sort of order. I therefore term this strategy, *‘Cultivate the simples appropriate to each order,’* and cite Waddington’s ‘epigenetic landscape’ along with his ‘chreods’ as an outstanding example of its fruits. This strategy tries to meet Whitehead’s demand for a natural philosophy that regards "the red glow of the sunset. . . as much part of nature as the molecules and electric waves by which men of science would explain the phenomenon" (Whitehead, 1970, p. 29). That the ontologically unprejudiced exhibition of the domains of ‘sunset colors’ and of electric waves, each in its own terms, does indeed allow us to account for the "coherence of things" (*ibid.*) without succumbing to the nothing-but of the waves, is one of the points I shall try to make below. The problem is to discover in what sense this coherence, which of course includes the methodologically reductionist relation, is nevertheless richer than it. I suggest that language is sufficiently powerful to express this enrichment, and that it is a form of *knowledge* which is being thus expressed, albeit not of *scientific* knowledge in the sense of Weizsaecker ("testable predictions on precisely formulated alternatives"); from this point of view, the first and second strategy appear to be complementary. It must be admitted, however, that the second is weaker than the first: opposition to physicalist monism dictates its employment, but it cannot by itself overthrow it. For the reductionist can always argue that, while it may be good heuristics to develop concepts peculiarly fitted to each of the rungs (if they are not already available in ordinary language), these will be necessarily anthropomorphic and their sole function in the scientific enterprise is to invite reduction.

The third strategy is rather speculative. Like the second, it seeks the simples in structuring any domain of knowledge, but tries to give this search a sharper edge by applying a lesson learned from physics. So far, simples have been taken as concepts that seem elementary in an intuitive way: a leaf, for example, is an intuitively obvious constituent in plant morphology. As one learns one’s way about in any field of inquiry, one gradually becomes aware of the ‘chreods’ that lie close to the level of immediate perception through the senses or the intellect. But perhaps our ordinary perceptive powers are not sufficiently acute to discover the deeper-lying chreods. Indeed we know from physics that, as we dig deeper, the basic notions become very abstract, i.e., non-intuitive. The first strategy is satisfied with pointing out that, in the end, at least the *axioms* of unitary physics become transparent. It is possible, however, that progress on the higher rungs, for example in biology, depends on an enrichment of our perceptive faculties, and since it is structures we wish to recognize in science, this means an enrichment of our mathematical imagination. This is precisely what David Bohm has been after in his work with ‘implicate’ (or ‘enfolded’) orders, which so far he has discussed only in relation to physics, but clearly means to apply in other fields as well, such as in perception theory and in cognitive psychology (Bohm 1973 and 1974). Bohm believes that if we learn to think in ‘non-local’ orders, i.e., in orders quite other than those based on the Cartesian *res extensa,* we will be able to understand the aspect of wholeness in quantum mechanics, which in a formal sense we already know to be there, intuitively as well. Implicate orders express "the intimate interconnection of different systems that are not in spatial contact" (Bohm and Hiley 1975), and will be needed wherever spatial (or temporal) wholeness is to be given a mathematical form. The example presented below under the title, *'Is there a mathematics for wholes?'*, is an attempt to apply a primitive instance of implicate order to plant morphology. The germ of this idea was already known to Whitehead, and to the mathematician F. Klein, both of whom speculated about its use in classical mechanics (Whitehead 1898). In adapting it to biology, George Adams (d.1963) introduced the notion of 'formative forces,' which correspond to the 'formative causes' mentioned by Bohm (Bohm 1973, p. 22). The true testing ground for the implicate-order strategy, it seems to me, may indeed be biology rather than physics, where abstract methods are so powerful as to perhaps make it dispensable: just as the old style building-block materialist was refuted not by philosophical polemic, but by the one authority in which he trusted, i.e., by physics itself, so the nothing-but reductionist in contemporary biology will modify his views should it be possible some day to provide him with a mathematical language that fills the currently existing gap between our formal knowledge of gene structure and combinations, and our intuitive apprehension of growth and shape. This language, both Adams and Bohm agree, will have to be that of an implicate topological or projective order, not the explicate metrical order of classical physics. What the precise relationship between the novel morphology and traditional biochemistry might be is a question I have not been able to resolve; Bohm's and Adams' expectations diverge on this point.

Think Physics to the End

Why should one expect physics to develop toward a unitary theory, and what could be the meaning of such a theory?

Physics develops in a sequence of 'closed' theories, to use Heisenberg's term for a mathematical structure with associated physical semantic that cannot be improved upon by means of 'small' changes (as, for example, Newton's law of gravitation cannot be improved by modifying the number two in the exponent of the distance term). When a 'deeper' closed theory is found (as, in the case of gravitation, general relativity), the older theory is not simply discredited, but its predictions are upheld within certain parameter ranges specified by the newer theory, which adds correct predictions of its own outside those ranges. Classical mechanics united terrestrial and celestial kinematics in a unified dynamics. During the past century, electromagnetic theory united electrostatics, magnetostatics, and network theory with optics in one stroke; special relativity combined classical mechanics with electromagnetic theory; general relativity combined the theory of gravitation with physical geometry and special relativity; and quantum mechanics united much of physics with, at least in principle, all of chemistry. It is at least as puzzling to think of an infinite progression of ever more general theories in physics as it is to postulate a final, unitary theory. (What is still missing is chiefly a theory of elementary particles, which Weizsaecker believes to be implicit in quantum mechanics itself, to become explicit once the correct symmetry group is applied.)

Weizsaecker conceives the unitary theory, which encompasses all other as special cases, to be the formal expression of the preconditions of experience (Weizsaecker 1971a and 1971b). This thesis was inspired by Kant, but goes well beyond Kant: only the regulatives of science, e.g., the principle of causality, were in Kant's opinion *a priori;* the special laws would have to be formulated on the basis of special experience. If unitary physics spans all special laws, however, then all physics dispenses with special experience and depends solely on its preconditions. In principle, then, unitary physics ought to be deducible from a sufficiently detailed analysis of terms such as time, logic, observation, number. So long as this task appears too formidable, we must try to construct the theory by working from both ends: by axiomatizing the existing most general theory, i.e., quantum mechanics, in a manner that invites interpretation in terms of plausible preconditions, and by logically analyzing the preconditions that occur to one upon reflection so as to reconstruct the theory. In trying to close the gap, one finds additional preconditions of which one had previously been unaware, and, looking in the other direction, one tries out new axioms, for example concerning symmetry conditions suggested by the local analyses. The most cursory analysis of experience shows it to presuppose the structure of time: we learn from facts of the past to predict future events, and we test these when they are no longer future but present or past. Weizsaecker tries to develop a logic of temporal propositions that incorporates these features. The logic would be a probability theory based on a time-dependent axiomatics, which somehow must include the axiom of indeterminism (or its equivalent, the 'superposition' axiom).

Granted this much, Weizsaecker can reconstruct the Hilbert space structure of quantum mechanics for the case of the most elementary objects conceivable. An object of this sort is not a smallest something in physical space; it is, rather, the smallest unit of information, i.e., a single yes-no decision, termed an ‘ur,’ or a ‘simple alternative.’ Its Hilbert space is a two-dimensional complex vector space, and a simple mathematical development shows that complex bodies constituted by urs admit of a natural description in a three-dimensional real space.

Thus Weizsaecker explains the structure of space from quantum mechanics, and quantum mechanics from the structure of time. Although the details of his project are far from being carried out, the basic scheme stands: the unity of physics, and therefore (since knowledge and the known are not to be separated) the unity of physical nature, reflect the unity of time. ‘Physical’ nature, to Weizsaecker, means nature objectified -- any part of nature, including, for example, a living cell, or even the human mind which, insofar as it is analyzable in terms of yes-no questions, is fully subject to the laws of unitary physics. Therein lies Weizsaecker’s ‘reductionism.’ It does not reduce mind to palpable 19th-century matter, nor even to a something situated in physical space; and it leaves open the possibility of other, non-objectivating modes of encountering mind, in which another ‘Thou’ is met. If matter is what obeys the laws of physics, then it is an aspect of all that exists in the universe, and rather than juxtaposing it to life or mind, it is but a *mode* of experiencing these. A reductionism that claims no more than this is a reductionism with all the poison drawn from it.

Cultivate the Simples Appropriate to Each Order

Ordinary language provides us with elementary concepts on all levels of nature. Deliberate scientific work begins with a search for elementary terms -- the ‘primitives’ or ‘simples’ -- even more peculiarly fitted to the analysis of the subject at hand, in one with the search for patterns in which to view their interrelations. It has been a principle of good craftsmanship with all empiricists from Occam to Bridgeman to tailor their terms and theories as closely to the phenomenally given as possible. Occam’s razor, Bridgeman’s admonition to make the least down payment on future conceptualizations (Bridgeman 1959, p. 10), are born of the same spirit of faithfulness unto the phenomena. (Mach, too, was of this persuasion.) Tackling color theory in this spirit, as I will now show, one immediately obtains the simples appropriate (in a clearly specifiable sense) to that field; these simples are *not* the electromagnetic frequencies high school physics tells us colors ‘really’ are. Examples of this sort, taken from well-established sciences, may serve as practicing ground for biology and the higher-rung domains in which the shaping of the appropriate simples is still an open problem. Here I will confine myself to the 'lowest' level of that discipline (optics) where it is closest to physics, and where the nature of its relative autonomy can therefore best be studied.

Let us recall, to begin with, the 'color circle' on which we usually represent the universe of possible hues and saturations. (A third elementary determinant of color, brightness, need not concern us in the present context; its prepresentation would require a third dimension.) As we move around the circle clock-fashion starting, say, at red, we pass through the successively neighboring hues: orange, yellow, green, blue, violet, purple, and back to red. At the rim of the circle, the hues are at their most saturated (darkest); as we move inward along a spoke, the hue remains constant but becomes progressively less saturated, until we reach white at the center. Actually, this qualitative (mathematically speaking: topological) representation of the color world is two steps removed from physics, not one. The representation I want is obtained by noting that any color can be matched by superposing three standard (but arbitrarily chosen) 'primary lights,' and choosing as coordinates the relative contribution of each of these primaries. As a result, one now finds oneself in a so-called projective, rather than topological, plane, in which the color 'circle' is actually a noncircular closed curve whose exact shape need not concern us here, with the White center somewhere inside. The point to hold onto is that the mathematics on this particular rung of color science (which used to be referred to quite universally as that of 'psycho-physics'), is neither quantitative (metric), as in physics, nor purely qualitative (topological), as in the description that satisfies our common-sense curiosity in the structure of the color world, but in between, namely, projective. I will now discuss the appositeness of two types of color primitives with respect to this rung.

All of us are familiar with Newton's decomposition of sunlight (white) by means of a prism: he allowed a ray to enter through a small hole, and displayed a sequence of highly saturated colors from red through green to violet on a screen beyond the prism. It is a characteristic of these 'spectral colors' that they cannot be further resolved into constituent hues by passage through another prism; that they stand in a one-to-one correspondence with a particular angle of refraction (i.e., with a spatial property); and that, in the context of physical optics, each turns out to be quantifiable in terms of a spatial periodicity (the wavelength). It is important to note, however, that *only* the spectral colors correspond one-to-one to a wavelength; every other color corresponds to a *set* of possible spectral-color distributions, the so-called spectral ‘metamers.’ In other words, the Newtonian spectral wavelengths designate one-to-one every point on the rim of the color circle (or projective closed curve) between red and violet, but do not designate in a unique fashion the purple segment of the rim, nor any of the points inside the circle.

Almost two hundred years ago, the poet Goethe experimented with prismatic colors and hit upon an entirely different set of color simples (Goethe 1791). He held up a prism against a white wall, expecting to see the Newtonian spectrum displayed, and noticed instead that the wall remained white except where it was crossed by dark cracks, which the prism resolved into hues much brighter than the Newtonian ones. Goethe concluded that the minimum condition for the genesis of prismatic colors was a simple black-white border, and the colors he then saw, termed *‘edge colors’* today, he took as the true primitives for a theory of color, while he considered the Newtonian spectral colors to be compound, i.e., derivative. It is a simple matter today to prove that, by combining these primitives pairwise in two possible ways, every color point in the projective (or topological) plane is covered in strict one-to-one correspondence. The two combinations are ‘parallel’ and ‘series’: i.e., one edge-color filter is inserted in front of one light source, the other in front of a second, and the two beams are superposed on a screen (parallel combination), or the two edge-color filters are placed one behind the other in front of a single source (series combination) The Newtonian spectral colors are obtained through the series combination of complementary pairs of edge colors (pairs that add up to White when combined in parallel), and thus are in fact compound in terms of these simples, as Goethe had claimed. Conversely, the edge colors can be resolved into Newtonian spectra; there is no reason, other than ontological prejudice, for calling one primitive ‘more fundamental’ than the other.

The Newtonian simples are quantifiable and specify color uniquely insofar as it links up with physics; the edge colors are projectively defined and specify the colors whenever we talk of the color universe as a whole -- as of course we do in any theory of color, not only on the psychophysical level, but on the next higher (topological) level as well. It turns out that there are still higher rungs in color theory (which Goethe tried to structure with his notion of the ‘Urphaenomen,’ the ‘archetypal phenomenon’), and that on each of these the edge colors retain their basic role.

How do the levels of color physics (wavelengths) and psycho-physics (projective color plan) cohere? The reductionist answer is that the electromagnetic input spectrum, processed by the neurophysiology of the cones in the retina, generates the color ‘signal space’ represented by the color plane. Can our second strategy add any further dimension to this coherence?

In most textbooks on color science, the following relation between the wavelengths and c corresponding to complementary hues is mentioned, with the added remark that it seems to be purely empirical,’ i.e., an accidental relation and not part of any theory:

(1) (a -)(c - b)c,

where a, b, c are numerical constants. I would like to suggest, however, that there is a way of viewing this relation such that it becomes perfectly meaningful, provided only we look in the ‘counter-reductionist’ direction, i.e., we try to understand the lower rung in terms of the higher, instead of explaining the higher in terms of the lower. The richer coherence we seek depends on that understanding.

Complementary hues, it can be shown, lie on a straight line through the White point in the projective plane. Their designation in terms of wavelengths, as in (1), is a foreign body in the color plane, since a projective (or topological) universe knows nothing of a metric; the wavelengths are simply imported from the level of physics, i.e., from interference measurements made in physical space. To parametrize hues in a manner *intrinsic* to the color plane (i.e., properly ‘assimilated’ to that order), we must proceed differently. The hues appearing angularly distributed about the White point, we introduce a projective (non-metric) angular measure, which is given by

(2) (d - h) (h c - e) =f,

where d, e, f are arbitrary constants, and h, hc are the hue-parameter values of a complementary pair. It is clear that, by setting the arbitrary constants in (2) equal to the particular values a,b,c in (1), the hue scale will be in the units of wavelength. In other words, the class of permissible metrics for hue, specified by the projective measure (2), includes the metric of physical space as a special case. It is decisive to realize that there is nothing matter-of-course about this state of affairs.

What we are here being told is that the metric of physical space is a specialization of a projective measure not descriptive of phenomena in physical space (such as the projective measure relating the electromagnetic tensors in vacuum, which of course must include the metric of physical space as a special case), but of phenomena in a space of sense experience. In other (psycho-physical) spaces of sense experience (I have specifically examined only that of acoustic pitch and of optical brightness), the relation to the physical metric seems to be similarly that of a higher geometry (albeit affine, rather than projective) to one of its metric models. We are therefore able to understand that some of the physical quantities are born out of the more qualitative mathematical structures of sense experience as a straightforward quantification thereof. This manner of coherence between two adjacent rungs is *not* explicable in terms of the signal transformation scheme mentioned before; rather, an evolutionary principle of neurophysiological realizability seems to be involved that is yet to be clarified.

Is there a Mathematics for Wholes?

We normally think of a plane as made up of the totality of its points, but the converse is equally possible: a point can be thought of as the totality of planes passing through it, and in fact is thus conceived in the field of mathematics mentioned in the preceding section, *viz.*, projective geometry. Figures and theorems of point-like and of plane-like character appear always in parallel in that geometry and with equal justification, however odd the latter at first may seem to our intuition, which is unused to structures whose parts are larger (in ordinary space) than the whole. We can even specialize projective geometry in a manner parallel to the specialization that gives us Euclidean geometry, to obtain what Whitehead termed ‘anti-space,’ and Adams ‘counter-space’ (Adams and Wicher 1960): a space characterized by an ‘absolute point center,’ corresponding to the ‘absolute plane at infinity’ that lifts Euclidean geometry out of the totality of geometries contained in projective space. What this geometry (and projective geometry in general) teaches us is that *structure need not be internal,* it can be external to the object as viewed in ordinary space. Thus we have the choice, in plane projective geometry, of constructing an ellipse (using a straightedge only) point by point, or else tangent by tangent; we can feel, as we work with the latter, how the *periphery* shapes the figure. (In three dimensions, it is tangent planes rather than lines; and in the differential geometric and topological generalizations, it is tangent surface elements rather than planes.) Whitehead was apparently the first to wonder why this plane-like geometry should not be applicable in nature, when its parallel, the point-like geometry, is so ubiquitous; he did begin noticing projective elements in the science of statics, and F. Klein's student, E. Study, explored the 'plane-wise' representation of mechanical rotation, an idea further developed by G. Adams (in unpublished manuscripts). It is also clear that electromagnetic theory can be understood in these terms; in fact, the Maxwell equations are a purely projective theory in vacuum, the metric entering only through the material properties, such as the permeability and the dialectric constant.

The exploration of the projective and counter-space points of view in physics does promise to throw new light on old relations, but seems unlikely, unless I am mistaken., to produce new results. Perhaps physics can serve as a training ground for the novel mathematical imagination here required -- and this would be a worth-while effort, provided Adams is right in thinking that counter-space geometry *will* lead to new results in biology (Adams and Whicher 1960). His point is that morphological changes in living things, if we view them intuitively, do seem to proceed from, or in, the periphery -- think of the blastula or neurula in embryology, or of the unfolding of leaves in botany. Accordingly, he introduces force fields that act in the periphery rather than in a point as in physics, and conceives of every growing point (such as the tip of the shoot) as the absolute center of a counter-space. In this way Adams does seem to catch some growth processes in mathematical form, but it is not clear to me how the surface-like forces are supposed to act on the material they shape. Adams' language here sounds vitalist; the forces are said to 'cause' morphological changes by interacting with matter at points where it is in a 'chaotic state.' Yet this is surely incorrect; at least on the microlevel matter is extremely highly organized. (Its correctness on the level of macro-shape throws no light on our problem.) I think Bohm (1973) is right in invoking the *causa formalis* in connection with implicate orders, ruling out, for the formative forces, an explanatory role of the *causa efficiens* type, which is reserved to physicalist explanation. Even in saying this, of course, we are merely *posing* a difficult problem, not solving it.[4]

If this approach is still too primitive, how can we further develop it in the direction of Bohm's implicate orders? What the two have in common is that Bohm's paradigm, the Hilbert space implicate order, is also a projective geometry, though one greatly enriched in comparison with the ordinary projective geometry we have so far considered. Two large steps separate the two. The first corresponds to the transition from 'geometric optics' (rays and phase fronts) to 'physical optics' (waves, interference). Whereas in the ordinary projective case, space and counter-space (explicate and implicate) are rigidly correlated, their association with a wave equation unfreezes them to some extent by introducing periodic or even nonperiodic motion. The form of this motion (explicate) is represented implicately by spectra, which are thus a further training ground on the road to the more basic implicate orders. Into every point of the intensity distribution across an aperture, for example, the entire spectrum is enfolded as a superposition of moving planar structures; and conversely, every spectral wave front sweeps over all points in space, thus contributing to the intensity everywhere. The second step then introduces operators to achieve the full Hilbert space structure. I cannot imagine that anything less will do for the 'new morphology.' Just as quantum mechanics is needed to, and does perfectly, fill the gap between the atomic structure of crystals and their beautiful shape in space, so too it will be needed to link the biochemistry of genetic code and cellular processes to the growth and shape of living things -- provided, that is, that such a link can be found at all. Quantum mechanics thus plays a central role in the first as well as the third strategy, but for different reasons: in the first, the analysis of its meaning takes the sting out of reductionism, in the third it becomes a guide in the development of our perceptual and conceptual appreciation of living forms.

I mention in conclusion the work of R. Thom (1970/71), which presents an enrichment of our morphological understanding perhaps more immediately applicable to the morphological sciences than quantum mechanics can be at the present moment; in fact, I suspect Thom's method to be indicative of the bridge that needs to be constructed between the macro- and the micro-realm. The topological mathematics he employs lends itself to interpretation in terms of implicate orders, although Thom is not himself interested in making this explicit. It remains to be seen whether his approach (or the cohomology theory used by Bohm, or any other approach now known) is adequate to the mathematical innovation sought: to the direct description of growth, and of the metamorphosis of forms, in space and time.

NOTES

l) For an excellent discussion of ontological physical reductionism as a fission product of Cartesian dualism, see Jonas 1966, pp. 38-92.

2) Some points of similarity between Whitehead's and Husserl's philosophies are discussed by R. Wiehl in his thorough Introduction to Whitehead 1971.

3) This is also the position of D. Bohm.

4) The fact that George Adams was a disciple of Rudolf Steiner, who taught a 'Western style' of consciousness expansion called 'Anthroposophy,' and thought well of projective geometry, explains his constant references to the 'cosmic' and 'spiritual' significance of counter-space. Although I fear his hopes for the idea may be inflated, I think nevertheless that its suggestive wealth merits attention.

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Mind in Nature: the Interface of Science and Philosophy by John B. and David R. Griffin Cobb, Jr.

Part 2: Mind and Order

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Chapter 3: Temporal Order and Spatial Order: Their Differences and Relations by Milic Capek

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If we look at the subject catalogue of nearly any university library, we find that not only the books dealing with space and time are listed under the same heading, but also that in many of them both concepts are treated jointly as their very titles indicate: *Space and Time, Space, Time and Matter; Space, Time and Motion;* and even *Space, Time and Deity,* etc. This is certainly not accidental; nor is it accidental that with a few exceptions the word 'space' regularly appears in the titles before 'time.' This is due to the fact that the properties of space and time are, or at least appear to us, quite similar and, furthermore, that the spatial relations seem to us as somehow more fundamental, *more solid,* and easier to grasp than the elusive temporal relations. Hence our instinctive tendency to believe that the relations of succession can be adequately symbolized by geometrical relations.

The purpose of this paper is to trace the sources of this belief, its remarkable persistence through centuries of philosophical and theological speculation, and its disastrous influence not only on philosophy, but also on the interpretation of some recent and contemporary physical theories. Finally I want to show that an attentive analysis of both our introspective experience as well as of the revolutionary discoveries of twentieth-century physics indicates that, not only are temporal relations basic and irreducible to spatial relations, but also that spatial relations are of a derivative kind, being mere approximations or idealizations of those strata of experience in which the temporal aspect is less prominent and can be disregarded for practical purposes. Time, or more accurately, *becoming* seems to be more fundamental in the light of available evidence, while spatial relations are mere instantaneous cross-sections in what Whitehead called the ‘creative advance of nature’ and Bergson, before him, ‘true duration.’ Such instantaneous cuts have their usefulness and justification in our macroscopic and macrochronic perspective, but their pragmatic usefulness should not be confused with objective ontological status.

There are two approaches to the origin of the concept of time: on one side, Jean Piaget’s recent investigations of the formation of the notion of time in children; on the other side, the analysis of the development of the concept of time in adult humanity, more specifically, in the philosophical and scientific community. It is remarkable how complementary and convergent are the results obtained in two such apparently disparate areas -- child psychology and history of ideas. Piaget showed how young children (4-6 or even 7 years old) have considerable difficulty in differentiating temporal from spatial relations. Hence the succession is confused with spatial order; the duration of concomitant motions is judged erroneously from the distance covered by the moving bodies without taking into account the differences in speed; and the relation of simultaneity is not disentangled from spatial coincidence. Only gradually and after considerable groping and in a higher age (7-8 years) do children succeed in differentiating the temporal order from the spatial order, i.e., the temporal ‘before-after’ relation from the spatial ‘before-after.’ Similarly, the duration of motion is dissociated from the length of its trajectory, and the coincidence in time (i.e., simultaneity) is not confused with the coincidence in space. This is, of course, an extremely concise and simplified account. Piaget discovered that the formation of the notion of time proceeds by three successive stages, with the boundaries slightly different in different children; it is only in the third stage that the notion of duration is entirely freed from what Bergson called ‘the fallacy of spatialization,’ in the sense that it is understood how several different motions with different speeds and covering different distances can occur within one and the same interval of time. Thus the distinction is finally drawn not only between time and the spatial trajectory of motion, but also between time and motion itself (Piaget 1937).

It would be absurd to claim that there is a complete analogy between the formation of the notion of time in the child and the development of the concept of time in humanity. The situation is far more complex; yet, some interesting similarities do exist and they are hardly accidental. The early Pythagoreans identified time with the celestial sphere, that is, with the circular trajectories of the daily motion; later, time was identified with the rotating motion of the celestial sphere. The reference to the celestial sphere and its motion had far-reaching effects on the subsequent development of the concept of time: it focused the attention of philosophers on the regular periodicity of the celestial motions by which time can be measured and thus it deepened the distinction between the qualitative content of time and its metrical aspects; the correlation of time with spatial motion became the source of *the relational theory of time,* according to which "time is nothing by itself," as Lucretius wrote (*De rerum natura,* 1,495f.), and cannot be separated from concrete changes occurring in it; finally, the alleged inseparability of time from spatial displacements created the tendency to exaggerate the analogy between space and time and, eventually, to spatialize time entirely and thus virtually to eliminate it.

This extreme tendency is conspicuous in *the Eleatic school.* Zeno’s four arguments against the reality of motion were based on the assimilation of time to a geometrical line. According to Zeno, temporal intervals are adequately symbolized by spatial segments: they both are divisible *ad infinitum,* and to the point-like extremities of linear trajectories correspond the durationless extremities of temporal intervals -- instants. From this the impossibility of building motion from the motionless positions, and durations from the durationless instants, followed naturally. Hence, in Zeno’s mind his teacher, Parmenides, ridiculed by his opponents for his denial of time and motion, was vindicated and avenged.

Eleatism was the metaphysics of timeless Being in its most radical form and, although it has never reappeared in its extreme form, it exerted a lasting influence on the subsequent development of Western thought. In truth, such systems as those of Spinoza and Bradley came very close to Eleatism; but instead of eliminating time, change and motion entirely, they half-heartedly retained them in treating them as mere ‘appearances,’ as having some sort of existence or rather semi-existence which was of an inferior and less dignified kind than that of immutable Being. In truth, it can be argued that even Parmenides treated change and motion at least as ‘appearances,’ as belonging at least to the illusory realm of phenomena and not as mere non-entities; otherwise the division of his poem into two parts -- "The Way of Truth" and "The Way of Opinion" -- would lose its meaning. But this is a historical question; what is important in this context is the fact that the subsequent development of Greek, medieval and modern philosophy was largely dominated by the contrast between the timeless realm of Being and the temporal realm of change; in this sense, it was a continuation of the dialogue between Parmenides and Heraclitus, with Parmenides having an upper hand. In most philosophical and theological systems Being was endowed with a more dignified status of the true reality, of which the temporal realm is merely a pale, shadowy replica. From Plato, who defined time as a moving (i.e., imperfect) image of eternity, down to St. Thomas, who stressed the perfect immutability of his Supreme Being in terms indistinguishable from the language of the Eleatic school, we can trace the same persistent theme -- a metaphysical dichotomy of Being and Becoming, of perfection and imperfection, of the timeless and the temporal realms. To this dichotomy corresponds the epistemological dichotomy of two kinds of knowledge -- the true knowledge of the all-embracing timeless truth which only God possesses and man’s imperfect knowledge confined to the temporal realm. The incompleteness of human knowledge is due to the temporal incompleteness of the realm to which it is confined. It is easy to see how the timelessness of God and of his knowledge led to the theological determinism, to the predestinationism of St. Augustine, St. Thomas and Calvin; for the abolition of time and becoming on the divine level eliminates entirely the ambiguity of the future which is uncertain only to our imperfect, time-bound insight, but which is in its completeness timelessly present in the mind of God.

This trend continued in modern philosophy and to some extent in modem science, in spite of the Copernican and Cartesian revolutions. Spinoza merely secularized the God of Aquinas and Calvin by equating him with the impersonal, but equally static and equally timeless, order of nature (*Deus sive natura*); and Laplace’s ‘omniscient mind’ is nothing but a secularized and depersonalized version of the God of the

Scholastics and of the Protestant Reformation. This accounts for a "secret alliance of theological and naturalistic determinism" of which Professor Hartshorne once wrote (Hartshorne 1932, p. 429). I like to quote this because I regard it as one of the most insightful and also most neglected remarks concerning the history of ideas. There is no doubt that the preferential treatment of the concept of Being, with the concomitant tendency to debase the status of time, becoming and change continued until the last decades of the last century, when the first process philosophers -- Renouvier, Boutroux and Bergson in France, and William James in the United States -- tried to reverse the centuries-old trend. (I am not mentioning Hegel, since his status as a process thinker is rather ambiguous, as is shown by the two divergent interpretations of his philosophy -- that of Croce and J. N. Findlay, in contrast to the static interpretation of J. E. McTaggart.)

I would like to conclude this digression into the history of ideas with the following words which Friedrich Nietzsche wrote in 1888:

> You ask me which of the philosophers' traits are really idiosyncracies? For example, their lack of historical sense, their hatred of the very idea of becoming, their Egypticism. They think that they show their *respect* for a subject when they de-historicize it, -- *sub specie aeterni* -- when they turn it into a mummy. All that philosophers have handled for thousands of years have been concept-mummies; nothing real escaped their grasp alive. When these honorable idolators of concepts worship something, they kill it and stuff it; they threaten the life of everything they worship. Death, change, old age, as well as procreation and growth, are to their mind objections -- even refutations. Whatever has being, does not become; whatever becomes does not have being. Now they all believe, desperately even, in what has being. . . .They place that which comes at the end -- unfortunately! for it ought not to come at all! -- namely, the 'highest concepts' which means the most general, the emptiest concepts, the last smoke of evaporating reality, in the beginning, *as* the beginning. This again is nothing but their way of showing reverence: the higher *may* not grow out of the lower, may not have grown at all. . . .
>
> But Heraclitus will remain eternally right with his

> assertion that being is an empty fiction. The apparent world is the only one: the ‘true’ world is merely added by a lie (Nietzsche 1954, pp. 479-482).

This is a temperamental revolt against the perennial metaphysics of Being presaging the birth of process philosophy. (Curiously enough, *Twilight of Idols*, from which this passage is taken, was published only one month before Bergson wrote a preface to his first book.) But it is ironical to see how much Nietzsche, despite his furious attack on the metaphysics of Being, remained committed to it. He -- like some ancient Greek philosophers, perhaps even Heraclitus -- still accepted the idea of eternal recurrence, that is, in the words of Mircea Eliade, "Ontology uncontaminated by time and becoming." For, in the cyclical theory of time, what will be already has been, and what has been will be; the distinction between the past and the future -- and with it time itself -- is abolished. Another instance of spatialization of time.

The evolution of modern science in this respect was more ambiguous. On one side it exhibits the tendency similar to that which we observed in the history of modern philosophy. This is only natural, since modern science and modern philosophy have not developed independently, but have perpetually interacted and influenced each other; in truth, until the post-Kantian period they were so intertwined that it is difficult to speak of separate histories. This explains why certain ideas were shared by both scientists and philosophers. I have already mentioned Spinoza and Laplace, who were both equally intransigent in their insistence on rigorous determinism and equally explicit in their reduction of time to a mere illusory appearance. (What is less known is that Immanuel Kant in his *Critique of Practical Reason* expressed Laplace’s idea of timeless or becomingless determinism twenty-five years before Laplace wrote his famous passage in his *Essai philosophique sur les probabilities*.) I have already mentioned how the medieval theological determinism transformed itself into modern naturalistic determinism, which dominated modern science and a large part of modern philosophy. Emile Meyerson showed convincingly in a number of his books how an elimination of time was a theme common to both science and philosophy in the last three centuries. There is no question that the fact that time was symbolized by a geometrical line (t-axis), which had the role of an independent variable on which various physical quantities depend, greatly contributed to this view. For it is too easy to forget that even in this geometrical symbolism time is not represented by a static ready-made line, but by an incomplete line which is being continuously extended ‘into the future,’ as its terminal point, representing the present moment, is continuously moving; it is difficult to resist the notion that the future positions on the t-axis somehow pre-exist prior to their occupation by the moving present, and that all events -- present, past and future -- coexist on the ‘fourth dimension’ which is as complete and as static as the other three spatial dimensions. This view of time as the fourth dimension is usually associated with the theory of relativity, but it can be traced far back to the past pre-relativistic period: it was Descartes who called time a ‘dimension’ and d’Alembert who called it ‘the fourth dimension,’ while Lagrange called mechanics ‘geometry of four dimensions.’ In truth, the roots of this becomingless view go as far back as Zeno of Elea, who was probably the first who treated time and motion as a static geometrical line: his view that the allegedly flying arrow is motionless in all points of its trajectory has an obvious affinity with the strange view of some of our contemporaries according to which successive moments exist ‘tenselessly’ on the fourth dimension called ‘time.’

But even if we do not forget that in the geometrical diagram ‘the t-line’ is perpetually being extended by the continual forward motion of its terminal point, representing the present moment, the risk of serious confusions is hardly lessened. For, to confuse time with motion is only slightly less misleading than to confuse it with the trajectory of motion. In other words, in speaking of time, the kinematic metaphors are hardly better than the static and geometrical ones. How many confusions were and are still caused by an assimilation of time to motion! The metaphorical expressions, ‘direction of time,’ and ‘time arrow,’ are very fashionable and are justified to a certain extent. They express in kinematic terms the basic asymmetry of time, the distinction between past and future. The image of time as a ‘flow’ was used already by early Greek thinkers -- let us only remember of Heraclitus -- and was retained even by sober Newton in his *Principia*. But as soon as this kinematic metaphor is taken literally, serious difficulties arise. We may ask, for instance: "Whence and whither does time flow?" The conventional answer, "From the past to the future," seems to satisfy most people. Time thus becomes a metaphysical river whose source is in the infinitely distant past and its estuary in the infinitely distant future. More abstractly, but not in an essentially different way, time is described as a motion *along* a straight line; the moving point stands for the present instant, the path already covered corresponds to the past, the points not yet occupied correspond to the future events. But as every motion in space is relative and can be transformed into a rest by an appropriate change of the frame of reference, it is permissible to regard the present moment as *stationary* and future events as *moving toward the past* with an equal and opposite velocity, to wit, opposite with respect to the velocity of the present moment in the first picture. Instead of the present's advancing toward the future, future events retreat toward the motionless present, pass through it, and then sink into the deeper and deeper past. Now which of these descriptions is correct? Does time flow forwards, from the past to the future, or backwards, from the future to the past?

The only possible answer is that both descriptions are *equally inadequate;* both are metaphorical attempts to translate into spatial and kinematic terms *the elusive and essentially incomplete nature of time.* As soon as we try to illustrate the nature of time by comparing it to motion, the principle of kinematic relativity of motion will sooner or later sneak into our illustrations and diagrams; hence two apparently contradictory answers concerning the alleged direction of time. If, however, we forget that the word 'direction' is borrowed from geometry and kinematics and therefore can be applied to time only in a metaphorical sense, we may thoughtlessly draw all consequences from the alleged analogy between 'movement of time' and movement of bodies. Thus we may think that, as the direction of motion in space may change, the time direction may change too; as a material particle may reverse its motion and pass again through the positions previously occupied, 'the moving present' can also return to the past; or as the motions in space may be circular, the course of time may be circular too. Both the theory of reversible time and the theory of eternal recurrence are based on such false kinematic analogies. As I tried to show in my first book (Capek 1969) as well as in some of my articles, such theories, when closely analyzed, cannot be even stated in a self-consistent language, since they use alternately and surreptitiously two incompatible temporal descriptions. Such antagonistic and contradictory descriptions are merely clumsy translations into geometrical and kinematic terms of the *basic irreversibility of becoming* which cannot be meaningfully separated from the very nature of time.

The criticism of the confusion of time with motion represented another trend in the development of physics which was clearly incompatible with the trend just described. This is why I said that the development of physics, unlike that of philosophy, was far more ambiguous. One of the first instances of such criticism is to be found in Aristotle's *Physics.* Although Aristotle insisted on the inseparability of time and motion, he was careful not to identify them. He did not fail to observe that the motions with different velocities and covering different distances can take place within one and the same interval of time, so that none of them could be identified with time itself. It is true that there is, according to Aristotle, one privileged motion -- the rotation of the sphere of the fixed stars -- which measures accurately the objective flow of time; in its insistence on the close correlation of time with the universal celestial clock, Aristotle's theory of time remained relational. But there are certainly the shades of Newton in it. What prevented him from reaching Newton's conclusion about the independence of time from its concrete physical content was, besides the Eleatic influences, his belief in the universal cosmic clock which was, so to speak, a physical embodiment of the oneness and uniformity of time. When the astronomical revolution of the sixteenth century -- in which the Italian philosophers of the Renaissance played a far more important role than historians of science admit -- removed the universal cosmic clock, there were two alternative ways open to physics and philosophy of nature: either to retain the relational theory of time and to hold with Bruno (Bruno 1879, p. 144) that "there are as many times as there are the stars" (*tot tempora quot astra*), since there is no body possessing a privileged rotation motion, and the only body which allegedly had it -- the sphere of the fixed stars -- has been swept away; or to save the unity and homogeneity of time by separating it from any particular motion -- and this is what Newton did, anticipated in this respect by Isaac Barrow and, in particular, Gassendi. Thus the absolute theory of time -- and with it classical physics itself -- was born.

In the eyes of a philosopher, time has acquired in classical physics a strangely ambiguous character. The name of both Newton and Laplace belong to classical physics. Yet, these two giants of the classical era had entirely different views of time. According to Newton, time is ultimately real, even on the divine level; this is why he regarded it as *sensorium dei*. In it everything exists, even space; for space *endures in time*, and what we call 'enduring space' is really nothing but a continuous succession of instantaneous spaces. According to Laplace, time is merely the fourth dimension of space, as static as the other three dimensions; its apparent incompleteness is illusory, being merely, as Bergson observed, "the infirmity of a mind that cannot know everything at once (Bergson 1944, p. 45). Who then was right, Newton or Laplace?

Today it is tempting to say that they were both wrong, since they both belong to the classical era which is now definitely over. But such a bare negative statement will certainly not satisfy a philosopher interested in the ultimate status of time and becoming. When the relativity theory came into existence, there was at first the widespread tendency to regard it as another confirmation of the Laplacean view of time as the additional fourth dimension. Long was the list of those -- not only of popularizers, but philosophers as well, and even some physicists -- who interpreted Minkowski's four-dimensional continuum *not as the four-dimensional process,* essentially incomplete, but as a sort of a *four-dimensional hyperspace,* whose fourth dimension exists in its completeness as much as the three spatial dimensions. Although this misinterpretation had been effectively criticized, not only by philosophers such as Bergson, Meyerson, Whitehead and Reichenbach, but also by a number of physicists -- among them Einstein himself, Langevin, Eddington, etc. -- it was again revived recently by Costa de Beauregard, Adolf Gruenbaum, and J. J. Smart, and apparently accepted by W. Quine. I criticized this revived misinterpretation in a number of previous articles (Capek 1951, 1955, 1965, 1966) and in both my books (Capek 1969, esp. Ch. XI, XVII, and Append. I, II; 1971, pp. 226-256). Hence I prefer to restate the main arguments against the static misinterpretation in a concise form only. They are as follows:

1. To a historian of ideas, it is clear that this misinterpretation is another instance of the perennial tendency to spatialize time which can be traced to the very dawn of Western thought. This in itself would not be a decisive argument against it, but it acquires its significance in conjunction with other arguments, in particular with the unsolvable epistemological difficulty to which such elimination of time leads.

2. The most plausible argument for the static interpretation is the relativization of simultaneity and succession. But this relativization is far from being unqualified and, when attentively analyzed, it leads to an elimination of instantaneous space without weakening in any sense the ontological status of becoming.

3. Finally, the static interpretation does not eliminate becoming; it merely relegates it into the subjective, 'phenomenal' realm. But in this way it creates an intolerable dualism of two completely heterogeneous realms without any attempt to relate them in some intelligible way.

Let me comment on these three points.

Re 1. This point has been already lengthily and sufficiently covered and there is no need to return to it.

Re 2. This point requires rather lengthy discussion. The relativization of simultaneity and succession has been and still is regarded as an argument against the objectivity of time and/or becoming. If there is no objective ‘Now’ unambiguously separating the past from the future -- in other words, if what is simultaneous for one frame of reference is not so for another system -- is it still meaningful to uphold the objectivity of succession and the reality of becoming? This is how the argument is usually formulated and in this form it was accepted by Quine when he wrote that the principle of relativity "leaves no reasonable alternative to treating time as space-like." But despite its superficial plausibility, the argument collapses under a closer scrutiny.

In the first place, it is simply not true that simultaneity and succession are unqualifiedly relativized. What is relative is only the simultaneity of the events *occurring at different places;* the simultaneity of the isotopic events (i.e., occurring at the same place) remains a simultaneity for any conceivable observer. It is true that, strictly speaking, there are no such events: as long as they remain different they cannot be exactly at the same point; and as long as they are rigorously isotopic, they merge into a single event. Thus the thesis is reduced to the apparent triviality that each event is *simultaneous with itself* But it ceases to be trivial if we add that each event is simultaneous *only with itself* That this is not trivial is obvious from the fact that it was denied, for instance, by Kurt Goedel (1949, pp. 560-561), who accepted the possibility of self-intersecting world-lines -- that is, the possibility of a Wellsian trip to the past and back to the present. Thus we would have an event which, besides being simultaneous with itself, would be also simultaneous with its future descendant. Even if we disregard the difficulty of stating this view in a self-consistent language, its incompatibility with relativity theory is obvious. For in the relativistic universe no body can move with a velocity greater than that of light; in the language of the relativistic space-time diagram, it can never enter the forbidden zone of ‘Elsewhere’ outside of its own causal future; *a fortiori* it cannot cross the Elsewhere region and re-enter its own past. Here we see the relevance of Eddington’s insightful remark that, in the relativistic world, the past is separated from the future *even more effectively* than in the universe of Newton (Eddington 1925, p. 178). (In the Newtonian universe the past is separated from the future by an ‘infinitely thin’ layer of instantaneous space which contains all events objectively simultaneous with Here-Now; in the universe of Einstein the separation is effected by the four-dimensional region of Elsewhere.) Goedel's hypothesis shows also a disastrous effect of false geometrical analogies; apparently the fact that there are some curves (e.g., lemniscate or Descarte's leaf) which intersect themselves in the so-called singular points is for some mathematical minds a sufficient reason to believe that 'the curve of time' can behave in a similar way. This is a fallacy of geometrization or spatialization at its worst; it is certainly revealing that Goedel is proudly aware of the philosophical tradition to which he belongs -- that of Parmenides and McTaggart, whose names he mentions.

Equally important -- probably even more important -- is the limited extent to which succession is relativized. As early as 1911, Paul Langevin pointed out that only the succession of *causally unrelated events* can be changed into a simultaneity or even be reversed by an appropriate change of the frame of reference; the succession of causally related events remains qualitatively (though not metrically) invariant for any conceivable observer. Here is what, in my view, is philosophically the most significant result of relativity: that while *there are no juxtapositions of events which would remain justapositions in all frames of reference, there are certain types of succession which preserve their character of succession for any possible observer.* This certainly cannot be described as any weakening of the objective status of becoming; but it does away with the classical notion of instantaneous space defined as a three-dimensional layer of objectively (absolutely) simultaneous events.

This means that it is far more accurate to characterize Minkowski's fusion of space with time as a *temporalization* or *dynamization* of space than as a spatialization of time. Minkowski's universe is a network of the irreversible causal lines ('world-lines'), but without any instantaneous, i.e., purely spatial, connections. This is a deeper meaning of the relativization of simultaneity, whose more correct term should be *elimination* of simultaneity; once we realize that the terms 'class of simultaneous events' and 'instantaneous space' are entirely synonymous, we shall also see that a negation of one implies a negation of the other. The four-dimensional becoming contains the regions of causal independence (the so-called regions of 'Elsewhere' which could be equally well called *'Elsewhen');* it contains topologically invariant successions, but it does *not* contain any instantaneous transversal cuts, any purely spatial distances. As Whitehead observed, since the advent of relativity, "spatial relations must stretch through time" (Whitehead

1925, p. 6); in other words, there are only *spatio-temporal,* but no merely spatial distances. If we furthermore consider the space-time of the general-theory of relativity, with its locally variable and changing curvature, and, in particular, if we consider the expanding space of modern cosmogony, we will agree that the term ‘dynamization of space’ is not inappropriate and that we can even speak of incorporation of space into becoming. In any case, nothing is left of the traditional space since its fundamental constituting feature -- the relation of *coexistence* (*juxtaposition*, Kantian *auseinander or nebeneinander*) -- has no physical basis. Briefly: if we take relativity seriously, we must deny the reality of space in the sense *of simultaneous juxtaposition of points.*

Two objections will come immediately to our mind. First, is it not true that nothing is left of the Newtonian concept of time as well? It cannot be denied that the classical concept of time is also profoundly modified. The time of relativity is neither a uniformly flowing metaphysical river, nor is it an immaterial invisible clock in God’s mind, as Newton imagined. Yet, as Whitehead (1920, p. 17) observed as early as in 1920, the variety of metrically discordant temporal series is entirely compatible with one single underlying ‘creative advance of nature,’ or, in less poetic words, with universal becoming. Thus one basic feature of Newtonian time remains intact: *its incompleteness.* This, too, can be proved rigorously and without any appeal to metaphors by drawing another consequence from Minkowski’s same formula. It can be shown that no event which is still unreal for me, i.e., which is still in my causal future, can be included in the causal past of *any possible observer.* (By ‘possible observer’ I mean any observer located either in my causal past or anywhere in my Elsewhere region.) Since the inclusion of the events in the causal past of some observer is a necessary condition of their observability, it means that future events are *intrinsically unobservable* and thus it is entirely superfluous to postulate their existence. It is far more natural to regard them as *genuinely future.* i.e., as actually not yet existing. The physical emptiness of the future is another inevitable consequence of special relativity.

The second objection is the following: is it not true that the character of spatiality is in some sense preserved in Minkowski’s time-space? This is certainly true provided that we carefully distinguish between spatiality in a broader sense and the classical notion of static instantaneous space. The four-dimensional world process consists of an enormous number of world-lines which occasionally interact, but which mostly run independently of each other. In this sense, the world process has a certain *transversal width,* since it contains *contemporary* parts. But ‘contemporary’ is not co-instantaneous! This is more than a mere terminological difference. As said before, the four-dimensional becoming does not yield to any instantaneous cuts. In other words, there is no *simultaneity* of *instants*. But, as Bergson observed, the relativistic universe does not exclude *the simultaneity* of *intervals*, i.e., contemporaneity of temporal series, even if they are metrically discordant. Minkowski’s time-space is, to use another of Bergson’s terms, *‘extensive becoming’* (Bergson 1944, p. 265; 1965, pp. 52-53), which cannot be properly decomposed into one-dimensional time and three-dimensional instantaneous space. Such decomposition was possible in the classical space-time and this precisely distinguishes it from the relativistic time-space.

Commenting on both the relativity and quantum theories, Whitehead (1925, p. 54) observed in 1925 that "nature is nothing at an instant." If this is difficult to our visual imagination, Whitehead, following again in this respect Bergson, tried to remove the difficulty by using an auditory model: "In an analogous way, a note of music is nothing at an instant, but it also requires its whole period in which to manifest itself." The fact that melody does not exist at an instant does not make it unreal; on the contrary it shows the fictitious character of durationless instants. Similarly, time-space does not cease to be real because it does not yield to any instantaneous, purely spatial, cuts. But this impossibility of instantaneous cuts is entirely compatible with *the transversal width* of becoming, i.e., with the co-presence, or rather, *co-becoming* of the world-lines. In an analogous way, there are different melodies co-present within a polyphonic pattern. In this respect an auditory model is free of the limitations of visual models and geometrical diagrams.

Re. 3. The epistemological difficulty of the static interpretation of space-time can be dealt with briefly. As stated above, becoming and succession cannot be simply denied, but only confined to the subjective realm, to be made, in Gruenbaum’s words, ‘mind-dependent.’ This is the meaning of his statement that "coming into being is only *coming into present awareness"* (Gruenbaum 1963, p. 329; italics his). This can mean -- if it means anything at all -- only one thing: that what I experience as a new present moment existed *prior to* and *independently of* my deceptive temporal experience timelessly -- or, as it is fashionable now to say, tenselessly -- in the becomingless physical world. There are thus two realms: the realm of physical reality devoid of becoming in which all events that appear to us in succession are ‘tenselessly’ juxtaposed, and our private ‘stream of consciousness’ where there is a genuine succession and becoming. This is a dualism far more extreme than that of Descartes, for in Cartesian dualism, mind and matter, in spite of their heterogeneity, both shared at least the general temporal character. But for those who deny the reality of physical becoming the difficulty is doubled, since their two realms do not even share this temporal character! No attempt is even made to relate such altogether heterogeneous realms; no explanation is offered *why* and *how* the becomingless reality manifests itself in a gradually unfolding temporal form in the subjective realm. The difficulty is only increased by the physicalistic leanings of J. J. Smart, Quine and Gruenbaum himself, for if the subjective realm itself is a part of the becomingless physical reality, we should not have even the *illusion* of becoming, since the successive character of our stream of consciousness would become impossible! Briefly, the static interpretation of physical reality is nothing but a relapse into a strange Eleatic myth with all its oddities and contradictions, not only completely divorced from our immediate experience, but incompatible with contemporary physical science properly interpreted.

We are now returning after a long detour to the results of Piaget’s investigations. It appears that the fallacy of spatialization of time is committed by young children and -- quite a number of philosophers! This conclusion may sound offensive and disrespectful; but it is far less offensive than it sounds. Not all the features of a child’s mind are objectionable. Did not, for instance, Aristotle say that a proper trait of a philosopher’s mind is the capacity of wonder -- which children certainly have more than an average adult? In one of his other studies Piaget (1957) discovered that the children’s minds in their earliest stage, when not yet shaped by the influence of macroscopic environment, have no notion of a permanent object and are thus closer to the microphysical world of the impermanent ‘particles’ than an average adult mind. But the case of the spatializing fallacy is amusingly different. Children gradually realize that their confusions of time with spatial trajectory contradicts their own experience -- sensory and, especially, introspective -- and they give up spatialization; philosophers, while they are fully aware of the same contradiction, retain spatialization and deny experience -- and are even proud of it!

The question why the fallacy of spatialization does not entirely disappear with childhood would require another paper. Let me only indicate a sketch of the answer, which only a biological, evolutionary theory of knowledge can provide. Human mind and organism are adjusted to the realm of middle dimensions and middle velocities, in which Euclidian geometry, Newtonian mechanics and classical determinism very approximately hold. Perceptible motions of our bodies and of surrounding objects are very slow with respect to the velocity of light and gravitation -- a velocity which for us is practically infinite. Thus the motions of macroscopic bodies appear on the background of the network of practically instantaneous interactions. By the further natural process of abstraction and idealization, the notion of space as a network of instantaneous connections and as the container of everything existing emerges. It is not accidental that for c = oo the transformation of Lorentz passes over into that of Galileo. Hence a persistent tendency to translate every experience into visual and spatial terms -- even at the price of distorting, or even eliminating it.

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Mind in Nature: the Interface of Science and Philosophy by John B. and David R. Griffin Cobb, Jr.

Part 2: Mind and Order

John B. Cobb, Jr. is Professor of Theology at the School of Theology at Claremont, Avery professor of Religion at Claremont Graduate School, and Director of the Center for Process Studies. David Ray Griffin teaches Philosophy of religion at the School of theology at Claremont and Claremont Graduate School and is Executive Director of the Center for Process Studies. Published by University Press of America, 1977. This book was prepared for Religion Online by Ted and Winnie Brock.

Chapter 4: Free Will in a Hierarchic Context by Arthur Koestler, Responses by Charles Hartshorne and Bernhard Rensch

Arthur Koestler has published 30 books, ranging from political novels to theoretical works on creativity, evolution and parapsychology. His works are now being republished in a collected edition (The Danube Edition) by Hutchinson in London and by Macmillan and Random House in New York.

It is a common experience that you hear or read a sentence which remains implanted in your memory like a seed beneath the snow. Such an implantation happened to me many years ago when I read Bergson’s phrase: "The unconsciousness of a falling stone is something quite different from the unconsciousness of a growing cabbage." Comparing this to the Cartesian brand of dualism which restricts consciousness to human thinking, we are faced with two diametrically opposed conceptions: the first implies pan-psychism in one form or another, a continuum stretching from the rudiments of sentience in the cabbage to human self-awareness, the second places a kind of iron curtain between matter and mind.

This curtain seemed to be raised by a few inches in the nineteen twenties, in those heroic days when de Broglie and Schroedinger de-materialized matter like the stage magician who makes the lady vanish from the box, while Heisenberg (1969) eased her out of the straitjacket of determinism and proclaimed that the principle of complementarity agreed "very nicely" with the mind-body dualism -- the implication being that the particle aspect of the electron was analogous to the body, its wave aspect to the mind.

This led to a quasi-schizophrenic split in the *Zeitgeist* to which David Bohm has also alluded in his paper: I mean the contrast between the developments in physics on the one hand, and of academic psychology on the other. While the dominant school in physics emphasized the unpredictability of the fundamental processes in nature, the dominant school in psychology proclaimed its programme "to predict and to control human activity" (Watson 1925, p. 11). At the time when Heisenberg (1969, pp. 63-64) wrote that "when we descend to the atomic level, the objective world in space and time no longer exists" -- at the same time Skinner (1953, pp. 30-31) proclaimed that "since mental events. . . . are asserted to lack the dimensions of physical science, we have an additional reason for rejecting them." And when Eddington coined his celebrated aphorism "the stuff of the world is mind-stuff," the Behaviourists declared the mind to be a dirty four-letter word.

Now the *Zeitgeist* seems to be moving away from naive Reductionism, but as yet no coherent alternative system seems to be in sight. The indeterminacy of the micro-level cannot be transferred, through a short-cut, to the macro-level. God may be playing dice with the world, but He sees to it that it should be a fair game where the capers of the dice must conform to the Gaussian curve or the Poisson distribution. This may be an even more miraculous achievement than to control the balls on the Newtonian billiard table -- John von Neumann called the laws of probability sheer black magic. But they nevertheless prevent rash extrapolations from the indeterminacy on the quantum level to the robust determinacy of our everyday world.

A possible way out of this cul-de-sac is offered by the concept of multi-leveled hierarchic organisation. It seems to provide the missing link between pan-psychism and Cartesianism. The hierarchic model replaces the pan-psychist's continuously ascending curve from protoplasmic to human consciousness by a series of discrete steps -- a staircase instead of a slope; and replaces the single Cartesian discontinuity by a series of transitions.

In his paper on biological hierarchy, H. H. Pattee (1970, pp. 117-136) wrote that hierarchic organisation is the central problem whether we consider the origin of life, philogeny or ontogeny. He went on: "It is the central problem of the brain, when there appears to be an unlimited possibility for new hierarchic levels of description. These are all problems of hierarchical organisation. Theoretical biology must face this problem as fundamental, since hierarchical control is the essential and distinguishing characteristic of life." Or, to quote Paul Weiss (1969, pp. 3f.): "The phenomenon of hierarchical structure is a real one, presented to us by the biological object, and not the fiction of one speculative mind." It is at the same time a conceptual tool, a way of thinking, an alternative to the linear chaining of events torn from their multi-leveled context -- like a thread extracted from a Persian carpet and suspended in a vacuum. One might say that hierarchical thinking relates to linear causality as the theory of algebraic functions relates to elementary arithmetic.

At this point I must introduce a bit of jargon, essential to the particular conception of hierarchy that I have described elsewhere (1967) and summarised in a paper read at the symposium "Beyond Reductionism." If I may quote very briefly from it (Koestler 1969, pp. 1 92f.):

> The organism in its structural aspects is not an aggregation of elementary parts, and in its functional aspects not a chain of elementary units of behaviour; it is to be regarded as a multi-leveled hierarchy of semi-autonomous [i.e., self-regulating] sub-wholes, branching into sub-wholes of a lower order, and so on. Sub-wholes on any level of the hierarchy are referred to as *holons.* Parts and wholes in an absolute sense (as envisaged respectively by Behaviourists and Gestaltists) do not exist in the domains of life. The holon, as its name indicates, derived from the Greek *holos,* whole, with the suffix *on,* indicating a particle or part, is meant to be descriptive of a Janus-faced entity which displays both the quasi-autonomous, self-governing

> properties of wholes and the dependent properties of parts. The term holon may be applied to any stable sub-whole in a biological, social or cognitive hierarchy which displays rule-governed behaviour and/or structural Gestalt constancy.

I must refrain from going further into the cognitive framework of this particular model and confine myself to those basic aspects of the hierarchies of behaviour which are relevant to our present context.

All instinctive and learnt behaviour may be described in terms of hierarchies of sub-skills or subroutines, i.e., *behavioural holons.* The activities of these holons are rule-governed, but also adaptable within the constraints imposed by the rules. At this point it is essential to make a categorical distinction between (a) the *fixed rules,* and (b) the *flexible strategies* which between them control all organised activities of animal and man, regardless whether we consider instinctive behaviour, sensory-motor skills, or creative problem solving. It seems that the neglect of this fundamental distinction between invariant rules and variable strategies has led to much confusion in psychology, although the distinction becomes obvious when we turn to concrete examples. Take two creatures at opposite ends of the scale: a common spider spinning its web and a chess champion pondering his next move. The chess-player is controlled by the fixed rules of the game which define the permissible moves, but at the same time he is applying flexible strategies in his search for the most promising move among the permissible ones, guided by past experience and feedbacks from the environment, i.e., the position on the board. Thus the canon determines the rules of the game, strategy decides the actual course of the game. Now, the common spider too employs flexible strategies -- it will suspend its web from three, four, or more points of attachment, according to the lay of the land, but it will always arrive at the well-known symmetrical pattern where the radial threads bisect the laterals at equal angles according to genetically fixed rules of the game.

Let me now turn to the deceptively trivial experience that one and the same activity, such as tying my shoelaces, can be performed automatically, without conscious awareness of my own actions, or accompanied by various degrees of awareness. Driving along a familiar road with little traffic, I can hand control over to the ‘automatic pilot’ in my nervous system and think about eternity. In other words, there is a shift of control of the ongoing activity from higher to lower levels of the hierarchy. *Vice versa,* overtaking another car requires an upward shift to partial or full alertness and a rapid evaluation of risks which involves higher levels of the cognitive hierarchy.

The acquisition of a new skill, such as touch-typing, requires a high degree of concentration, whereas with increasing mastery and practice my fingers can be left to look after themselves 'automatically,' as we say. This condensation of learning transforms mental into mechanical activities -- mind processes into machine processes. It starts with infancy and never stops. To paraphrase Ludwig von Bertalanffy: we are not machines, but most of the day we act as machines. We do so even in such complex activities as adding up a column of figures. Karl Lashley once quoted a colleague of his, a Professor of Psychology, who told him: "When I have to give a lecture I turn my mouth loose and go to sleep."

Thus consciousness may be described in a negative way as that special attribute of an activity *which decreases in direct proportion to habit formation.* This is less paradoxical than it sounds, if one remembers that Norbert Wiener, following in Schroedinger's footsteps, defined information as "essentially a negative entropy."

The transformation of learning into routine is accompanied by a dimming of the lights of awareness. We expect therefore that the opposite process will take place when routine is disturbed by running into some unexpected obstacle or problem: that this will cause a sudden switch from 'mechanical' to 'minding' or 'mindful' behaviour. Let a kitten suddenly cross the road on which you have been driving absentmindedly, and your previously absent mind will return in a flash, to take over control, to make a rapid decision whether to run over the kitten or risk the safety of your passengers. What happens in a crisis, or in any less dramatic problem situation involving unexpected, puzzling or discordant experiences, is this sudden shift of control of an ongoing activity to a higher level in the many-leveled hierarchy, from a semi-automatic to a more conscious performance, because the decision to be made or the problem to be solved is beyond the competence of the automatic pilot and must be referred to higher quarters. Needless to say, the implementation of the decision must still rely on automatised sub-routines -- braking or swerving -- which are triggered into activity by the command post.

It would seem that this sudden transfer of control of behaviour from a lower to a higher level of the hierarchy -- analogous to a quantum jump --

is the essence of conscious decision-making and of the subjective experience of free will. Its opposite is the mechanisation of routine, the enslavement to habit. We thus arrive at a dynamic view of a continual two-way traffic up and down in the hierarchy of behaviour.

Habit-formation implies a steady downward traffic, as on a moving escalator. There is a positive and a negative aspect to this phenomenon. On the positive side, it conforms to the principle of parsimony, or least action. If the laws of grammar and syntax did not function unconsciously, in the gaps between the words, we could not attend to meaning.

On the negative side, the downward traffic on the escalator tends to turn men into slaves of habit. The mechanisation of behaviour, like *rigor mortis,* affects first the extremities -- the lowest, subordinate branches of the hierarchy, comparable to the ethnologist's fixed action patterns -- one's characteristic gait, handwriting and accent of speech. However cleverly you try to disguise your handwriting, you cannot fool the expert. But mechanisation also tends to spread into the cognitive hierarchy, and force the stream of consciousness into fixed riverbeds -- Bergson's *homme automate* programmed by a computer with built-in prejudices.

We can now turn from this all too familiar phenomenon to the *upward* traffic in the hierarchy: the abrupt transfer of the controls of an ongoing activity from a mechanical to a mindful level, and the concomitant experience of free will governing choice and decision. A striking description by Wilder Penfield of an experiment during a brain-operation may be relevant in this context (Penfield 1961):

> When the neurosurgeon applies an electrode to the motor area of the patient's cerebral cortex causing the opposite hand to move, and when he asks the patient why he moved the hand, the response is: "I didn't do it. You made me do it". . . .
>
> Once when I warned such a patient of my intention to stimulate the motor areas of the cortex, and challenged him to keep his hand from moving when the electrode was applied, he seized it with the other hand and struggled to hold it still. Thus one hand, under the control of the right hemisphere driven by an electrode, and the other hand,

> which he controlled through the left hemisphere, were caused to struggle against each other. Behind the ‘brain action’ of one hemisphere was the patient’s mind. Behind the action of the other hemisphere was the electrode.

It is interesting to compare the reaction of Penfield’s patient with the reaction of subjects who are made to carry out a post-hypnotic suggestion -- like taking off a shoe while having tea at 5 o’clock in the afternoon. In both cases the subject’s actions have been caused by the experimenter; but whereas the subject who does not know that he is obeying a post-hypnotic command automatically finds a more or less plausible rationalisation why he took off his shoe, Penfield’s patients realise that they are obeying a physical compulsion: "I never had a patient say, ‘I just wanted to do that anyway!’"

One must conclude that the hypnotist’s intervention affects a higher level of the mind-brain hierarchy than the surgeon’s needle. And to convince an opponent in a discussion that his theory is mistaken affects an even higher, more complex level. The step down from the level of reasoned persuasion to the level of hypnotic suggestion, or operant conditioning, means a transition from a highly mental to a comparatively mechanical level, and the same applies to the further step down to the neurosurgeon’s needle. But each transition is a relative, not an absolute, affair. To quote Thorpe (1966) at the Eccles Symposium: "The evidence suggests that at the lower levels of the evolutionary scale consciousness, if it exists, must be of a very generalised kind, so to say unstructured; and that with the development of purposive behaviour and a powerful faculty of attention, consciousness associated with expectation will become more and more vivid and precise."

However, these gradations in ‘structuring, vividness and precision’ exist not only in philogeny but also among members of the same species at different stages of development and in different situations. Each upward shift in the hierarchy produces more vivid and structural states of consciousness; each downward step is a transition from the mental to the mechanical. Classical dualism knows only a single mind-body barrier. The hierarchic approach implies a serialistic instead of a dualistic view; the transformation of physical into mental events, and vice versa, is effected not by a single leap over the barrier, but by a series of operational steps up or down the hierarchy.

Consider for a moment how we convert variations of air pressure arriving at the ear-drum, which are physical events, into ideas, which are mental events. It is not done in one go. In order to understand language we must perform a series of quantum jumps, so to speak, from one level of the speech hierarchy to the next higher one: phonemes are meaningless and can only be interpreted on the level of morphemes, words must be referred to context, sentences to a larger frame of reference. The spelling out of a previously unverbalised idea or image involves the reverse process: it converts a mental event into the mechanical motions of the organs of speech. This again is achieved by a series of steps, each of which triggers off pre-set neural mechanisms, activates linguistic holons of a more and more automatised type; the canons of grammar and syntax exert their rule unconsciously, automatically; and the last step in articulating the sounds of speech is performed by entirely mechanised patterns of muscle contractions. Chomsky's phycholinguistic hierarchy was anticipated in *A Midsummer Night's Dream.*

> As imagination bodies forth
> The forms of things unknown, the poet's pen
> Turns them to shapes, and gives to airy nothing
> A local habitation and a name.

Each step downward in the conversion of airy nothings into spatial motions of the vocal chords entails a handing over of control to more automatised automatisms: each step upward in the reverse conversion leads to more mentalistic processes of mentation. All this seems to indicate that the mind-machine dichotomy is not localised along a single boundary, but is present on every level of the hierarchy.

On this view, the categorical distinction between mind and body fades away and instead of it 'mental' and 'mechanical' become complementary attributes of behavioural holons on every level. The dominance of one aspect or the other -- whether the holons' activities are preformed mindfully or mechanically -- depends of course partly on its position or rank within the hierarchy, but also, and perhaps even more, on the momentary flow of traffic in the hierarchy, whether the shifts of control proceed in an upward or downward direction. Thus even the lower reaches of the hierarchy regulated by the autonomic nervous system can apparently be brought under mental control by bio-feedback or meditation; and vice versa, I can perform the supposedly mental activity of reading a printed page -- without taking in a single word.

We are in the habit of talking of mind as if it were a thing, which it is not -- nor is matter, for that matter. Minding, thinking, mentating are processes in a complementary or reciprocal relation to mechanical processes. Let me hasten to say that I am using here the physicist's term 'complementary' as a very vague analogy, and not as an explanation. But as an analogy it has its uses. An electron will behave as a wave or a corpuscle according to circumstances. Andrew Cochran (1972, pp. 235-249) has suggested that the quantum-mechanical wave properties of electrons reflect a rudimentary consciousness of matter, and that the "dual aspects of man are a direct result of the dual aspects of matter." Here Cochran seems to be guilty of the sin which Whitehead called 'misplaced concreteness,' but at least the physicist's perplexities are a comfort to the biologist; and though the complementarity principle leaves a host of problems unanswered, at least it poses a few new questions.

We know that the manifestations of the electron's wave aspect or corpuscular aspect depends on the experimental set-up. In the cloud chamber it behaves as a corpuscle; in other experiments it is refracted as a wave. With animals and men it also depends to a large extent on the experimental situation -- the contingencies of the environment -- whether their mentalistic or mechanical aspect will dominate. Thus a skill practised and repeated in a monotonous environment in the absence of novelty tends to degenerate into mechanical routine. And vice versa, we have seen that a challenging environment which contains unexpected features or obstacles, and poses new problems which must be referred to higher echelons in the hierarchy, will cause a shift from mechanical to mindful behaviour. Such sudden upward shifts from mechanical routine towards originality and improvisation have been observed by ethologists throughout the animal kingdom from insects upward to birds, rats and chimpanzees. They may be regarded as precursors of human creativity, and point to the existence of unsuspected potentials in the organism which are dormant in the normal routines of existence but emerge in response to new challenges offered by the environment -- a zoological analogy to Toynbee's paradigm of Challenge and Response.

To return to man: the 'spelling out' of an intention -- whether it is the expression of an idea or just the lighting of a cigarette -- is a process of triggering patterns of sub-routines into action, behavioural holons on subordinate levels; it is a process of *particularisation* of a general intent. On the other hand, the referring of decisions to higher levels is an *integrative* process which tends to establish a higher degree of coordination and wholeness of experience. Thus every upward shift would represent a quasi-holistic move, every downward shift a particularising move, the former characterised by heightened awareness and mentalistic attributes, the latter by diminishing awareness and mechanistic attributes.

How does free will fit into this tentative model? To repeat what has been said before: the subroutines on which our thoughts and actions are based are governed by fixed rules and more or less flexible strategies. The rules of chess define the permissible moves; strategy determines the choice of the actual move. The question is, how are these strategic choices made? Down on the visceral level, they are guided by the closed feedback loops of homeostatic regulations. Even such a complex sensory-motor skill as riding a bicycle is self-regulating in the sense that the cyclist's strategy is governed by kinesthetic and visual feedbacks without the necessity of referring decisions to superior levels -- except if the road is barred. But when we enter the higher levels of the hierarchy, the relative importance of rules and strategies undergoes a subtle change. Compare playing noughts and crosses (tick-tack-toe) with playing chess. In both cases my strategic choice of the next move is 'free' in the sense of not being determined by the rules of the game. But noughts and crosses offers only a few alternative choices, guided by relatively simple strategies, which can even be codified to form a secondary set of non-statutory constraints, as it were. The chess-player, on the other hand, is guided by considerations on much higher levels of complexity with an incomparably larger variety of alternative choices, that is, more degrees of freedom. Moreover, the strategic precepts which guide his choice again form an ascending hierarchy. On the lowest level are tactical precepts such as occupying the centre squares, avoiding loss of material through forks and pins, protecting the king -- precepts which every duffer can master, but which the master is free to overrule by shifting his attention to the next higher levels of strategy, where material may be sacrificed and the king exposed in an apparently crazy move which, however, is more promising from the viewpoint of the game as a whole. Thus in the course of a game decisions have to be constantly referred to higher echelons with more degrees of freedom, and each shift upward is accompanied by a heightening of awareness and the experience of making a free choice. Generally speaking, in these sophisticated domains the constraining code of rules (whether of chess or of the grammar of speech) operate more or less automatically, on unconscious or preconscious levels, whereas the strategic choices are aided by the beam of focal awareness. In writing down a sentence, I do not have to worry about the rules of spelling, but ah, for the choice of the fitting adjective, the *mot juste!*

To repeat: the degrees of freedom in the hierarchy increase with ascending order, and each upward shift of attention to higher levels, each handing over of decision to higher echelons, is accompanied by the experience of free choice. But is it merely a subjective experience? I think not. After all, freedom cannot be defined in absolute, only in relative, terms, as freedom *from* some specific constraint. The ordinary prisoner has more freedom than one in solitary confinement; democracy allows more freedom than tyranny; and so on. Similar gradations are found in the multi-leveled hierarchy, where with each step upwards the relative importance of the constraints decreases and the number of choices increases.

However, this model will only be found useful if we assume that the hierarchy is open-ended toward infinite regress, both in the upward and downward direction. And there seems to be some justification for this assumption. Matter is no longer an ultimate concept; the hierarchy of macroscopic, molecular, atomic, subatomic levels trails away without hitting rock-bottom until matter dissolves into patterns of energy-concentration, and then perhaps into tensions in space. In the opposite direction we are faced with the same situation: there is an ascending series of levels, leading from automatic and semi-automatic reactions, through awareness and self-awareness, to the self's awareness of its awareness of itself, and so on, without hitting a ceiling.

To put it in a different way: the higher the level to which the decision is referred, the less predictable the choice. We tend to assume that the ultimate decision rests with the apex of the hierarchy -- but the apex itself is not at rest. It keeps receding. The self, which has the ultimate responsibility for a man's actions, eludes the grasp of its own awareness. Looking downward in the hierarchy of behaviour, a man is only aware of the task in hand, an awareness that fades with each step down into the dimness of routine, the darkness of visceral processes, the various degrees of unawareness of the growing cabbage and the falling stone, and finally dissolves in the indeterminacy of the Janus-faced electron.

But in the upward direction the hierarchy is also open-ended and leads to the infinite regress of the self. Looking upward, or inwards, man has a feeling of wholeness, of a core to his personality from which his decisions emanate, and which in Penfield's phrase "controls his thinking and directs the searchlight of his attention" (Penfield 1961). But the metaphor is deceptive. When a priest chides a penitent for indulging in sinful thoughts, they both assume that behind the agency which controls his actual sinful thinking there is another agency which decides what subject he should think about; and so on *ad infinitum.* The ultimate culprit, the self which directs the searchlight of my attention, can never be caught in its focal beam. The experiencing subject can never fully become the object of his experience; at best he can achieve successive approximations. If learning and knowing consist in making oneself a private model of the universe, it follows that the model can never include a complete model of itself, because it must always lag one step behind the process which it is supposed to represent. With each upward-shift of awareness toward the apex of the hierarchy -- the self as an integrated whole -- it recedes like a mirage. "Know thyself" is the most venerable and the most tantalizing command. Total awareness of the self, the identity of the knower and the known, though always in sight is never achieved. It could only be achieved by reaching the peak of the hierarchy which is always one step removed from the climber.

This is an old conundrum, but it seems to blossom into new life in the context of the open-ended hierarchy. Determinism fades away not only on the subatomic quantum level, but also in the upward direction, where on successively higher levels the constraints diminish, and the degrees of freedom increase, *ad infinitum.* At the same time the nightmarish concept of predictability and predestination is swallowed up in the infinite regress. Man is neither a plaything of the gods, nor a marionette suspended on his chromosomes. More soberly, similar conclusions are implied in Karl Popper's (1950) proposition that no information-processing system can embody within itself an up-to-date representation of itself, including that representation. Somewhat similar arguments have been advanced by Michael Polanyi (1966) and Donald McKay (1966).

Some philosophers dislike the concept of infinite regress because it reminds them of the little man inside the little man inside the little man. But we cannot get away from the infinite. What would mathematics, what would physics be, without the infinitesimal calculus? Self-consciousness has been compared to a mirror in which the individual contemplates his own activities. It would perhaps be more appropriate to compare it to a Hall of Mirrors where one mirror reflects one's reflection in another mirror, and so on. Infinity stares us in the face, whether we look at the stars or search for our own identities. Reductionism has no use for it, but a true science of life must let infinity in and never lose sight of it.

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RESPONSE TO KOESTLER'S PAPER

By Charles Hartshorne

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A puzzling question to me is the topic currently discussed under such captions as 'systems analysis' (Bertalanffy, Laszlo), or 'holograms' (Bohm), or as 'holons' by Koestler. The mathematics of the discussion is, alas, beyond me. Informally I have some difficulty in grasping the distinction between:

1. Any member of a set of interacting individuals (each a sequence or society of momentary actualities) is influenced by all others;

and

2. Any member is influenced by the whole formed by the entire set.

Of course, an existing whole is no mere 'sum of the parts,' since each part or member interacts, has definite relations of influencing and being influenced by the others. Each member has its own perspective on the others. This is built into the psychicalist idea of 'prehension,' the relational aspect common to memory and perception, the aspect Leibniz failed to appreciate. But what is added by taking the totality of individual agents as itself an agent?

There is one very important qualification to the above. Given a system or composite of individuals, all on a comparable level, for instance molecular or cellular, then in some cases, given integration of activities (thus molecules in a cell, or cells in a vertebrate animal), there may be what Leibniz called a 'dominant monad' or what Whitehead calls a 'society of presiding occasions.' The sequence of experience in a waking vertebrate animal is the paradigm case. In one sense such a presiding individual is only another of the interacting agents, but in another sense it stands for the totality. It does this because its dominance consists in an exceptional adequacy of prehending and being prehended. Thus a cell in a nervous system interacts directly and strongly only with a few neighboring cells, whereas a human experience directly prehends and is prehended by a multitude of cells. It sums up to some extent the bodily totality. But it is not literally the totality. Also, in dreamless sleep there are no presiding occasions above the cellular level; the cells are on their own. And this seems to be true at all times of the constituents of the blood, such as the phagocytes. It is also probably true of the cells of a tree. Each cell, in such cases, responds to neighboring cells and to lower level singulars -- molecules, atoms, particles.

RESPONSE TO KOESTLER'S PAPER

By Bernhard Rensch

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I fully agree with Dr. Koestler's description of mental functions as a hierarchical order of different levels between 'mechanical' and mindful processes. But in my opinion it is possible to assume that even voluntary thinking can be regarded as a determined process. This means that we have not a 'free will.' When, for instance, a chess player has a choice between different moves, he will not only be guided by the rules of the play, but he will evaluate several possibilities. His decision is guided by the *dominant idea* to choose the most advantageous move. All our voluntary thinking is guided by such dominant ideas, when we want to solve a problem or plan an action. All voluntary thinking is motivated and this means ultimately that it is determined. However, it is often difficult to analyze the course of our thinking afterwards, because we have to do with an interaction of many different factors. Our thinking is guided by the abilities of our brain, by personal mental abilities or weaknesses, by the feeling tone of relevant associations, by memory traces which we have stored, by actual sensations, mainly by exciting ones, and by special moods. As this interplay is extremely complicated, we can not pretend to have certainty that our voluntary thinking and acting is not free, but we can say that this is most probable.

In simpler cases it is possible to judge the course of the brain functions. When I train a rat to discriminate a cross from a circle and to prefer the former one (because only this is rewarded during the training period), then I can predict that the rat will choose the cross later on, although now both patterns are rewarded. Or when I know a child very well and know what he has learned before in arithmetic, then I can predict with a high degree of probability the course of his considerations and their result when I offer him a new arithmetrical task which does not exceed the realm of his knowledge. The voluntary thinking processes of adult men are only too complicated to become sufficiently analyzed. And we can understand when Max Planck once said that even Kant's deepest thoughts and Beethoven's best musical productions were ultimately *necessitated.* However, later on Planck made some reservations because he became aware of the moral and juridical difficulties when we deny free will (cf. B. Rensch, *Hippokrates* 24: 1019-1032, 1963; B. Rensch, *Biophilosophy*, ch. 7A, New York: Columbia University Press, 1971).

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Mind in Nature: the Interface of Science and Philosophy by John B. and David R. Griffin Cobb, Jr.

Part 2: Mind and Order

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Chapter 5: Some Whiteheadian Comments by John B. Cobb, Jr.

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Common to the four essays of Part Two is an opposition to the reductive determinism so often viewed as the appropriate consequence of science. It is appropriate that determinism had its spokesman at the conference in the person of Rensch, and that Rensch defends it again in his comments on Koestler's paper. This dominant view holds that, when prediction of behavior and thought is not possible, this is because of the complexity of the determining factors rather than because of indeterminacy or freedom.

Zucker describes three strategies for responding to the scientific tendency toward reductive determinism. One of them, that of Carl von Weizsaecker, is to carry through the Kantian program to the end. It will then be seen that scientific axioms are themselves a function of the structures of human thought. Whitehead's philosophy is incompatible with this program, since he believes that the laws governing our cosmic epoch are contingent, exemplifying only some among the many possibilities investigated by mathematicians. The characteristics of our world are, for Whitehead, in principle to be discovered empirically.

The second strategy is to cultivate the simples appropriate to each order. This strategy assumes that the simples are hierarchically ordered and that the wholes that are the simples of each level are more than the sum of their parts. Koestler's paper develops a position of this kind with sophistication and appropriate caution. Holons function as the simples at each level of analysis; but he recognizes that these are subject to analysis in terms of other holons. Hence reductionism is not overcome by a hierarchical ordering of holons as such. Even the fact that at the lower end the holons dissolve "in the indeterminacy of the Janus-faced electron" (above, p. 65) does not overcome the threat of reductionism to human freedom; for Koestler knows that the "indeterminacy of the micro-level cannot be transferred. . . . to the macro-level" (above, p. 60). The question is instead whether at the higher levels the agent of thought or action can itself be a part (perhaps a holon) into which the event is analyzed. If the self that acts or thinks were a part of what is experienced, then Koestler believes we could not affirm human freedom. But because the self that objectifies itself is never itself finally objectified, human freedom is real.

From a Whiteheadian point of view the transcendence by the agent of its participant holons is indeed essential to freedom, but it is understood in a way that is not dependent on the peculiarity of high-grade human experience. As Capek shows, determinism, and with it reductionism generally, has followed from the spatialization of time, a spatialization still too readily applied in our sciences. Once that is wholly uprooted from our thought and time is recognized as primary, the threat to freedom is greatly weakened. The holons now appear as the effects of the past in the new agent-event, but this new agent-event transcends the holons as the present always transcends the past. The event cannot be an object for itself, since to be object is to be past, whereas the present is always subjectively immediate. In its subjective immediacy every agent-event or experience constitutes itself in relation to its holons, objects, or past. In a world of process, determination by the past is never complete.

Hartshorne points out another factor in this alternative to reductionism which also strengthens Koestler's basic case. For him, as for Whitehead, there is an important distinction between wholes, such as animals, that give rise to and include a new order of entity, such as the animal's individual experience, and other organic wholes, such as vegetables, in which this does not occur. Where no new or higher-order individual entity appears, the freedom of the whole is still to be found only in its individual parts, although this may be enhanced by their participation in the whole. Where a higher-order entity does emerge, radically new dimensions of freedom may also occur.

In Zucker's third strategy to counter reductionism, attention is directed to the nature of the individuals which science studies. If these individuals can be understood as wholes that have properties quite other than those traditionally assigned them by reductive determinism, then the meaning of reduction is profoundly altered. Whitehead contributed to this counter-strategy as well as to the preceding one.

In his early writing, Whitehead defined nature in terms of the public sphere, that which is given to the knower through sense experience. Thus nature was the external aspect of events. Beginning with *Science and the Modern World*, Whitehead concluded that science itself requires that the knower be included in nature, and he supplemented his earlier treatment of events with a discussion of their internal aspect. *Process and Reality* provides an elaborate treatment of the internal development of events as perceptual processes, and it can be read as an account of how the outwardly perceived is related to the inner perception. Each 'microscopic process' of the becoming of an individual entity or event is a particular internalization of the entire 'macroscopic process,' which is the whole actual world as it gives birth to that event. One purpose of this conference was to discover whether thinking of this sort is relevant to biological theory on such subjects as evolution.

Bohm's paper indicates that, whether or not biologists are ready to take account of internality in their theoretical formulations, there is at least one physicist who sees this as the way ahead in quantum theory. His idea of an enfolded or implicate order is correlative with Whitehead's notion of microscopic process as internalizing the macroscopic one. Enfolded into each entity is the order of the public world, so that the order of natural entities is not, as generally supposed, only or primarily the pattern of external (spatio-temporal) relations among events, but also the internal order within the individual entity.

Bohm's vision is remarkably congruent with that of Whitehead. They share in criticizing ‘simple location.’ What is in one respect localized is in another respect "enfolded throughout the whole of space (and time)" (above, p. 40). For both thinkers the physical is characterized by dominant inheritance from the past, the mental by appropriation of the new (above, p. 41). Still, there are significant differences. Bohm interprets the implications of his theory as close to that of Spinoza (above, p. 41), whereas Whitehead consciously differentiated himself from Spinozistic monism. For Whitehead each entity or momentary event is a holomovement enfolding in some measure, however trivial, its entire given universe, but the universe in its entirety is made up of innumerable past individual holomovements. They resemble one another through their enfolding of much the same universe of events, but they differ because no two have identical perspectives. Bohm, after developing the notions of implicate order and holomovement in relation to particular entities or events, attributes this order to the universe as a whole rather than to its individual parts. What Bohm calls ‘the implicate depths of the holomovement’ corresponds with what Whitehead calls the ‘primordial nature of God.’ But for Whitehead this principle of novelty and concretion by itself is abstract and does not include or subordinate to itself the events of nature to which it provides ordered novelty and novel order. Thus Whitehead is pluralistic where Bohm tends toward monism in his stress on the underlying unity.

Zucker’s proposals for mathematical formulations of the implicate order indicate that the basic concept is open to a Whiteheadian pluralistic and realistic interpretation. He shows also the concrete steps in mathematical physics that will be required if the potential of Bohm’s vision is to be actualized and is eventually to inform biology.

From a Whiteheadian perspective, Bohm’s emphasis on an implicate order oriented to quantum theory needs supplementation by Capek’s emphasis on the primacy of time oriented to relativity theory. Perhaps the implicate order of quantum physics can be understood more relativistically and perhaps relativity theory can be reformulated in terms of quanta. If so, theoretical physics may break out of its present impasse. Whitehead’s philosophy of nature may hold the potentiality of assisting science in achieving this unification of quantum and relativity theory.

Bohm notes that we also need "a development that is capable of making full contact with modem science, and yet opens up a way to assimilate common experience and general philosophical reflection on this experience, to give a single, whole, unfragmented world view" (above, p. 42). One of Whitehead's great appeals has been that his union of the objective and subjective worlds overcomes in principle the dualism of fact and value and of natural science and the humanities. Perhaps the developments required in quantum and relativity theory to bring them into unity with each other will also lead to a mode of thinking that will unify science with the other dimensions of human thought and experience. Perhaps Whitehead can help to nurture this process as well.

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Mind in Nature: the Interface of Science and Philosophy by John B. and David R. Griffin Cobb, Jr.

Part 3: The Primacy of Mind

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Chapter 1: Arguments for Panpsychistic Identism by Bernhard Rensch and Response by Charles Hartshorne

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1. Introduction

We have not yet formed a consistent epistemological picture of the world. Many philosophers and scientists hold a psychophysical parallelism or they defend an interactionism, an idealism, a materialism or an identism. I will try to discuss some arguments in favor of a panpsychistic identism, a conception which can be regarded as a special version of materialism or as a link between materialism and critical idealism. Being a biologist who, since my student days, has been also concerned with philosophical questions, I believe that certain biological considerations may help clarify and perhaps solve some epistemological problems.

When I wrote *Biophilosophie* in 1968 (English edition 1971), my conception was mainly based on biological facts and classical epistemology. In this paper I will also consider some more recent publications on identism and materialism and mention my objections to psychophysical parallelism and interactionism.

2. Definitions and Methods

Discussions of epistemological problems often turn on different semantic interpretations. I believe that it is possible to avoid such difficulties to a large extent by clear definitions. It may be useful therefore to begin by briefly defining some main concepts which I will apply. As far as possible I will try to follow their classical meaning.

By *psychic phenomena* I understand *all* immediately 'given' conscious experiences, that is to say, sensations, mental images, feelings, thoughts and processes of volition. All these experiences are absolutely indubitable reality for each human individual. I base my philosophical deductions on these reliable facts, but I do not hold a *phenomenalism* which pretends that objects only exist so far as they are perceived by a sentient being.

All psychic phenomena are merged in a stream of consciousness. All psychic experience is therefore part of a *process.* In recent times this fact has been mainly emphasized by Wundt (1874, c.f. 1908), James (1890), Ziehen (1913) and Whitehead (1929). Ziehen called the basic elements of consciousness 'gignomena,' which means 'something which is becoming.'

Consciousness or awareness should not be confused with *self-awareness.* The latter concept supposes the existence of a concept of one's own self, which is only developed in man and apparently in apes, who are able to recognize themselves in a mirror.

Feigl (1958, 1967) called psychic phenomena '*raw feels.'* He could choose this concept because the verb 'to feel' is often used for perceiving and connected mental processes. But 'to feel' has a twofold sense. The word is also used for positive and negative feeling tones accompanying sensations, mental images or more complex thoughts. As we need a clear concept for these ‘real’ feelings, it seems better to avoid the term ‘raw feels.’

Sometimes, mainly introduced by psychoanalysts, the word *mental* is used to include unconscious brain processes. But this contradicts the meaning of ‘mental’ which always means ‘conscious.’ The wrong use of ‘mental’ obscures the fundamental difference of immediately ‘given’ psychic phenomena and scientifically deduced physiological brain processes.

The term *identism* will be used in my lecture in the sense of a *factual* identification of mind and matter. This means for instance: the sensation ‘red’ *is* a certain brain process. If we would admit that the properties of the physiological and the psychological side were not the same, we would still have to do with a kind of dualism, at least what Kim (1966) called a ‘dualistic materialism.’

It is certainly desirable to use the principle of *parsimony* (economy) corresponding to Occam’s razor: "entia non sunt multiplicanda praeter necessitatem." However, its value sometimes seems to be overestimated (Smart 1966; Hinton 1970). The parsimony of the components of an explanation cannot be regarded as an argument for truth (economy argument), for there are too many cases in which initial explanations proved to be much too simple. The former conceptions of atoms, of gene action and of contraction of muscles are typical examples. And all monistic philosophical tendencies finally lead to a whole series of irreducible ultimate entities and laws (cf.. Rensch 1971 a, 1974).

3. Critique of Psychophysical Parallelism and Interactionism

Although recent epistemological literature shows an increase of discussions on materialism and identism, dualistic views are still prevalent.

As I already pointed out in a previous symposium on reductionism at the Villa Serbelloni (Rensch 1974), there are objections to dualistic views. This is particularly true with regard to *psychophysical parallelism.*

A. Parallelism

Biological analyses of brain processes lead to the conclusion that they are causal events like all physiological processes. We always find a sequence of biochemical and physical processes, including changes between kinetic and potential energy. It is therefore very probable -- and at least demonstrable for the single sections by electrophysiological methods -- that a human brain-guided action, which is released by a sensation, is a gapless sequence.

Let me demonstrate this by the following simple example. A person sees a candlestick, and grasps it. In this case, light rays from the candlestick stimulate the sense cells in the retina and release excitations which run to the visual center of the forebrain. There these excitations release further excitations which -- possibly mediated by fibers of associative regions -- run to the motoric center of the right hand and from there to the muscles of the right hand, where they cause contractions, so that the hand moves towards the candlestick and grasps it. The excitations of the sensoric and the associative regions normally correspond to conscious processes. The statement that we have to do here with a continuous process, without a temporal gap between physiological and conscious components, led to the conclusion that the latter run parallel. But this means that the psychic phenomena were only *epiphenomena*, apparently not necessary for the described action. And we know that they can really fail. When we are used to grasping the candlestick every evening, corresponding sensations and thoughts can be totally lacking. The same is the case when we climb well-known stairs, play a well-known melody on the piano and so on. Such often-performed actions gradually become unconscious, run off ‘mechanically’ as a continuous process.

However, if psychical processes are not necessary, but are only epiphenomena, then they would be superfluous events. They would not have any selection value, and it would not be understandable why they have been developed, maintained, improved and have become more and more complicated during phylogeny.

Running parallel also means that mental processes must be synchronized by innumerable specific laws, for all kinds of sensations -- red, sweet, cold, painful and so on -- all mental images, feelings, thoughts and acts of volition must have a special physiological correspondence. And these supposed laws (Ziehen: laws of parallelity) could not be reduced to a general principle like the many causal laws which are consequences of general causality. Geulincx and Leibniz compared the psychophysical relations with two running clocks regulated in a parallel manner by divine influence. But this figurative comparison does not explain anything.

B. Interactionism

Philosophers like Lotze, Rehmke, James, Becher, Popper, and many others, brain physiologists like Adrian, Sherrington and Eccles, and most psychoanalysts suppose that mind and matter are totally different, but that a psychophysical interactionism takes place. They assume that sensory excitations 'cause' sensations, and volition 'causes' excitations of brain neurons.

The assumption of interactionism has the advantage that it explains why increasingly complicated psychic phenomena evolved and why they must not be regarded as epiphenomena. When psychic processes are capable of directing the behavior of animals, it becomes understandable that they successively improved by natural selection. These conclusions of Huxley (1962) and Thorpe (1966) are plausible on the basis of a dualistic conception.

However, the hypothesis of interactionism meets with difficulties. The law of the conservation of energy would be infringed if psychical phenomena would 'cause' physiological brain processes, for they would yield additional energy, and if physiological brain processes would 'cause' psychic phenomena, energy would get lost. This objection was already discussed at the end of the nineteenth century. The German philosopher Rehmke (1905) tried to find a way out of the dilemma. He assumed that this interactionism means that kinetic energy of excitations would be transformed into potential energy of psychic processes and vice versa. However, psychic processes are not something inactive like potential energy. And the supposed transformation is not compatible with a dualistic conception which assumes that psychic phenomena are 'immaterial' and fundamentally different from material processes. Ostwald (1902) believed that the energy of excitations would be transformed into 'psychic energy.' This would mean that psychic phenomena are only regarded as a new kind of physiological process and not as something totally different. Only a panpsychistic identism would avoid such difficulties.

My main objections to all dualistic opinions, however, still remain to be given. Parallelists as well as interactionists presuppose the existence of two totally different kinds of realities. They regard scientific facts as primary reality. However, this is not true. Primary facts are only the experienced psychic phenomena, and all scientific 'facts' are the result of *conclusions,* drawn by logical processes of induction and deduction.

Moreover we must ask: If psychic phenomena were something immaterial, fundamentally different from matter -- although having figurative qualities and spatial and temporal characteristics -- occuring point-like in the brains of animals and man, whence should they have come? Dualists must suppose that they did not exist on our planet, and probably in the whole solar system, before animals and man existed. We will come back to this decisive question when the arguments for panpsychistic identism are discussed (Part 6).

4. Different Versions of Identism

The objections against dualism suggest the preference of a monistic conception, and this means an identistic opinion. As many and partly contradictory versions of such epistemological views exist, it would be going too far to discuss these conceptions and their historical roots in more detail. I will therefore restrict my statements to some characteristic examples.

The main founder of identism -- partly anticipated already by Parmenides -- was Spinoza. His epistemological conception was based on purely rationalistic deductions. In his *Ethics* (1677; cf. 1914, Proposition VII, part II) he wrote that the 'thinking substance' and the 'extended substance' are one and the same, which is comprehended now through this, now through that 'attribute.' But this 'substantia' did not mean 'matter,' but something neutral, comprising both matter and mind. He did not clearly speak about the mode of connection between both attributes. In part I of Proposition XXIX he only mentioned that all is determined by necessity of the 'divine nature' (for correspondence to modern panpsychistic identism, see Rensch 1972). Later on, the detailed analysis of psychical phenomena allowed more exactly founded identistic views.

Fechner (1907), physicist and founder of psychophysics, emphasized that matter, space, time and laws are abstractions from conscious processes. He called his view 'materialistic,' in so far as "it does not allow the possibility of any human thought without a brain and a movement in this brain." However, he concludes that it is a conception of identity "in so far as both, body and soul, are only two modes of appearance of the same essence which it is possible to attain from an inner or an outer point of view." The philosophers Avenarius (1888-1891), Mach (1922, p. 255) and Ziehen (1913, 1934, 1939) also held a panpsychistic identism. Schlick (1925) held a similar opinion. He wrote (p. 267, my translation): "The world is a richly varied configuration of interdependent qualities; some of these are given factors in my (or another's) consciousness, and I call these subjective or psychic, others are not directly given to any consciousness and these I term objective or extramental -- the concept of the psychical does not arise in this connection." This view comes very near to my own conception; however, it differs, because Schlick also writes (p. 293): "Consciousness cannot be the essence of the brain particles for they are present even when consciousness is absent, as in death or sleep." I would object that in death and sleep the biochemical compounds may be identical, but not the type of electric potentials and fields which is necessary for the stream of consciousness. It would be possible and more consistent to assume that all 'matter,' including electrical fields, has a protopsychical nature, but can only become experienced when it is integrated in certain complicated physico-chemical systems and pertains to a stream of consciousness (cf. Part 6).

Whitehead's, considerations (1929) also led to a panpsychistic view. He wanted to make the results of scientific findings compatible with metaphysics. He supposed that our mental phenomena are derivative modifications of primitive elements and that even elementary particles have a certain mental quality. He therefore spoke of 'physical feelings.' This term may perhaps lead to misunderstandings, because 'feeling' normally means human or animal perceiving, or it denotes only the positive or negative feeling tones which accompany sensations and mental images. I prefer to speak of the 'protopsychic nature or essence' of the so-called 'matter,' the 'ultimate last.' When phylogenetic and ontogenetic considerations led me to coin this term (in 1968), I was not yet aware that it corresponds more or less to Whitehead's 'physical feeling.'

Among present philosophers, apparently Feigl (1967) is a prominent representative of those identists who deduce their conception from the experienced psychic phenomena. He characterizes his view in the following manner (p. 107): "It shares with certain forms of idealistic metaphysics in a very limited and ([hope) purified way, a conception of reality and combines with it the tenable component of materialism, viz., the conviction that the basic laws of the universe are ‘physical.’" This conception of present psychophysiological knowledge allows the assumption that certain types of cerebral processes are identical with the experienced ‘raw feels.’ I share this view, but I disagree on an important point. Feigl emphasizes that he rejects panpsychism which "pervades all of physical reality" (p. 84). I believe that this restriction is contradictory. Feigi identifies certain physiological brain processes with psychic phenomena in a panpsychistic sense, but he seems not to consider the fact that all the basic elements of brain processes, the molecules, atoms, ions, particles, electric currents and electric fields, can also occur outside the brain and in non-living conditions. In any opinion the identification of physiological brain processes and mental processes inevitably leads to the consequence that all matter must have a protopsychic nature, a prestage of consciousness in its most general sense. I share this opinion with Hartshorne (1967). Among present scientists, Wright (1953, 1964) and Birch (1974) hold a panpsychistic identism.

Some strict materialists deny in effect their own mental processes and only recognize chemical and physical processes. But in so far as materialists also discuss sensations, mental images and thoughts as experienced realities, they could perhaps more correctly be called *materialistic identists.* But all types of identism, including the panpsychistic version, which is more justified in my opinion, allow a physiological, chemical and physical analysis of the relevant brain processes and can lead to a ‘physicalistic’ picture of the world, provided that one agrees that ‘matter’ must not only be characterized by energy or mass, spin, charge and spatial and temporal characteristics, but also by the protopsychical nature of these characteristics. The question, whether such identism can be based on facts, depends to a large degree upon our knowledge of physiological brain processes. It will therefore be useful to review briefly some main findings of this fascinating science.

5. Support for Identism Based Upon the Relation of Brain Processed and Conscious Phenomena

One consideration supporting identism is *the precise correspondence between many physiological brain processes and psychic phenomena.* At present, brain physiology is one of the most exciting fields of biological research. Skillful cytological, biochemical, electrophysiological, autoradiographical and psychological methods, brain operations and psychiatric observations have led to a rapid advance during the last two decades. However, in spite of all progress, our knowledge of the relations of physiological brain processes to conscious phenomena is still quite limited and not yet sufficient to come to a definite decision for a dualistic or an identistic opinion, particularly interactionism or factual identism. But I believe the arguments for identism already prevail.

The correspondence of certain psychic processes to physiological brain processes could be proved by many observations and experiments. I will mention only a few. (I) The destruction of single forebrain-regions often leads to the loss of corresponding sensations or mental images. (II) All kinds of brain operations alter the personality of a patient to some degree; many pharmaca, particularly lysergic acid, alter the brain functions to great extents; and the male and female sexual hormones cause the psychic differences between man and woman -- injections of the opposite hormone can alter the sexual mentality to a high degree. (III) Recent investigations have shown that neurons in the sensory regions seem to be biochemically specialized for transmitting particular sensations. (IV) A close correspondence exists between stimuli and sensations. Those stimuli, and only those, which can be arranged in unidimensional series like light rays, sound waves or degrees of temperature correspond to sensations which can also be arranged in a continuous series. The same holds good for the intensities of stimuli and sensations. (V) Long-term memory, which is based upon material memory traces and therefore (unlike short-term memory) cannot be extinguished by electric shocks, can be prevented by the injection of compounds which prevent the formation of proteins. (This indicates that protein-compounds are involved in material memory traces.) (VI) Innumerable electrophysiological investigations have proved that the oscillations of action potentials in the brain are different when different conscious processes occur. The electroencephalogram (EEC) of a relaxing person mainly shows regular alpha-waves; when the person begins to calculate, finer beta-waves are superimposed on the alpha-waves. (VIII) In non-narcotized patients Penfield (1955, 1968) could raise mental images of known persons and of voices by electrical stimulation of the temporal lobe of the forebrain.

In spite of all our knowledge about direct correspondence of physiological brain processes and psychic phenomena, some modern philosophers and psychologists still doubt that any kind of localization could be possible. They do not deny that our consciousness is connected with our body and head. But Nagel (1970, pp. 217-218) believes that "a thought has no location at all"; Feigi (1967, p. 39) writes: "it is simply nonsense to ask about the location of a concept"; and Polten (1973, p. 55) even pretends "that physiologists certainly have not shown any necessary connection of memory with brain tissues and it is arguable that it cannot be done in principle." I hope that my brief remarks about the correspondence of physiological brain processes and psychic phenomena sufficiently show that such skepticism is not justified.

Certainly, we are only beginning to understand the psychophysiological correspondence. However, most brain physiologists are already convinced of a correspondence of material brain processes and conscious phenomena and their research is guided by this idea. Much further investigation will be needed, but *the hypothesis of an identity of psychic phenomena and corresponding physiological brain processes already has a sound basis.*

6. Arguments Supporting the Panpsychistic Version of Identism

Kant (1787) assumed that something extramental exists, but in his time physics and chemistry had only analyzed this ‘matter’ in a very insufficient manner. He therefore argued that the ‘thing in itself’ is inscrutable and developed a philosophy which is termed ‘critical idealism.’ At present, we have quite detailed knowledge about molecules, ions, atoms, elementary particles, electromagnetic waves, electric fields and all kinds of material processes, but we are still not yet able to say what ‘matter’ ultimately is like. As I tried to show in the preceding part, we also know something about the structure and function of that part of brain matter to which psychic phenomena correspond.

This *psychophysically acting brain substance is,* however, *composed of the same atoms, ions and elementary particles which we find outside living beings.* And the same holds true for oscillations of electric currents and electric fields which the brain produces. All this psychophysical substrate is developed during embryogenesis from compounds of the blood stream coming from the placenta, and that means that it ultimately derives from the food of the mother. After birth the brain cells in question are nourished by the food of the growing child. Some weeks later the brain cells no longer divide, but they show an almost frequent turnover of many of their protein compounds. Hence, there is no particular ‘psychophysical matter’ involved in the brain cells and their functions. Only a special systemic order of atoms in certain molecules of different types of brain cells, steady activity of these cells and excitations coming from sensoric nerves and running to associative and motoric centers are the basis of the peculiarity of brain function. We must therefore ask: Whence can the correspondent psychic phenomena come, if they should be something totally different from matter?

This question seems to be unanswerable. Sherrington (1940) raised it, but did not find an answer. However, when we attribute a protopsychic nature to all matter, then conscious phenomena become understandable. When atoms form a molecule, absolutely new chemical and physical characteristics arise in consequence of new systemic relations. For instance, by combination of the light metal sodium with the gas chlorine, salt arises, the characteristics of which are totally different from the characteristics of its atoms. If we now ascribe a protopsychic nature to atoms, the protopsychic characteristics, too, could produce new protopsychic characteristics by these new systemic relations. The much more complicated integration in large molecules of neurons and of neurons in an active brain would lead to still more complicated systemic relations and not only to protopsychic ones, but also to real psychic phenomena, to sensations and mental images. Panpsychistic identism assumes that the physical characteristics *are* also the psychic characteristics. But they can only be experienced if they belong to a complex physiological process in a human or animal brain, which we call the ‘stream of consciousness.’ Motoric excitations and many excitations in the brainstem and the cerebellum do not belong to this process.

This panpsychistic conception may appear to be nothing more than a bold hypothesis. However, it can be supported by other considerations (Wright 1964; Rensch 1968, 1969, 1971, 1974). In the first place *the phylogenetic development of psychic processes* suggests this assumption. Certainly, sensations, mental images, feelings and thoughts are private experiences of each human individual. But they are indubitable reality. We can be informed about corresponding phenomena of our fellow men by language, and it would be absurd to hold a solipsism. It is more difficult to judge about psychic phenomena of animals. We can do it only with conclusions from analogy. But these conclusions are very cogent in higher animals. In a little lesser degree the behavior of lower vertebrates allows the conclusion that these animals have sensations, feelings and memory. Fish can learn different optical or acoustical tasks. Large species master up to six successively learned visual discriminations simultaneously. Fish are subject to the simultaneous color contrast and to optical illusions in the same manner as man. Of course, we can never exactly know what kind of sensations, feelings and mental images they experience. But it is sufficient for our questioning that the conclusion is justified that fish, too, absolutely behave as if they have psychic phenomena. Moreover, electrophysiological investigations show continuous, changing oscillations of electric potentials. This allows the conclusion that their perceptions and mental images are united in a stream of consciousness in waking conditions.

However, some higher invertebrate animals also show similar achievements. Bees, bumblebees and cuttlefish like the Octopus have well-functioning eyes. Their brain is divided in regions with different coordinated functions, and it is composed of several hundred thousands of nerve cells (the honey bee has about 800,000). They can learn to discriminate colors and black and white patterns and can master all 3 or 4 learned tasks on the same day. Bees are also subjected to simultaneous color contrast. It is therefore possible and even probable that they experience sensations and memory, that is to say, conscious phenomena, but surely not in the sense of human experience which is connected with a concept of one's own self. It is natural to assume that they also experience positive and negative feeling tones, because they prefer certain tastes and reject other ones. The satisfaction of all feeding, copulating and cleaning drives in animals is probably guided by such feeling tones.

In animals of still lower levels of organization the conclusions from analogy are much vaguer. However, the lowliest worms have sense organs, nerve cells and nerve centers, and these cells function more or less in the same manner as those of higher animals. And these animals can learn at least in the sense of conditioned reflexes. The same is possibly the case in coelenterates. If we suppose that the lowest multicellular invertebrates would also have sensations, these would be separated events -- they would not belong to a 'stream of consciousness.'

Protozoa have no nerve-like fibers (as formerly assumed), and they cannot learn. However, unicellular organisms show positive and negative 'sense reactions' to chemical stimuli, particularly to those which indicate food or a partner for copulation or conjugation. It seems therefore to be possible to assume that they have single sensations or prestages of sensations. Such speculation can only be based on the fact that all animal evolution was a continuous process and that sensations of multicellular animals must have some phylogenetic prestages.

If we regard sensations as immaterial things which are totally different from all material, physiological processes, it would be difficult to imagine from where these psychic phenomena should have come. Wright (1964, p. 113) wrote: "Emergence of mind from no mind is sheer magic." But when we suppose that all matter has a protopsychic nature -- an assumption which was already suggested by our considerations of the brain functions -- then the phylogenetical development of sensations and other mental processes would become understandable. The integration of certain atoms and complicated molecules into neurons in the course of phylogeny, and further on into nervous systems and brains, could produce psychic processes. These would arise by new systemic relations, beginning with protopsychic prestages of sensations and leading to real sensations, memory and all higher psychic phenomena.

This assumption has a particular advantage. It would mean *that the whole evolution of our earth and of life could be regarded as a continuous causal process.* At present it is increasingly probable that life originated gradually from inorganic matter due to causal biochemical processes. In prebiological times, prestages of organisms, at first so-called protobionts, developed in the ‘primeval soup.’ About 3 billion years ago true unicellular organisms had already developed (cf. Fox 1965, 1971; Oparin 1968; Buvet and Ponamperuma 1971; Kaplan 1972). This continuous development suggests the assumption of a corresponding development of protopsychic and psychic phenomena of organic matter in the sense of a panpsychistic identism.

The panpsychistic hypothesis becomes perhaps still more convincing when we consider *the individual development of mental processes of man.* A fertilized human egg and the following multicellular stages do not indicate sensations or other psychic phenomena. Only after sense-cells, nerve-cells and a brain have been developed can the fetus have sensations, and after birth the behavior of the young child shows that it surely experiences sensations with positive and negative feeling tones and begins to develop associations and memory. If these phenomena would be something immaterial, fundamentally different from material physiological processes, we must ask again:

Where do these psychic processes come from? Should we believe that a 'soul' has been 'inserted' in some stage of the ontogenetical development? And how can it happen that this 'soul' shows characteristics of parents and grandparents? Twin research has clearly proved that many psychic characteristics are inherited.

All mental characteristics are ultimately transmitted from parents to children by the germ cells and by the arrangement of genes on the threadlike molecules of desoxyribonucleid acid (DNA), the general chemical structure of which is well known. As these molecules are capable of transmitting psychic characteristics from one generation to the next one, it is natural to assume that molecules have a protopsychic nature. And as they are composed of atoms which also compose other types of molecules, it becomes probable that all molecules, atoms and their elementary particles have such a protopsychic nature. This allows the conclusion that sensations and mental images arise by the integration of protopsychic characteristics of 'matter.'

When we now ask what *physics* knows about 'matter,' we can state that the present concept no more means something 'solid,' 'substantial.' Mass is equivalent to energy and can become radiation. 'Matter' can only be defined as a complex of relations between energy, charge, spin, speed and spatial and temporal relations. And all these concepts do not mean something 'solid.' This fact allows us to try a description of 'matter' by a mathematical 'world formula.' It was an unnecessary former hypothesis that all these components must have a 'carrier.' Our present conception of matter is much more compatible with panpsychistic identism than all former conceptions.

Summing up, we can state that many considerations speak in favor of a panpsychistic identism:

(1) the precise correspondence between many physiological brain processes and psychic phenomena; (2) the fact that the psychophysical substrate of our brain contains the same atoms, elementary particles and fields of energy which can occur outside the brain; (3) the phylogenetic development of psychic phenomena can be understood best when we suppose a protopsychic nature of all 'matter'; if we assume that mental phenomena would be something fundamentally different from physiological processes, it would be difficult to conceive whence it should have come in the course of evolution; (4) the ontogeny of psychic phenomena is a still stronger argument in favor of panpsychistic identism, particularly because DNA-molecules are able to transmit

mental characteristics to the next generation; (5) present physics no longer defines matter as something ‘solid,’ but as a complex of relations between energy, charge, spin, speed and spatial and temporal characteristics; this definition is compatible with panpsychistic identism, when we assume that matter is something protopsychical. *One final comment:* The assumption of protopsychic matter is no more revolutionary than our epistemological knowledge that all objects which we see have no color, because color only arises in sense cells and brain.

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RESPONSE TO RENSCH'S PAPER

By Charles Hartshorne

Charles Hartshorne has taught philosophy primarily at the University of Chicago, Emory University, and the University of Texas; at the latter he is now Emeritus Ashbel Smith Professor of Philosophy.

There is an apparent contradiction between the mutual influence between mental and bodily events and the doctrine (which I hold) that the data of experience are independent of that experience. The contradiction is removed by the following theory, derived from Whitehead, and so far as I know, first clearly stated by him. If mind, call it M, and body (physiological process), call it B, interact, then any mental state M at time t, which influences a bodily state, say B at time t^1, will be temporally *prior* to that bodily state, and it will be temporally *subsequent* to any bodily state which influences it. Then, assuming that events depend only upon their temporal predecessors, the independence of the data will be preserved. In Whitehead's system, all influence is taken to have the temporal structure of antecedent and independent condition and subsequent dependent result.

Rensch cites experiments in which electrical stimulation of the cortex produced, without detectable time interval, psychical phenomena. He admits (in conversation) that strict simultaneity is not absolutely proved. Since the causal concept above explicated says nothing about the extent of the time difference between condition and its most immediate results, it is not clear how such observations or any others could show the invalidity of the concept. Here, too, the issue seems logical, not factual.

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Mind in Nature: the Interface of Science and Philosophy by John B. and David R. Griffin Cobb, Jr.

Part 3: The Primacy of Mind

John B. Cobb, Jr. is Professor of Theology at the School of Theology at Claremont, Avery professor of Religion at Claremont Graduate School, and Director of the Center for Process Studies. David Ray Griffin teaches Philosophy of religion at the School of theology at Claremont and Claremont Graduate School and is Executive Director of the Center for Process Studies. Published by University Press of America, 1977. This book was prepared for Religion Online by Ted and Winnie Brock.

Chapter 2. Panpsychism and Science by Sewall Wright

Sewall Wright has been Ernest D. Burton Distinguished Service Professor at the University of Chicago and Leon J. Cole Professor of Genetics at the University of Wisconsin. He has been Professor Emeritus at Wisconsin since 1960.

I am speaking here as a zoologist, specifically a geneticist, who has been concerned with the implications of his field for the philosophy of science. While it is a field that is much less mature than physics, it occupies such a central position in the general field of knowledge that its implications should be given special weight.

A physicist or chemist can get along fairly well with a commonsense dualism in attempting to discover the laws of nature which govern the vast world of inanimate things. The occurrence of beings like himself, composed of matter that seems to be inhabited by minds capable of some control over the course of events, may be somewhat disturbing, but mankind constitutes such an infinitesimal portion of the cosmos that the physical scientist may for the moment ignore it in his difficult task of finding the basis of cosmic order.

The humanists and social scientists can adopt the same commonsense philosophy while concerning themselves solely with the activities of human beings.

The biologist is continually in trouble. The objects of his study range from a class of molecules that have the basic self-duplicating property of living things, through cells which suggest purely physical systems, through animals which give increasing evidence of having minds, to human beings in whom streams of consciousness seem to involve continual choices of action, at the opposite pole from control by impersonal laws of nature. The zoologist cannot escape the problem of the relation of matter and mind.

Implications of Physical Science

Let us compare further the two kinds of knowledge which must somehow be reconciled in a unified philosophy of science. While the physical scientists have not yet arrived at a fully satisfactory account of the most elementary particles, they have acquired precise knowledge of the hierarchy of entities starting from proton, neutron and electron, through atom and molecule, to objects of our own order of size for which the precision of the laws of mechanics have made possible the extraordinary achievements of technology. Beyond this comes the detailed knowledge of the surface of the earth of the geologist, the astronomer’s knowledge of the sun and planets, stars in general, our galaxy and the array of galaxies, leading again to the fringes of knowledge in cosmological studies.

The dominant philosophy of physical science since the time of Galileo, with some wavering in the present century, has been that of the famous dictum of Laplace:

> An intellect which at a given instant knew all the forces acting in nature and the positions of all things of which this world consists -- supposing the said intellect were vast enough to subject these data to analysis -- would embrace in the same formula the motions of the greatest bodies in the universe and those of the slightest atoms;

> nothing would be uncertain for it, and the future, like the past, would be present to its eyes.

Streams of Consciousness

In marked contrast is the kind of knowledge provided to each person in his own stream of consciousness. At any moment this has a focus, but one which shifts continually, now on perception of the outside world, now on a memory which has somehow been stored out of mind (perhaps for many decades), now on an emotional state, now on a toothache, now on construction of an abstract pattern of thought, now on communication with others, but again and again on the often painful process of choosing among courses of action, and then of acting.

Nothing could contrast more than the precise determinism of our knowledge of the external world when pains are taken to control conditions, and the fitful character and apparent freedom of choice of the stream of consciousness.

The latter, nevertheless, is obviously the primary reality. The former is wholly derived from bits of the streams of consciousness of many observers and is restricted to those aspects which can be communicated. It can be stored best in books, but actively exists only in minds, within which it appears to consist of a set of rather pale second-hand deductions. Its restriction to the so-called primary properties of matter (location in space, changes in this, and association of matter with forces describable in turn only by changes in location) contrasts with the richness of the stream of consciousness. Colors and sounds are reduced to wavelengths; sensations of heat and cold are reduced to readings on a thermometer; taste, smell, feel are ignored in precise formulations.

It now turns out, moreover, that even position in space is not absolute but relative to circumstances of the observers, each of whom has his own private four dimensions of space and time for locating events. Apparently exact agreement is possible only because communication is restricted to observers who are not moving relatively to each other at velocities of more than a minute fraction of the velocity of light.

Moreover, all of this common knowledge of the so-called primary properties is based on measurements in terms of units: centimeter, gram, second, with operational definitions which are recipes for *voluntary* actions. Reality clearly consists primarily of streams of consciousness.

This fact must take precedence over the laws of nature of physical science in arriving at a unified philosophy of science, even though it must be largely ignored in science itself.

Statistical Laws of Nature

In my own case, I started as a student with the usual conviction that biology, and science in general, requires a rigorously deterministic viewpoint. I still, indeed, hold this viewpoint in practice, but with a radical revision of the philosophical implications of science. My deterministic viewpoint in zoology was somewhat disturbed by reading Bergson in 1912, but not for long. What really made over my thinking was reading (in 1914) Karl Pearson's *Grammar of Science* (published in 1892), and a book, *The Origin and Nature of Life* (1912), by the biochemist, Benjamin Moore. Curiously enough the philosophic position that I arrived at was not held by either and was vigorously opposed by Pearson.

What I derived from Pearson was a different attitude toward what I then considered the absolute laws of nature. He treated them as merely condensed descriptions of how things are observed to behave, no different in kind from statistical laws describing human behavior, such as the law of supply and demand or the regression of marriage rate on the volume of trade.

Another idea that he firmly implanted was the uniqueness in principle of every event:

> The causes of any individual thing thus widen out into unmanageable history of the Universe. . . It is useful to remember how essentially the causes of any finite portion of the Universe to the history of the Universe as a whole.

Thus it is not possible to deal deterministically with single events. Science can only deal with *classes* of more or less similar events and thus is necessarily statistical.

The Physical and Biologic Hierarchies

From Moore, I derived a vivid appreciation of the importance of the hierarchic structure of existence. The crucial point was that a living organism is more comparable to a molecule or atom among inanimate things than to a mere unorganized aggregation of materials like a stone. Conversely a molecule or atom might seem much like a little organism if we could observe the incessant activity which the physical scientists now attribute to them.

These ideas and others seemed to me to point to dual-aspect panpsychism as the simplest synthesis, in spite of the opposition of Pearson to any metaphysical speculation and Moore's ignoring of the issue.

I must admit that I have not found many scientists who appreciate its simplicity. The only member of the faculty of the University of Chicago with whom I discussed it during my long stay there who at all shared this viewpoint was Charles Hartshorne of the Philosophy Department, who had arrived at it along an utterly different route. Among zoologists, much the closest in viewpoint seems to be Bernard Rensch, who probably also arrived at it along a different route.

Matter and Mind

There have been several different views of the relations between matter and mind. It is impossible, as brought out by Berkeley and Hume, to disprove solipsism, the view that the observer's stream of consciousness is all that exists. Most babies, however, probably learn within a week or two after birth that they are subject to combinations of unwished-for sensations of such consistency as to indicate something real. With the later dawn of self-consciousness, they learn that there are others with streams of consciousness like their own who can be communicated with. I should emphasize here, to avoid what seems to be a common misunderstanding, that the term 'consciousness' by no means necessarily implies self-consciousness.

Primitive peoples are said to share the animistic viewpoint that all things are more or less like human beings in their capacities for spontaneous action. At a later cultural stage a sharp distinction is usually made between two kinds of existence which, it is supposed, may occur separately as mindless matter and as disembodied mind but, at least in man, in an association of body and soul. It is usually thought that this is indissoluble in life but that the soul persists after death without communication with the living. The spiritualists, including some scientists, however, believe that communication with disembodied spirits is a real phenomenon. The regularity with which supposed evidence has been shown to be fraudulent, as well as the difficulty of reconciliation with natural science, has led most persons to profound skepticism.

Modern science has developed in the main under the concept that nonliving matter is wholly mindless and is subject to completely deterministic laws of nature. A good many scientists have held, however, that there is some vital principle in all living things, not necessarily mind, which is absent in nonliving matter. The list of leading recent biologists who have been vitalists includes Hans Driesch, S.H. Jannings, Ralph Lillie and Edmond Sinnott. Bergson developed his philosophical system around the concept of an *elan vital*.

Most scientists as well as most nonscientists have probably assumed that the higher animals, at least, have minds; though some, no doubt, have followed Descartes in considering all living beings other than man as mere automata.

The prevailing trend in biology, however, has been away from vitalism and any causal influence of mind on the course of events, toward a complete reduction to the principles of physics and chemistry. Jacques Loeb was the leader in America at the beginning of this century in insisting on the exclusion of all but physico-chemical explanations in biology. The limit of this trend would seem to be complete materialism, the denial of mind as a category of existence. This, however, is an absurdity. Mind, even though denied any role in the inexorable course of events, must be retained at least as an observer.

Emergence of Life and Mind

If the nonliving world is completely devoid of mind and if, as it seems necessary to believe, there was a time when no life could have existed, living beings must either have had a supernatural origin or have been developed somehow from nonliving matter. Linnacus accounted for the origin of all species of plants and animals by separate creation. Lamarck, by advocating evolution, pushed creation back to a possible single origin of life.

The apparent gap between nonliving and living has now been bridged by nucleic acids, a class of polymeric organic molecules composed of a succession of small units (nucleotides) of four sorts, the order of which determines an indefinitely large number of different specificities. The latter is also true of the proteins (composed of 20 kinds of amino acids). They are the principal component, other than water, of all living forms, but the nucleic acids alone have the remarkable property of being capable of duplicating their patterns, whatever they may be, from small molecules in their medium. They may be considered living molecules. They can evolve by duplication of their specificities as of the new type if, by any accident, they undergo a change (or mutation). They, as genes, are the units of heredity. They determine the synthesis of protein molecules of the most diverse specificities according to a code in which succession of three nucleotides determine one amino acid. The essential identity of the code in the most diverse organisms is strong evidence for a single origin of life on earth.

Nucleotides and amino acids are substances which, there is reason to believe, could have been formed, and polymerized into nucleic acid and protein respectively, under certain conditions on a lifeless earth. The origin of living organisms from lifeless matter is thus a reasonable hypothesis.

This brings us back to the question of the origin of the mind. Lloyd Morgan (1933; cf. Wright 1935) treated the origin of mind in the course of evolution as a phenomenon of the same sort as the emergence of a new organ or physiological capacity. A new organ, however, involves nothing more mysterious than differential growth, leading for example to an outpocketing from flat tissue that turns out to be useful and can be further elaborated. Similarly, loss, addition or rearrangement in a protein molecule may enable it to bind other molecules in such a way as to catalyze a new metabolic process. Emergence of either of these sorts, however surprising their consequences, poses no serious philosophical difficulty. Emergence of mind from no mind at all is sheer magic. We conclude that the evolution of mind must have been coextensive with the evolution of the body. Moreover, mind must already have been there when life arose and indeed must be a universal aspect of existence -- still assuming that mind cannot arise from nothing.

The emergence of mind in the course of individual development from the fertilized egg presents a similar problem and one that is an everyday occurrence instead of a single event in the remote past. It would appear that the mind of a human being must develop from something of the nature of mind in the fertilized egg and, back of this, in the separate germ cells and in the nucleic acid molecules.

Panpsychism

As already noted the living cell, because of its tightly organized character, is more comparable to a molecule than to a mere aggregation of matter. It may be thought of as a supermolecule composed principally of C, H, O, N, P and S. Multicellular organisms, including man, are in turn not mere aggregations of cells, but so tightly organized that they may be considered super-super-molecules, ultimately with properties which are wholly those of the component atoms in the very complex combination. The arguments from continuity require the presence of mind in cells and, back of this, in molecules, atoms, and all that exists.

This can be looked at in two ways: According to dualistic panpsychism, matter and mind are two modes of existence which are universally associated. In the philosophy of Spinoza such an association was a necessary consequence of his identification of God and the universe and his conception of extension and thought as two of the attributes of God.

This dualistic panpsychism is not quite the same as monistic panpsychism, according to which mind and matter are merely two aspects of the same reality: as it is to itself and as it seems to other minds with which it interacts.

FIG. I/3.2 GRAPHIC HERE

If A and B represent two minds, largely private, but nevertheless capable of interacting directly or indirectly: A perceives certain regularities in its stream of consciousness which it ascribes to an external reality, B; but, as it does not enter into B’s stream of consciousness, it in general tends to consider B as merely an unconscious source of disturbance, i.e., as matter. B similarly deduces matter, A, from the interaction with A’s stream of consciousness.

Each is aware of many such external realities and these are perceived to have interactions with each other which can be arranged in a coordinate system consisting of two dimensions of direction in addition to one of remoteness. The order of succession of events provides a fourth dimension, time.

In certain cases, the behavior of external matter is of such a nature as to indicate the presence of a stream of consciousness, another mind, with which varying degrees of communication become possible. In still other cases, the external reality parallels the internal so completely as to compel identification as a peripheral aspect of the observer himself, his own body. In most eases, however, there is no indication of any mind and the objective world thus seems to consist largely of mindless matter.

Under the dual-aspect view, the objective world of natural science with its hierarchies of physical and biological entities must exactly parallel an inner world of mind. Because of the flowing character of the latter, parallelism should be sought not in matter as mere mass and occupation of space, but rather in the incessant action which modern physics finds in its units; the wavelike properties of proteins, neutrons and electrons, photons and its other elementary entities, down to Planck's quanta as the ultimate known units of action. At a higher level is the incessant action within molecules, including nucleic acid and protein. The metabolic activities within a cell, and its activities in relation to other cells may be considered the external aspects of the cell's stream of consciousness. Introspection throws some light on the matter in the case of the multicellular organism. My own stream of consciousness obviously includes that of only a minute portion of my cells at any time. In a considerable part of the time (in dreamless sleep) it does not exist, although the cells continue their activities. When it does exist, it focuses now on one thing, now on another, the external aspects of which are the integrated activities of different but overlapping sets of cortical neurons which come successfully into dominance. That there is any unity in the stream of consciousness indicates that those of separate cells fuse. They cannot be the windowless monads of Leibniz.

The store of memory, carried along out of mind in ways that are the object of active research, undoubtedly contributes most, by activation of its components, to the unification, except in the rare cases in which two independent stores are built up, giving the basis for dominance at different times of one or the other of two personalities.

When we pass to the next higher step in the biologic hierarchy, the social organism, we at once perceive a difficulty. We speak of the 'spirit of America,' but it is difficult to think of this as anything but a figure of speech. It can, indeed, exist only as a feeling of consensus in the minds of separate individuals.

Choice and Determinism

Subjectively, mind seems to involve the continual exercise of choice, always of course within a limited range of possibilities. How is this freedom to be reconciled with the apparent determinism of natural science? Part of the answer is, already noted, that the laws of nature are ultimately statistical and no more preclude choice on the part of individual components than do statistical laws of human behavior.

There could not be statistical regularity, however, without at least some regularity in the behavior of individuals. Freedom of the will is sometimes treated as if it were equivalent to caprice, but mere chance is as little characteristic of free choice as absolute determinism. If one situation is much like another, the choice of the best course of action is likely to be the same. Apparent determinism along a chain of cause and effect may be looked upon as the external aspect of a sequence of choices.

It is to be noted that physics itself has had to abandon Laplace’s concept of absolute determinism since Pearson wrote the *Grammar of Science.* Because of Heisenberg’s principle of indeterminacy, physical science has had to arrive at statistical mechanics as its ultimate form of statement.

This still leaves the question as to how the larger organisms can behave other than by statistical laws which should simulate complete determinism with the utmost precision because of the large number of elementary components (some 1032 protons and neutrons). It is, however, of the essence of an organism (as of a man-made machine) that it contains numerous switch or trigger mechanisms which bypass purely statistical behavior. I like an illustration of this which I used in a class discussion in May, 1927, a day or two after Lindberg’s flight across the Atlantic, which seemed almost as sensational an achievement then as the first flight to the moon a few years ago.

It was a rather remarkable phenomenon from a purely physical standpoint when a great mass of material rose from the ground in Long Island, moved steadily in spite of buffeting winds across the Atlantic and finally settled down gently at the Paris Airport. Yet if an engineer could have studied the air pressures on wings, cabin and ailerons (the movements a the latter under control of the lever), the motion of the propellers, the mechanical connections of these to the motor, and the gas explosions in the latter, he would have found that the plane was merely following a necessary course, determined at all moments by well-established physical principles -- except that this would not account for the motions of the levers. This, however, would have involved only an infinitesimal portion of the total energy transactions.

A physiologist, taking up the analysis at this point, would find that the levers moved as they did because of a certain succession of muscle contractions in the pilot's arm. He might trace the energy transactions in the latter in full detail to the consumption of a certain amount of glucose and find that they were strictly in accord with the conservation of energy, except that he might not understand why there was a particular succession of stimuli from neuromuscular junctions. Another physiologist would find that these were controlled by a chain of neurons from the brain connected by synapses. The energy transactions are here infinitesimal compared with those in muscles, but again have been shown to be in accord with the conservation of energy. He might not understand just what happened in the synapses which determined which neurons were activated, but would find that only an infinitesimal amount of the energy of the nerve currents was involved. The flight of the plane would be fully accounted for deterministically except for the product of a succession of infinitesimals. Yet the whole was according to Lindberg's plan.

A high degree of freedom of choice by the whole is thus consistent with apparent deterministic behavior of the parts. This is very different from control of the whole by minute indeterminacies, something that is prevented by self-regulatory processes.

Respect for the choices of the entities at all levels in the hierarchy does set limits to the freedom of each. The dual-aspect hypothesis implies that each event depends 100 percent on choice as the inner aspect of physical causation, but, with the whole history of the universe converging on it, it depends on the resolution of the choices of all entities at all levels in the hierarchy. The whole can dominate only in ways that involve concurrence of the parts.

Clifford and Pearson

As I have noted, I arrived at this dual-aspect panpsychism in 1914 after reading Pearson's *Grammar of Science* and Moore's *Origin and Nature of Life.* I was surprised after looking into these books for the first time in 60 years to find that I had not taken this philosophic position directly from either author. Pearson did, however, insist that the field of science is the contents of the minds of normal observers, not the things themselves. He said:

> Immediate sense-impressions form permanent impressions in the brain which psychically correspond to memory. The union of immediate sense-impressions with associated stored impressions leads to the formation of ‘constructs’ which we project ‘outside ourselves’ and term phenomena. The real world lies for us in such constructs, not in the shadowy things-in-themselves. . . . These are the facts of science and its field is essentially the contents of the mind. It (scientific law) is a brief description in mental shorthand of as wide a range as possible of our sense impressions.

Pearson’s definition of consciousness differs from mine:

> When an interval elapses between sense-impression and exertion, filled by cerebral activity marking the revival and combination of past sense impressions stored as impressions, we are said to think or to be conscious. . . . Consciousness has no meaning beyond nervous systems akin to our own.

Pearson thus did not consider mere instantaneous awareness of a sensation as consciousness. He included decision making in consciousness but considered its apparent freedom a delusion.

With respect to metaphysics he wrote:

> The concepts of the metaphysicians, Kant’s thing-in-itself or Clifford’s ‘mind stuff are in my sense of the words unreal. They cannot become immediate sense impressions.

Obviously I did not derive the concept of dual-aspect panpsychism directly from Pearson. There is also no suggestion of it in Moore. It was however, the ideas which I derived from them that led me to it in 1914.

The first reference to this viewpoint, which I encountered later, was in a paper by Troland (1922), who presented it very clearly and referred to a number of earlier presentations going back to Fechner in 1863 and included Clifford (1879), which I then read and found a very clear presentation. Pearson (who had edited a posthumous volume of Clifford's mathematical papers) fully accepted Clifford's concept of matter and of physical phenomena, frequently using the term 'construct' (which he credited to Clifford), but rejected his monistic concept (without giving any exposition beyond the vague reference to "Clifford's 'mind stuff,'" quoted above). This reference did not tempt me in 1914 to look up Clifford, but I evidently reconstructed his position from what Pearson did accept of his views on matter, as more acceptable to me than Pearson's. Pearson seems to have derived his philosophy of science largely from Clifford but left out the keystone. After taking the *Grammar of Science* back to the library and reading Moore's book and mulling over them, I seem to have put Clifford's keystone in place without realizing that Pearson had rejected it.

My purpose, and I presume that of all others who have approached the subject from the scientific side, has been to find a metaphysics which, with the minimum of speculation, finds a place for the obviously primary reality of the stream of consciousness, while fully accepting the findings of science. Those who have reached a similar conclusion on the primacy of mind, but from the viewpoint of philosophy, such as Whitehead (1925) and Hartshorne (1942, 1954), have built up more elaborate metaphysical systems.

This difference in aim has led to some divergence in dealing with the Universe as the world of mind, within which all subordinate minds must be included in some sense, from either point of view. The question is whether, at one extreme, the mind of the Universe is all-knowing and omnipotent, or at the other, it is merely that which is superimposed on the point-to-point interactions of the minds of the components as the integrating factor, in much the same relation as that of my mind to the minds of my cells and lower entities in the hierarchy of existence. As one concerned with the philosophy of science rather than philosophy in general, I must take the latter view, recognizing that there is a great deal that science does not and probably never will know.

When the astronomers tell us that it requires more than a billion years for a message to pass from certain observed objects to our galaxy at the maximum velocity accepted by physics (3x 10^{10} cm/sec.) and that, apart from this, there is integration only by universal gravitation, the universe seems rather loosely integrated. It is possible that my time scale is too infinitesimal to recognize organization on a cosmic scale, but here I am disturbed by the big-bang theory of cosmology. If the universe, as we know it, is exploding and has been doing so for only a moderate number of billions of years, after a condensed phase in which all prior organization must have been obliterated, the likelihood of a high state of organization as a whole seems small indeed.

The astronomers do not, however, appear to have reached definitive views on cosmology. Perhaps there was no big bang. Perhaps there are means of communication vastly more rapid than the velocity of light. A philosophy of science must, however, restrict itself to interpretations based on the current findings of science with the caveat that these are certain to change in ways which we cannot predict.

Science and Philosophy

Finally, what differences in the methodology of science are suggested by adoption of dual-aspect panpsychism in place of determinism? I fully agree with Pearson here that science is restricted to verifiable knowledge and thus must exclude the knowledge of our streams of consciousness, because it is unverifiable by anyone else. We must continue to accept a rigorous determinism as far as possible, and supplement this by probability distributions where necessary, even though we interpret the determinism philosophically as the external aspect of choices throughout the hierarchy of existence and make use of this philosophical interpretation in choosing topics for research. Some use of subjective terms may be warranted in describing the behavior of human beings and perhaps of higher animals to avoid ponderous circumlocutions, but should be avoided in attempts at the most precise formulations. I stated this emphatically in the first paper in which I indicated my philosophical position, a review (1921) of a book by C. M. Child on *The Origin and Development of the Nervous System:*

> The theory, as a mechanistic one, seems the very antithesis of such views as those set forth by Driesch with his quasi-intellectual factor, the entelechy, as the guiding spirit of development, and by Bergson with his elan vital. In a sense, however, there is a curious approach. Under Child’s theory there is complete continuity from the reaction of the cell with its environment, which constitutes the primary metabolic gradient, and from the later reactions, by which the pattern of the developing

> embryo is laid down in accordance with the changing gradient pattern, to the intellectual processes by which the adult organism adjusts its relations to the outside world. Since awareness is certainly associated with the dominating nervous activities in the latter case, it seems necessary to grant the possibility of its presence in the former unless we wish to assume that it is arbitrarily superimposed upon metabolic gradients at a certain level of complexity. Moreover as a state of consciousness in the higher case is certainly closer to reality than any impressions which it may make on other consciousness the question at least seems open as to whether the entelechy may not be the reality of which the metabolic gradient, however much correlated with environmental factors, is merely the outward show. However this may be, it does not, of course, detract at all from the vastly greater significance to science of such a conception as that which Child presents.

I took the same attitude on the roles of science and philosophy in my first major paper on evolution in 1931. In this paper, I tried to interpret evolution as a continually shifting balance, spatially and temporally, among what I called the pressures of mutation, selection, and migration on gene frequencies, in conjunction with the effects of random drift composed of random variations in these pressures and of local accidents of sampling. These provide material for inter-group selection at a level, the interaction system, higher than that provided for by mass selection of individual mutations. There was no reference to any role of mind except in a paragraph immediately before the summary in which I indicated both my philosophic position and what I considered the necessity for restriction to deterministic and probabilistic statements in a scientific treatment. I would like to cite this paragraph which has continued to be my position in many papers on the subject:

> The present discussion has dealt with the problem of evolution as one depending wholly on mechanisms and chance. In recent years, there has been some tendency to revert to more or less mystical conceptions revolving about such phrases as ‘emergent evolution’ and ‘creative evolution.’ The writer must confess to a certain sympathy with such viewpoints philosophically, but feels that they can have no place in an attempt of scientific analysis of

> the problem. One may recognize that the only reality directly experienced is that of mind, including choice; that mechanism is merely a term for regular behavior, and that there can be no ultimate explanation in terms of mechanism -- merely analytic description. Such a description, however, is the essential task of science and because of these very considerations, objective and subjective terms cannot be used in the same description without something like 100 percent duplication. Whatever incompleteness is involved in scientific analysis, applies to the simplest problems of mechanics as well as to evolution. It is present in most aggravated form, perhaps in the development and behavior of individual organisms, but even here there seems to be no necessary limit (short of quantum phenomena) to the extent to which mechanistic analysis may be carried. An organism appears to be a system linked up in such a way through chains of trigger mechanisms that a high degree of freedom of behavior as a whole merely requires departures from regularity of behavior among the ultimate parts of the order of infinitesimals raised to powers as high as the lengths of the above chains. This view implies considerable limitations on the synthetic phases of science, but in any case it seems to have reached the point of demonstration in the field of quantum physics, that prediction can be expressed only in terms of probabilities, decreasing with the period of time. As to evolution, its entities, species and ecologic systems, are much less closely knit than individual organisms. One may conceive of the process as involving freedom, most readily traceable in the factor called here individual adaptability. This, however, is a subjective interpretation and can have no place in the objective scientific analysis of the problem.

I would now write ‘individual selection’ and ‘selective diffusion’ in place of ‘individual adaptability’ as referring to coefficients which are actually used in the mathematical formulation but which nevertheless represent processes which may involve choices made by individual organisms. Otherwise this quotation reflects my position in this and all later papers on the subject.

No doubt Pearson was correct in feeling some danger to science in accepting a philosophy of science which recognizes choice as real, but I do not think that this is serious if it is also recognized that determinism is necessarily the external aspect of the chains of choices at all levels. There is also a danger of which I think Pearson was not sufficiently aware in being satisfied with a statistical description as ultimate. This may lead to premature abandonment of analysis in cases in which analysis could be pushed further by one who believes firmly that there is a deterministic mechanism to be found. The remedy is a clear recognition of the danger and a lively interest in carrying analysis as far as possible up and down the hierarchy of being.

Pearson undoubtedly felt more satisfied with a merely statistical account of resemblance's of individuals to their parents and more remote ancestors than did geneticists with a deterministic metaphysics. He violently opposed the Mendelian analysis of heredity after its rediscovery in 1900. The latter indeed is also statistical. The geneticists, however, were not satisfied with merely enunciating laws of heredity. They looked on the latter as indicative of real entities and became concerned with where they were in the cells and what they did. Geneticists passed from the formal genetics of individuals to cytogenetics at the cellular level, to the biochemistry of DNA in duplication and in protein synthesis at the molecular level, back to physiological and developmental genetics again at the cellular level and back to the level of the individual in behavioral genetics and beyond the individual to population genetics and the theory of evolution. All have been pursued rigorously from the external deterministic and probabilistic standpoints. This process is, I think, a necessary precursor of any attempt at a philosophical interpretation.

There is also the opposite danger that failure to accept the reality of choice, a fatalistic acceptance of absolute determinism, may lead to such slackening of individual and social effort as to bring about the end of civilization.

My final conclusion is that there is real satisfaction in a philosophy which can bring under a common viewpoint the vast body of secondary but verifiable knowledge of the external world which constitutes science, with its necessarily deterministic and probabilistic interpretations, and the primary but private knowledge which each of us has of his own stream of consciousness, more or less continually directed toward the finding of an acceptable course through the difficulties of the external world by means of voluntary actions.

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Mind in Nature: the Interface of Science and Philosophy by John B. and David R. Griffin Cobb, Jr.

Part 3: The Primacy of Mind

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Chapter 3: Physics and Psychics: The Place of Mind in Nature by Charles Hartshorne

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Charles Peirce (1931, pars 1.252, 255) divided empirical science into two branches, physics and psychics, both terms being used broadly, so that physics includes astronomy, geology, etc., while psychics includes biology, sociology, linguistics, history, and so forth. Peirce distinguished psychics from physics by attributing to the former but not the latter the admission of final causes. He did not hold that the division between the two forms of knowledge expresses an absolute and ultimate distinction in the nature of things. As an ‘objective idealist’ he thought that it is in psychics not in physics that the universal principles are encountered. On his view, the ultimate constituents of nature are all at least sentient, and there are no cases of efficient causation entirely devoid of any teleological aspect. I shall argue in my own way for the ultimacy of the psychical account of nature.

In physics, what properties are assigned to natural processes? Or, what questions is the physicist seeking to answer? In part he is seeking to predict, and in this sense explain, our sense perceptions. But in order to do this he finds it sufficient to attribute to physical nature apart from our experiences a remarkably limited class of properties: geometrical (spatio-temporal) quantities and patterns and ways in which changes in the quantities and patterns in one process cause changes in the quantities and patterns of other processes. These are all *structural* (spatio-temporal-causal) properties, as contrasted with *qualitative* ones, e.g., blue, sweet, pleasant, as given in sensation. The difference between positive and negative electricity, or between high and low frequency waves, may seem, and in nature may be, partly qualitative; but physics as a theory of nature takes into account only the spatio-temporal aspects or consequences of such qualities, whatever the latter may be. Physics thinks of nature as causally related spatio-temporal geometrical structures. Qualities as such, what Peirce (1931, pars. 1.300-318) called *monads, firsts,* or 'feeling qualities,' are omitted from the account of things found in physics and chemistry, except for the methodological point that we detect the presence of the various magnitudes and spatio-temporal structures by our qualitative human sense perceptions, visual or tactual. Thus we detect long wave lengths of light by our perceptions of red and short ones by our perceptions of blue. But in principle, I presume, we could design a machine to do this detecting for us, and then the red and blue as sensory qualities would be dispensed with. It has been said that a blind man can understand the whole of physical science. And in any case, when a physicist discusses the velocity of light, or the red-shift which shows that the universe is expanding, he is talking about something that would be there in nature if there were no animals with sensations of color left. It is not an official doctrine of physics, whatever some philosophers or some physicists may hold, that nature is dependent upon man for its existence or basic properties. Here I agree with Popper, as well as Einstein, against some quantum physicists.

In psychics a much greater range of properties is dealt with. Spatio-temporal-causal properties -- the shapes, motions, bodily behavior and interactions of animals, plants, and other things -- are not ignored. But psychics asks questions going far beyond those put in physics: how or what does an animal feel, intend, think purpose, love, or hate? Also *why* does it move or behave as it does? Here ‘why’ connotes, as it does not in physics, "With what motive, intention, or purpose, or inspired or irritated by what pleasant or unpleasant sensation or memory?" Not a whisper of this is officially present in what physicists or chemists say about their subject matters, even though sometimes physicists, in intended metaphor, speak of the ‘excited’ or ‘satisfied’ states of atoms.

Thus we have two forms of inquiry, the one restricting itself to the study of behavior, the description of behavior being austerely limited to geometrical and arithmetical properties, and the other also studying behavior, but interpreting it as far more than merely that, and as having its meaning, and perhaps also in part its causal explanation, in terms of a large class of concepts excluded from the physicists’ explanations. A central question of our culture simply is, "What is the relation between these two forms of inquiry?" Either the additional concepts of psychics are ultimately relevant to the whole of nature, or they are not. If they are not relevant, then mere behavior, as causally conditioned spatio-temporal changes and nothing more, is the only universal principle, and what we learn by studying animals adds nothing (beyond unusual complexity or subtlety) to our concept of reality in general. At most, such study so interpreted shows us that one corner of nature is in some respects absolutely peculiar, revealing the introduction of unprecedented forms of reality not to be explained by anything found in the rest of nature. This hard dualism appeals to few scientists; so we need not be surprised that there is a tendency to insist that the additional psychical concepts are mere complications, or mere ‘emergent properties,’ which should not influence our basic conception of reality or knowledge.

The sense and degree to which psychologists are behaviorists gets its significance from the fact that, in studying animals, that is, the sort of thing that we ourselves are, we have a dual access to reality, which we do not have in studying inanimate nature. We know what it is like to be a person studying rocks or molecules, in a sense in which we do not know what it is like to be a rock or a molecule. By memory we can generalize about the nature of our own experience, and then by analogy form some conception of the nature of ape, canine, or porpoise experience. But, with a rock, all that we seem to have are our human perceptions of it, these perceptions being how the rock influences our psychophysical being under certain conditions. We know the rock ‘from the outside,’ ourselves ‘from the inside.’ We know animality by being an animal; we do not know inanimate nature by being inanimate. This is simple, but I believe it is not superficial.

Either we can learn something about nature at large by reflecting upon ourselves as samples of natural fact, or we cannot. I hold that dualists and materialists alike are in effect telling us that from animals we can learn only about animals, but not about gases, fluids, or minerals. Note that if it is conceivable that these thinkers are wrong, they are barring the path of inquiry. For, if we can learn from animals something important about inanimate nature, we can do it only by rejecting both dualism and materialism. The dualist says that the psychical aspect found in animals occurs only there, and the materialist, too, says this, adding, however, that even in animals it is nothing theoretically very crucial but is only a special case in the panorama of reality.

What is the third possibility? Obviously this, that the ‘additional’ factors (over and above mere behavior) that are dealt with in psychics but ignored in physics are *in principle* universally applicable, provided we conceive these factors in their fully generalized variables. Just as physics generalizes variables of movement so that they can apply not only to a human hunter and his fleeing prey, but also to stars, planets, atoms, and photons, so psychics needs to generalize such ideas as feeling, perceiving, remembering, anticipating, intending, liking and disliking, so that they can apply not only to animals, but even to the real individual constituents of the vegetable and mineral portions of nature.

Say what you please about this being a reversion to ‘primitive hylozoism,’ or ‘primitive animism,’ it remains true that it is one of the three options we confront (if we ignore mere subjectivism or positivism) and that the other two are also open to easy rejection. How popular is dualism among scientists? How many scientists or philosophers are really happy with materialistic monism? Psychical monism avoids the most obvious demerits of its two rivals. It is a monism, yet it is not a materialism. I am confident that in time these two advantages will reverse the contemporary fashion among some philosophers and some scientists of inclining toward materialism. We cannot remain mere dualists, for that means giving up the hope of universal explanatory principles; and we cannot agree upon the materialistic form of monism, not only because it is an attempt to explain away mind, but also because it leaves ‘matter’ essentially mysterious. Neither psychics nor physics can satisfy us so long as the former is taken to exhibit either a purely special case of general but merely physical principles, or a sheer exception to the general principles. Rather, *what we now know as psychics is indeed a special case of the general principles. However, the principles themselves are not merely, or most basically, physical but are* *psychical in a generalized sense.* On this view ‘mind’ is not confined to a corner of nature but is everywhere in it, just as behavior is. But *mind is the substance,* and mere behavior, in the sense of spatio-temporal change, is the shadow, the skeletal outline only, the causal geometry, of nature.

In asking about mind or the psychical in nature I am not asking only, or even chiefly, Where in nature is thinking going on? I am asking also, and more particularly, Where in nature is there feeling, perceiving, remembering, desiring, liking and disliking, not necessarily in the higher forms of these functions that we human beings are capable of, but in *some* form, however primitive and simple, however odd or strange, when compared to our human forms?

First I had better say something about what makes our human way of experiencing and thinking different from that of other animals. The key to our human superiority is, scientists agree, in our symbolic power, as shown in all human languages. What is sometimes called the ‘language’ of birds, or bees, or monkeys is a very different thing from any human language. There is nothing like grammatical structure, systematic ways of combining words into sentences and paragraphs, nothing like nouns, verbs, adjectives, prepositions, pronouns. Grammar is uniquely human. Capacity for it is common to all races and both sexes, and that alone is enough to show what is wrong with racism and male chauvinism.

Psychology can study the behavior of animals and try to guess what forms of perception, emotion, memory, and perhaps learning or problem solving of simple kinds are going on in these creatures. But the question arises, Where is the lower boundary of this science of animal mind? There is a book on "the psychology of microorganisms." I believe the book justifies its title. If so, mind in a broad sense pervades the entire animal kingdom. But what about plants, and what about so-called inanimate nature, the rocks and other minerals, and the liquids and gases?

First the plants. Modern botany accepts the cell theory of living things. All living things that we can see without a microscope consist of many far smaller living things that we cannot see, each of which is an organized individual. Is there a psychology of single cells? They do react to stimuli, and they do organize their internal activities remarkably well. This is most obvious in single-celled animals and plants, but I believe it is a reasonable assumption in all cells. It follows that, even if it is right (and some dispute this) to deny feeling or sensation to a tree or flowering plant, still the cells of which trees or plants consist may feel, may enjoy their activities. In that case, mind in some form may pervade the entire kingdom of living things. I take this view, and so do some other philosophers and some scientists. But some of these (e.g., Cochran 1971) go further. They believe (with Wordsworth and Shelley) that mind is everywhere in nature, even in inanimate things.

What are the reasons for thinking that inanimate objects such as rocks and chairs are devoid of mind? I can see four reasons:

1. Their inertness, inactivity, motionlessness. They do not seem to do anything.

2. Their lack of freedom in the sense of initiative, creative departure from mere routine. The predictability of astronomical events is a good example. The sole motions seem wholly matters of routine, or statistical upshots of huge members of microevents, as in the sun’s corona.

3. Their lack of individuality in the sense of unity and uniqueness. If a chair has parts -- pieces of wood, metal, plastic, etc -- why assign feeling or memory, say, to the whole chair rather than to each piece of wood, each nail or screw? In non-living things visible to the naked eye there is no clear distinction between whole and part, and no dynamic unity, as though something like a sequence of experiences were influencing the parts.

4. Their lack of apparent intrinsic purpose.

These are four valid reasons for denying that rocks or chairs are individual cases of mind. But this is compatible with psychicalism, which asserts, not that all things are or have minds (as the word ‘panpsychism’ may seem literally to connote), but only that all concrete or physical things (a) are minds of some high or low kind, or (b) are composed of minds, and that only active singulars are individually sentient.

Macroscopic inanimate objects are now known to be not the unitary, simply solid, inactive things they appear to be, but rather collections of numerous distinct, highly active things (molecules, atoms, particles). And there is no evidence that such things are wholly devoid of initiative; what evidence there is suggests the opposite.

As for purpose, we must distinguish between conscious purposes, formulated conceptually and deliberately aiming at more or less remote future results, and primitive, short-run, naive intentions. For example, when a bird sits on eggs, this may have nothing to do with foresight of the potential fledglings. It may be that the animal merely feels like assuming this posture, feels comfortable in it, and when forced to leave the eggs has a desire to return to them. Even so, this is a genuine though short-run purpose. Much more naive cases can be imagined. Fully generalized, concern for the future is a variable with an enormous, indeed infinite, range. There may be purpose, or at least desires, referring only to a tiny fraction of a second ahead, just as there may be memories with similarly short-run effective scope toward the past. To know that an active singular represented no value on this variable we should have to have absolute knowledge such as only deity could have. And with Leibniz and Berkeley I see no reason why God should create such entities, nor what his knowledge of them could have in common with his knowledge of sentient creatures realizing values. The latter knowledge is sympathetic participation, the former could be nothing of the kind. In the philosophies of Peirce and Whitehead, and even more explicitly in mine, sympathy, 'feeling of feeling,' is an ultimate principle, applicable to deity and every other singular actuality.

It is worth noting, too, that Darwinism explains the seemingly purposiveness of organs and other inherited factors by natural selection operating between groups of individuals assumed to be striving to achieve various short-run objectives, as when the rabbit tries to mate or to escape the fox. Individual purposes are really implicit in the scheme all along, and what is explained is not purpose as such, but only how through many generations there has been a slow increase in the variety and complexity of the purposes. Mutations are indeed not, so far as we know, selected by any overall purpose favoring evolution; but this is compatible with there being short-run and very naive purposes, desires, or feelings in the atoms and molecules constituting the genes, as well as in every cell and every metazoan with a nervous system.

Cosmic teleology may be seen in the basic laws which evolutionary explanation assume and which made possible the glorious 'web of life' of which Darwin so wonderfully speaks. But the laws are statistical; they are not Newtonian or classical. They explain how the details of evolution were *possible*, not why precisely those details occurred. Biology is a fantastically unpredictive science, and this is no mere matter of complexity. I hold that it is absurd in principle to think of predicting details of animal behavior (not to mention animal feelings). Even Skinner is not really doing that. The illusion that he is doing it arises partly from not taking seriously the full meaning of ‘details.’ Tell him the kind of action you want the pigeon to perform and he may give what you ask; but by details I do not mean a *kind* of action, but the precise unique movements.

What are the advantages of giving up the notion of mere dead, mindless physical things? Are there any advantages to scientists? With Leibniz I suspect that the main advantages of the doctrine are philosophical, in enabling us to arrive at a view of life and nature in which the results of science are given their significance along with the values with which art, ethics, and religion are concerned. In a list of advantages that could be given, some would be relevant to strictly philosophical, religious, aesthetic and ethical issues. The partial list given here will be limited to some advantages which are of relevance to scientists as well as philosophers:

1. We get rid of the problem, "How could mere matter produce life and minds?" Instead, the problem is only, "How did higher types of mind develop out of lower types?" But we have that problem anyway in the evolution of animals. So we have reduced two problems to one.

2. We do justice to the fact, which strikes nearly every scientist, that between so-called ‘lifeless’ matter and primitive forms of living matter there is only a relative difference, not an absolute one. Science thinks of life as a complication of what was there all along. On the view I am defending, this is correct. In principle, life (in a generalized sense) and mind were there all along, but in primitive forms, much more primitive even than in a single plant cell.

3. Psychicalism has the signal advantage, hinted at by Francis Bacon, that it can construe causal connectedness of events in terms of generalized concepts of memory and perception. Materialism and dualism lack these resources and are in Hume’s predicament about causality. Memory and perception are effects whose causes are intrinsically given to them. These are our only clues to the intelligible connectedness of events.

4. A special case of psychicalism’s advantage in understanding causal relations is its ability to do what many scientists and philosophers have

despaired of doing, give some explanation of how mind and body are related in animals. Why is it that one's thoughts and feelings vary with changing states of one's body, and why is it that with changing states of one's mind one's body also changes? If one suffers some terrible disappointment, it may make one physically sick; and if one catches a disease one may become delirious and think and feel in strange ways.

Take the case of pain. We have this feeling if certain cells of ours undergo damage. But if the cells have their own feelings, they can hardly enjoy being damaged. So what is our suffering but our participating in their suffering? Hurt certain of my cells and you hurt me. Hurt my friend and you hurt me. My cells are the friends I have always with me and always care about, whereas my other friends I may be separated from and may forget or learn to dislike. The mind-body relation, I suggest, as Plato hinted long ago, is a relation of sympathy; it is the most instinctive of all forms of sympathy, the form we are born with and do not have to learn. I seriously believe, and not alone I, that this is the key to the influence of body upon mind. There is mind on both sides of the relation, but mind on very different levels. The gap between the levels is crossed by a kind of sympathy. We share in the emotional life of our cells. That is why, in good health, we can have a feeling of wellbeing. Our cells are enjoying themselves, and our sense of the goodness of being alive is partly our vague sense of the goodness of their lives for them. This is how the bodily cells influence our feelings.

"But why," you may ask, "do our feelings influence the bodily cells?" I answer, "By sympathy in the reverse direction." We in our human way share in the subhuman emotional life of cells; they in their subhuman way share in our emotional life. Since cells are limited creatures, compared to us, the vagueness I just spoke of in our sense of cellular feelings must be much more extreme in the cell's sense of our feelings. The higher type of mind can have better grasp of lower types than lower types can have of higher types. That is why we human beings have science and other creatures do not.

I admit one possible objection. Scientists do not much like the idea of mind influencing body. 'Interaction' is the name given to this doctrine. It would be simpler for physiology if one could suppose that physical activities in the body are entirely uninfluenced by our thoughts and feelings. I am not impressed by this argument, since I think that nature is not constructed for the convenience of physiologists. And one still has to find some way to relate our experiences to physiological facts.

5. We solve the problem which Berkeley saw so clearly of relating primary and secondary qualities in the scheme of things. The primary qualities are abstract causal-geometrical relationships; the secondary qualities are more concrete and apply to the terms standing in these relationships. They give something of the internal natures of events, whereas causal geometry only relates events to other events. Psychicalism holds that something more or less like our secondary qualities are in all active singulars.

6. Including, as one should, the more objective of the so-called tertiary or value qualities with the secondary (the two are really inseparable), we can give a psychical account of the relation between perception and behavior and go part of the way toward answering the question "Why?" of behavior. Thus, why do animals tend to eat sweet things and avoid bitter tasting things? Because these qualities are intrinsically emotional, the one positively, the other negatively, reinforcing eating. To taste something as sweet is already an incipient acceptance of it, to taste it as bitter is an incipient rejection of it. This account can be connected, as I have shown elsewhere (Hartshorne 1934, pp. 243-266), with relevant facts of physiology and evolutionary biology. But mere physics cannot include such an account.

7. Carlyle said, "To know is to sympathize." It is arguable that at least knowledge of our friends, and even of our enemies, is of this nature. The doctrine of mere matter, mere mindless and feeling-less stuff or process, puts a limit to the things with which we can sympathize. But the psychicalist view holds that physical nature is mind in other than human forms with which we have more or less mutual participation. A great physicist once said to me, "To understand an atom you must sympathize with it." Perhaps he knew what he was talking about. This man understands molecular structure so well that he has been called ‘Mr. Molecule.’

Wright, Thorpe, Zucker, and Waddington ask what psychicalism could contribute methodologically to *scientific* work. My view is that the help natural science can derive from a current philosophy is largely for the future to disclose. A philosophical insight implies a program of empirical research for a thousand or five thousand years. Parmenides and Zeno produced Democritus with his atoms, and after twenty centuries Dalton, Lobachewsky, Planck, and others began to find something like the right way to conceive the smaller active constituents. However, I do think a few examples can be given even now.

Even if science is necessarily limited to a purely behavioristic view of its results (which I do not grant), psychicalism can at least have heuristic value. As a minor illustration: I have written two books (*The Philosophy and Psychology of Sensation,* 1934 and *Born to Sing,* 1973) which, with all their faults (especially apparent to me in the earlier work), contain pointers, I believe, by which competent investigators might be helped to deal with some problems in psycho-physiology and in the study of animal behavior. In both cases psychicalistic ideas were useful in arriving at some empirical facts, for example, about the composite nature of 'loudness' as a variable of sense experience (Hartshorne 1934, pp. 61-72), or the biological significance of 'highly developed' bird song, or of contrast and uncertainty in the sequence of songs or phrases (Hartshorne 1973, pp. 106-112, 117f, 119-136, 151-188).

In a recent issue of the journal *Behavior* there are two articles (Baker 1973; Dawkins 1973) making positive use of one feature of process philosophy, its concept of creative novelty transcending causal determinateness other than statistical. Process philosophy is not referred to, but it is that philosophy which best fits what these investigators are doing.

It is arguable that, had Einstein known a metaphysics more favorable to quantum physics than the Spinozism and other similar doctrines influencing him, he might not have spent the latter decades of his life vainly attempting to recover the absolute 'incarnate reason' of classical causality which had been made irrelevant by twentieth-century discoveries, including his own. Materialism and unqualified mechanism seem no longer helpful, even in physics.

The greatest geneticist I have known (Sewall Wright) believes with me that there is nothing in all nature except mind on various levels. The greatest two philosophers of recent times, on my criteria, also believed this. So have many other fine intellects. I am proud to be in their company. We are not a majority, but an elite minority.

It is in order to ask why a view with so many advantages should be a minority view. There are several possible explanations. (a) I have already discussed the primary one: since, owing to the limited resolving power of our perceptions, the sentience of most of nature is hidden from our direct and distinct experience, it was natural enough for early civilized man to form the division of nature into animal, vegetable, and mineral or inanimate. Crystallizing into common sense, and backed by Aristotle, the view acquired massive inertia which lasts to this day. (b) It was also strengthened and seemingly confirmed by the Newtonian period in science which, like Greek atomism, but even mote so, did indeed view matter in terms contradictory to psychical conceptions of it. The fact that science has now destroyed the Newtonian framework (so far as relevant to the issue we are discussing) seems not to have been properly grasped by most philosophers, though Whitehead (1926) has spelled out the story with great power. (c) When Darwinism destroyed the old teleology (which never was a good form of psychicalism, since it implied that the divine psyche was the only one that decided anything), biology seemed to confirm the prejudice against attributing purpose or other psychical factors to nature in general. But since more than one of the leading living Darwinians hold the psychical view, this reason can scarcely be conclusive against psychicalism as such. And indeed it is not logically relevant to that issue, but only to the question, Just what form of psychicalism is worth considering? (d) Science and philosophy alike require constant vigilance against the danger of anthropomorphism. It is easy to caricature psychicalism so that it looks like an anthropomorphism. We psychicalists are accused of attributing human traits to the subhuman, yes, even to the inanimate. In fact we attribute not a single specifically human trait even to apes, let alone to atoms. We do not say that apes or atoms remember, perceive, or know as human beings remember, perceive and know. Yet there is evidence that apes do remember, perceive, and know. In the broadest behavioral sense, remembering is taking account in present action of past events (experience) within the individual in question; perceiving is taking account in present action of past events in the environment. Even atoms take at least the immediate past into account; for if they did not there could be no causal account of their behavior. Therefore, the psychicalist holds, they either remember or perceive or both. (For good reasons it is perception, not memory, that is to be thought of as strictly universal. In the first experience of a new individual, memory must by definition be lacking; insofar as electrons and the like lack enduring individual identity, neither can they remember. But they must perceive, take account of, past events around them.)

I believe the charge of anthropomorphism can with good reason be reversed. Those who say that, apart from the specifically human forms, or the specifically mammalian or animal forms, nature is devoid of psychical traits altogether are indeed exaggerating the role of man or manlike creatures in the world. They are saying that our kind of creature introduces mind as such into nature. Apart from us and our kind there is nothing with intrinsic life, feeling, value, or any sort whatever. Is this not in a class with the idea that our planet is at the center of the universe? Behaviorists point to the public observability of behavior compared to mind taken as something more than just behavior. But if science officially limits itself to behavior, this does not mean that unofficially we cease to acknowledge, in ourselves at least, such qualities as pleasure, pain, sweetness, sourness, fragrance, happiness, joy, sorrow, love, and hate. If we refuse to grant anything generically (of course not specifically) like these to other creatures, we are indeed self-centered or anthropomorphic, whatever we may say.

A version of the charge of anthropomorphism is the objection (urged, e.g., by Dobzhansky) that psychicalism takes a special late form of reality and imputes it also to earlier forms (the charge of 'preformationism'). But this begs the question, which is precisely whether mind as such or in general *is* a special form of reality. Animal mind is indeed a special form. But as the psychicalist uses the words, mind, or the psychical, is an infinite variable, coextensive in range with 'active singulars,' and what is not an active singular he takes to be an aggregate of singulars or else an abstraction there-from. Viewed from without, or through the sense organs, the psychical appears as behavior, but from within, or in itself, it is feeling, memory, anticipation, and the like. On the higher levels only does it include what we normally mean by 'thought' or 'consciousness.' Lower creatures feel but scarcely know or think, and if we speak of them as conscious, as Wright does, we stretch the sense of the word. This can be done, but then we need another word to distinguish high-level, thoughtful, cognitive experience or feeling from mere experience or feeling. The verbal confusion arises because in adult human beings, feelings are always more or less thoughtful or conscious. But how far is a baby 'conscious' of its feelings? Does it not simply feel, without judging how it feels, which is what 'conscious' normally connotes? (e) The disinclination of many to accept psychicalism probably arises partly from the immense demands which the doctrine make upon one's imagination. How are we to imagine feelings as different from ours as an atom is from our bodies? However, since physicists now agree that the structural aspects of atoms are unimaginable, though mathematically expressible, I wonder if this ground of objection retains any validity. Once more I suggest that the 'pathetic fallacy' is to be balanced against the possibility of a 'prosaic fallacy': supposing the world to be as tame as our sluggish convention-ridden imaginations imply (f) An objection sometimes raised to the doctrine of psychicalism is that it seems to violate the valid principle that concepts must express contrast. If 'mind,' at least as 'feeling,' applies everywhere, do not these concepts lose all distinctive meaning? However, as Leibniz showed, two contrasts remain: that between active singulars and groups of these, only the former of which literally feel; and that between low and high levels or degrees of feeling, or minding. Thus contrast is preserved. This logical discovery of Leibniz seems insufficiently appreciated.

Conclusion

Since the only non-question-begging reason for denying feelings to some parts of nature is their lack (for our direct perception) of signs of activity, individual unity, initiative, and purpose, and since physics and chemistry have demonstrated how limited in penetration our mere sense perceptions are, how radically they fail to disclose what is really there in nature, it follows that the entire traditional foundation for materialism and dualism alike has been destroyed by the advance of knowledge. These doctrines are based on imputing to sense perception an adequacy for direct disclosure of the secrets of nature which we now know it does not have. There is no part of nature which we know or could know to be lacking entirely in any of the four respects mentioned. Consequently the concept of 'mere dead insentient matter' is an appeal to invincible ignorance. At no time will this expression ever constitute knowledge. Long ago Leibniz saw this with wonderful clarity, but he hid the importance of his insight by interweaving it with some of the most extraordinary fantasies in intellectual history, as well as with the consequences of some pseudo-axioms that he for the first time conceived with full sharpness so that their logical implications were apparent. The reactions of many scholars to this dazzling mixture have been a revealing test of their naivete in metaphysics. Some have defended it as not necessarily untrue in essentials; most have attacked it as so incredible that we have little to learn from it except how far one great mind managed to go ingeniously wrong. Yet the truth, as I see it, is that, in spite of some fundamental blunders, Leibniz took the greatest single step in the second millennium of philosophy (in East and West) toward a rational analysis of the concept of physical reality.

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Mind in Nature: the Interface of Science and Philosophy by John B. and David R. Griffin Cobb, Jr.

Part 3: The Primacy of Mind

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Chapter 4: Some Whiteheadian Comments by David Ray Griffin

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The above three authors (ed: Rensch: Arguments for Panpsychistic Identism; Wright: Panpsycism and Science; Hartshorne: Phisics and Psychics: The Place of Mind in Nature) obviously agree on many points. They all agree that our knowledge of our own experience is primary, in comparison with which all scientific knowledge is derivative and inferential, and that no system based on the latter is acceptable if it makes 'mind' (used broadly to refer to experience at any level) less real than non-mind. They also agree, in Wright's words, that "emergence of mind from no mind at all is sheer magic." And, on the basis of these two points, they also agree, in Hartshorne's words, that " 'mind' is not confined to a corner of nature but is everywhere in it, just as behavior is." And on all these points they are at one with Whitehead.

However, they do not agree with each other on every topic. I will point out four topics upon which there are differences among the three men, and upon which one or more of them is in disagreement with Whitehead: (1) The use and meaning of 'panpsychism'; (2) the mind-brain relation; (3) freedom and determinism; (4) philosophy and science. Hartshorne's position on the latter three points is close to Whitehead's, so the statement of his position can be taken as a statement of Whitehead's. However, in regard to the first issue, a distinction between them must be made.

1. *The Use and Meaning of 'Panpsychism.'* Hartshorne has used the term *panpsychism.'* But the term literally suggests that *all* things have or are psyches, while he (as well as Wright) stresses that only genuine individuals, not aggregates (such as rocks), have or are psyches. For this reason he now prefers the term 'psychicalism.'

However, Whitehead never uses the term 'panpsychism,' and his probable reasons for avoiding it would also apply to 'psychicalism.' He uses the term 'soul' (the translation of 'psyche') only for the series of dominant or presiding occasions in the higher vertebrates. There are hence three differentiating characteristics implied by his use of the term 'psyche' which make it inapplicable even to all individuals. A psyche is a series of (1) very high-grade occasions which (2) are the dominant occasions in an organism and (3) are ordered into a personally-ordered society. It is this high-grade society which is termed the soul. Accordingly, if 'psyche' is understood as Whitehead uses it, Whitehead is no panpsychist, or even a psychicalist.

However, sometimes the word 'panpsychism' is used to mean that all things, or better, all individuals, have minds. Whitehead uses the term 'mind' in four ways. Hence, deciding whether he is a 'panpsychist' in the sense of attributing mind to all individuals depends upon which of the four meanings of 'mind' is in view. In the first place, Whitehead sometimes uses 'mind' synonymously with 'psyche' (as in speaking of the mind-body relation); hence the considerations in the previous paragraph would apply here also. Second, Whitehead sometimes uses 'mind' to refer to a purely mental substance, one which has no essential connection with physical actualities, and as such is not essentially subject to efficient causation. This use of 'mind' does not refer to anything in his own system, of course, but is a purely historical usage. It applies to Descartes' view of the human mind. It applies also to

Leibnizian ‘monads,’ since they were not subject to efficient causation from other monads, and had no ‘physical’ properties. Hence, since Whitehead believes every actual entity is subject to efficient causation, he obviously is not a panpsychist in the sense of believing that all individuals are Cartesian minds or mental substances.

Third, some actual occasions have ‘intellectual operations,’ which involve consciousness. Whitehead says:

> The complex of such intellectual operations is sometimes termed the ‘mind’ of the actual occasion; and the actual occasion is also termed ‘conscious.’ But the term ‘mind’ conveys the suggestion of independent substance. This is not meant here: a better term is the ‘consciousness’ belonging to the actual occasion (PR 326).

This passage makes clear that Whitehead does not like to use ‘mind’ in this sense, since it suggests a Cartesian substance. But, more importantly, Whitehead does not attribute ‘mind’ in this sense to all genuine individuals, since some, indeed most, actual occasions are blind -- "‘blind’ in the sense that no intellectual operations are involved" (PR 326). Otherwise expressed, most occasions have no consciousness. Hence, in distinction from Wright, Whitehead believes the term ‘consciousness’ should be reserved for a very high-grade and rare form of experience.

However, there is a fourth sense in which Whitehead uses the term ‘mind,’ and in this sense he does attribute it to all actual occasions. Every actual occasion has ‘mentality,’ which for Whitehead simply means that it has an appetitive element, an aim towards the achievement of some value. Whitehead says:

> This subjective aim is not primarily intellectual; it is the lure for feeling. This lure for feeling is the germ of mind. Here I am using the term ‘mind’ to mean the complex of mental operations involved in the constitution of an actual entity. Mental operations do not necessarily involve consciousness (PR 130).

As this and other passages indicate, all genuine individuals (actual entities) have ‘mind’ in this sense, although it is a variable which is present only ‘negligibly’ or ‘in germ’ in low-grade individuals.

There is yet another possible meaning to ‘panpsychism.’ It could mean only that all actualities have or are experiences. This is the denial of what Whitehead terms ‘vacuous actuality,’ i.e., actual things which have no inner reality, and hence are not subjects for themselves, but are mere objects for others. Cartesian ‘extended things’ and Hobbesian atoms are examples. Whitehead denies all such vacuous actualities, affirming instead that all actual entities are ‘occasions of experience.’

The conclusion of this discussion is that Whitehead’s position can be legitimately called panpsychism, if this means attributing experience to all genuine individuals, and also if this means attributing ‘mentality’ to all of them (with the proviso that the mentality may be present only in germ.) However, since Whitehead did not use the term ‘panpsychism’ himself, and rejects most of its normal connotations, it is probably more confusing than helpful to use it or any other derivate of ‘psyche’ to describe his position. Insofar as a short-hand term is needed, ‘panexperientialism’ would be better, as long as the ‘pan’ is taken to refer to all genuine individuals. In the ensuing discussion I will sometimes use this term to refer to the position which Wright, Hartshorne, and Rensch hold in common with Whitehead. When ‘panpsychism’ is used, it is used as a synonym for panexperientialism.

2. *The Mind-Brain Relation.* Whereas all three men are, with Whitehead, panexperientialists, they differ on the whole-part constitution of experiencing things. One aspect of this difference is a difference on the relation between the human mind and the brain. Hartshorne’s position is closest to Whitehead’s, while Rensch’s is most removed.

Rensch distinguishes between protopsychic phenomena, which he attributes to inorganic entities, and *real* psychic phenomena, which arise out of certain systemic relations among protopsychic entities. The whole which has the real psychic qualities does involve integrations of the protopsychic qualities, but is not thought to involve a new entity in which the psychic qualities are located, and which might be thought to interact with its parts. The relation between ‘mind’ and ‘brain’ is analagous. Psychic qualities of the human type arise out of the systemic relations among the parts of the brain. But the ‘mind’ is not a new entity which emerges which might then interact with the brain. Rather, brain and mind are numerically identical; ‘mind’ is the name for the brain processes as experienced from within.

Hartshorne and Whitehead believe that some ‘wholes’ are indeed aggregates, whose properties are due entirely to the properties of the parts and the relations among them. But they believe there are other types of wholes, in which a new level of actual entity arises out of the systemic relations among the parts. For example, the living cell is not analyzable exhaustively into its inorganic parts (molecules, atoms, etc.). There is also a series of living actual entities, which have a more complex type of experience than do the inorganic entities. The difference from Rensch’s position is subtle: it is agreed that the peculiar experiential qualities of cells are dependent upon the systemic relations among the parts, and it is agreed that the higher-level experiences are integrations of the data provided by these parts. The difference is that a higher-level ‘stream of experiences,’ as fully actual as the lower level ones, is thought to emerge out of the systemic relations. And this higher-level series of experiences is thought to have its own causal efficacy, which can influence the enduring parts upon which it is dependent.

The relation between the mind and the brain is understood analogously. The brain is composed of myriads of cells with complex systemic relations. Each cell has its own experience. ‘Mind’ is a word for that stream of experiences which integrates data (feelings) from the cells into higher-level occasions of experience, some of which attain consciousness. The mind, while not being an ontologically different type of individual than the cells, is numerically distinct from them, and can thus be thought to interact with them. Its integrations of data received from the cells constitute new experiences which provide data (feelings) which can in turn affect the cells.

Rensch is not animated primarily against this kind of interactionism. Most of his arguments against interactionism are directed against a dualistic form of it. He does offer one argument which would apply also against a panexperientialist interactionism. But, as Hartshorne mentions in his "Response" to Rensch’s paper, the latter conceded in conversation that measurement could not be precise enough to press this argument.

3. *Freedom and Determinism.* The issue of freedom and determinism is the one on which disagreement is strongest. Rensch affirms classic determinism (see Rensch 1971a and 1974, as well as his "Responses" to Plamondon’s and Koestler’s papers). For him, the attribution of ‘mental’ characteristics to entities does not imply attributing self-determination to them. Wright, on the other hand, virtually identifies the two issues, speaking of "the adoption of dual-aspect panpsychism in place of determinism." This accords with Whitehead’s view, for whom the

'mental pole' of an entity is that entity's self-determining operations. As stated above, Whitehead attributes 'mentality' in this sense even to the lowest-grade individuals.

However, the dramatic difference from Rensch's determinism results only when this attribution is combined with the different view on whole-part relations discussed above. Whitehead believes that the mental pole of low-grade entities is negligible. Furthermore, whatever iota of freedom there is in low-grade individuals is cancelled out in aggregates in which there are large numbers of individuals without any higher-grade individual to coordinate their spontaneities. Hence, a significant degree of freedom emerges only because of the emergence of higher-level actualities with non-negligible self-determination. The behavior of macroscopic entities, such as human beings, is free to a significant extent, due to the fact that such a higher-level actuality, the mind, has a significant degree of causal efficacy back upon the body. Whitehead expresses terminologically the significant degree to which the mind controls the body by referring to moments in the stream of human experience as 'dominant' occasions of experience. Wright's paper, and Hartshorne's even more clearly, reflect Whitehead's position on this issue.

4. *Philosophy and Science.* If a scientist held a panexperientialist philosophy of nature, rather than a materialistic view, should this have any implications for his work as a scientist, e.g., in methodology, in the interpretation of results, or at least in the choice of projects? Rensch's version of panpsychism would not seem to have any such implications, and his paper does not discuss this issue. Hence, I will limit this discussion to a contrast of Wright's position with that of Hartshorne and Whitehead.

Wright mentions that a scientist's panpsychist beliefs might suggest certain research topics to him. But otherwise he believes that one's scientific work should be kept separate from one's philosophy of science. In particular, one's view that all individuals have a subjective side, and exercise free choice, must not be allowed to influence one's scientific procedure or interpretation. One must presuppose determinism (even though science itself has now revealed it to be only statistical), and all 'subjective' terms must be excluded from attempts at precise scientific formulations.

Hartshorne agrees that the advantages of panexperientialism are primarily philosophical, in helping one achieve a unified view of reality in which the results of science are coordinated with aesthetic, ethical, and religious values. However, he also believes it can be helpful to science as such. Although he suspects that the nature of this help is largely for the future to disclose, he does suggest some presently recognizable advantages of thinking of all individuals as having subjective or experiential qualities.

The difference between the two men here rests upon a different understanding of science. Wright holds that it deals not with things in themselves, but with the contents of the minds of normal observers, and in fact only those contents which are verifiable by other persons. Hence, all subjective aspects must be excluded -- even though as a panpsychist one believes the subjective to be the primary reality. As a scientist, one does not use one's own immediately known psychic characteristics to interpret other beings. Hartshorne does not believe that science is limited to a purely behavioristic viewpoint. The scientist *qua* scientist could use subjective notions such as memory, feeling, anticipation, and purpose to explain the behavior of individuals.

This difference is in turn based upon a more basic difference. Hartshorne believes that the scientist should be trying to *explain* the behavior of the various phenomena studied. In his list of advantages he refers primarily to the possibilities 'psychicalism' gives for understanding causality (both efficient and final), and hence for explaining *why* things behave as they do. Wright believes that the task of science is simply to describe, not to explain. Hence, while he agrees with Hartshorne that explanation requires subjective notions, he does not see a need to introduce such notions into science.

Hartshorne is here in fundamental agreement with Whitehead. The latter does in places say that science's methodological exclusion of all subjective characteristics, such as feeling and final causation, is justifiable, as long as it is recognized as a method that deals with only part of the evidence (MT 154-156; FR II). However, he also suggests that the categories used by science in the past four centuries are not irreformable, and that these categories have now become too narrow for science itself. He believes that this is true in physics as well as in the biological sciences (SMW 97, 121-122). In particular, he believes that the fact that the human mind is now considered a genuine part of nature, thanks to the theory of evolution and the science of physiology, means that the categories needed to describe it should be generalized to other natural unities. And he believes that this expansion is needed if science is to fulfill its original motivating drive, which is to find *explanatory* descriptions of the facts of reality. In his view, without the drive to find satisfactory explanations, the scientific mentality would never have developed (Al 161-164; MT 148-149).

EXPLANATION OF SYMBOLS FOR WHITEHEAD'S WORKS

AI *Adventures of Ideas.* Macmillan, 1933.

FR *The Function of Reason.* Princeton University Press, 1929; Beacon, 1958.

MT *Modes of Thought.* Free Press, 1966.

PR *Process and Reality*. Macmillan, 1929.

SMW *Science and the Modern World.* Macmillan, 1926.

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Mind in Nature: the Interface of Science and Philosophy by John B. and David R. Griffin Cobb, Jr.

Part 4: Mind and Organism

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Chapter 1: Some Main Philosophical Issues in Contemporary Scientific Thought by Ivor Leclerc

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I.

The philosophical issue which is quite fundamental to scientific thought is that of the ultimate nature of the physical. It is necessary today that this issue be very much to the fore because the course of scientific development in the last hundred years and more has rendered unacceptable the conception of the physical which had dominated scientific thought since the seventeenth century. In particular this issue is of primary importance to the consideration of the philosophical problems involved in biology, the topic of this book.

The most effective approach to this fundamental issue at the present time is to start with the conception of the physical which has determined modern scientific thought until this century. To become clear about that conception is also important because there is still a very considerable carry-over of features and aspects of that conception in contemporary scientific thinking as tacit presuppositions, presuppositions which are inconsistent with the new conception of the physical now requisite and in our time in the process of formulation.

Modern science was grounded in the seventeenth century in a radically new conception of the physical, the conception of the physical as 'matter.' It is of crucial significance for scientific thought today to appreciate what is entailed in that conception of the physical. The concept of 'matter' goes back to Aristotle,[1] and throughout the entire medieval epoch until the beginning of the modem period the Aristotelian conception persisted of 'matter' as the correlative of 'form' in the physical existent. That is, 'matter' meant one ingredient in the physical existent, that which is formed, that which is the recipient of definiteness -- as such it itself being without any definiteness or character; the other ingredient was 'form,' that whereby the existent was 'what' it was, with a particular definiteness as this or that. Further, in medieval thought it was explicitly maintained that the component which is 'matter' was sheerly *passive* -- 'matter' was a passive recipient, a merely passive potentiality for 'form'; by contrast all *activity* or *agency* was ascribed to 'form.'[2]

The great philosophical innovation of the seventeenth century was to conceive 'matter' as *per se* the physical existent; 'form' was separated from matter to become an independent, mental or psychical, existent. This dualism of all existence into two ultimate kinds, physical and mental, has been determinative of almost all thought since that time. It is a doctrine which today needs to be subjected to searching scrutiny. What is of immediate significance to us is that, in conceiving the physical existent as 'matter,' seventeenth-century thought accepted and carried over as the essential connotation of 'matter' (which is indeed grounded in the etymology of the term[3]) what it had been in the medieval epoch, namely of sheer *passive potentiality*. Thus in the modern conception, the physical existent as 'matter' was in itself completely devoid of *activity* or *agency* -- it was strictly 'inert,' as Kepler was the first to characterize it; it was *'movable'* but could not move itself, as Newton insisted. Since the physical as 'matter' was without activity, this entailed that it was in itself changeless, i.e., without any internal change, and thus incapable of any process of 'becoming.' The only change possible in respect of the physical as 'matter' was a purely external change of place, i,e., of *being moved* from one place to another.

But the result of the development of science has been that in this century there has occurred a *de facto* abandonment of that early modern conception of the physical. It is now on the whole implicitly or explicitly accepted in the basic sciences that physical existents are somehow and in some respect 'active.' This, as Whitehead among the earliest clearly appreciated, amounts to a radical change in the philosophical conception of the physical, a change indeed no less radical than had been the introduction of the conception of the physical as 'matter' in the seventeenth century.

The fundamental philosophical implication of the contemporary scientific development, as Whitehead perceived, was the rejection of all which was entailed in the concept of 'matter.' That concept had implied that the physical existents were sheerly passive, in themselves changeless; the necessity today is to conceive physical existents as 'active,' as in a process of becoming. Secondly, the concept of the physical as 'matter' implied that physical existents are capable only of undergoing locomotive change, and accordingly the science of physics had understood physical existence solely in terms of bodies in motion. The conception of the physical as in a 'process of becoming,' on the contrary, entails other kinds of change in addition to locomotion, kinds which are not reducible to locomotive change. This opens up new vistas for the understanding of physical existence which, as Whitehead saw, bring the sciences of physics and biology much closer together than had been possible on the antecedent conception.

II.

The general philosophical problem of the nature of the physical has to be articulated into a number of more special, interconnected problems. This had been clear to the more perspicacious thinkers of the seventeenth century, such as Descartes. It was seen that there was the problem as to what precisely was entailed in the conception of the physical as 'matter' in respect of the diverse plurality of entities in which the physical manifests itself. It was not sufficient to maintain simply that they were all 'material.' For in some respect there is a difference in status among these entities. The problem of this difference in status had come to the fore toward the end of the first quarter of the century as a result of the rejection of the medieval Aristotelian conception of organic entities as constituting unitary wholes and as such identifiable as primary physical existents.

In the early seventeenth century the conviction had grown that these wholes, of which living organisms were the paradigm instances, were not integral wholes but were rather composites, strictly aggregates -- which is to say that they were wholes which were no more than the sum of their constituents. Thus, it was maintained, it was the ultimate constituents which had to be conceived as the true primary physical existents. These were conceived as the ultimate units of matter, in themselves not further divisible, i.e., 'atomic' in the etymological sense of the term. Since the material atoms were the primary physical existents, it meant that all other entities had the derivative status of mere aggregate collections, their features as composites being no more than the arithmetical sum of the features of the constituents.[4] This was incontestably demonstrable, it was thought, in experiments in mechanics, in which it made no difference what mass of matter was used, for the laws of motion were indifferently exhibited by all composites; clearly therefore these laws must hold too for the indivisible atomic constituents of those composite bodies.

Thus, in terms of this theory, the philosophical problem concerning the status respectively of the plurality of entities received a relatively simple solution. This was to conceive all entities as divided into two groups, the one constituted by all the primary physical existents, the atoms of matter, and the other constituted by all the various aggregate composites of the primary existents.

Although this theory of material atomism came to dominate by the end of the seventeenth century -- and continued to do so completely until the present century -- we should take account of the alternative theory of Descartes in order further to elucidate the philosophical problem of the status of the plurality of entities. Descartes regarded the theory of material atomism as involving insuperable difficulties, such as that of divisibility, difficulties which he was able to avoid with a very different conception of the physical as 'matter.' Descartes maintained that the physical *per se* was constituted by one entity, a one *res extensa;* that is, there was one ultimate physical existent, a single 'matter' indefinitely extended and indefinitely divisible. The plurality of entities, the bodies which are the subject-matter of the science of physics, he conceived as derivative from the one *res extensa* or matter, constituted by the differential locomotion of parts of the one ultimate *res extensa*. Thus, despite his difference from the theory of material atomism, Descartes similarly divided all entities into two basic groups, in his case a one primary physical entity, and the group constituted by all derivative entities, the plurality of bodies which, he agreed, were composites of varying degrees of complexity by reason of the differential motion of their constituent parts. Both Descartes and the material atomists were agreed that the character of all composites was no more than the arithmetical sum of their parts, and that the character of composites was accordingly exhaustively analyzable and understandable in terms of the locomotion of the constituent parts. Descartes, for example, explicitly regarded human and animal bodies as complex machines. That is, biological organisms had a status no different from any other composite.

III.

In the subsequent centuries scientific inquiry has revealed an increasing number and complexity of entities, but the philosophical problem of the relative status of these entities has been largely ignored. Yet the philosophical problem has become ever greater. For the diversity of entities -- in physics: atoms, electrons, protons, neutrons, positrons, etc., etc.; in chemistry: atoms and molecules; in biochemistry and molecular biology: highly complex structures of simpler molecules, and cells; in biology: again molecular structures, cells, structures of cells into organs, a vast variety of different kinds of organisms -- is not being conceived in these sciences as mere aggregates understood mechanically in terms of the locomotion of constituents. Rather it has become increasingly clear that composite entities are constituted by *relatednesses* or *patterns of relationship* among the constituents.

The *scientific* problem is the clarification of the relations of the entities constituting a composite, for example the number of constituents and the pattern or structure displayed in their relationship to each other. The *philosophical* problem is respecting the relations *per se*, to understand the nature of relations, and particularly those involved such that they result in just those composites with just those features exhibited by the composites. For example, consider the chemical theory of molecules as exhibiting definite structural relationships of their constituent atoms. The philosophical issue is that, since the particular features of the molecules (as gaseous, liquid, solid, as acid or alkaline, etc., etc.) are directly correlative to structural relationships, the composite wholes could not be the mere arithmetical sum of the constituents; ‘structural relationship' implies something more than 'arithmetical sum.' The philosophical problem is how 'structural relationships' and the features dependent upon them are to be accounted for.

This philosophical problem of the nature of relations drives us back to the more ultimate problem of the nature of the physical existents: what must be their nature such that they can have relations which are constitutive of structural composites? For example, what must be the nature of physical existents such that the composite, the molecule of water, not only consists of one oxygen atom and two hydrogen atoms, but that they are at a particular distance from each other and in a particular three-dimensional pattern? It is evident that this composite structure is completely inexplicable in terms of the physical existent conceived as 'matter.' For the concept of matter' contains nothing whatever whereby such a structural relationship could result. The locomotion of material particles might fortuitously eventuate briefly in such a geometrical pattern, but there is no reason whatever in their nature as 'matter' why they should continue in that pattern -- on the contrary, their *not* so continuing is what would follow from the concept of 'matter.' Also the conception of the constituent entities as 'matter' provides nothing whereby there could be what are termed 'valency bonds' between the atoms. It is evident that quite a different conception of the nature of physical existents is necessary.

Philosophically considered the conception of the physical as 'active' provides the requisite basis for the physical existents to be in structural relationship. Leibniz had seen this in the seventeenth century, and so had Kant in the next century (in his pre-critical writings). For if a relationship is to make a difference to the entities involved, as opposed to being purely 'external'[5] -- and such a difference is precisely what is involved in a 'structural relationship' -- then that relationship can only be effected by the *acting* of the entities concerned; since unless they act to bring about a relationship, any relationship which there might be would be entirely external, as it is in the case of the physical conceived as 'matter.' The fundamental acting of a physical existent must therefore be relational acting. This is what both Leibniz and Kant maintained. And this is what Whitehead has maintained in this century with his doctrine of 'prehension' -- acting for him is a prehensive relating. In terms of such acting not only is structural relationship accounted for, but also the phenomenon of 'bonds' between the entities.

IV.

We need now, with the conception of the physical as ‘acting,’ to return to the philosophical problem raised in Section II of the status respectively of the different kinds of entity. Specifically the question here is: which are to be identified as ‘acting’ entities in the primary sense -- as opposed to being only derivatively acting, that is, by virtue of the acting of the constituents of the entity in question? For example, are we to conceive chemical atoms as active in the primary sense while molecules are active only derivatively? But atoms, in current theory, are themselves composites; does this then imply that they too are derivatively active, it being their constituents, electrons, protons, etc., which are primarily active? But some at least of these constituents, e.g., protons, would themselves seem to be composite, so that by the logic of this argument the truly active entities must be identified with the ultimate constituents, those which are not themselves composite.

This position is very persuasive, and has been adopted by a number of thinkers, for example, Leibniz in the seventeenth century, Kant in the eighteenth, and Whitehead in this century. Whitehead’s ‘actual entities,’ like the ‘monads’ of Leibniz and Kant, are such ultimate acting entities. Thus this position, like that of material atomism, makes a basic distinction in status among entities between those comprising the ultimate constituents, which are ‘simple,’ in the sense of not being composites, and those which are composites. Further, in this position, as in material atomism, all composites are alike in philosophical status; that is, there are no fundamentally different kinds among them -- analogous to the difference in kind exemplified by constituents and composites -- which means that the diversity among composites is to be understood entirely in terms of degrees of complexity of relationships among the constituents.

The question must be raised as to whether the diverse plurality and character of composites is adequately explicable solely in terms of the acting of the ultimate constituents. Further, does that theory adequately account for complex composites as constituted by hierarchical structures of less complex composites, e.g., of structures of atoms to constitute molecules, of structures of molecules to constitute cells, of structures of cells to constitute a biological organism? Are such hierarchies of composites necessitated at all by the theory of actual (or acting) entities as solely the ultimate constituents, any more than it is by the theory of material atomism? In the case of the latter theory the fact of such hierarchies of composites is strictly gratuitous, as it is merely a state of affairs which is empirically found to be the case; in terms of that theory composites cannot be any more than pure aggregates. In the former theory, since acting is relating, composites are not mere aggregates; but is the fact of hierarchies of composites constituting more complex ones any more than a merely empirically discovered state of affairs? Why should there be such hierarchies? Is it necessitated by the constituents as relationally acting? That necessitates only that there be structured composites, but not *hierarchical* structures of such composites.

Yet the evidence of scientific research testifies to these hierarchies having an importance of a kind too great for their existence to be merely fortuitous. An alternative theory seems to me to be necessary to account for them. For such a theory, the first requirement is to reject the view of acting pertaining only to the ultimate constituents of composites. This opens up the way for a conception of composites as *per se* acting entities. I have elsewhere[6] propounded such a theory -- which can be only adumbrated here -- in which the actings of the constituents integrate to compose a single, higher-level entity, which *per se* as an integral whole acts relationally with respect to other such entities. An atom, composed of electrons, protons, etc., would be an instance of such a composite entity having its own agency as such, i.e., not derivatively from its constituents. Likewise molecules would be higher-level entities, *per se* the subjects of non-derivative agency. Still higher-level composites constituted of a hierarchy of lower level entities are biological organisms.

On such a theory, therefore, composites of various grades of complexity would have the status of being actual physical existents in their own right, and not as such ‘reducible’ to their ultimate constituents -- as in the theory of material atomism, molecules and biological organisms are reducible to the ultimate constituents.

V.

Closely connected with the foregoing issues is another set of philosophical problems. These have become of increasing moment with the developments of our time in molecular biology. The central problem is to explain the fact that some complex molecular structures come to have biological features.

This problem has, of course, been under consideration for the past hundred years and more, and gave rise to the theory of ‘emergent evolution.’ This concept of ‘emergence,’ however, philosophically considered, is no solution; rather it only more specifically raises the problem, namely of how emergence is possible. Now there is not only emergence *of* something, but also emergence *from* something. And with the dominance of the conception of the physical as 'matter,' this meant that what emerges are 'biological' entities *from* 'matter.' In terms of the physical as 'matter,' the biological entities could, however, not be fundamentally different in nature from their material constituents; that is, biological entities are intelligible purely in terms of their chemical constituents, which in turn are reducible to their 'physical' constituents, which is to say that biological entities are basically intelligible in purely mechanistic terms. This doctrine has been opposed by thinkers maintaining a doctrine of 'vitalism,' namely that biological entities, manifesting the feature of 'life,' are generically different, i.e., not reducible to 'matter.' Since, however, biological entities evidently have the 'material' entities as their constituents, it is inexplicable, on the given presuppositions, how the emergence of life is possible.

Other thinkers, recognizing the impossibility of the derivation of something with a generically different feature from what is completely devoid of that feature, have put forward a doctrine of 'panpsychism.' This involves a complete rejection of the doctrine of the ultimate existents as 'matter'; the doctrine maintains instead that they are fundamentally 'psychical' in nature. This had been the doctrine of Leibniz in the seventeenth century, and Leibniz saw the philosophical implications of this theory with great clarity. It entailed that bodies, equated with 'matter,' must be derivative from the ultimate psychical constituents as composites of them, all the characteristics of 'body' (extension, impenetrability, mobility, etc.) as well as the passivity of 'matter' being analyzable as features displayed by composites of such psychical existents in relation.[7] Apart from the particular difficulties in which Leibniz's theory is involved, such as that it has the consequence that all relations must be *phenomenal* (thus necessitating his recourse to God as the principle of pre-established harmony), the doctrine of panpsychism has a paradoxical consequence. This is that the 'physical' existent is essentially 'psychical' in nature.

Now a paradox betokens something amiss with the theory. The root trouble with it is that, although it intends to overcome the consequences of the ontological dualism introduced in the seventeenth century, it proceeds by tacitly accepting that dualism. For it is that dualism which had elevated the psychical or mental into the status of an independent existent; and panpsychism proclaims this to be the only kind of existent.

What is necessary in the situation today is a rethinking of the general problem of the nature of the physical, and, in getting clear about that, of the particular problem of the ontological status of the psychical or mental. That is, it is to be determined what kind of being or existence is to be accorded to the psychical or mental, and what therefore is its relation to the physical. A solution to this should enable us to explain how complex molecules are able to have biological characteristics.

VI.

The philosophical issue here -- and it is a quite fundamental one -- is whether the basic acting of an existent is, or can be, a psychical or mental act. That is, it is necessary to question the ontological thesis of Descartes -- which is in fact a Neoplatonic one, going back to Plotinus in the 3rd century AD. -- which has been the foundation of most modern philosophy. Descartes had maintained that the only act of being is an act of 'thinking'; physical existence in his doctrine is without any acting of its own -- it simply 'is,' by God's creative act. But the philosophical situation has been radically altered by recent scientific developments, which have demonstrated that the physical is in itself 'active.' The question we therefore today face is whether there are two ultimate and distinct kinds of acting, physical and mental -- that is, actings constitutive of two ultimate and distinct kinds of existent. I submit that molecular biology evidences to the contrary. The need therefore is for an alternative theory of the status of the psychical or mental.

We have seen that physical acting must be a physical relating, that is, a relating of one physical existent to another. This is what Whitehead was maintaining in his doctrine of 'prehension':[8] for him the basic acting of an actual entity is an act of 'prehending,' i.e., of 'grasping' another actual entity. He specifically termed this basic act a *'physical* prehension,' thus making terminologically explicit that for him the basic act is a physical relating.

Now in analyzing we necessarily employ general or universal terms -- here, 'acting,' 'prehending,' 'relating.' But what *exists* are individual instances, concrete, definite; that is, each individual relational acting has a very specific definiteness or character whereby it is *that* uniquely determinate, individual act, and distinguishable as such. There are two points being made in this. The first is that every 'act' is necessarily individual and *perse* unique; that is, by its nature as an 'act' it is there and then, and *that* act cannot be again -- which is to say that *it* is not repeatable; ‘repetition’ must necessarily consist in a numerically different act, with the same character or definiteness. For -- and this is the second point -- it is ‘definiteness’ which is universalizable, i.e., capable of being shared by many, for such a capability is precisely what constitutes the nature of the ‘universal’; as Aristotle said, "that is called universal which is such as to belong to more than one."[9]

This enables us to recognize a fundamental distinction between a physical act and a mental act. A physical act is an individual particular relating to another individual physical entity. A mental act on the other hand is concerned with the universal or general; it has the universal as its object. A mental act is a grasping of a universal character or definiteness. This was in fact clear early in the history of philosophy, whence mental acting was termed ‘conceiving,’ from *concipere*, to take hold or lay hold of, to take to oneself, to take in, take, receive. That is, in its original philosophical use, the term conceiving’ meant a mental ‘taking hold of’ the form of definiteness manifested in an individual existent. The abstract noun ‘conception’ means the act of conceiving and/or the fact of conceiving, i.e., of taking hold of and holding something in the mind, and thus frequently also connotes ‘what’ is so held -- in this being synonymous with ‘concept,’ or ‘thought,’ or ‘idea’ in its modern usage. ‘What’ is so held as a universal. Even when we speak of ‘conceiving’ an individual or ‘having a concept of’ an individual, we are conceiving that individual *in terms of* the universals which determine its definiteness or character.

There is a necessary relation of the mental to the physical act, in a twofold way. The first is that the definiteness which is conceived, i.e., grasped and held by the mental act, must initially be derived from the physical. This is indispensable if there is to be knowledge of the physical, as the history of philosophy of the last three centuries has made clear.[10] The second is that mental acting is required by the physical in the process of physical acting. The reason for this is that physical acting is not either simply fortuitous change nor is it a mere mechanical interconnection; physical acting as a relating is ‘directed to’ another entity, and this entails the factor of ‘end’ -- this is not a mere anthropomorphic projection; the concept of ‘end’ is implied in the concept of ‘acting.’ Now acting as directed to an end necessitates the mental, for ‘end’ cannot be involved without the mental. This means that the theory of mental acting as constitutive of a distinct and separate mental or psychical existent is untenable; mental acting must be seen as a factor or ingredient in the total physical existent -- which was

Whitehead's doctrine in conceiving the mental as one 'pole' of an actual entity.[11]

VII.

We are now in a position to deal with the problem of how it is possible for biological features to develop in complex molecules. Biological molecules -- -such as for example the DNA molecule -- are found to be complex structures of less complex chemical molecules. What distinguishes the biological molecules is not only greater complexity of structure, but certain features of activity not possessed by the less complex chemical molecules. Now activity can in no way arise from what is completely in itself devoid of activity. But we have shown that the conception of the physical as matter,' i.e., as devoid of acting, is to be wholly rejected. This means that the difference between the very complex biological molecules and the less complex chemical ones must be analyzed in terms of degrees in complexity of activity. Further, this higher degree of complexity of activity is bound up with the higher complexity of structure.

The factor which makes possible not only complexity of structure, but *any* structural relationship at all, is the mental acting which is ingredient in the physical existent -- structural relationship, as the outcome of inter-*acting*, entails the factor of 'end,' which necessitates mental acting. What is requisite to account for degrees of complexity of structure is conceptual origination in respect of ends, and this is precisely the function of mentality. For, as we have seen, mental acting initiates by conceiving, i.e., grasping, the definiteness of the physical, and holding it in abstraction in its universality. In its abstract universality the definiteness is a *possibility* for actuality. But every abstract definiteness, in its universality, is related to every other universal definiteness;[12] it is in the nature of mental acting to be able to grasp, conceive, an alternative definiteness. There is clearly a continuous spectrum of alternatives, and there must be degrees in mental capacity to conceive alternatives at varying 'distances' from any given definiteness.[13]

It is the conceiving of alternatives different from the past which enables physical acting to actualize changes in structural interrelationship and achieve greater complexity of structure. And greater complexity of structure in turn involves the possible conception of ever more complex alternatives, which can thus result in patterns of physical acting. Such structures of greater complexity accordingly are able thereby to have a range of alternative responses to environmental changes -- in contrast to the much more restricted and unvarying responses of which simpler structures are alone capable. It is this greater capacity for a range of alternative responses which constitutes the basis for the capacity for ‘adaptation’ to the environment characteristic of biological organisms, both in the sense of the adaptation of the organism to its environment, and the organism’s adaptation of its environment to it -- under the latter, basic is the inclusion of parts of the environment into its own complex structure as ‘food.’

VIII.

In conclusion I shall deal briefly with one more philosophical issue which is of the utmost moment for contemporary scientific thought. This is the problem of the nature of change involved in the physical, that is, the problem of motion, *motus*, what the Greeks called *kinesis*. In terms of the theory of the physical as ‘matter, as we have seen, only one kind of change is possible, namely locomotion, change in respect of place. But with the rejection of that theory of the physical, with on the contrary a conception of the physical as ‘active,’ we face a quite different situation respecting the problem of change.

To conceive ‘acting’ as basically analyzable into locomotive change -- as seems to be the tacit presupposition in much scientific thinking still -- is entirely inadequate. As we have seen, physical acting must be fundamentally a relating, and relating cannot be understood in terms of mere ‘impact,’ for this can result at most in only change of place -- and indeed, as was clear to thinkers like Descartes, Newton, Leibniz and Kant, on the conception of the physical as in itself passive ‘matter,’ even change of place could not occur upon mere impact, there being necessary also an ‘act’ setting the impacted body into motion. Physical acting conceived as a relating, as Kant particularly insisted, entails an internal change being effected in the other entity.

This means that fundamentally the ‘change’ entailed in the ‘acting’ of a physical existent cannot be essentially locomotive change; rather locomotive change must be seen as either only one aspect of the change involved in and constituting ‘acting,’ or as only the resultant of the change involved in ‘acting’-- the latter is the view of Leibniz and of Whitehead; I would myself incline to the former alternative. But this difference does not affect the important point, which is that the interrelatedness of physical existents is not to be understood as being essentially mechanistic.

This is not to deny that physical interrelationships can be conceived mechanistically. Today it has become most important to understand correctly the concept of 'mechanism.' To conceive something mechanistically is to conceive it in terms of locomotion. In the theory of the physical as 'matter,' the relations of physical entities can be conceived and understood *only* mechanistically, i.e., only in terms of their locomotive changes. In the conception of the physical as 'acting,' on the other hand, change of other kinds in addition to locomotive change are admitted, so that a mechanistic analysis must accordingly be only of an *aspect* of physical acting, which means that since it leaves out of account other aspects or features of change or motion, it is an *abstraction.* Of course there can be no disputing that for some purposes such abstraction is entirely legitimate and indeed necessary. But what has to be avoided is what Whitehead has called the 'fallacy of misplaced concreteness,' namely mistaking the abstraction for the whole concrete, in this case taking locomotion to be the only kind of motion or change.

For an understanding of the change or motion fundamental in physical acting, it is necessary to concentrate on that acting as producing structural relationships. This is clearly requisite in molecular biology, but it is not less so in chemistry. This emphasis on acting's producing structural relationships is also necessary today in physics; to put the primary emphasis on this instead of on locomotion will complete thc revolutionary transformation which has been occurring in twentieth-century physics.[14] This also basically alters the relation to each other of the sciences of biology, chemistry, and physics. In the earlier conception of the fundamental motion or change of the physical as locomotion, it was necessary to conceive biology as reductive to chemistry, and chemistry as reductive to physics. But with the different conception of physical change as acting necessitated today, the sciences of physics, chemistry and biology must be seen as concerned respectively with entities exhibiting different grades of complexity of structural interrelationship. These different grades of complexity will also represent different kinds of physical existents -- for such structures must be more than mere aggregates, as we have seen -- with distinct features. The biological kind, for example, by virtue of its structure's making possible the requisite degree of conceptual origination, is that having the characteristic of 'life.'

NOTES

1. But the term ‘matter’ is much later, and has a different etymology from the Greek *hyle,* a difference which has influenced the connotation of the term in later usage. See note 3 below.

2. This conception of ‘matter’ as essentially passive, with ‘form’ the principle of activity, is Neoplatonic, and doubtfully to be ascribed to Aristotle.

3. *Materia* means the stuff of which things are made, e.g., by a craftsman; it is the recipient of a form given to it. The word is from the same base as *mater,* mother; in ancient times the role of the mother in generation was thought to be merely the recipient of the new life sown in her, she herself contributing nothing to it. Cf. F. M. Cornford, *Plato's Cosmology* (1937), p. 187.

4. Cf. Newton, *Principia,* "The Rules of Reasoning in Philosophy" at the beginning of Book III.

5. Which means that it would be a relationship only to an external observer; as far as the entity itself is concerned, it is devoid of any relationship at all.

6. In my *The Nature of Physical Existence* (Humanities Press; 1972), ch. 24; cf. also "The Problem of the Physical Existent" in *International Philosophical Quarterly* IX (1969): 40-62

7. For a more detailed analysis of Leibniz's theory see my *The Nature of Physical Existence,* chs. 22-24

8. The term derives from *prehendere,* to grasp, seize, catch; cognate with , to take in, hold.

9. *Metaphysics,* 7, 1038b11.

10. Or should be seen not to have done so; this was quite clear to Kant -- cf. *Critique of Pure Reason,* beginning of Introduction.

11. Because the confusion still persists, it should perhaps be explicitly stated that the ‘mental’ does not entail ‘consciousness’ -- the latter is a

feature possible only for fairly high-grade mentality.

12. This is what Whitehead speaks of as its ‘relational essence’ -- see his chapter on "Abstraction" in *Science and the Modern World.*

13. I say ‘must be’ because we humans not only are not capable of conceiving *all* alternatives, but quite evidently differ quite considerably among ourselves in respect of the capacity to conceive alternatives. The range in diminishing capacity clearly manifests itself in the other primates compared with man, and on further down the scale in animal species. There is no intrinsic reason why this diminishing capacity should not extend indefinitely, to the simplest physical existents.

14. It seems to me that this is the direction in which the thought of David Bohm is going.

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Mind in Nature: the Interface of Science and Philosophy by John B. and David R. Griffin Cobb, Jr.

Part 4: Mind and Organism

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Chapter 2: Whitehead and the Philosophy of Science by Ann Plamondon and Response by Bernard Rensch

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At present there are two widely divergent schools of thought dominating the philosophy of science (see Hesse 1974, Introduction). The older school is generally referred to as the formalist, or the logical empiricist, tradition. Although members of this tradition[1] have rejected a thoroughgoing logical positivism, their position with respect to fundamental issues in the philosophy of science is in varying degrees indebted to positivistic doctrines. In general, this school can be characterized by its acceptance of a logic of science; that is, its members maintain that there is a logic with respect to such scientific activities as the testing of theories, theoretical explanation, and conceptual change.

The alternative tradition has been referred to as historical relativism (Popper 1970; Hesse 1974, Introduction). It is characterized by the rejection of a logic of science. The members of this tradition[2] base their discussion of fundamental methodological issues on arguments from historical examples. That is, with respect to those issues for which the formalist tradition describes a logic, these philosophers seem to deny the existence of a logical structure which transcends particular historical examples.

Many philosophers of science see merit in both traditions and cannot be placed within either. However, among these thinkers, few have seen importance in explicating a *general* logic of science. One philosopher who has insisted on the value of such a logic is Mary Hesse. In a recent work (Hesse 1974, pp. 6-7) she has defended the attempt to explicate a logic of science on the grounds that its function is three-fold: Such a logic (i) provides criteria for ‘good science’ and is thereby normative as well as descriptive; (ii) as normative, it can show the aim of methodology and the adequacy of methodologies in terms of fulfilling that aim; and (iii) it has as its principal aim understanding, not the suggestion of research techniques.

I am in agreement with Hesse in regard to the value and the function of a logic of science. At the same time, I wish to maintain that a logic of science cannot perform these roles unless it has itself received grounding in a more general, *viz.*, metaphysical, theory. I do not intend to attempt a lengthy defense of this thesis. I hope that it will be sufficient to note that an ‘understanding’ which falls short of understanding on the highest level of generality must be interpreted and criticized by this highest level. Such interpretation and criticism are necessary to show the interconnection of concepts on the lower level of ‘understanding’ and to show that these concepts do not involve incompatible presuppositions. In brief, I am suggesting that metaphysics has an essential role in the philosophy of science -- that of the understanding and the grounding of scientific concepts and methodology. That is, the fundamental concepts of a metaphysical system should give an analysis of the foundational concepts of the sciences in such a way that these concepts themselves provide a grounding -- a general logic -- of the methodology of the sciences.

To perform this task a metaphysics must itself be well elaborated and well criticized. Contemporary philosophy of science is in need of a metaphysics which has already met certain logical (consistency and coherence) and empirical (applicability) criteria. This paper takes as a premise that at present the metaphysics which has best met these criteria is a process metaphysics based on the system of A. N. Whitehead. The aim of this paper is to develop a logic of science from certain concepts elaborated in Whitehead's metaphysics. In what follows I refer to this logic of science as the 'process view.' I do not mean to suggest that all process philosophers would or should be in agreement with it. It is based on an interpretation of Whitehead. The term 'process view' was chosen because the concept of organism is central in my interpretation; Whitehead called his process philosophy the 'philosophy of organism.'

I find the organizing principles of this process view in its basic agreement with the formalist understanding of the doctrine of emergence. An elucidation of the agreement here, however, involves concepts which provide a context *for* an alternative which challenges the formalist position with respect to the logic of other key issues in the philosophy of science, *viz.*, with respect to the nature and status of laws, the role and justification of induction, the model of theoretical explanation, and the intelligibility of conceptual change.

In this paper I shall discuss the aspects of agreement in the formalist and process views of emergence, suggest the fundamental categories for philosophy of science which result, develop the process view based on these categories, and contrast this process view with the formalist view of laws, induction, explanation, and conceptual change.

I. Emergence

According to the formalists, emergence, insofar as this doctrine has validity, is a thesis about unpredictability: (i) the unpredictability in hierarchically structured wholes of properties at higher levels of organization from properties of lower levels of organization and (ii) the unpredictability in evolutionary development of later forms of organization from earlier ones (Nagel 1961, pp. 366-380). These two aspects of emergence usually receive independent treatment. For the process view, there is an important relationship between them. This relationship can best be considered after a discussion of the first-mentioned thesis.

Predictability and unpredictability refer to the possibility of deducing one set of statements from another. The statements which constitute the premises of the deduction are those describing the ‘parts’ of a ‘whole.’ The question is whether or not the properties of the parts (which differ from the properties of the whole they organize), in the specific relationship which organizes the whole, suffice for the prediction of the properties of that whole.

The formalist position is that there is unpredictability in at least two important senses. First, the deduction in question is not possible when the premises are constituted merely of statements about the properties of the parts in that relationship. What must be added are premises elaborating a theory which describes the behavior of those parts in forming wholes. That is, from a statement of a theory describing generally the potentiality of parts to organize wholes and the statement of the condition of a particular organizing relation, a statement describing a whole with particular properties can be deduced. Second, the conclusion as to the properties of the whole may follow from one theory about the potential behavior of parts and the organizing relation in question and yet may not follow from another theory (and the same organizing relation).

At first glance the process view of emergence does not appear to be primarily a thesis about predictability. Rather it seems to be an empirical theory about the modification of parts in forming a whole, or, more precisely, about the reciprocal relationships in wholes between the parts and the plan of the whole. Whitehead expressed this reciprocity of part and whole most clearly in *Science and the Modern World.*

The parts of the body are really portions of the environment of the total bodily event, but so related that their mutual aspects, each in the other, are peculiarly effective in modifying the pattern of either. This arises from the intimate character of the relation of whole to part. The body is a portion of the environment for the part, and the part is a portion of the environment for the body; only they are peculiarly sensitive, each to the modification of the other. This sensitiveness is so arranged that the part adjusts itself to preserve the stability of the pattern of the body (Whitehead 1925, p. 214).

The concrete enduring entities are organisms, so that the plan of the *whole* influences the very characters of the subordinate organisms which enter into it. In the case of an animal, the mental states enter into the plan of the total organism and thus modify the plans of the successive subordinate organisms until the ultimate smallest organisms, such as electrons, are reached. Thus an electron within a living body is different from an electron outside it by reason of the plan of the body. The electron blindly runs either within or without the body; but it runs within the body in accordance with its character within the body; that is to say, in accordance with the general plan of the body, and this plan includes the mental state. But the principle of modification is perfectly general throughout nature, and represents no property peculiar to living bodies (*ibid.,* pp. 115-116).

It seems possible that there may be physical laws expressing the modification of the ultimate basic organisms when they form part of higher organisms with adequate compactness of pattern. It would, however, be entirely in consonance with the empirically observed actions of environments, if the direct effects of aspects as between the whole body and its parts were negligible. We should expect transmission. In this way the modification of total pattern would transmit itself by means of a series of modifications of a descending series of parts, so that finally the modification of the cell changes its aspect in the molecule, thus effecting a corresponding alteration in the molecule -- or in some subtler entity. Thus the question for physiology is the question of the physics of molecules in cells of different characters (*ibid.,* pp. 215-216).

There is an important sense, however, in which these passages about modification are referring to the possibility of prediction. Since there is modification of parts to form wholes, the very possibility of explaining or predicting the properties of the whole by those of the parts depends upon a theory about the potential behavior of parts forming wholes, as the formalist interpretation suggests. Further, and still in accord with the formalist position, some theories will be inadequate to the explanation or prediction.

On the other hand, the formalist interpretation affirms the empirical situation emphasized by the process interpretation and lays down the logical structure for explanation and prediction required by this empirical situation.

It would seem, then, that there is a wide area of agreement between formalism and process philosophy about the doctrine of emergence. The most important points of agreement can be listed as follows:

1. Hierarchically structured wholes are not aggregates, because theories

about the parts of such wholes (taken individually) do not suffice to deduce their relationship in wholes. Wider theories are required for the deduction; these theories affirm the potentiality of parts to behave differently in and out of the various wholes they can organize.

2. Understanding of a hierarchically structured whole can be achieved by an understanding of its parts only when there is a theory explaining the relations of the parts in wholes. Such understanding is possible because the theory involves statements about the potential relationships of parts in the various wholes they organize. Then the behavior of a part in a given whole can be deduced from its full range of possible behaviors.

3. There is reciprocity in the determination of parts and whole; the parts determine the whole in the sense that the whole is an organization of the parts (the parts in interrelationship), but there is modification of parts according to the wholes they organize and thereby determination of the parts by the whole.

What is important in this agreement of formalism and process philosophy on the doctrine of emergence is that certain presuppositions become obvious -- presuppositions not explicit in a formalist philosophy of science, and indeed, not compatible with its anti-metaphysical stance. The chief of these is the internal relatedness of part and whole. The possibility of deduction (and thereby prediction) set out by formalism has taken account of the theses that parts have potential to act differently in different wholes, that parts are modified according to the wholes they organize, and that a complete description of parts involves reference to this modification. These theses entail that the interrelationship of parts is not distinguishable from their nature. Their possibilities for relationship are constitutive of their nature.

The internal relatedness of part and whole is not reflected in the formalist discussion of laws, induction, explanation, and conceptual change. Hence a logic of science structured on this internal relatedness will constitute a genuine alternative to the formalist logic of science.

II. Organism

In discussing the reciprocity of part and whole, Whitehead used the suggestive terms ‘organism’ and ‘environment.’ ("The body [whole] is a portion of the environment for the part, and the part is a portion of the environment for the body"; "The concrete enduring entities are organisms, so that the plan of the *whole* influences the very characters of the subordinate organisms which enter into it.") His usage here is clearly a stretching of the ordinary usage of these terms. I wish to suggest that an elucidation of these stretched meanings provides a framework for the discussion of the fundamental issues in the philosophy of science mentioned above.

Whitehead used the term ‘organism’ to refer to physical as well as biological entities. "Science is taking on a new aspect which is neither purely physical nor purely biological. It is becoming the study of organisms. Biology is the study of larger organisms; whereas physics is the study of the smaller organisms" (Whitehead 1925, p. 150). 1 think that there is sufficient evidence that the primary reference of this term is to wholes which are not aggregates. Such wholes, as we have seen, are reciprocally related to their parts. On this interpretation, ‘organism’ can refer to atoms, molecules, even ecosystems; for in each case, there is modification of the parts in accordance with the pattern of the more complex hierarchically structured whole.

This understanding of ‘organism’ makes clear the relatedness of emergence of properties of hierarchically structured wholes and emergence in evolution. Leclerc (this volume) has clearly shown that stability of hierarchically structured wholes (of a low or high level of complexity) is incompatible with the understanding of such wholes as aggregates (see also Leclerc 1972, Chs. 23 and 24; Bohm 1969; Bronowski 1970). This very stability, in turn, is a necessary condition for emergence in evolution. Evolution involves the development of "complex organisms from antecedent states of less complex organisms" (Whitehead 1925, p. 157). But there can be no development of more from less complex on an aggregate view of wholes. An aggregate is no more or less complex than the entities by which it is constituted. An organism composed of subordinate organisms, on the other hand, can display increasing complexity because a new order comes about in the organization.

The presuppositions underlying the unpredictability of properties at higher levels of organization from lower levels (internal relatedness of whole and parts) make possible the development of later forms of organization from earlier ones. Process philosophy is, however, in agreement with formalism with respect to the unpredictability of later forms of organization from earlier ones.

III. Environment

‘Organism’ and ‘environment’ are correlatives. Hence the understanding of ‘environment’ cannot be separated from that of ‘organism.’ Whitehead’s uses of ‘environment’ cluster around two senses, both of which make essential reference to ‘order.’ (1) ‘Environment’ refers to the order expressed by organisms and the order pervading organisms. ‘But the character of an environment is the sum of the characters of the various societies of actual entities which jointly constitute that environment" (Whitehead 1929, pp. 168-169). "The environment automatically develops with the species, and the species with the environment (Whitehead 1925, p. 161). (2) ‘Environment’ refers to the order necessary to sustain order. "Any actual occasion belonging to an assigned species requires an environment adapted to that species, so that the presupposition of a species involves a presupposition concerning the environment" (Whitehead 1929, p. 314). "Also survival requires order, and to presuppose survival, apart from the type of order which that type of survival requires, is a contradiction" (Whitehead 1929, p. 311).

Both senses of ‘environment’ seem to be another mode of stating the reciprocity of whole and parts. They are referring to the internal relatedness of organism and environment. The order of the environment is determined by the organisms it sustains, and the organisms could not remain in (that state of) existence without the order provided by that environment. Each is what it is because of its relationship to the other. Further, what constitutes an environment on one level of abstraction may be an organism to a wider environment. That is, it may contribute to the characteristics of wider environments whose order is necessary for its continued existence. The implication is that there are layers of environmental order.

It seems that the senses of ‘environment’ may be expressed in the following meaning: environment’ refers to the order obtaining in a finite spatio-temporal region relevant to the existence of more special structures of order.[3] It is clear that Whitehead intended ‘environment’ to be defined in terms of order. It is also clear that an environment is finite; this follows from his conception of order. Order and disorder are correlatives; order is never complete, merely dominant in some region. It is the reference of order to a finite region that constitutes the justification of setting limits to a consideration of environmental influences. With this understanding of ‘organism’ and ‘environment’ in hand, I wish to turn to the development of the process view of laws, induction, explanation, and conceptual change.

IV. Laws

The formalist tradition in the philosophy of science has maintained some version of the view that a law-like statement is of universal form, capable of being put into conditional form. A true law-like statement is a law (Nagel 1961, Ch. 4; Hempel 1966, pp. 54-58). It is maintained, however, that such a characterization is inadequate to demarcate laws as different in kind from accidental generalizations -- statements such as "All the rocks in this box contain iron" and "All the screws in Smith's present car are rusty." Hence a set of criteria is required to mark off laws from such accidental generalizations. It is generally agreed that the list of criteria supply some necessary, but not sufficient, conditions for demarcation.

Many criteria have been proposed for marking off laws from accidental generalizations. Space prohibits consideration of more than a sampling of the most frequently mentioned criteria, *viz.:*

(i) Laws are unlike accidental generalizations in that they make no reference to particular places, times, and objects, or are derivable from more fundamental laws which do not make such reference (Hempel and Oppenheim 1948, p. 156; Achinstein 1971, p.30).

(ii) Laws are unlike accidental generalizations in possessing unrestricted generality (Hempel and Oppenheim 1948, p. 156; Nagel 1961, p. 59; and Achinstein 1971, pp. 26-27).

(iii) Laws are unlike accidental generalizations in supporting subjunctive conditionals (Hempel 1966, p. 56; Nagel 1961, pp. 68-72).

(iv) Laws are unlike accidental generalizations in that they function differently (in an explanation) and we therefore have a different attitude toward them (Smart 1968, pp. 63-64; Nagel 1961, pp. 64-66; Achinstein 1971, pp. 46-48; Scriven 1961, p. 100; Pap 1962, pp. 301-305; and Braithwaite 1953, p. 11).

A consideration of these criteria will be simplified if another kind of statement is added to this discussion -- that of a biological generalization, such as "Albinotic mice always breed true" or "All living matter contains DNA." Biological generalizations have been considered by some philosophers of science as different in kind from laws because of the failure they seem to share with accidental generalizations to meet the conditions for law-likeness (Toulmin 1953, Ch. 2; Smart 1963, pp. 52-57 and 1968, p. 92).

Criteria (i) and (ii) are logically related. The mention of particular places, times, objects guarantees the restricted relevance of a statement to a particular spatio-temporal region and thereby the restricted generality of that statement. According to the process view, these criteria cannot demarcate laws, biological, and accidental generalizations because all of these statements implicitly refer to some environment. The environment referred to by accidental generalizations is the most special. For example, the order which must obtain for a generalization such as "All the screws in Smith’s present car are rusty" to hold true is very special indeed. The order presupposed for biological generalizations to hold is less special and that for laws less special still; but an environmental order is presupposed for all. Hence there is an implicit reference to environments and thereby a reference to particular spatio-temporal regions of varying generality in all of these statements. It seems, then, that laws as well as biological and accidental generalizations fail to meet criteria (i) and (ii).

The distinction intended by criterion (iii) can perhaps be clarified by considering the purported differences in the relationship between a law, a biological generalization; an accidental generalization and their corresponding subjunctive conditionals. It is claimed, on the one hand, that "All freely falling bodies fall with constant acceleration" supports the subjunctive conditional "If a body were a freely falling body, it would fall with constant acceleration." On the other hand, the biological generalization "All ravens are black" does not support "If an organism were a raven, it would be black," and the accidental generalization "All the screws in Smith’s present car are rusty" does not support "If a screw were a screw in Smith’s present car, it would be rusty" (Nagel 1961, pp. 68-69). But this distinction also loses validity when the concept of environment is taken into account. The failure comes about because the truth of the subjunctive conditional involves an environment wider than that to which the biological generalization and the accidental generalization are known to apply. It may well be that the conditions of this wider environment are capable of supporting counter-instances to the biological and accidental generalizations and, hence, these generalizations do not support conditionals about this wider environment. This is to say that we believe the biological and accidental generalizations fail to support subjunctive conditionals because we believe we are unwarranted in extending these generalizations to environments for which we lack important information or to environments we believe to have importantly different features than the original environment. However, if we were making such an extension in the case of a law, we should have the same reservations. We believe the subjunctive conditional to be supported by the law only when we assume the environment presupposed by the law to be so encompassing as to include the case of the subjunctive conditional. Hence it seems that criterion (iii) does not suffice to show that the laws and accidental generalizations are different in kind.

The difference in our attitude towards laws and accidental generalizations referred to by criterion (iv) is evidenced by the relationship of each to counter-instances. A law is not readily abandoned in the face of a counter-instance; an accidental generalization is readily abandoned. The reasons that laws are not abandoned are that laws belong to a theory or that the nature of their support makes abandonment difficult. These reasons constitute a reference to systematic import (Achinstein 1971, pp. 46-49; Nagel 1961, pp. 64-66). Laws belong to a theory and thereby systematize other basic uniformities. Laws are based on support other than instances falling within the scope of prediction of the law. Hence a law is not independent of other laws and its abandonment would require change in these laws. In brief the tenacity with which we hold on to a law is an indication of its place in the body of scientific knowledge at a particular time. In contrast, accidental generalizations do not systematize more basic uniformities and are not supported by the same Variety of evidence as laws. Hence abandoning accidental generalizations does not require widespread modification because these generalizations lack the systematic import possessed by laws. However, systematic import is related to environment; the systematizing power of a law depends on the environment presumed. We hesitate to abandon laws because, for a particular environment, they are useful in systematizing other uniformities. In another environment they may fail to systematize, and, in such circumstances, they would be easily abandoned. But it is difficult to maintain that biological and accidental generalizations do not systematize for any environment. Even though an accidental generalization is a low-level generalization and does not ordinarily systematize other uniformities, there is a sense in which it can usefully systematize phenomena in the special environment in which it holds. We abandon biological and accidental generalizations more easily because of the special-ness of the environment presumed; our reluctance to abandon laws is based on their usefulness in an implicit wider environment. Then a distinction in kind between laws and biological and accidental generalizations cannot be based on systematic import. Systematic import is relative to a particular environment, and the ease with which a generalization is abandoned depends on its usefulness and this, in turn, depends upon the specialness of the environment.

This sampling of the criteria should make it clear that the distinction between laws, biological generalizations, and accidental generalizations is a difficult one to define. Each of these statements presupposes a particular set of environmental conditions in order to hold; and when the notion of environment is made explicit, the usual criteria do not suffice to distinguish between them.

The process view of laws is able to account for the difference between laws and biological generalizations, on the one hand, and accidental generalizations, on the other, by the notion of dominant, but not complete, order in an environment. Accidental generalizations are either true or false. They are true if every organism mentioned in the generalization can be so characterized and false otherwise. A true accidental generalization is, in effect, descriptive of an environment without disorder. Laws, as well as accidental generalizations, depend upon the characteristics of the organisms in the environments for which they are formulated. Whitehead used the term ‘immanence’ to express this feature of laws. But although laws are immanent, they merely represent the dominant order of an environment. They do so because of the element of disorder in wide environments.

In contrast with accidental generalizations, the fact of disorder renders the terms ‘true’ and ‘false’ irrelevant to the characterization of laws. The dominant order referred to by a law can tolerate disorder up to a certain point and the law still systematize the organisms in the environment. For an accidental generalization, the failure of the organisms to exhibit the characteristic(s) referred to in the generalization renders it inapplicable because it is false. Yet the failure of organisms to exhibit the characteristic(s) of the dominant order of the environment described by the law need not render the law inapplicable.

On the process view, biological generalizations also represent dominant orders of environments. As theoretical biology advances, there is reason to believe that biological generalizations will be formulated which range over increasingly wider environments. However, since biological organisms require more special environments than do physico-chemical organisms, there is no reason for thinking that biological generalizations will come to represent dominant orders of environments as wide as those represented by physical laws.

The process view of laws is, then, that they are to be conceived as statements of the dominant characteristics of wide, or general, environments. The point at which an environment is wide enough for its dominant order to be described as a ‘law’ is more or less arbitrary. Any particular law is an abstraction of a dominant order on a certain level of generality from the total existing order. This is due to the fact that an environment is bound up with wider environments whose characteristic features are not those dominant in it. But, in turn, the characteristic features of the wider environments are abstractions. Hence even the most general laws are not universal but represent a dominant character of a particular level of a hierarchy of order.

Further implications for characterizing laws can be drawn. First, since there is disorder and laws represent merely the dominant environmental order, all laws should be conceived as fundamentally statistical in character. They are the ‘communal customs,’ the ‘large average effects,’ the ‘average regulative conditions’ to which Whitehead refers. Second, since laws are immanent and since neither the environment nor the organisms it supports are unchanging, an environment can become incapable of supporting the organisms it once supported. New dominant orders, capable of supporting new types of organisms can arise. Then it is clear that an order can pass out of dominance and new dominant orders can arise. Laws are, in brief, capable of evolving.

Hence the process view of laws conceives them as statements of dominant orders of environments. Since environments are finite spatio-temporal regions, laws are restricted and not universal.[4] Because of the disorder in any environment, laws are essentially statistical in character. Finally, since laws are capable of evolving, they are non-necessary statements (Cf. Bohm 1957, pp. 137-140 and pp. 146-152. See also Bohm 1969).

V. Induction

On the whole formalists have given priority to deductive reasoning in science. They have pointed out important reasons for calling the role of induction into question. Two general areas of issues are relevant to discussing the process view. First, the role of induction in theory formation is very much a matter of dispute. One problem that has been pointed out here is the occurrence of new terms in theories which are not found in the observational data (or lower-level uniformities) on which they are based and which they systematize. It is not clear how the introduction of these terms can be justified (Hempel 1966, pp. 14-15). Another difficulty is that theory seems to be prior to observation in an important sense, *viz.,* a theory is presupposed in ascertaining the relevant data, or uniformities (Hempel 1966, pp. 11-12; Popper 1963, pp. 46-47). These difficulties have led to a variety of positions about induction within the formalist tradition which range from the view that theory formation is not in its essence inference from particular to general (Goodman 1955, p. 68), to the view that there is no inference involved in theory formation, only conjecture (Popper 1963, p. 192; Hempel 1966, p. 15). The second area of issues concerns the problem of the justification of inductive inference. The formalist tradition conceives this problem tobe the justification of a general principle of induction (a principle which, in conjunction with observational data, could provide a deductive inference to the general conclusion). It is argued that all possible ways of justifying such a principle lead to difficulties: An empirical justification involves an infinite regress, while a metaphysical justification (one based on synthetic *a priori* categories) involves triviality or circularity (Popper 1959, Ch. I and 1963, p. 47). The charge of circularity seems especially appropriate to the conception of metaphysical method held by Whitehead. Whitehead maintained that the categories of speculative philosophy were in an important sense ‘generalizations’ from experience. In face of the apparent insolubility of the justification of a general principle of induction. formalists have limited the required justification to the role of induction in making valid inferences to predictions; this constitutes the "new riddle of induction" (Goodman 1955, p. 68).

The process view I am presenting takes the problems raised by the formalists to be genuine. Theoretical inference is not in its essence a generalization from particulars; it is not a general principle of induction which requires justification, but rather, a justifiable inference pattern. The process view approaches these problems by an application of the notions of organism and environment. The framework of organism-environment provides an explication not only of the role of induction in prediction, but also a role for induction in theory formation. That is, on the process view, inductive inference to theories and to predictions are essentially related.

The process view of induction takes the following passage from Whitehead (1929, p. 314) to set the solution to the "new riddle of induction": "Thus the basis of all probability and induction is the fact of analogy between an environment presupposed and an environment directly experienced." A reconsideration of the internal relationship between organism and environment will allow the development of a justifiable inference pattern based on this passage.

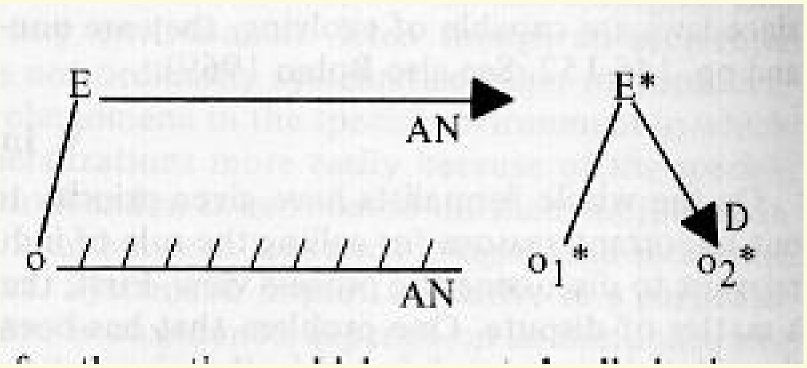
An inductive inference (such as that involved in theory formation) shifts reference from one environment (E) to another (E*). Each environment is necessary for the existence of its organisms. The organisms of E (o) cannot exist without the order provided by E, and those of E* (0*) cannot exist without the environmental order of E*. Hence an analogy between organisms of the different environments will provide a warrant for an inference as to the analogy between the environmental orders. Further, since laws are a statement of dominant environmental order, there is a context for inferring predictions about the behavior of other organisms in the environment to which reference has been shifted -- organisms not explicitly considered in the original analogies. The inference pattern can be schematized as follows (see Hesse 1968 and 1970; Plamondon 1973):

where E and E* represent environments;

AN represents an analogical inference;

/ / / / / / / / / AN represents an analogical relation; and

D represents a deduction from E* to predictions.



This inductive inference pattern fully accounts for the notions which suggested a limitation to the role of induction in scientific reasoning. First, new terms can be introduced in inference to theories because the laws constituting the theory are abstracted from an environmental order developed by analogy from another environmental order. Second, the induction to the new set of laws is not a generalization from particulars; the role of prior theory in guiding observation (of data or selection of uniformities) is accounted for. Third, it is an inductive inference pattern and not a general principle of induction that is being explicated. In addition to the explication of the inference pattern, the categories of a process philosophy of science provide for the justification of the inference pattern as well. Because of the internal relatedness of organism and environment, the positive analogy between organisms of the two environments justifies an inference with respect to the analogical relationship of the two environments. Inductive inference to theories is thereby justified. Prediction of the behavior of (as yet) unobserved organisms in the environment inferred to is grounded, ultimately, in the analogy between the environments. In brief, theoretical inference takes place by way of a model whose order is already known; the environment F is a model for the elucidation of E*.

The reference of the problem of induction to the organism-environment relation seems to me to be essential. Without the internal relatedness of organism and environment, no inductive inference can be justified. I take this to be Whitehead's meaning when he writes: "The question, as to what will happen to an unspecified entity in an unspecified environment, has no answer" (Whitehead 1929, p. 312).

VI. Explanation

The formalist view of explanation involves the ideal of deductive form (Hempel and Oppenheim 1948; see also Braithwaite 1953, Chs. l-2; Nagel 1961, Ch. 2; Popper *1959,* sec. 12). The explanans consists of statements of antecedent conditions and general laws. The explanandum is a description of the empirical phenomenon to be explained. There are three formal conditions and one empirical condition which must be met for an explanation to be given. The formal conditions are: The explanans deductively entails the explanandum; the explanans contains at least one universal law which is actually used in the deduction; and the explanans has empirical import. The empirical condition of adequacy is that the statements of the explanans have not been falsified. In addition, it is claimed that prediction has the same logical structure as explanation.

It is clear that the process philosophy of science as developed thus far cannot accept the deductive model of explanation. The model requires at least one universal law to be included in the explanans, yet there are no universal laws on the process view -- all laws are statistical in character.

The process view of scientific explanation can be developed from Whitehead's general understanding of explanation. He maintained that scientific explanation is to be conceived as a species of metaphysical explanation. They share a common aim, *viz.,* the understanding of facts (less general principles) in terms of general principles (more general principles). These explanatory principles are attained by a method Whitehead calls (descriptive) 'generalization.' This 'generalization' consists in the discovery of generic principles from a study of specific facts (or lower-level principles). Generic principles give 'synoptic vision.'

The method of generalization by which science and philosophy explain is easily given a negative characterization: This method is not in its essence deductive. Rather the role of deduction is in the verification process -- in testing the scope of the principles arrived at by generalization.

Whitehead's understanding of explanation adds further support to the impossibility of conceiving explanation in the process philosophy of science in terms of the deductive model. The essence of explanation is not deductive; the explanandum is not explained by virtue of being deductively derived from the explanans. The role of deduction is an auxiliary one bound up with confirmation. This was made clear in the explication of justifiable inductive inference on the process view. In this inference pattern the deductive inference is to predictions which test the proposed dominant order of an environment elaborated analogically, not deductively, from the model of another environmental order.

Any attempt at a positive characterization of generalization is hampered by Whitehead's occasional references to the impossibility of such a characterization. He uses such terms as 'self evidence' and 'direct insight' in describing this method. On other occasions, however, he seems to attempt a positive characterization: "Words and phrases must be stretched toward a generality foreign to their ordinary usage; and however such elements of language be stabilized as technicalities, they remain metaphors mutely appealing for the imaginative leap" (Whitehead 1929, p. 6). It is the notions of metaphor and the stretching of meanings which I find to be the key in a model of explanation for the process view. A view of scientific explanation as metaphorical has been developed as a supplement to the deductive model of explanation by some contemporary philosophers of science (Black 1962, pp. 25-47 and pp. 219-243; Hesse 1966, pp. 157-177; MacCormac 1971). 1 shall sketch the model they propose and then relate this model to the process framework of organism-environment.

According to the metaphorical view of explanation, there is a literal description of both the explanans and the explanadum. However, language is used metaphorically when words ordinarily used in the literal description of the explanans are transferred to the explanandum. In this transfer, the meanings of the terms of both the explanans and the explanandum undergo change; they come to be seen as analogous. Explanation consists in a metaphorical redescription of the explanandum. This view is not committed to the thesis that all metaphors explain. A necessary condition for a metaphor to explain is the existence of a positive analogy between the two domains (explanans, explanandum). The function of theory in an explanation is to pick out this positive analogy; theoretical concepts are metaphors in this sense. In the picking out of the analogy, there is a meaning shift which consists in an extension of meaning. This extended meaning corresponds to the generic meaning referred to by the process view of explanation by generalization.

The process view is a metaphorical view of explanation. The essence of explanation is not deduction but a 'synoptic vision' gained in finding generic categories from restricted fact or laws. The abstraction of such categories is based on analogy, yet involves new meaning. The ordinary usage of terms is stretched in the generalization. The stretching suggests application of the category beyond the facts or laws from which it arose. A coherent set of generic categories constitutes a theory. The theory is essentially an abstraction of analogies between systems. Theories in science abstract analogies between more special systems; metaphysical theories abstract analogies between more general systems, e.g., the sciences themselves.

The explanatory function of metaphor turns on the stretching of language by the metaphor. This stretching is made possible by analogy and makes possible new hypotheses. The necessary condition of analogy for the explanation links the metaphorical view of explanation to the process framework of organism-environment. This is because the inference potential of analogy is grounded in the internal relatedness of organisms and the environment which sustains them. This suggests that the stretching of language is dependent on the environment as well. In brief, this suggests that meaning is environmentally dependent.

The dependence of meaning on a presupposed environment explains how the stretching of meaning in a metaphor is possible. It is possible because the extended meaning depends, not upon the original environment presupposed for the original meaning, but upon a different environment presupposed for the stretched meaning.

The change in the presupposed environment brings with it changes in the presupposed dominant order. This shift in environmental order underlies the suggestiveness of the metaphor; the new dominant order makes possible new associations of terms -- associations not possible prior to the metaphor. Such associations were not possible because they were not included in the systematic associations of terms in the original environment. They are now possible because of such systematic associations in the new environment.

Hence the role of metaphor in explanation depends not only upon analogy, but also upon the more detailed specification of the presupposed environment brought about in the stretching of meaning by the metaphorical use of language.

VII. Conceptual Change

The formalists make a radical distinction between observational and theoretical language (Hempel and Oppenheim 1948; Nagel 1961, Chs. 2 and *5;* Popper 1959, sec. 12). Their view is that there is a fundamental observational language the terms of which have a fixed meaning. This thesis of fixed meaning is referred to as meaning invariance. The observational language is thought to be prior to and independent of theoretical language. The theoretical language, however, is dependent on the observational language; theoretical terms are given meaning by observational terms. Successive (or competing) theories do not, then, give a different meaning to observational statements.

This distinction allows conceptual change to be explained by the deductive model. An earlier theory is explained by its successor by deducing it from the later theory and statements about the domain of application. The deduction presupposes that the meanings of the terms of the two theories are fixed; the deduction could not be carried out if the meanings of terms changed in the successor theory.

The process view is incompatible with this understanding of conceptual change. This is because the concept of environment entails meaning variance. Meaning is environmentally dependent and varies with environmental variation. This constitutes a reversal of the formalist position in an Important sense. Observational meaning becomes dependent on theoretical meaning. The meaning of scientific terms depends on a theoretical framework.

It is clear that the thesis of meaning variance has implications for an understanding of conceptual change. What these implications are is, however, a matter of dispute (see Achinstein 1964; Feyerabend 1962, 1963, and 1970; Hanson 1958; Kordig l971(a) and 1971(b); Shapere 1964 and 1966; Shea 1971; Toulmin 1972). The radical interpretation currently under discussion (Kuhn 1970a and 1970b) is that a change of theoretical framework entails a change of meaning for every term in a scientific theory. Conceptual change is therefore ‘revolutionary.’

The difficulty in conceiving conceptual change as revolutionary is that this understanding seems to make conceptual change unintelligible. Serious difficulties arise with respect to how to conceive of the relationship of the ‘same’ term in successive theories. In particular, if the terms are discontinuous in meaning, it is not clear how one could ever come to understand the terms in the later theory.

The process view does not accept this radical interpretation of the implications of meaning variance. There is not an absolute discontinuity between the 'same' terms in successive theories. This follows from an understanding of the 'change' that takes place in an environmental change. The change can be understood as a displacement in the environmental order. Such displacement is a displacement with respect to the analogies and similarity relationships of the environment. This presupposes a connection with the order displaced. A discontinuity of order, on the other hand, would be a replacement of one order with another. Such replacement would constitute an unintelligible change.

On the process view conceptual change is based on an interpretation of meaning variance as a function of displacement in theoretical framework. In the displacement of a conceptual framework, the meanings of terms can be extended or stretched. This suggests that the model for conceptual change can be taken from the metaphorical model of explanation.

The view that explanatory categories in science are to be conceived as metaphors has built into it a mechanism for conceptual change by way of metaphor. The same features which account for the explanatory function of metaphor account for the possibility of intelligible conceptual change. These features are, first, the positive analogy of the term in successive theories and, second, the hypothesis-producing potential of placing the term from the earlier into the later displaced framework. Without the first, there seems to be no possibility of understanding the meaning of terms which appear in both theories. The analogies between the terms in the two theories make possible the understanding of the meaning of the term in the later theory. Withou.t the second, no sense can be made of a real change in meaning. The hypotheses suggested by this aspect of the metaphor lead to the development of the framework which gives the term its new meaning. The meaning is changed because the term has a different association with the other terms in the respective framework.

In contrast to the revolutionary view of conceptual change, the process view can make sense of the relationship of the 'same' term in successive theories. The meanings of the 'same' terms are given continuity by the positive analogy of the terms in both theoretical frameworks. It is just because of this analogy that it makes sense to use the same sign in both frameworks. The meaning of the term in the earlier theory is the basis for the extended meaning of the term in its successor.

The stretching of meaning in conceptual change is essentially the grasping of a clearer generic meaning of which the meanings in the earlier theory are species. Successor theories represent ‘synoptic vision’ with respect to meaning.

VIII. Science and Logic

In concluding I wish to emphasize that the process philosophy of science turns away from the deductivism of formalism. It conceives the logic of science as a thoroughgoing inductivism. This inductive logic is grounded in the fundamental process categories of organism and environment. The application of these categories gives an understanding to scientific methodology not only in the sense that these categories show an interconnection between the fundamental issues and a consistent logic of their solutions, but also in the sense that this methodology has itself been set within the framework of a metaphysical system.

NOTES

[1] For example, Carl Hempel, Karl Popper, and Ernest Nagel.

[2] For example, P. K. Feyerabend, N. R. Hanson, T. S. Kuhn, and S. Toulmin.

[3] In terms of Griffin’s distinction (below, pp. 123f.) of metaphysical and cosmological principles, I am taking ‘environment’ to be a metaphysical category. Any particular environmental order, however, is cosmological.

[4] Laws of nature on the process view are cosmological, not metaphysical, generalizations. See Griffin (next article.).

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RESPONSE TO PLAMONDON'S PAPER

By Bernhard Rensch

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I believe that we have not only to do with generalizations in biology, but also with a great number of *laws*. But in consequence of the enormous structural and biochemical complication of living beings, many laws thwart one another. Mendel's first two laws, for instance, are infringed by the law of mutation, which is valid in all animals and plants. In this way exceptions arise and we only speak of *rules*. In other cases the interaction of different laws is much more complicated. But it is possible to assume that ultimately *all* biological events are determined by laws, mainly by causal laws, in some cases by laws of probability (effective in gene recombination and mutation), the law of conservation of energy and the lawful acting of microphysical constants. We therefore have to do with a determination in a broader sense, a *polynomistic determination* (cf. my *Biophilosophy*, 1971).

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Mind in Nature: the Interface of Science and Philosophy by John B. and David R. Griffin Cobb, Jr.

Part 4: Mind and Organism

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Chapter 3: Whitehead's Philosophy and Some General Notions of Physics and Biology by David R. Griffin

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Many readers of this volume may find the Whiteheadian notions scattered throughout it helpfully suggestive, without being concerned with Whitehead's methodological justification for his ideas, or with the more precise understanding of his philosophy that can only be attained by learning some of his technical vocabulary. However, other readers may have these concerns. The present essay is written for them.

Alfred North Whitehead believed that there should be positive mutual relationships between metaphysical philosophy and the special sciences. He further believed that his own philosophy, which he called the 'philosophy of organism,' was more compatible with modern science than previous philosophies, and provided a more adequate set of fundamental notions for interpreting each of the special sciences, as well as their interrelations. His own applications were limited primarily to "the most general notions of physics and biology" (PR vi).

In the first section of this paper, I will discuss Whitehead's understanding of metaphysics and its relation to the special sciences. In the second part, I will sketch his procedure for drawing his fundamental categories from human experience and applying them to all of reality. [n the third part, I will focus upon some of the implications of his fundamental categories for understanding the objects of physics. In the fourth part, I will briefly point out how the previous ideas allow for a nonreductionistic biology which avoids dualism, including vitalism.

I. The Mutually-Beneficial Relations Between Metaphysics and the Special Sciences

Metaphysics is the endeavor to develop a set of fundamental categories in terms of which every element of our experience can be interpreted (PR 4). This means that it must develop a set of notions that will coordinate and thereby reconcile the more limited sets of ideas suggested by religion, ethics, and aesthetics, as well as the various special sciences (SMW ixf.; PR vi, 23). Furthermore, these special ideas must be made compatible with the 'common sense' or common experience of humanity as a whole. "those presumptions, which, in despite of criticism, we still employ for the regulation of our lives." These ultimate presuppositions of our 'practice' provide the final test (PR 19, 25, 229, 502).

The method of metaphysics is to begin with factors based upon one topic of human interest, such as physics or psychology, imaginatively to generalize those factors in such a way that they might apply to all fields of interest, and then to test these generalizations by trying to apply them to the facts in these other fields (PR 7f., 24f.). "In default of such extended application, a generalization started from physics, for example, remains merely an alternative expression of notions applicable to physics" (PR 8). Insofar as the application fails in other fields, the generalizations need to be reformed, and then tested again.

Because of its task, metaphysics must combine boldness and humility (PR 25). It must be bold by the very nature of its undertaking, to frame categories which all facts whatsoever must exemplify (PR 5, 67). And, if any progress is to be made, it must state its categorical scheme with precision and definiteness, in order that its implications can be clearly deduced and then confronted with the facts (PR x, 12, 13, 16). On the other hand, it must think of this categorical scheme as a working hypothesis and be humble before logic and the facts of experience (AI 286; PR 25). It is in terms of the second of these criteria that most philosophies exhibit misplaced boldness: "Failure to include some obvious elements of experience in the scope of the system is met by boldly denying the facts' (PR 9). Of course, Whitehead knows that "the appeal to the facts is a difficult operation," since the facts as stated are always interpreted in terms of some set of general notions. The "received notions as to fact" are in doubt as well as the new theory (PR 13). Accordingly, what from one set of notions may appear to be facts of experience that must be included within any adequate philosophy may seem, from another metaphysical point of view, simply a false verbal interpretation of the real facts (PR 16-18). Nevertheless, Whitehead believes that there are real facts independent of human interpretation (PR 18f.), that some of these are reflected in the common presuppositions of civilized humanity, and that philosophy, while it can never hope to state the ultimate generalities with finality, can make progress in approximating them (PR x, 6, 11, 13, 19, 20f.).

Science, then, aids metaphysics in two ways: it provides a possible starting point for its imaginative generalizations, and it provides some of the facts against which these generalizations are to be tested and reformed.

Each of the special sciences deals with one type of facts, and as such it does not make statements about facts lying outside that type (PR 14). Nevertheless, these sciences have a tendency toward overstatement, to assume that the categories as they have formulated them in terms of their special interests are adequate for interpreting all facts (PR 8). Even apart from this dogmatism, a special science will be likely to state its basic principles in a manner that will prevent their coordination with the basic principles of the other sciences, and with the presuppositions of religion, ethics, and aesthetics, as well as with other inescapable presuppositions of human 'practice.' For example, the scientific principles formulated in the 17th century were primarily based upon the current physics, and were such as to be unsuited to biology, due to the total displacement of 'final causation' by mechanistic explanation (SMW 60, 150; PR 128f.). This sometimes led to reductionistic doctrines which violate our experience of freedom and responsibility, which is "too large to be put aside merely as misconstruction" (PR 74). It also has led to outright inconsistency: "A scientific realism, based on mechanism, is conjoined with an unwavering belief in the world of men and of the higher animals as being composed of self-determining organisms" (SMW 110). Hence, both logic and the facts of experience are violated.

Accordingly, "one aim of philosophy is to challenge the half-truths constituting the scientific first principles" (PR 15). On the principle that all general truths form a coherent system, metaphysics suggests how the general principles of a given science might be reformulated so as to be compatible with the even wider generalities of metaphysics, and hence not to be in conflict with the general principles of the other special areas of interest (PR 15). This suggestion might take the form, for example, of changing the denial that the entities of physics have any capacity for self-determination to the assertion that this capacity is ‘negligible.’ Since the difference between a ‘zero amount and a ‘negligible’ amount of some capacity is a difference in kind, this change would in principle allow the entities of physics to be interpreted in terms of the same categories used for interpreting entities in which the capacity for self-determination is not negligible.

Accordingly, Whitehead does not merely say that science should avoid becoming ‘scientism’ by recognizing that there are dimensions of reality to which its categories do not apply. He also says that these categories themselves should be reformulated. In asking whether there are aspects in nature that fail to receive expression in science, he says:

> I ask this question in the interest of science itself; for one main position in these lectures is a protest against the idea that the abstractions of science are irreformable and unalterable. . . . Is it not possible that the standardized concepts of science are only valid within narrow limitations, perhaps too narrow for science itself? (SMW 121, 122).

To anticipate the remainder of this paper: what Whitehead has in mind here is "the shift from materialism to organism, as the basic idea of physical science" (PR 471).

Furthermore, insofar as philosophy helps a science reformulate its basic ideas, it may help it see facts previously unnoticed. A new set of fundamental principles might provide the basis for deducing the existence of some previously unnoticed factors. This aids the interrogation of experience: "The observation acquires an enhanced penetration by reason of the expectation evoked by the conclusion of the argument" (PR 13).

These two ways in which metaphysical philosophy can influence science are summed up in a discussion of the relation between specialism and common sense. While it is the task of the special sciences to modify common sense, "philosophy is the welding of imagination and common sense into a restraint upon specialists, and also into an enlargement of their imaginations" (PR 26).

Before concluding this discussion of the mutually-helpful relationships Whitehead advocated between philosophy and the special sciences, the relevance of the distinction between ‘metaphysics’ and ‘cosmology’ should be mentioned. Although *Process and Reality* is subtitled "An Essay in Cosmology," it is really a combination of metaphysics and cosmology. Metaphysical principles about actuality are those which are without conceivable alternative, and hence apply in this and every possible world (PR 138f., 441). Cosmology is the attempt to describe the present order of the world in terms of principles which are special exemplifications of the most general, i.e., metaphysical, principles.

Accordingly, disagreements with Whitehead’s thought can occur on different levels, and some types of disagreement would be more serious than others. A disagreement with one of his basic metaphysical doctrines would probably entail disagreement with the whole philosophy. Disagreements with the principle of relativity (that it belongs to the nature of every being to be a potential ingredient in the becoming of actual entities), the principle of process (that how an actual entity becomes constitutes what it is), or the ontological principle (that only actual entities can exert influence) would be of this type. But disagreements with other statements made by Whitehead might be irrelevant in regard to the viability of the central metaphysical theses, since more than one description of the contingent aspects of the present universe would always be consistent with the metaphysical principles. When he discusses "the hierarchy of societies composing our present epoch," he says he is "deserting metaphysical generality" and only "considering the more special possibilities of explanation consistent with our general cosmological doctrine, but not necessitated by it" (PR 147). And he refers to these discussions as "conjectures." Hence, one could well disagree with some of Whitehead’s personal cosmological conjectures (and advancing scientific knowledge will surely necessitate this) without disagreeing with any of his fundamental principles.

II. Human Experience and Metaphysical Principles

The basic idea behind Whitehead's entire enterprise is probably best expressed in this statement: "All occasions proclaim themselves as actualities within the flux of a solid world, demanding a unity of interpretation" (PR 22). This is the idea that rules out all dualisms within the actual world. It is self-evident to Whitehead that, if the perceived solidarity of the world -- the perceived fact that it all hangs together -- is to be made intelligible, there must be a set of interpretative principles in terms of which all actualities can be described. This is why it is necessary to develop a 'one-substance cosmology,' i.e., one in which there is only *one type* of actual entities (PR 29; cf. 28).

The fact that for Whitehead there is only one genus of actual entities means that he can in principle derive notions from any species of actual entities in order to interpret other species. Accordingly, if an electron and a human psyche are both considered examples of actualities, he could hope to use ideas derived from each one to interpret the other. And this is what he does (with the important qualification that psyches and electrons are both considered temporally-ordered *societies* of actual entities, a notion to be explained below).

If human experience is genuinely a part of nature, and if there be only one type of actual entity within nature (an idea whose truth-value must finally be verified heuristically), then, since it is that part of nature one knows most intimately, it provides the best starting point for finding principles that can be generalized to all actual entities. In fact, it provides the very standard of actuality (PR 219). This means that Whitehead believes that "Locke's account of mental substance embodies, in a very special form, a more penetrating philosophic description than does Descartes' account of corporeal substance" (PR 29). In this respect Whitehead is one with Leibniz. However, the description of physical things must also find its place, which it did in Leibniz's *Monadology* only subordinately. "The philosophy of organism endeavors to hold the balance more evenly. But it does start with a generalization of Locke's account of mental operations" (PR 29). Consistent with this starting point, Whitehead says: "The final facts are, all alike, actual entities; and these actual entities are drops of experience, complex and interdependent" (PR 28).

The fact that Whitehead understands human experience to consist in discrete ‘drops’ or ‘actual occasions’ of experience may be an example of the fact that Whitehead’s generalizations were developed from more than one starting point, in this case modern quantum theory as well as psychology. He says:

> It is equally possible to arrive at this organic conception of the world if we start from the fundamental notions of modern physics, instead of. . . from psychology and physiology. In fact by reason of my own studies in mathematics and mathematical physics, I did in fact arrive at my convictions in this way (SMW 219f.).

In spite of this reciprocal influence, however, it is clear that Whitehead’s fundamental categories are generalizations from human experience (PR 172). The purpose of this part of the paper is to describe the principles by which this generalization is carried out and justified.

The first thing to do, when turning from a description of the capacities of an occasion of human experience to that of the lower organisms, is "to determine which among such capacities fade from realization into irrelevance" (PR 172). The necessity for this determination is explained:

> Any doctrine which refuses to place human experience outside nature, must descriptions of human experience factors which also enter into the description specialized natural occurrences. If there be no such factors, then the doctrine of experience as a fact within nature is mere bluff. . . . We should either admit dualism should point out the identical elements connecting human experience with physical (AI 237).

Whitehead agrees with the traditional principle that philosophical "generalization must be based upon the primary elements in actual experience as starting points" (PR 240). But which elements in experience are *primary in the relevant sense?* The answer to this requires a look at Whitehead’s critique of dominant epistemologies.

These epistemologies have held that the primary elements in experience are *barren universals,* and that all other elements must be classified as derivative. For purposes of criticism, Whitehead divides this view, normally called ‘sensationalism,’ into two parts, the ‘subjectivist principle' and the sensationalist principle,' corresponding respectively to the notions that the primary data of perception are *universals,* and that the reception of the primary data is *barren.*

Regarding the former, Whitehead says: "It is impossible to scrutinize too carefully the character to be assigned to the datum in the act of experience. The whole philosophical system depends on it" (PR 238). Now, the 'subjectivist principle' holds that "the datum in the act of experience can be adequately analyzed purely in terms of universals" (PR 239). Universals are qualities such as blueness and triangularity which can be exemplified in many instances. In other words, according to this dominant view, no *actual* things are directly experienced, and of course no causal efficacy of actual things is experienced. If one who holds the subjectivist principle posits the reality of a world of actual entities spatially and/or temporally beyond the present moment of experience, and the reality of causal interaction among these entities, one does so solely on the basis of inference, not direct knowledge. There is not even one instance of direct acquaintance with such other 'actualities' and their 'causal efficacy' that can be used as an analogical basis for grounding the use of these terms elsewhere (PR 77). Accordingly, on the basis of the empiricist doctrine (which Whitehead accepts) "that nothing is to be received into the philosophical scheme which is not discoverable as an element in subjective experience," the subjectivist principle entails that the notion of causal influence between actualities must be dismissed (PR 253).

In the light of the principles mentioned in Part 1, Whitehead has to believe that something is wrong with this analysis of the datum of experience. For the common sense of humanity is inflexibly objectivist. "We perceive other things which are in the world of actualities in the same sense as we are" (PR 240, cf. 78f., 83). And everyone in practice gives evidence of presupposing genuine causal influence between things. But if the subjectivist principle is consistently followed, it leads to the strange phenomenon of 'empiricists' explaining away the obvious facts of experience in obedience to an *a priori* doctrine (PR 220, 221).

Whitehead believes that the subjectivist principle is in turn rooted in the substance-quality dogma, i.e., the dogma that "the final metaphysical fact is always to be expressed as a quality inhering in a substance" (PR 239). This dogma, which makes the subject-predicate form of statement ultimate, implies that one 'substance' (i.e., actuality) is never 'qualified' by another one, but only by universal qualities, such as colors and shapes. This doctrine implies that actualities are essentially independent of each other. Accordingly, the most a ‘relationship’ can be is "the correlation of a pair of qualities one belonging exclusively to one individual, and the other exclusively to the other individual" (PR 219). In epistemology, this leads to the representative theory of perception, in which an experienced quality is said to ‘represent’ an exterior thing (PR 77f.). It cannot be admitted that the exterior thing is directly perceived, for that would mean that one actuality (the perceived thing) would be qualifying another one (the perceiver). It is this dogma, Whitehead believes, rather than an impartial analysis of immediate experience, which leads to the subjectivist principle. Hence, this principle must be rejected if we are to do justice to the perceived solidarity of the world, the basic character about reality to which a philosophy must be adequate.

Whitehead’s definition of the ‘sensationalist principle’ also focuses attention upon the question of the *primary* elements in experience. It is defined as the doctrine that "the primary activity in the act of experience is the bare subjective entertainment of the datum, devoid of any subjective form of reception" (PR 239). This implies that all emotional and purposive response must be considered derivative from the more primary conscious perception of those universals constituting the data of sense perception (PR 246). It is obviously essential to Whitehead’s program to reject this principle. For if he is to generalize the primary elements of human experience to all actualities, these primary elements cannot be factors, such as conscious sense experience, which rather obviously cannot be reasonably predicated of those actual entities at the base of the evolutionary process.

In explaining his rejection of the subjectivist and sensationalist principles, Whitehead distinguishes two modes of perception that are generally combined in human experience One mode is termed ‘perception in the mode of presentational immediacy,’ which involves as its most conspicuous aspect the perception of sense data as qualifying external regions. But (and this is Whitehead’s epistemological revolution) this mode is derivative from a more basic, temporally prior, mode, which he terms ‘perception in the mode of causal efficacy,’ or simply ‘prehension’ or ‘feeling.’ In this more fundamental mode, other actual entities are perceived, and the data are received not neutrally, but with *emotional and purposive subjective forms* of reception. Furthermore, the *data* themselves are prehended *as emotional feelings.* All of this is held to be involved in the primary phase of an act of human perception. Since these elements are prior to, rather than derivative from, what is normally referred to as ‘perception’ (i.e., presentational immediacy), it is not impossible in principle to attribute these elements to lower forms of actual entities. Since consciousness presupposes more basic forms of experience, rather than experience presupposing or being identical with consciousness (PR 83), it is possible to attribute experience to low-grade actual entities without supposing that they have *conscious* experience.

This revolutionary doctrine of what is *really* (temporally) prior in experience means that Whitehead believes that in most philosophy "experience has been explained in a thoroughly topsy-turvy fashion, the wrong end first" (PR 246). The essential fact that has been overlooked is that "clearness in consciousness is no evidence for primitiveness in the genetic process" (PR 263f.). Whitehead believes that "the opposite doctrine is more nearly true" (PR 264). He formulates this as a principle: "The late derivative elements are more clearly illuminated by consciousness than the primitive elements" (PR 246). Whitehead’s position is that consciousness can only illuminate those elements of experience which have been considerably simplified and integrated. Thus those elements of our experience which stand out clearly and distinctly in our consciousness are not its basic facts; they are the derivative modifications which arise in the process" (PR 243f.). Accordingly, the primary experience of receiving with emotional and purposive subjective form the causal influence of other actualities tends to be only dimly illuminated in consciousness precisely because it is primary. This is Whitehead’s basis for rejecting the Kantian ‘critical philosophy,’ which was based upon the inherited assumption that presentational immediacy was the primary fact of perception, so that the notion of causation (along with notions of value, emotion, and purpose) had to be derived from some source other than perception (PR 263).

Whitehead’s discussion of subhuman actual entities follows from the principles discussed above, *viz.*, that there is only one genus of actual entities, that one’s present experience constitutes the standard for defining actuality, and that subhuman actualities can be conceived in terms of the primary elements in human experience. Accordingly, in reference to perception, Whitehead says:

> We must assign the mode of causal efficacy to the fundamental constitution of an occasion so that in germ this mode belongs even to organisms of the lowest grade; while the mode of

> presentational immediacy requires the more sophistical activity of the latter stages of process, so as to belong only to organisms of a relatively high grade (PR 261).

And he believes this assignment to be harmonious with the observed facts:

> It does not seem to be the sense of causal awareness that the lower living things lack, so much as variety of sense-presentation, and then vivid distinctness of presentational immediacy. But animals, and even vegetables, in low forms of organism exhibit modes of behavior directed towards self-preservation. There is every indication of a vague feeling of causal relationship with the external world, of some intensity, vaguely defined as to quality, and with some vague definition as to locality. A jellyfish advances and withdraws, and in so doing exhibits some perception of causal relationship with the world beyond itself; a plant grows downwards to the damp earth, and upwards toward the light. There is thus some direct reason for attributing dim, slow feelings of causal nexus, although we have no reason for any ascription of the definite percepts in the mode of presentational immediacy (PR 268).

To make explicit what is implicit above: Since there is only one type of actual entity, ontology and epistemology partially coincide. An act of human perception (in the primary mode) provides an example of causation which can be generalized to the relations between other actual entities. The percipient's prehension of another actual entity is the perceived entity's causal influence upon the percipient (PR 91, 361).

The fact that the prehension of other actualities is a prehension' of them *as other* supplies the basis for one of Whitehead's central concepts, that prehensions have a 'vector' character (PR 28). Using 'feeling' in place of 'prehension,' Whitehead says: "Feelings are 'vectors'; for they feel what is *there* and transform it into what is *here*" (PR 133). This notion of the vector character of prehensions is basic to his attempt to describe the world as a multiplicity of actual things which are genuinely related. For the notion that prehensions are vectors is a rejection of the primary doctrine to which Whitehead is opposed, the doctrine of 'simple location,' which is the doctrine that an actual entity's location can be described without reference to other actualities in other regions of space and time (SMW 72, 84). And, since Whitehead defines 'matter' as anything which has this property of simple location (SMW 72), his doctrine that all actual entities have prehensions that are vectors constitutes his rejection of a materialistic view of nature. It should be noted, too, that his doctrine of the vector character of prehensions is simply an ontological restatement of the epistemological rejection of subjectivism. The human perception of other actual entities is an example of the vector-character of prehensions by all actual entities (PR 177).

There is more to be said about the datum of the primary mode of perception. In a passage in which ‘objectification’ is used for ‘prehension,’ Whitehead says:

> The more primitive mode of objectification is via emotional tone, and only in exceptional organisms does objectification, via sensation, supervene with any effectiveness. . . Thus the whole notion of prehension should be inverted. We prehend other actual entities more primitively by direct mediation of emotional tone, and only secondarily and waveringly by direct meditation of sense (PR 214).

This reception of emotional tone is combined with the vector-character of prehensions or feelings in order more fully to describe the primary phase of a moment of experience:

> The crude aboriginal character of direct perception is inheritance. What is inherited is feeling-tone with evidence of its origin: in other words, vector feeling-tone. Thus perception, in this primary sense, is perception of the settled world in the past as constituted by its feeling-tones, and as efficacious by reason of those feeling-tones (PR 182, 184).

Accordingly, Whitehead attributes to all actual entities this feeling of the emotional tone of other actual entities. In his words, "The more primitive types of experience are concerned with sense-reception, and not with sense-perception" (PR 174). By this he means that low-grade organisms receive and pass along sensa, which are for them emotional forms. They are ‘unspatialized,’ in the sense that the location of the actual entities from which they were derived is very vague. It is only in sense-perception, enjoyed by high-grade organisms, that the sensa are clearly perceived as qualifying some external region of space (PR 174, 177; AI 276).

This emotional character of the datum leads to another factor in human experience that is generalizable. The objective datum is not prehended neutrally, but with a ‘subjective form’ of reception, and therefore emotionally. The objective datum of a feeling was itself a feeling constitutive of a previous actual entity. In the first phase of a moment of experience, the previous feeling is received with a subjective form which conforms to its own subjective form. For example, a person feeling a previous angry feeling will initially feel it with anger. Accordingly, this first stage of a moment of experience is called the ‘conformal phase.’ This doctrine represents the rejection of the sensationalist principle, according to which the primary activity in perception would be a bare reception of a datum, devoid of any subjective form of reception. This conformal, non-orginative phase of experience, which "merely transforms the objective content into subjective feelings," is said to be "common to all modes of perception" (PR 179, 250). Accordingly, Whitehead affirms that even the actual entities studied by physics have emotional responses to their environments. The notion of physical energy in physics is an abstraction from the complex energy, emotional and purposive, which is embodied in an actual entity (Al 239; PR 178).

The notion of ‘purposiveness’ was mentioned in the preceding sentence. In order to discuss this notion, which is also thought to apply to all actual entities, another feature of actual entities must be emphasized. This is the idea that each actual entity is temporally atomic -- it is a brief event, and it is indivisible. This is why Whitehead could adopt William James’ expression, ‘drops of experience,’ to refer to actual entities. It is by virtue of this temporal atomicity that Whitehead can correlate efficient and final causation. He introduces this topic in the following way:

> It is notable that no biological science has been able to express itself apart from phraseology which is meaningless unless it refers to ideals proper to the organism in question. This aspect of the universe impressed itself on that great biologist and philosopher, Aristotle. His philosophy led to a wild over-stressing of the notion of final causes during the Christian middle ages; and thence, by a reaction, to the correlative overstressing of the notion of ‘efficient causes’ during the modern scientific period. One task of a sound metaphysics is to exhibit final and efficient causes in their proper relation to each other (PR 128f.).

Whitehead’s doctrine of temporal atomicity allows the two forms of causation to be complementary by assigning them to different phases of an actual occasion. The first phase is that of efficient causation, in that the occasion begins as reception of a multiplicity of influences from previous occasions. But once this rush of efficient causes has been allowed in, the monad’s window is closed, as it were, and the actual occasion has to decide precisely how to respond to its given data. "Efficient causation expresses the transition from actual entity to actual entity; and final causation expresses the internal process whereby the actual entity becomes itself" (PR 228). The occasion’s final cause is called its ‘subjective aim’; it is the aim at a determinate ‘satisfaction’ which is the conclusion of the occasion’s process of becoming (PR 1 34). Upon attaining satisfaction, the occasion is then an efficient cause partially determining the occasions which succeed it. It is because the temporal atomicity allows for two kinds of process, the internal process of self-determination called ‘concresence,’ as well as the efficient process of ‘transition’ from occasion to occasion, that there can be freedom in the universe (PR 135). No matter how much is determined for the occasion by the conditions from which it arises, "there is always a contingency left open for immediate decision" (PR 435; cf. 41, 75; AI 255).

Whitehead’s famous ‘ontological principle’ stresses the two kinds of causation. This is the principle that only actual entities can be the causes for anything, so that to ask for a *reason* is always to ask for one or more actual entities (PR 37). Whereas the acceptance of such a principle leads many to a mechanistic doctrine, Whitehead says that the ontological principle "could also be termed the principle of efficient, and final, causation’" (PR 36f.). For, the reason an actual occasion is what it is will lie in its own process of self-determination as well as in the efficient causation upon it.

Although self-determination is a metaphysical principle, so that every actual entity has at least some iota, it is a matter of degree. And in the low-grade entities studied by physics it is negligible. "For occasions of relatively slight experient intensity, their decisions of creative emphasis are individually negligible compared to the determined components which they receive and transmit" (PR 75). Accordingly, for many purposes the self-determination of the individual occasions can be ignored without serious distortion.

We are now in position to introduce Whitehead’s often-misunderstood doctrine that all actual entities, even those at the electronic level, have ‘mentality,’ or ‘conceptual prehensions.’ Whitehead emphasizes many times that he does not mean by this that all actual entities have intellect, or even consciousness (PR 35, 88, 130, 355, 366, 379, 416, 427). Nor does he mean simply that they all have experience, for actual entities are experiential through and through, even in the earliest phase, which is sometimes called the ‘physical’ phase. Rather, the mental pole is significant to the degree that the occasion originates any novelty, thereby creating something for itself beyond what it received from the past world. To the extent that the occasion has no autonomy over the past, but merely repeats and transmits what it receives, it is dominated by its physical pole. The origination of significant novelty only occurs in living occasions.

However, there is at least some iota of mental functioning in all occasions. One of the basic categories states that "from each physical feeling there is the derivation of a purely conceptual feeling" (PR 40). A ‘physical’ feeling is simply a feeling whose datum is another actual entity. A ‘conceptual’ feeling is one whose datum is a pure possibility, i.e., an ‘eternal object,’ which is Whitehead’s term for a ‘universal.’ These eternal objects include those of the ‘objective species,’ the mathematical forms, and those of the ‘subjective species,’ such as red, anger, aversion, and consciousness. Accordingly, this ‘category of conceptual valuation’ states that, e.g., after having a feeling of the green feeling in a previous actual entity, the present subject will in the second phase of its experience feel green *qua* green, i.e., as a pure possibility, in abstraction from its ingression in the actual world. The rise of these conceptual prehensions constitutes the essential phase of the mental pole of an actual entity. In commenting upon this category, Whitehead says: "This category maintains the old principle that mentality originates from sensitive experience. It lays down the principle that all sensitive experience originates mental operations" (PR 379)

However, the statement of the category thus far does not indicate the dynamic character of the mental pole. The category does not merely speak of conceptual reproduction, but of *valuation.* What is received is either valued upward (adversion) or downward (aversion) (PR 388). This is the becoming occasion’s determination of its own subjective form of response to its given data. The dynamic activity involved in conceptual valuation is best suggested by the use of the term ‘appetition’:

> Appetition is at once the conceptual valuation of an immediate physical feeling combined with the urge towards realization of the datum conceptually prehended. For example, ‘thirst’ is an immediate physical feeling integrated with the conceptual prehension of its quenching. . . . All physical experience is accompanied by an appetite for, or against, its continuance (PR 47f.).

Accordingly, mentality is closely correlated with self-determination: "Thus the conceptual registration is conceptual valuation; and the conceptual valuation introduces creative purpose. The mental pole introduces the subject as a determinant of its own concrescence (PR 380).

Actually, it is not the conceptual valuation as such that constitutes purposiveness, but the integration of this valuation with the physical feeling from which it was derived. This integration results in a ‘physical purpose’ (PR 380, 388). Insofar as this is all that occurs in the occasion, there is no significant novelty. The occasion simply receives the physical feelings, conforms their valuations, and transmits them to successors. Its own autonomous experience is negligible for the science tracing the transmissions (PR 374f.). Hence, by virtue of this doctrine of physical purpose, Whitehead can maintain that there is mentality in all actual entities and yet agree that this can be ignored without loss when one is concerned with certain abstractions from the full reality of nature.

Whitehead is impatient with those philosophers who simply state that "physical science is an abstraction." As such this is "a confession of philosophic failure. It is the business of rational thought to describe the more concrete fact from which that abstraction is derivable" (Al 239). In terms of the above discussion of what is truly primary in human experience, we are now in a position to understand a statement in which Whitehead summarizes how the "more concrete fact" from which science abstracts should be conceived: "The emotional appetitive elements in our conscious experience are those which most closely resemble the basic elements of all physical experience" (PR 248).

The uniqueness of Whitehead’s philosophy is probably best summarized in terms of the theory of prehension as a combination of the doctrines of temporal atomicity and of the primacy of causal efficacy. This theory of prehension means the overcoming of the dualistic notion that there are some concrete facts which are merely public and others which are merely private. Rather, the prehensions have public origins, the objective data; they have private subjective forms, based on the private aim of the actual occasion; and then the occasion, having unified its prehensions, passes back into publicity, providing data for new prehensions. Through this account Whitehead means to overcome "a complex of bifurcations, fatal to a satisfactory cosmology," i.e., "the separations of perceptual fact from emotional fact; and of causal fact from emotional fact, and from perceptual fact, and of perceptual fact, emotional fact, and causal fact, from purposive fact" (PR 444).

III. The Correlation of Principles of Metaphysics with those of Physics

The previous discussion indicates how Whitehead believes one can, by generalizing from occasions of human experience, talk meaningfully about the nature of nonhuman actual entities in themselves. And the advantages of some of the principles for making contact with principles of modern physics, such as quantum physics, is readily apparent. But how can Whitehead's principles account for the aspects of endurance and continuity?

Whitehead accounts for the endurance of things by his theory of societies. "The real actual things that endure are all societies. They are not actual occasions" (AI 262). The simplest type of society is one with purely temporal order: it is a series of actual occasions in which each occasion inherits a common form from the preceding member of the society and transmits it to its immediate successor. The common form is the defining characteristic of the society (PR 50f.). This type of society is called a 'temporally-ordered,' 'serially-ordered,' or 'personally-ordered' society, or an 'enduring object.' Examples are photons, electrons, protons, atoms, molecules, and psyches of human beings and other higher animals (AI 238; SMW 161f.; PR 139f., 141, 151, 269, 492). The society endures by repetition: each member repeats the form constituting the defining characteristic of the society. Enduring things are societies of occasions rather than single substances, so that 'repetition' replaces undifferentiated vacuous endurance.' This notion of repetition is central to the move from materialism to organicism in science. For it offers an alternative explanation for the apparent fact that the basic actualities of the world are describable in terms of passive endurances with essential or non-essential modifications. If this alternative is more adequate, the principle basis of materialism is undercut.

The previously discussed ideas of vectors and the conformal feelings of subjective form are used to understand the transmission of energy. Because Whitehead conceives the human psyche not to be a single actuality, but a temporally-ordered society of occasions of experience, and further believes all actual entities to be occasions of experience, he is able to use "the direct evidence as to the connectedness of one's immediate present occasion of experience with one's immediately past occasions . . . to suggest categories applying to the connectedness of all occasions in nature" (AI 284). Accordingly, he understands electrons and atoms in terms of "an analogy between the transference of energy from particular occasion to particular occasion in physical nature and the transference of affective tone, with its emotional energy, from one occasion to another in any human personality. The object-to-subject structure of human experience is reproduced in physical nature by this vector relation of particular to particular" (AI 242). This transference of affective tone, or subjective form, is "the most primitive form of the feeling of causal efficacy. In physics it is the transmission of a form of energy" (479f.).

Of course, this one-dimensional personal inheritance from occasion to occasion in the psyche provides no analogical basis for understanding the many-dimensional connections in nature, in which spatial as well as temporal relations are involved. But we also have direct experience of inheritance from our body, which is made up of innumerable actual occasions. Accordingly, the fact that "our dominant inheritance from our immediately past occasion is broken into by innumerable inheritances through other avenues" provides an analogy for understanding both the endurance of a molecule and the fact that it is subject to countless other influences (AI 243).

Whitehead answers the question as to the relation between continuity and quanta on the basis of discrete occasions of human experience which inherit subjective forms conformally:

> Thus, if the analogy is to hold. . ., we should expect a doctrine of quanta, where the individualities of the occasions are relevant, and a doctrine of continuity where the conformal transference of subjective form is the dominant fact. The notion of physical energy, which is at the base of physics, must then be conceived as an abstraction from the complex form of the final synthesis in which each occasion completes itself. It is the total vigor of each

> activity of experience (AI 239).

This is Whitehead’s attempt to state "the more concrete fact" from which physical science abstracts. But each occasion, as well as each of its constitutive prehensions, does have a quantitative aspect as well as a qualitative one (PR 486). The quantitative aspect of the prehensions, along with their spatio-temporal characteristics, are the ‘vectors’ of physics. "The ultimate physical entities for physical science are always vectors indicating transference" (PR 364f.). Mathematical physics translates Heraclitus’ saying, "All things flow," into "All things are vectors" (PR 471).

The occasion takes what it received from others and unifies it into a total satisfaction, which for the moment is private. The quantitative aspect of this satisfaction is the basis for the scalar localization of energy in physics (PR 177). The fact that in the later phases of an actual occasion this scalar form overwhelms the original vector form, and the fact that the scalar quantity of inertia was dominant in Newtonian physics, have led to a tendency to spatialize reality, to ignore the fact that all fundamental physical quantities are vector rather than scalar (PR 268, 319). Although overwhelmed in the satisfaction, the vector form is never totally lost; and the satisfaction will provide the basis for a subsequent vector transference. The fact "that scalar quantities are constructs derivative from vector quantities" is, of course, simply the scientific formulation of Whitehead’s fundamental doctrine that relations have primacy over qualities, that there are no independent actualities with their private qualities (PR 324). "In the language of physical science, the change from materialism to ‘organic realism’ . . . is the displacement of the notion of static stuff by the notion of fluent energy" (PR 471). The vector character of prehensions whereby the cause is incorporated into the effect is the basis for the cumulative character of time, and hence its irreversibility (PR 363). This is another of our basic presuppositions which the materialistic doctrine, with its merely external relations, could not justify.

Besides supporting the primacy of vector quantities, Whitehead believes his doctrine of individual actual occasions with their individual prehensions "gives a reason for the atomic quanta to be discerned in the building up of a quantity of energy" (PR 71, 179):

> The direct perception whereby the datum in the immediate subject is inherited from the past can thus, under an abstraction,

> be conceived as the transference of throbs of emotional energy, clothed in the specific forms provided by sensa. Since the vagueness in the experient subject will veil the separate objectifications wherein there are individual contributions to the total satisfaction, the emotional energy in the final satisfaction wears the aspect of a total intensity capable of all gradations of ideal variation. But in its origin it represents the totality arising from the contributions of separate objects to that form of energy. Thus, having regard to its origin, a real atomic structure of each form of energy is discernible, so much from each objectified actual occasion; and only a finite number of actual occasions will be relevant (PR 178).

Although for some purposes the mental pole of the occasions can be ignored, Whitehead says that even the physical world cannot be understood without reference to . . . the complex of mental operations" (PR 366). At least one aspect of what this means is explained in terms of the two species of eternal objects. The *intensity* of physical energy embodied by actual occasions is a function of the subjective species of eternal objects, while the peculiar *form* of the flux of energy refers to the objective species, the mathematical forms. The type of analysis normally applied by science, what Whitehead calls coordinate division, "preserves undistorted the elements of definiteness introduced by eternal objects of the objective species" (PR 447). But it abstracts from the total subject of the feelings, and hence from the subjective forms. "Thus insofar as the relationships of these feelings require an appeal to subjective forms for their explanation, the gap must be supplied by the introduction of arbitrary laws of nature regulating the relations of intensities" (PR 447). For physics the laws declaring how its entities mutually react are arbitrary, "because that science has abstracted from what the entities are in themselves" (SMW 155f.).

Also, the endurance of things such as molecules is an arbitrary fact, if material is taken to be fundamental. But if one takes organism to be fundamental, then endurance is the result of evolution (SMW 159). This statement is based upon the notion that all actual entities strive to achieve value. An enduring object represents "the self-retention of that which imposes itself as a definite attainment for its own sake" (SMW 137). An enduring object is the repetition of a certain set of eternal objects whose actualization is experienced as intrinsically valuable. The intensity of the value is increased by the repetition (PR 426). This endurance is compatible with the earlier description of the fact that in each occasion a conceptual prehension is derived from each physical prehension, and that this introduces a purpose into the occasion. For, the activity of lifting out an eternal object and feeling it as an eternal object, i.e., as a pure possibility in abstraction from all physical realizations, is a matter of degree. In low-grade occasions it is not lifted out completely. Accordingly, in the integrative phase of the occasion it is merely reunited with the physical feeling from which it was derived; the resulting feeling is called a 'physical purpose.' The only possible alteration is in the intensity of subjective form with which it is felt. It is valued up (adverted), the physical feeling is thereby an element with some force of persistence into the future beyond its own subject." Hence, adversions promote the stability of enduring objects. But if the eternal object which is partially abstracted from a physical feeling is felt with aversion, the future objectification of the value in question is inhibited, and decay sets in (PR 286**,** 380, 422).

However, Whitehead does not believe there is any evidence for simple repetition based upon strict conformation from occasion to occasion, even in low-grade enduring objects (PR 285). There is some novelty realized, "so that even amid stability there is never undifferentiated endurance" (PR 381). The vibration and rhythm of these enduring objects is explained by the category of reversion, which is in turn explained in terms of Whitehead's aesthetic principles. 'Reversion' occurs when in the mental pole eternal objects are felt which are partly identical with but partially diverse from the eternal objects derived from the physical feelings of occasions in the actual world (PR 380). Reversion thereby introduces a contrast into the conceptual feeling, and as such promotes the depth of intensity that can be felt (PR 381, 424).

> When this reverted conceptual feeling acquires a relatively high intensity of upward valuation in its subjective form, the resulting integration of physical feeling, primary conceptual feeling, and secondary conceptual feeling, produces a more complex physical purpose than . . . when the reverted conceptual feeling was negligible (PR 425).

Whitehead then describes what goes on in the vibration of an enduring object:

> In the successive occasions of an enduring object in which the inheritance is governed by this complex physical purpose, the reverted conceptual feeling is transmitted into the next occasion

> as physical feeling, and the pattern of the original physical feeling now reappears as the datum in the reverted conceptual feeling. Thus along the route of the life-history there is a chain of contrasts in the physical feelings of the successive occasions. . . . Thus an enduring object gains the enhanced intensity of feeling arising from the contrast between inheritance and novel effect, and also gains the enhanced intensity arising from the combined inheritance of its stable rhythmic character throughout its life-history. . . . In this way the association of endurance with rhythm and physical vibration are to be explained. They arise out of the conditions for intensity and stability (PR 426).

Whitehead thereby does not leave the empirical facts as merely arbitrary, but tries to account for them on the basis of "the doctrine that an actual fact is a fact of aesthetic experience. All aesthetic experience is feeling arising out of the realization of contrast under identity" (PR 427; cf. 285).

IV. The Relation Between Inorganic, Living, and Conscious Organisms

If this paper were to stand alone, this fourth section would necessarily be quite lengthy. However, many of the ideas that would belong here are discussed elsewhere in the volume, especially in the papers by Hartshorne and Overman, and the "Whiteheadian Comments" by Cobb and myself. Hence, I will only point out very briefly some of the ways in which Whitehead's metaphysical ideas, and his related understanding of the objects of physics, form a foundation for seeing inorganic, living, and conscious organisms within one scheme of thought.

1. On the one hand, Whitehead holds that there is only one kind of actuality. All actual entities, even non-living ones, are 'organisms.' Inorganic, living, and conscious organisms are only different in degree, not in kind. Hence, the insoluble problem of all dualisms, understanding how two totally different kinds of actualities can causally interact, is avoided. To affirm that living things emerged out of non-living ones, and that conscious beings emerged out of non-conscious ones, is not to affirm that the lower beings or processes produced something totally different from themselves.

On the other hand, Whitehead also holds that there are many different levels within the one kind of actuality. Living organisms have more 'mentality' than non-living ones, which means that they have more power of self-determination. And conscious beings have more self-determining power than non-conscious ones. Accordingly, Whitehead does not reduce the activity of complex beings to a mere function of the activity of the simplest, parts. (Leclerc -- above, p. 104 -- is misleading on this issue.) The higher-level actualities are dependent upon the lower-level ones; but the higher-level ones are equally actual, and have their own efficacy. Hence, the activity of the living cell is not totally a product of the inorganic constituents, but is partly due to the living occasions within the cell. The activity of the human being is not totally a product of the bodily cells, but is partly due to the central series of actual occasions which sometimes is conscious.

2. On the one hand, Whitehead has a doctrine of causality as real influence. Hence, he provides a basis for scientific theory, which is always couched in language which presupposes genuine causal influence (not mere constant conjunction). This point, combined with the previous one, means that he can talk about the causal influence, for example, of molecules within the cell upon the cell's series of living occasions, which can for practical purposes be regarded as the 'cell as a whole,' and he can speak about the returned causal influence of the living occasions upon the molecular constituents. Hence, he can talk about causal interaction between part and whole (when the empirical evidence calls for it). Likewise, he can talk about causal interaction between the central series of experiences in the human being (the mind, or psyche) and the bodily cells.

On the other hand, his doctrine of causal influence is not a doctrine of total determination of the effect by the causes. Hence, to say that the cell is influenced by its inorganic parts is not to affirm that it operates mechanistically; to say that the human psyche is influenced by its body is not to affirm that the human being's activity is totally determined by inorganic, or even nonconscious, processes. *No* organism is totally determined by the efficient causes upon it, since every actual occasion has at least some iota of mentality or self-determination. And the higher-level actualities are even less completely determined by efficient causes.

3. Whitehead accounts for the fact that some of the things in the world have no power of self-determination. He does this with his idea of two basic ways in which enduring objects can be organized into macroscopic societies. On the one hand, they can form a mere aggregate, such as a rock. This type of thing, although it is *composed* of

partially self-determining organisms, itself has no power of self-determination. This is because there is no one series of higher-level actualities ('dominant occasions') within the society which can coordinate the activities of the myriad members. Hence, the spontaneities of the individuals cancel each other out.

On the other hand, some macroscopic things have self-determination. These are societies in which there is a series of higher-level occasions of experience, a series which is the 'dominant' member in the society. This domination is not complete, but it can be strong enough to give the society as a whole a significant degree of unity of response to the causes upon it. Animals, especially the higher vertebrates, exemplify this kind of hierarchical organization. However, this kind of order, in which a society of actual entities acts with a significant degree of unity, is not unique to animals. Whitehead also refers to cells, molecules, atoms, and electrons and protons as organisms with significant unity, to be contrasted with those things which are mere aggregates (SMW 161 f.). Precisely how Whitehead himself understood the relation between the lower-level and higher-level actual occasions within an organism of organisms' is not clear from his writings. In regard to the living cell, he does refer to the series of living occasions as 'regnant,' and to the molecular enduring objects as 'subservient' (PR 157). And he does say that atoms and molecules are 'organisms' of a higher type than electrons (*ibid*) Furthermore, he refers to molecules as enduring objects, and he speaks of molecular as well as of electronic and protonic actual occasions (PR 114, 123, 124, 139, 141). He is perhaps best understood as intending that the molecule can be treated as an enduring object (i.e., a serially-ordered society of actual occasions) by virtue of the fact that it contains a series of regnant molecular occasions. Likewise, an electron or a proton would be an enduring object by virtue of the fact that, besides the "yet more ultimate actual entities" within the electronic or protonic society (PR 139), the "electronic and protonic actual entities" (PR 139) are regnant occasions within the society in which they are members. Because of the regnant status of the series of electronic, protonic, or molecular occasions, the electron, proton, or molecule has a significant degree of unity of response to its environment (internal and external), and thus can be spoken of, for practical purposes, as a series of actual occasions.

I believe this is the best way to account for Whitehead's various statements that are relevant to this issue. But in any case, it is clear that Whitehead means that there are various levels of 'organisms of organisms,' or hierarchical societies, which are to be contrasted with those types of societies which do not have a hierarchical order and hence no overall unity of activity. It is by virtue of this distinction between *two basic types of organization* that Whitehead accounts for those things which manifestly are devoid of the power of self-determination, without positing a dualism between *two kinds of actual entities.* It is also on the basis of this distinction, along with the notion that there are various levels of actualities, that Whitehead explains our common belief not only that some macroscopic beings have freedom, but also that some have more freedom than others.

Accordingly, on the basis of his fundamental notions, Whitehead does not find it necessary to explain' our beliefs about living and conscious beings by explaining them away. He is able to conform to "those presumptions, which, in despite of criticism, we still employ for the regulation of our lives," (PR 229) which should serve as "the final test of all science and philosophy" (PR 502).

EXPLANATION OF SYMBOLS FOR WHITEHEAD'S WORKS

AI *Adventures of Ideas.* Macmillan, 1933.

PR *Process and Reality*. Macmillan, 1929.

SMW *Science and the Modern World.* Macmillan, 1926.

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Mind in Nature: the Interface of Science and Philosophy by John B. and David R. Griffin Cobb, Jr.

Part 4: Mind and Organism

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Chapter 4: Can Whitehead Help Us Learn What We're Talking About? by Richard H. Overman

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"He doesn't know what he's talking about!" Isn't this what we all feel like blurting out occasionally? Especially when we find someone else's language failing to express what *we* know! Still, in our better moments we refrain from such outbursts, because in our depths we know that, in the part of our lives concerned with language, hardly anything is more difficult than being sure *what* we mean. We know that when we are speaking seriously, we are trying to let *something* up into awareness -- the 'what' which is the true subject matter of our speaking -- and we are trying to become well-enough acquainted with it so we can deliver it in words. But there's many a slip 'twixt the 'what' and the lip! Indeed, unless we already know that ‘something’ quite well, our speaking may deliver something else by mistake. Anyone who tries to explain a minority viewpoint knows that his listeners may suspect him of just such an error, and he will know that a certain lightheartedness is necessary when hearing his words treated as a ‘Cloud of Unknowing’ or a huge trash heap! By ‘lightheartedness’ I am not speaking of childish frivolity in constructing one’s speech, or of shallow willingness to retrench. I mean the ability to be quite serious in trying to plumb the depths, to ‘draw up Leviathan’ into words, while at the same time being amused when one’s linguistic ‘fishline’ keeps pulling up minnows, blowfishes, and an occasional old tire. I mean the ability to be quite responsible for what one says, while at the same time knowing that his accuser is correct in exclaiming, "He doesn’t know what he’s talking about!"

Therefore, one must answer on two levels when he is asked, "Have I understood what you mean?" The easy level concerns whether the listener has grasped the *conscious intention* of the speaker, and most arguments in the worlds of politics, science, and theology remain at this level. But the more important, and much more difficult, answer concerns whether *either* person, listener *or* speaker, has fished up that *deep ‘something’ or ‘what’* which may be pressing for expression then, meaning to be said. Sometimes it appears that we will go to almost any lengths to *avoid* looking deeper for that ‘something’ just beyond the edges of clear consciousness! But if there is anything to St. Paul’s notion that mysteries are cleared up in heaven, I am sure the first words of Plato upon entering those portals were the same as those of Lamarck, Darwin, and Einstein: "Aha! So *that’s* what I was talking about!"

May I draw two ‘morals’ from this story? The first is short, concerning the way we should read the essays in this volume. Our whole civilization seems to act as though restoring things to their ‘natural’ state would mean making them *dead,* and this crisis in our world has a lot to do with our ancestors’ enjoyment in dealing with easy, clear, conscious meanings and their dislike in looking for that deeper ‘something.’ So, if we want to help cure our sick world we had better remember that the *real* subject matter of this hook is not likely to emerge unless each of us looks *through* the conscious language of the essays, asking, "Now what *is* it that he doesn’t know he is saying?"

The second ‘moral’ is longer, and I will dwell on it in the rest of this paper. But briefly, it is this: ‘orthodox’ scientific uneasiness about the role of purpose or final causation in planetary evolution has its grounds partly in the fact that over the centuries most people who have tried to describe the role of purpose on Earth haven't known 'what' they were talking about. They have known that somehow or other *everything* depends on purposes somewhere, in something or other -- or in something *and* another -- but they have hardly ever had a very clear grasp of just *where* the purposes are, in *what* things, and *how* much. So sometimes they have rendered to God the purposes that really were Caesar's, and sometimes they have credited crowds of Caesar's liver cells with a unified conscious vision of the future which only Caesar's soul could have enjoyed. The result, as we all know, has been the gradual eliminating of the notion of purpose from scientific thought. And not merely from *scientific* thought, for it has been suppressed in *theological* thought as well! I don't know which is more perplexing, to be told by a 'Fundamentalist' in theology that all the purposes of the universe are hoarded everlastingly in heaven by God, or to be told by a 'Fundamentalist' in science that there just *aren't* any purposes. Either way, my own purposes *here on Earth* (which are more obvious to me than either God or evolution!) seem to be neatly explained away. The two 'Fundamentalists' seem to agree in giving me a perplexing bit of advice: "Why worry? You're really dead!"

But all this perplexity is unnecessary -- the fact that a lot of people haven't known *'what'* they were talking about for centuries is important, but it is not grounds for assuming they were talking of *nothing!* On the contrary, the very persistence of language about purpose indicates that people are trying to speak of *something* -- *the* question is, *what?* At this point, Whitehead's analysis is particularly helpful, for he helps us understand *where* the purposes of the world are, in *what* kinds of things, and *how* they are related to the intricate patterns of physical causation we may discover through scientific research. In other words, he can help people who experience purposes to know much more closely 'what' they are talking about, so that the whole discussion of purposes in our world can move on beyond the typical confusion of the last few centuries. Perhaps, if we are granted time, some more purified currents of thought may emerge to support life instead of death!

'Life' and 'Purpose' in Evolution[1]

Most of our trouble in discussing 'life' and 'purpose' comes from assuming that the subjects which are 'alive' and enjoy 'purposes' are the things which appear before our eyes, enduring through time. But

Whitehead directs our attention away from such enduring things to the individual 'occasions of experience,' *momentary events whose subjective aims determine their becoming.* In thinking of the world we rarely consider the purposes of these basic entities; instead, we tend to be conscious of and think almost entirely of *collections* of entities, arranged in complex spatial and temporal patterns. Whitehead calls any such group of occasions with some sort of connectedness a nexus,' and a nexus which shows some trait shared by *each* member *in dependence on the others* he calls a 'society' (PR 30, 50f.). The common trait is called the 'defining characteristic' of the society. For example, what we usually call 'an electron' really is a society of occasions, each of which is a distinct subjective process of becoming, flickeringly brief in duration; each inherits some characteristic forms (which we call 'electronic') from a predecessor and mediates them to a successor. Taken together, any such nexus of occasions composing a society stretching through time is an enduring object' (PR 51f.); so a 'molecule' also is an enduring object -- but it is composed of more-complex 'molecular' occasions in a temporally-ordered society which also contains sub-societies of atoms. Ordinary objects of our experience, such as rocks and tables, are composed of many strands of enduring objects; and the story of planetary evolution focuses on the careers of incredibly complex organisms which may be analyzed into societies with sub-societies of many kinds. But even the most complex order of life can be analyzed ultimately into the relationships among short-lived occasions with subjective aims. The reasons for things, Whitehead insists, always lie in actual entities (PR 28); and since all these are invisible to our eyes, it is no wonder that we often speak confusedly!

Nearly everyone agrees that a moment of 'human' experience is richer, more intense, more laden with intrinsic value than a moment of 'electronic' experience. Also we believe that this complex human experience has evolved gradually from some such simpler kinds of entities. But *how?* Here is one great 'problem' faced by nature, which has its solution in the events which Dobzhansky and Thorpe call 'evolutionary emergences.' But for Whitehead, nature's 'problem' can be solved only if *two* mutually-dependent kinds of emergences are occurring: (a) more complex *societies of occasions* must emerge if there is to be (b) the emergence of higher-grade *individual occasions* which then are the final loci of actuality and value. As Birch suggests (above, p. 15), this view of 'emergence' does not in Whitehead's view allow us to suggest that new *explanatory categories* (such as 'subjectivity' or mentality') emerge partway along the evolutionary way; but

Dobzhansky's belief that evolution is "emergence of new patterns" (above p. 21) certainly can be accepted as a statement about new kinds of societies of societies, and new grades of actual entities within these societies.

Yet 'emergence' alone is not enough. No matter how complex the actual entities in a society, the society only 'counts' in evolution if it has a method of *surviving*. Whitehead saw two ways in which nature has solved this 'problem' of 'survival':

1. Material bodies, such as rocks and stars, are composed of societies which persist because their occasions are dominated by massive, average feelings of their environments. In turn, this reflects the fact that the subjective aims of such entities are confined ordinarily very closely to what Whitehead calls 'physical purposes' (PR 280, 406 ff.) -- that is, aims merely to repeat in themselves and pass on the physical characteristics of their immediate surroundings. Mentality in these entities is real, but it operates at a trivial level, serving only to eliminate any novel possibilities which may have entered into their predecessors and to suppress any fresh novelty within themselves beyond that which may account for the vibratory phenomena of these basic societies. Such societies are what we call 'inorganic,' and we correctly recognize them as being dominated by the patterns of physical feeling which stimulate our sense organs and scientific instruments.

Now, it is basic to Whitehead's vision that each occasion is first a subject whose process of becoming is absolutely private; only afterwards is it an object which can have an effect on subsequent subjects. I stress: *nothing is simultaneously a subject for itself and an object for other subjects.* Because the subjective immediacy of every occasion is quite private, there is no way for scientific research to peer in and 'verify' the reality of subjectivity in the world. (Anyone who says, *"Show* me a subject with purposes and then I'll believe in it!" is only muddled -- what he *means* is, "The only kind of 'subject' I'm willing to believe in is one which really is an 'object.'" And one of the clearest examples of 'not knowing what we're talking about' is to say that 'subjects' are 'objects'!) Nevertheless, no real problems are posed to the quest for scientific understanding by the fact that we cannot get 'inside' the subjectivity of an occasion in a rock or a star with our research instruments. This is because the subjective aim of such an occasion is so nearly limited to repeating the physical patterns which we *can* detect; in other words, if we pay attention only to the physical characteristics of these enduring objects, we are not missing anything very significant. Only when we are considering much more complex occasions, e.g., moments of *human* experience, are there *significant* aspects of aim and mentality which elude our instruments (see below).

The high-grade organisms we study in biological evolution contain many subordinate enduring objects; molecules and cells, for example, comprise the environment for atoms and electrons in our bodies. Since every occasion somehow is influenced by its environment, a sodium atom within a living body is different from one outside it, say, in a salt mine. Yet the atom in the living body is just as 'law-abiding,' just as dominated by 'physical purposes, as one we might study outside the body in a crystal. Sodium atoms are just as much 'conformists' inside the body as outside it, but *the pattern of physical feeling to which they conform* is different in the body. So, if we are able to discover statistical laws describing the average behavior of such tiny enduring objects in salt mines, we should expect to find analogous laws which describe the slightly-different behavior of their 'cousins' in livers and brains. Also, in speaking of the differences, we can avoid cumbersome notions such as 'emergent properties of sodium' merely by recalling that the occasions of sodium which conform to one pattern of physical feeling in a salt mine are not the *same* occasions which later (after the salt has been eaten) conform to a somewhat different pattern of physical feeling in a human brain.

2. The second way for societies of occasions to survive is by *changing their defining characteristics*, done by admitting novelty in the form of conceptual feeling. As Whitehead puts it, the world advances into novelty along a road paved with 'propositions' (PR 284). This advance occurs wherever the mentality of an occasion entertains a possibility of that occasion's becoming something more than it would become by merely conforming to past matter-of-fact. The decision to synthesize some novelty with inherited physical feeling is directed by subjective aim. For this to succeed, of course, the 'something more' must be a quality of newness which can be introduced without destroying the already-existing characteristics of the society. Also, in low-grade living societies this purposive adaptation occurs quite without any consciousness; all that is required is that an occasion be able to incorporate some alternative for itself *beyond* what is supplied by physical feelings of its past. *But it is this subjective aim to incorporate novelty which lies behind all purposive adaptation to the environment.*

Societies in which this method of 'survival' is important are what Whitehead calls 'living societies' (PR 156). In this sense, then, 'life' is the escape from physical routine. But why has such an important factor in evolution always eluded the grasp of those most anxious to demonstrate its reality? Here we can recall that *all* subjectivity is private. But we can point also to Whitehead's judgment that 'life' is a characteristic of 'empty space' (PR 161). Of course he does not mean to discover life we must take a voyage in a rocket ship! Rather, he uses the term 'empty space' to designate a state of affairs which we do recognize most easily in the apparent void beyond Earth's atmosphere, but which occurs also within animal organisms. We have seen that inorganic societies, such as rock molecules, endure through time by repeating endlessly their patterns of physical feeling, and that it is just this endurance through time of a definite pattern of physical feeling which 'catches our eye.' Thus interstellar 'empty space' is 'empty' for us because it is deficient in such enduring objects. Now, the occasions which cause us to call a society 'living' are characterized by *a certain freedom from domination by the physical past*, and just to the extent that they are characterized by novelty they too become unlikely candidates to 'register' on our sense organs. From the perspective of those sense organs, then, these occasions occur in the 'empty space' of cells. A scientist studying a living cell can hope to detect its atoms and molecules, which are strands of physical inheritance, but the 'life' of the cell will elude his gaze. He can only infer the presence of occasions which account for 'life' by noticing the slight but definite ways they modify the typical patterns of physical feeling displayed by the enduring objects which he *can* perceive. For example, we may infer the presence of living societies in cells when we find that certain chemical reactions occur there but not elsewhere.

This account of 'life' as a characteristic of cells means that in the human organism there are billions of centers of life, not one. Since we cannot identify 'life' with 'self,' how then should we speak of that center of bodily experience which we call the 'soul' or 'personality'? For Whitehead, the 'soul' is composed of a series of 'presiding' or 'dominant' occasions in our bodies; he supposes that these 'dominant occasions' occur in or about the brain so as to receive from the brain a peculiarly-focussed 'report' of bodily experience, not available to any other occasion. But the human 'soul' is only the most complex example of what Whitehead calls a 'living nexus,' and we should note two general characteristics of all such nexus.[2] First, the continued existence of any 'living nexus' seems to depend upon the support of inorganic societies; this helps us understand why living organisms require food and why a 'soul' is always somehow embodied.[3] Second, each occasion in a 'living nexus' introduces some novelty through its mental pole. Now, Whitehead supposed that even in the lowest forms of life the mentality in any 'living nexus' is "canalized into some faint form of mutual conformity" (PR 164), allowing for the emergence of a society whose defining characteristic is mental. Such a society is composed of occasions each of which is able to sum up the mental experience of its predecessors in such a way that *any novelty which enters into a new occasion builds upon that which was experienced by earlier occasions.* Higher animals all seem to contain at least one such society, called a 'living person,' present in the body *in addition to* the cells and molecules of the central nervous system, even though dependent upon them. The human 'living person' or 'soul' is what I call 'myself,' as known to introspection.

The overall picture, then, is one of 'life' on Earth as a movement from mere physical order to mental novelty, and from mental novelty to coordinated inheritance of mental novelty. It is of some interest that Whitehead's use of the word 'life' changed in a way reflecting his interest in this same movement: his earlier discussion of 'life' in *Process and Reality* (PR 156 ff.) stressed the *emergence* of novelty (so that he spoke of individual 'living occasions' as the loci of this emergence in the 'living societies'), but his later discussion in *Adventures of Ideas* (AI 266 ff.) focussed more on the *coordination* of novelty (so that he used the word 'life' only to designate a characteristic of a 'living society' enduring through time). Either way, we can trace the 'upward thrust' of evolution to *final causation in nature* -- the subjective aims of actual occasions.

The Inheritance of Acquired Characteristics

Arguments about the inheritance of acquired characteristics -- what I shall call here 'Lamarckian inheritance,' with due apology to Lamarck! -- commonly prove fruitless because someone proposes, in effect, that we try to consider the life of an animal as though it were one of Whitehead's occasions, with a single subjective aim determining the whole course of its life. A clear example of what happens if we don't know what we are talking about! So here let us try to sort out carefully the *several grades of actual occasions* discussed by Whitehead, and the *several kinds of aggregations* of occasions which seem to occur in nature. There are four discernible grades of actual occasions, listed here in order of increasing complexity (PR 269).

1. There are the very primitive occasions, as in the ‘empty space’ beyond Earth’s atmosphere.

2. There are the occasions in *inorganic* enduring objects, such as electrons and rock molecules.

3. There are the occasions in *living* enduring objects (‘living nexus’), enjoying a degree of conceptual novelty

4. There are the occasions in the life histories of ‘living persons’ with *conscious* knowledge.

Comparing these, we see tremendous differences in actual subjective attainment and complexity of mentality, differences sufficient to account for our conviction that ‘life’ really is *very* different from the inorganic realm. Between the world of rocks and a world of people, there *has* been a series of ‘emergences’ -- new forms of actuality have appeared. But, as noted above, we should not suppose that any new abstract categories of explanation have emerged! I stress this mainly because one old error in explaining the evolution of ‘mind’ seems quite persistent: the notion that ‘bodies’ evolved first through purely physical means, and then later ‘minds’ appeared, exhibiting mentality. This really is an effort to explain the vast gulf between inorganic and organic *actuality* by proposing that ‘subjectivity’ and ‘mentality’ emerged partway through Earth’s history. On the contrary, Whitehead insists that *every* occasion in this long history is, during its moment of becoming, a *subject* governed by subjective aim and characterized by both a *physical* and a *mental* pole of experience.

In addition to four grades of actual occasions, Whitehead also distinguishes four kinds of aggregations of occasions on Earth:

> 1. There are the inorganic things which persist for long periods of time.
>
> 2. There are the vegetable-grade things, complex ‘democracies of cells’ whose occasions seem to have no aims beyond survival.
>
> 3. There are the animal-grade things, where some occasions, at

least, seem to enjoy aims for experience richer than necessary for mere survival.

4. There is human life, with its immense powers of novel conceptuality.

Now, if we combine both modes of analysis, we have roughly five kinds of occurrences in nature, shading off into each other:

1. There is the inframolecular activity studied by physics.

2. There is the inorganic realm of molecules.

3. There is cell life with its complex societies.

4. There is vegetable life, with its 'republic' of cells.

5. There is animal life, exhibiting in its higher forms some central direction.

The higher organisms which most interest us thus can be analyzed into complexly-related levels of social order. Beginning with the lowest level, there are societies of electrons, and there are the occasions in cellular 'empty space' which account for the life of the body. Within the cells and in the body fluids there are societies of atoms and molecules; what we call 'metabolism' springs from the delicately-balanced forms of atomic and molecular order at this level. Then there are societies of cells in organs and tissues; some of these societies may be dispersed widely through the body, as in the case of blood cells. Finally, in some animals there is a society of 'dominant occasions.

To clarify the problem of 'Lamarckian inheritance,' we need to ask just how influences may be transmitted among the levels of social order sketched above. The 'traditional' (and erroneous) proposal amounts to a claim that influences from either the dominant occasions or some cellular occasions are transmitted to the molecular occasions in sexual cells which are responsible for the succession of organisms between generations -- as though the giraffe's aim to stretch his neck somehow could cause his DNA molecules to 'stretch' too! Now, anyone who claims that doesn't know 'what' he is talking about! But by analyzing a few key notions we may be able to see what he *is* talking about. Let us take Lamarck's notion of 'adaptation to a need imposed by the environment' and ask how the analysis of actual occasions may help us find its meaning. Whitehead notes that the upward thrust of evolution has produced animals increasingly able to adapt the environment to themselves (FR 4-5), and this suggests that 'adaptation' concerns not only an occasion's mode of *responding to a given world* but also its mode of *altering the world beyond itself*. The first sense of 'adaptation' springs from subjective aims to increase the intensity of experience so that potentially-destructive feelings from the environment may be absorbed and integrated. (We gain a hint of this in our own experience whenever we are able to 'contain' a sharp insult without 'blowing up.') In this case, a 'need imposed by the environment' is any influence in the actual world of an occasion which threatens to disrupt its achievement. Applying this insight, we can see how to use the time-honored expression 'natural selection' in a more adequate way: evolution toward 'adaptation' with the environment involves the survival of societies whose occasions aim to incorporate in a richer experience influences which might otherwise be destructive of the society's defining characteristics.

This reference to societies, and the above reference to 'altering the world beyond itself,' can be clarified by noting that the subjective aim of an occasion is never merely for some intensity of experience within itself. Always there is some aim for achievement in its 'relevant future,' i.e., in whatever occasions are significantly derived from it. This aim for achievement in another, later occasion(s) is the ground both of altruism and of our sense that the past pays a claim upon us. Therefore, a 'need imposed by the environment' will be experienced by an occasion not merely as a 'threat' to its own subjective fulfillment but also in terms of its capacity to disrupt the future which that occasion is able to affect by its aims. Probably one of the least complex 'relevant futures' is that for a single occasion in an electron; the aims of such an occasion may reach no further than its immediate successor; if so, no one need suppose that an electronic occasion 'cares' whether the electron survives as an enduring object. But occasions in higher-grade societies entertain aims for more inclusive futures. For example, the subjective aim of a single occasion within a complex DNA-molecule's life history as an enduring object might include aims to perpetuate the existence of its own atomic and molecular sub-societies. Even so, a 'need imposed by the environment' will be experienced only as a threat to that (very limited!) future -- there is no reason to suppose that in its aim to 'adapt' to that 'need' the DNA-molecular-occasion is taking into account anything more complex. The amount of conceptual novelty it can introduce is tiny indeed, and the ‘cleverest’ DNA-molecular-occasion in the world is oblivious of the fact that its aims may have an effect on the welfare of the human ‘living person’ who happens to inhabit the same organism!

Let us now consider the subjective aims which may be typical of even more complex occasions. Just as we can speak of ‘electronic’ occasions composing an enduring electron, we can speak of ‘cellular’ occasions composing an enduring cell; and we note that a cell is a complex society of societies. Let us consider, say, a liver-cell-occasion. Such occasions might well entertain aims for the welfare of adjoining cells; but since the liver seems to be a ‘republic’ of cells, we would not expect to find in the liver any occasion which has aims for the future welfare of the entire organ, or for the body beyond the liver. More likely, we are dealing with aims which do not extend much beyond an urge to perpetuate the molecular sub-societies on which the life of the cell and its neighbors depend. At least, this conjecture is in line with our knowledge of the habits of liver cells; they show a remarkable plasticity of response to insult, but this has definite limits. For example, liver-cell-occasions seem unable to absorb into their experience the kind of threat posed by molecular carbon tetrachloride in their environment, and in the presence of carbon tetrachloride the order of the cells is disrupted -- which is very bad news for the human ‘living person’ up above! Likewise, we should not suppose that the liver cells aim to store glycogen in order to benefit the muscles; carbohydrate metabolism in the liver merely expresses the complex ways in which the many sub-societies in those cells are ‘pleased’ to enjoy themselves in their immediate environments. For most purposes, then, we are quite safe in regarding physiological processes as dominated by patterns of physical feeling, and in expecting that research will reveal the ‘machinery’ of living cells to be more complex than we have yet imagined.

At first glance, the previous sentence may seem to contradict our claim that purpose and novelty are basic to evolution. But this is not so. In the first place, every liver cell *aims* to ‘run its machinery’ the way it does. Second, most cellular activities are examples of long-standing evolutionary ‘success stories’; the novelty required for their appearance has long-since passed over into patterns of efficient causation, and any additional novelty would be principally disruptive. Third -- and most important for understanding the emergence of large-scale evolutionary change -- the amount of novelty introduced by a single cellular occasion is extremely small when compared with the power of its physical inheritance. But if we recall that each subjective occasion quickly becomes an object for its successor's experience, we can see how a tiny increment of novelty in one occasion may be inherited physically by its successors without any requirement for repeated novelty of mental experience. Later occasions merely *inherit* these patterns from the past but do not *introduce* them; final causation quickly passes over into efficient causation, and the net result after millions of years is the unbelievably complicated patterns of efficient causation which we observe. The peach tree blindly produces its seeds, the ovum blindly divides when it is fertilized. Still, none of these patterns *evolved* through 'blind mechanism' -- in every case, they must be traced finally to the cumulative power of subjective aims. Even 'chance,' which has been recognized in this century as a very important factor in evolution, merely designates the way in which many patterns of physical causation arise from the *uncoordinated* aims of many occasions. *The inheritance of acquired characteristics of feeling is fundamental to evolution.*

In the last few paragraphs I have tried to show that there *is* 'Lamarckian inheritance,' if we see that the term applies to the transition from one *occasion* to a successor and not to the transition from one *animal* to another animal generation. Also I have suggested that the aims of low-grade occasions in cells do not 'trickle up' to include interest in higher-grade bodily occasions, even though the physical results of those aims may well affect the entire body. But can the aims of higher-grade bodily occasions 'trickle down' to the cellular and molecular level? It seems clear enough that my own human aims affect some occasions in my brain cells, and through them, occasions in my arm, as I sit here typing. My aim to strike an 'e' -- or even to type a complete word 'the' triggers a burst of physical responses in my brain cells, which in turn mediate these 'amplified' feelings to adjacent occasions in other brain cells and in neurons. Finally, the fingers move. If I am a skilled typist, the whole sequence of events ending up in the typed word may require introducing novelty only at the outset. But if I am just now learning to type, I am aware of aims to make many mid-course corrections' in the movements of my fingers. The existing patterns of physical feeling in my brain cells have to be deflected repeatedly by fresh novelty -- now this way, now that way, in a tedious sequence of trial-and-error, before these tiny bodily societies learn the new patterns which enable them to respond to my aims to type. Without these repeated opportunities to gain 'feedback' by noting the actual way my fingers are moving, I would be helpless in my effort to discover just which patterns of physical feeling in my brain cells *should* be deflected by some fresh novelty. But once learned, these new patterns of brain-experience may produce muscular movements even without my consciously intending them -- perhaps the arching of my fingers as I drum them idly on my writing board is a reenacting of the skill first learned at my typewriter, or at the piano. In such ways, then, novelty in a high-grade occasion *can* ‘trickle down’ to influence lower-grade occasions. But there must be some ‘feedback system’ if high-grade novelty is to be *effective* in influencing the larger bodily pattern.

Can my aims ‘trickle down’ in this fashion so as to influence such occasions as those in my chromosomes? For example, if I come from a long line of brown-eyed people, can I aim to alter the DNA molecules in my reproductive cells so as to pass on to my son ‘genes for blue-eyedness’? Two facts stand in the way of supposing that such aims can be effective. First, there is no bodily ‘transmission line’ connecting my aims with my chromosomes in the way my central and peripheral nervous systems connect my aims with my muscles. Second, even if there *were* such a transmission route, my aims to have genes for blue-eyedness are bound to be ineffective because I have no way of getting ‘feedback’ from my chromosomes. In learning to type, successive occasions of my soul probably introduced novel ‘mid-course corrections’ thousands or millions of times; but the only way I can discover the typical condition of DNA in my spermatozoa is by having a child. In short, genetic change is random with regard to any aims of my soul which might ‘trickle down.’

Any ‘trickle-down’ theory assumes that novelty introduced in the mentality of an occasion produces its effects by triggering some pattern of efficient causation. According to Whitehead, however, there is another way in which the mentality of one occasion can produce effects beyond itself. He says that the *mental* pole of an occasion can take account of the *mentality* of other occasions spatially removed from it, even though *physical* effects must be mediated through spatially-contiguous occasions. Thus he proposes a ‘doctrine of immediate objectification’ (PR 469) for the mental poles of occasions, citing as evidence the occurrence of telepathy. In principle, then, it is possible that the mentality of a human personality might *immediately* affect various bodily sub-societies. Modern psychosomatic medicine has made some progress in analyzing along these lines; for example, it seems quite possible that the emotional tone of my soul may *directly* alter the patterns of physical feeling in my stomach.[4] Still, we should not suppose too quickly that the aims of a human personality have any very effective direct influence on the molecules of body cells, other than those in the brain. First, any *direct* effect of my aims on cells remote from my soul will be garbled and intermixed with the *indirect* effects of the same aims as mediated by many routes of physical contact -- the situation is analogous to the problem of understanding a speaker in an echo chamber. Second, the mentality of occasions in my soul is quite unlikely to entertain the sort of simplified possibilities which really would need to be ‘dangled’ before cellular and molecular occasions; surely an aim ‘to have a blue-eyed son’ would overwhelm the tiny creatures in my chromosomes!

We can conclude, then, that ‘Lamarckian inheritance’ does occur as an expression of the ways in which feelings are transmitted from one occasion to the next. But it is quite limited in scope by the available routes of transmission in organisms. The proper interpretation of Lamarckian notions in genetics thus depends fully on knowing ‘what’ we are talking about: all new patterns of efficient causation in animal bodies can be traced to *some* occasions’ subjective aims. But knowing *which* occasions, and *when* in the development of that line of creatures, makes all the difference. We can never know just how ‘the giraffe got his long neck,’ but like everything else in evolution it *is* the result of subjectivity and purpose.

EXPLANATION OF SYMBOLS FOR WHITEHEAD’S WORKS

AI *Adventures of Ideas*. Macmillan, 1933.

FR *The Function of Reason.* Princeton University Press, 1929; Beacon, 1958.

PR *Process and Reality*. Macmillan, 1929.

NOTES

[1] The following sections of this essay contain some ideas and several short quotations from my book *Evolution and the Christian Doctrine of Creation* (Westminster Press, 1967), Clv IV, "A Whiteheadian Interpretation of Evolutionary Theory."

[2] ‘Nexus’ is the plural of ‘nexus.’

[3] Whether human souls may be freed of their dependence on bodies is for Whitehead " -- another question" (Al 267).

[4] Unfortunately, research has not yet attended carefully to the question of whether my soul may influence *your* stomach!

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Mind in Nature: the Interface of Science and Philosophy by John B. and David R. Griffin Cobb, Jr.

Part 4: Mind and Organism

John B. Cobb, Jr. is Professor of Theology at the School of Theology at Claremont, Avery professor of Religion at Claremont Graduate School, and Director of the Center for Process Studies. David Ray Griffin teaches Philosophy of religion at the School of theology at Claremont and Claremont Graduate School and is Executive Director of the Center for Process Studies. Published by University Press of America, 1977. This book was prepared for Religion Online by Ted and Winnie Brock.

Chapter 5: Whitehead and Modern Science by C. H. Waddington

C. H. Waddington taught and did research at the Department of Genetics in the University of Edinburgh. He died in 1975.

The invitation to take part in this symposium came at a time which was rather awkward for me. I had for a year or two been thinking that it might be useful to write a book about Whitehead and the relevance of his thought to some of our present controversies, particularly in relation to biology, and the 'anti-science' movement. I had in fact decided to do so, when I had cleared off my plate a number of things which were already on it. But I had not fully thought out just what I would have to say, and I confess that I still have not yet done so. So my paper now must have a rather interim, half-prepared character; it will be another year or so before I can hope to have properly sorted out whatever I may find I have to contribute. I shall therefore present here only a rather expanded version of the notes I used when I gave the talk in the Villa Serbelloni, rather than a definitive essay.

The points I want to make come under four headings:

I. Whitehead and Reductionism

The controversy between reductionism and anti-reductionism (which in my young days in the 'thirties we used to refer to as between material materialism and organicism) is usually stated in something like the following terms. We (and science in general) start by accepting the real existence of certain scientific objects -- atoms, electrons, gravitation, light, etc. The question at issue is whether we can account for everything -- e.g., all biological processes, including behaviour (and some people would include, others exclude, mind and/or conscious self-awareness) -- in terms of those entities, as reductionists and mechanists claimed, or do we have to invoke something else, which might be organizing relations' or 'system properties,' as anti-reductionists and organicists argued.

Whitehead stated that we start somewhere else; not with objects, but with 'events' which are four-dimensional happenings, i.e., processes. All knowledge, and all talk, is derived from experiences of events. Scientific objects -- atoms, etc -- are not basic, but are derivative, intellectual constructs invented to assist us to understand events.

This view removes the whole heat from the controversy. Reductionism simply does what it says it is going to do, namely it reduces, from the experienced event to an intellectually constructed object, which is useful in making sense out of the particular aspect of the event we are interested in at the time. If we get interested in some other aspect, e.g., if we change from considering the blood circulation of an animal to its nest-building, we have a perfect right to invent new appropriate objects. But, in the interests of consistency, we shall only invent new objects when we cannot escape from doing so; usually, it is sufficient slightly to modify the description of our previous objects, e.g., when we modify the definition of the atom to accommodate it to new observations about radioactivity or atom-smashing, or new types of chemical combination. The point is, the definition which is given of a scientific object at any given point in history is not inviolable, so that the only change possible would be to add something ('organizing relations') to it; what happens is that the definition itself is changed.

II. Whitehead and the Complexity of Events

For Whitehead real existents were events. Each event has a definite character, but this results from the 'concrescence' of an infinite number of objects (which are essentially relations with other events, 'prehensions') into a unity. In doing science we have, on the one hand, to try to formulate simple objects which express the most important causal relations between events, but at the same time we have to ensure that these objects include (as sub-objects) as many as possible of all those involved in the event. The thrust of Whitehead's thought is *not* to simplify unduly; every time you 'reduce' you leave something out, and scientific ideas are richer and nearer to nature the less that has had to be omitted in order to reach them.

I applied these ideas in embryology as follows. When I began working, the standard concepts of experimental embryology were such things as 'potencies.' A potency to develop into neural tissue was a simple concept, but it was in fact totally vacuous since it could not be analyzed into anything else. Reinforced by Whiteheadian principles, I was not afraid to substitute for this the concept that development depended on the activities of very large numbers of genes. It had to be supposed that these activities were brought together to result in some relatively unified type of action, e.g., to form a definitive nerve cell, rather than a definite muscle cell. This 'concrescence-like' process would have to involve a great many control circuits, cybernetic-type interactions and so on. Further, this unity would itself be a process. That implies that the unifying action is not a homeostasis, i.e., a set of interactions which ensure that a certain state of the system is stable; instead it is a homeothesis, which brings it about that a certain *process of change* is stable. When the developing system is disturbed it returns not to the state it was at when the disturbance occurred, but to some later part of the stabilized pathway of change. The stabilized pathway of change is named a 'chreod,' and the whole system of chreods in a complex developing system such as an egg gives rise to an 'epigenetic landscape.'

Note that this is quite a different conception from that which a few geneticists were beginning, at that time or shortly thereafter, to formulate from a reductionist point of view. They asked the question, What controls the activity of a single gene, turning it on or off? We are by now beginning to get quite good answers to this question as regards bacteria, and are even approaching it for higher organisms. But it is not actually the crucial question, which is, What controls the activity of the *complex interacting set* of genes, which produces a nerve cell or a muscle cell? We know that in general this control of complex development processes takes place earlier than the control of single genes, but I doubt whether we know any more about it now than we did when I first formulated it, around 1940.

If one approaches the problems of evolution with a similar readiness to accept that the process may essentially involve very numerous components, one again comes out with a set of questions which are characteristically Whiteheadian rather than present-day orthodox. For instance, one admits that in much of evolution (probably all above the bacteria), evolutionary changes involve enormous numbers of genes, rather than a selection of one or two particular genes (although that occurs in a few instances, possibly, for instance, in industrial melanism). Of course this is a point which Dobzhansky and Sewall Wright have emphasized, both from the practical and theoretical points of view. It reduces to very small proportions, almost negligible, in fact, the importance of the element of chance mutation, on which R. A. Fisher on the one hand and Jacques Monod on the other have reared such super-structures of rather emotional philosophizing.

Moreover, from the Whiteheadian point of view one has to recognize that the evolving events -- actual animals and plants as we meet them in real life -- are influenced by environmental factors as well as genetic. Further, all living things above a very low level of evolution play some role, active or passive, in deciding what environmental influences will act selectively on their populations. All this produces a much more interactive theory of evolution than the conventional ‘chance and necessity.’ The organism draws its genes from an enormously variegated gene pool; it develops under the influence of them and also under those of a probably pretty heterogeneous environment; and, at any given stage of its life, the way its genes and its previous environment have acted up to that point may have considerable effect on the nature of the environment to which it will next be subjected -- if the animal does not like it here it may migrate someplace else, and so on. We are dealing in fact with a Whiteheadian type of interacting network, rather than a straightforward linear sequence of cause and effect of the classical materialist kind.

III. Whitehead and the Nature of Organizing Relations

Absolutely central to Whitehead’s thought is the idea that a unified event, which has a definite characteristic identity or, otherwise expressed, is an organized unit, is built up by the bringing together in some way of its interactions with other entities in the world (‘the concrescence of prehensions’). How is this done? Since Whitehead wrote in the ‘twenties, the standard scientific ideas about the nature of effective interactions between entities have undergone a number of changes. I think they are just about now beginning to catch up with the first phase of Whitehead’s thought on the subject, that is, his thought up to and including *Science and the Modern World.* They have not yet caught up with his thinking in *Process and Reality.* I think science will proceed in that general direction, but I am not quite convinced that it will come to exactly the same conclusions as Whitehead does -- partly because I find it very difficult to make up my mind what those conclusions are. However, the first part of the story is considerably simpler.

The ‘classical’, idea of effective interactions was that of simple material causality, with one or two causes producing one or two effects in a simple linear manner. The next stage was to accept that in many entities we have to consider a large number of interacting components, and processes of cause-effect which are not simply linear, but may interest either by being linked into networks, or by various types of feed-back interaction, positive or negative and so on. These are the ideas which were first brought forward in biology by thinkers such as Needham and Woodger (with myself acquiescing on the side-lines) under the name ‘Organizing Relations,’ and by Bertalanffy, who conducted a vigorous propaganda campaign on their behalf, under the name of ‘Systems Theory, and finally by Norbert Wiener, with equal fervour, as ‘Cybernetics.’ These all essentially involved interaction -- though not simple linear interactions -- between material things.

A new step was taken with the introduction of ‘Information Theory.’ It became common to come across sentences such as the following (taken more or less by chance from the manuscript of a book entitled, *Information, Explanation and Meaning,* sent to me in advance of publication by its author E. H. Nutton). "The most general model of a natural process on which scientific explanation may be based is no longer the movement of a particle under the action of a force, but the storage (or organization) and the transmission of information within a system." ‘Information’ is, of course, not a material entity. This is the essential change made from the classical notion of effective interactions or the systems theory development of it.

However, Information Theory was developed by Shannon and Weaver, originally in relation to the transmission of messages along communication channels, such as the telephone wire. It is mainly a theory of *inactive* specificity, which does nothing and brings nothing about. This is a profound limitation on its powers of implication or explanation. It is, therefore, rapidly being displaced from the centre of scientific thought by theories which are concerned with active rather than inactive specificity. These are theories of Instructions (Automata Theory) or Programming. These have been, of course, specially developed in relation to computers, but they deal with interactions in terms of something which resembles information in that it is not material, but differs from it in that it does not merely describe a state, as does information, but both describes a process and, further, instructs that this process should be done. It is in terms of vectors, not of scalars.

For vectors were the basis of Whitehead's idea of prehensions, as was pointed out particularly by Victor Lowe in his essay on "The Development of Whitehead's Philosophy" (Schilpp, PA., ed., *The Philosophy of Alfred North Whitehead*, 1941, 1951). Whitehead always thought of interactions as (a) involving something much more general than the physical forces contemplated in classical dynamics, involving in fact specificities akin to those contemplated in Information Theory, but (b) always as active ingredients of *processes.* That makes them very similar to the basic components of recent ideas about Automata Theory and Programming.

Whitehead had to go one degree further. He was concerned with the organization of specific character; every event reacts with every other, but not with all aspects of every other. We have one of those systems of circular causation which are characteristic of the whole Whiteheadian way of thought about organic unity. Event A requires its specific character of A-ness only by means of its interactions with all the other events P,Q,R,S,T, etc. But it interacts only with certain aspects of event P, and which those aspects will be depends on the character of A. Thus the character of A both depends on, and decides, the nature of its interactions with P,Q, and the rest. (Note the parallel with the system of ideas about evolution in which I suggest that the character of a living organism is determined by the particular natural selection it is subjected to, and that the natural selection it is subjected to is dependent on what its character leads it to select out of the range of environments available to it.)

Whitehead came to express this notion by saying that the prehension of one event A for another event B was according to the *'Subjective Aim' of A,* and instead of 'prehensions' he began using the word 'feelings.' These are obviously very dangerous terms, and a great deal of thought and discussion is necessary to discover just what Whitehead meant by them. Certainly he intended to convey that the character of A, which was decisive in specifying the nature of its interactions with B, was a dynamic character which had some affinity with an intention or an objective, or instruction, rather than a mere static characteristic, such as a chemical composition is usually considered to be. How far he was justified in introducing clear references to human personality, by using words such as 'subjective' or 'feeling,' is difficult to decide. I am fairly certain he did not intend a simple pan-psychism in which every entity --every stick and stone--is supposed to have a 'stream of consciousness' in any way comparable to our own consciousness. Perhaps he would have ruffled fewer people's feelings if he had used, like the topologist Rene Thom, a less obviously loaded term, such as 'the logos' of an entity, which Thom defines as a figure which describes the totality of the regulatory mechanisms of a system.

I do not want to pursue the discussion of this matter in this section, the main emphasis of which has been to point out that Whitehead already in the 'twenties was thinking in terms very close to those of the Automata Theorists and Programmers of the present day. I should, however, also remark that the more subtle developments of Whitehead's thought seem to have been the inspiration for one of the most thorough and impressive discussions of the evolution of human mentality and language in its relation to cognate activities in earlier evolutionary forms, namely Suzanne Langer's impressive work, *Mind: An Essay on Human Feeling,* of which two volumes have so far appeared and a third is promised soon. Thorpe stated that he personally had found Whitehead's thought of little help in relation to his own work on animal behaviour which was largely concerned with birdsong, but I think Suzanne Langer has shown that it may indeed be illuminating to think of problems of animal communication and eventually human language in terms of instructions, subjective aims or feelings, rather than in terms of information and description of states of affairs.

IV. Whiteheadian Science and the Present Anti-Science Movement

This is the aspect of Whitehead's relevance to the thinking of the present day that I do not feel ready yet to go into very deeply.

In cannot be denied that at the present day there is a widely disseminated feeling, which affects many people quite deeply, that it is an inescapable consequence of the essential nature of science that it devalues, dehumanizes, impoverishes the relation between man and nature; anyone who regards nature scientifically must find himself alienated and estranged from it. Exponents of this view are Marcuse, Gillespie, Roszak and many others.

Whitehead was the Knight in Shining Armour (some people seem to think him only the White Knight) who rode out to do battle against any and every form of what he called the Bifurcation of Nature -- whether it was the Cartesian Dualism or the alienation which the sensitive soul feels when it learns that water may be represented as H_2O. As we have seen knowing *which* occasions, and *when* in the development of that line of creatures, makes all the difference. We can never know just how 'the giraffe got his long neck,' but like everything else in evolution it *is* the result of subjectivity and purpose. Now, all the effective components in this picture---the instructional interactions and the events with a specific character, into which they are drawn together -- have the character of intentions, so we are already, in our basic view of science, in a world in which conceptions of Value are at least not foreign and maybe are inescapable. If we approach science from the Whiteheadian point of view, the fortress which the anti-scientists will have to attack is not what they think it is, and may be capable of mounting a rather devastating counter-attack.

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Mind in Nature: the Interface of Science and Philosophy by John B. and David R. Griffin Cobb, Jr.

Part 4: Mind and Organism

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Chapter 6: Concluding Editorial Comments by John B. Cobb, Jr.

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In Parts One, Two and Three, the topics under consideration were evolution, order, and the theory of panpsychism, respectively. Process thought, and especially that of Whitehead, was taken into account in most of the essays, but some editorial comments were needed to make explicit the relation of the ideas presented to those of Whitehead. Part Four consists of essays specifically dealing with Whitehead's philosophy in its relation to science. Hence, there is no need here for comparable "Whiteheadian Comments." These concluding editorial comments will, therefore, only note some interrelations between Part Four and the preceding essays, and point to the potential of Whitehead's thought to renew the discipline of philosophy of nature as a bridge between science and philosophy.

The subject matter discussed more philosophically in these essays extensively overlaps that discussed in Parts One through Three. Overman’s paper contributes directly to the discussion of evolution, focusing on the role of purpose. Whereas for many scientists the category of purpose appears extraneous to their disciplines, for a Whiteheadian its exclusion must appear inappropriate. Leclerc shows (above) that there is no acting without an end that involves mentality, and for Whitehead every event is also an actualization or an acting. Hence what Whitehead calls the ‘subjective aim’ plays a role in all events whatsoever. If so, then the confusion that has resulted from the effort to discern the role of aim or purpose in the evolutionary process must be due to having sought it at the wrong places rather than to its total absence from the process. In his contribution to Part One, Waddington shows that animal choices affect the requirements for survival and thereby the process of genetic selection. Overman supplements this account of selection at the level of phenotypes by concentration on analogous processes on the lower rungs of the evolutionary ladder.

The dual focus on animals and on microscopic entities brings to attention again the distinction made by Zucker in Part Two. Reductionism may be countered either by stressing that complex wholes are more than their parts or by showing that the ultimate parts themselves have characteristics of value and subjectivity that are usually denied them. Whitehead is rightly claimed for both of these strategies. In Part Four, Waddington shows Whitehead’s effective influence in the former way, and Overman in the latter. Leclerc does not find in Whitehead an adequate account of the unity and integrity of complex wholes as agents explanatory of natural phenomena, and he calls for going beyond Whitehead in this respect. Griffin, on the other hand, offers an interpretation of Whitehead’s doctrine of societies which shows that Whitehead can be plausibly viewed as having already met this need.

Western languages generally and Western philosophies in particular have developed quite distinct vocabularies for speaking of the objective world of nature and the subjective world of human experience. Whitehead devoted his energy to overcoming this bifurcation of reality and of language. Hartshorne in Part Three describes this duality in terms of physicalism and psychicalism. For physicalism the categories developed for the understanding of the objective world are ultimate; for psychicalism, those of the subjective world are ultimate. Hartshorne argues that finally psychicalism is more satisfactory than physicalism. If the issue is put in this way, Whitehead would probably agree, but he maintained the balance of the two vocabularies more closely and tried to avoid the choice between them.

The essays in Part Four express diverse attitudes to this issue also, although the differences are mainly of emphasis and rhetoric. Leclerc contrasts the earlier view of external relations and of change as fundamentally locomotion with the Whiteheadian interest in internal relations and in change as fundamentally the process of becoming. Waddington sees a continuity between elementary entities and sophisticated human experience that can be expressed in terms of instructions. Plamondon discusses the continuities between events at all levels in terms of the interdependence of organisms and environments. In these ways the concerns expressed by Hartshorne are approached from the side of a more physicalistic language. Overman and Griffin, on the other hand, are comfortable with the subjective connotations of Whitehead's formulations in *Process and Reality*, and they use psychical rhetoric without hesitation. This suggests that they are less reluctant than Leclerc and Waddington to read Whitehead's latest writings as psychicalist, but Griffin has explained in his comments on Part Three the very limited and special sense in which Whitehead can correctly be seen as panpsychist. The hope for Whitehead's future influence must be that it will become increasingly possible to accept a conceptuality that is neither physicalist nor psychicalist in a traditional sense and that can shape a way of thinking that does not presuppose the bifurcation Whitehead struggles to overcome.

From the sixteenth through the eighteenth century, philosophy and science developed in close connection. During the nineteenth and twentieth centuries they have become quite separate. The disciplines of cosmology and philosophy of nature have fallen between the stools. Alfred North Whitehead is the major twentieth-century exception to this breakdown of an ancient and fruitful relation. Ivor Leclerc's recent book, *The Nature of Physical Existence*, is an effort to renew the philosophy of nature, building on Whitehead and going beyond him. The response indicates that the time may be ripe for such an undertaking. The editors of the present volume hope that it may be an additional impetus to such a discussion among philosophers and among scientists as well as between scientists and philosophers. But they realize that the task is an enormous one, that the established communities of philosophers of science on the one side and of practitioners of the sciences on the other are far apart, and that both find the issues dealt with at this conference remote. Two essays in this concluding Part reach out to these separated communities to suggest points of relevant contact.

The essay of Ann Plamondon is addressed to those who are involved in philosophy of science in the English-speaking world. For them the major questions are about logic and methodology. Plamondon derives from scattered discussions by Whitehead a philosophy of science that can be placed in the center of the dominant discussion as a worthy participant. Perhaps this may help to show the continuity of philosophy of nature with philosophy of science and draw more philosophers into the former discussion.

The essay of C. H. Waddington expresses how a practising biologist has in fact been influenced in the direction of research and the formulation of theory by Whitehead's philosophy of nature. This provides, through concrete and important illustration, proof of the potential fruitfulness of renewal of intimate relations between science and the philosophy of nature. Waddington believes that scientific thought is 'just about now beginning to catch up with the first phase of Whitehead's thought" (above, p. 144). He thinks science will proceed in the general direction Whitehead moved in his later work; but for him, as for all of us, that remains to be seen. The editors believe that the advance of science can be facilitated by an ongoing discussion with Whitehead's philosophy of nature, and hope that more philosophers and scientists will join in the discussion.

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