PANPSYCHISM AND SPECULATIVE BIOLOGY: A.N. WHITEHEAD AND C.H. WADDINGTON[1]

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Abstract. The geneticist C.H. Waddington found in A.N. Whitehead's metaphysics the power of generalization that produced the basic principles of process, creativity and choice, all of which provided a theoretical framework and informed the direction of his scientific research on the development and evolution of organisms. In this paper I begin by examining the flaws in a purely mechanistic and materialistic philosophy, show how Whitehead's concept of organism addresses these flaws and finally explore Whitehead's influence on Waddington. Both Whitehead and Waddington's views suggest a revolutionary change of paradigm in theoretical biology.

Keywords: Epigenetics, Metaphysics, Organicism, Panpsychism, C.H. Waddington, Alfred North Whitehead.

INTRODUCTION

Panpsychism, from the Greek *pan* (all) and *psyche* (mind, or soul) is a form of idealism that asserts mind is fundamental throughout all of actuality – from human beings to dolphins and butterflies, on to vegetation and further down to viruses, bacteria, cells, molecules, atoms and subatomic particles. A variation of panpsychism, panexperientialism, is the thesis that sentient experience in some rudimentary form is omnipresent in the universe. Throughout this essay I shall use the term "panpsychism" as the generic term that includes panexperientialism, a more accurate characterization of the view I am exploring. My interest in this view stems from the fact that it offers potential solutions to many perplexing problems with what might be called "orthodox mechanistic materialism," namely, the view

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that reality is constituted of matter and its physical properties, and explanations of nature must be purely mechanistic. Panpsychism accordingly challenges the orthodox materialistic tradition that purports to explain all of nature mechanistically and offers a paradigm that is based on the concept of purposive organisms.

Panpsychism has been ridiculed as absurd, tender-minded non-sense by materialists ever since it was first proposed in antiquity, but it has also been espoused by some of the greatest philosophers and even some scientists. Some of the most eminent philosophers who have held this view include: Thales, Empedocles, Anaxagoras, G.W. Leibniz, Baruch Spinoza, Josiah Royce, R.H. Lotze, G.T. Fechner, F.C.S. Schiller, Arthur Schopenhauer, Charles Peirce, Samuel Alexander, William James, F.H. Bradley, A.N. Whitehead, Bertrand Russell, Charles Hartshorne, Timothy Sprigge and Galen Strawson. Physicists who have advanced panpsychism include Henry Stapp and David Bohm mainly as a result of their attempts to make sense of quantum mechanics, and biologists and geneticists such as C.H. Waddington, W.E. Agar and Sewall Wright have also proposed panpsychism on the basis that it provides a theoretical foundation for biological explanations[2]. In this essay, I will focus attention on the connection between A.N. Whitehead and C.H. Waddington.

PROBLEMS WITH MATERIALISM

The first problem with a thorough-going materialism is the emergence problem. A strict materialism runs up against two enormous gaps in the attempt to explain the emergence of living organisms and consciousness in the course of cosmic evolution. How do living organisms evolve from non-living inert matter and how does consciousness, that inner self-reflective awareness, thinking, perception, will and emotion arise from what is devoid of any of these properties?[3] As Galen Strawson made the point, the emergence of sentience or consciousness "… cannot be brute in the sense of there being absolutely no reason in the nature of things why the emerging thing is as it is…." for every time it occurs it would be a miracle (2006, 18). Thus, it appears to be impossible to establish a clear line of demarcation within a hierarchical continuum of systems of increasing complexity,

[2] While some panpsychists such as F.H. Bradley have argued that physical science can only provide abstract structures or a symbolic representation of reality whereas direct introspection of mind provides the intrinsic nature of reality, others have argued that science can provide evidence of panpsychism such as the variety of behaviors of unicellular organisms. With regard to the latter, the sharp separation between science and metaphysics contained in Bradley's distinction between appearance and reality is rejected in favor of a naturalism in which science and metaphysics are on a continuum. Whitehead and Waddington were certainly proponents of the latter view. Metaphysics cannot be detached from the overall advance of knowledge.

[3] This is the main theme of the Cobb and Griffin volume of essays, *Mind in Nature: Essays on the Interface of Science and Philosophy*. For example, W. H. Thorpe wrote: "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." (1977, 11).

above which there is sentience and consciousness and below which there is none. The promise of reductionist strategies designed to explain living things and consciousness in terms of strict materialist and mechanistic concepts has failed to deliver.

No one knows when or how the lights came on at some point in the evolutionary process, but as William James realized, consciousness, however little, is an "illegitimate birth" in any view that professes to explain all the facts by continuous evolution (1891, 148–149). And as Whitehead made the point: "a thoroughgoing evolutionary philosophy is inconsistent with materialism. The aboriginal stuff, or material, from which a materialistic philosophy starts is incapable of evolution" ([1925] 1967, 134–35). The emergence of subjectivity, or what it is like to have an inside, is not the emergence of one more objective property. Here I take the concept of phenomenological consciousness, knowledge of our own inner, subjective nature – a basic sense of what it is like to be conscious from the inside – to be the most familiar reality against those who would argue for the de-psychologization of consciousness. Knowledge of our own conscious states is knowledge by direct acquaintance rather than knowledge by description[4]. The claim that consciousness is an illusion is, of course, an inevitable consequence of materialism but a desperately implausible thesis in its defense.

There is also the closely-related problem of explaining the emergence of purpose in the course of evolution given that it does exist in humans and other animals[5]. If the world is to be conceived as the changes in the external relations between bits of matter, how does one explain the emergence of various organisms

[4] Although Thomas Nagel became famous for the concept of what is today called "phenomenological consciousness" (1974), it was Timothy Sprigge who first introduced this idea into the debate over the mind-body problem. As he made the point: "One is wondering about consciousness which an object possesses whenever one wonders what it must be like being that object" (1971, 167). This is not an epistemological matter of our attempt to know what it is like to be some individual or creature, but rather an ontological claim concerning the reality of subjective experience.

[5] The two central mechanisms of Darwinian theory are natural selection and random inherited variation. He has widely been interpreted as banishing any suggestion of purpose in explanations of how evolution occurs, even though some passages of *On the Origin of Species* (1859) and *The Variation of Animals and Plants Under Domestication* (1868) suggest that organisms consciously make choices ([1859] 1902, 108–109; 1868, 271). What is clear is that Darwin thought there were processes other than natural selection that played a role in evolution (Noble and Noble, 2023, 27). Whitehead notes that Darwin's successors only focused on natural selection and the extermination of the unfit ([1933] 1961, 35–36). For example, the main features of the Neo-Darwinian theory that have become orthodox in biology include: mutation, diversity of genes as a result of recombination of genes in sexual reproduction and natural selection (Birch, 1977, 33). Waddington notes that man is a species of animal and as such "he is subject, like the rest of the living world, to the processes of evolution" (1961, 99). If human beings are conscious, purposive creatures, then this appears to create a problem for Neo-Darwinian evolution, since according to the theory, all living creatures are caught up in the great chain of being explained by purposeless mechanisms. Human beings cannot be an exception. Neo-Darwinian theory cannot embrace a purposeless world for all non-human animals and a purposeful world for human animals.

and animals, including ourselves, that clearly exhibit choices in the fulfillment of goals? How did various arrangements of chemicals – atoms of carbon, nitrogen, hydrogen and oxygen – evolve into purposeful, living organisms? In the absence of a complex nervous system, we are less inclined to attribute states of pleasure and pain, appetite and desire to organisms but how far down the evolutionary scale do we get some basic goal-orientation? These questions address another qualitative aspect of evolution intimately connected with life and consciousness that cannot be answered by the orthodox theory.

In addition to the emergence problem there is the mind-body problem, arguably *the* problem that has bedeviled philosophy. Where materialism again fails to explain how consciousness is possible, and the dualism of mind and body runs up against the impossible task of explaining how consciousness and the brain interact, panpsychism postulates a third alternative. Until recently, this view has been regarded as implausible by a majority of mainstream philosophers, but given the stalemate in solving the mind-body problem, the "tough-minded" rejection of this metaphysical hypothesis in the twentieth century has been replaced by a willingness at least to take seriously, and in some cases to endorse, panpsychism as a solution[6].

Instead of beginning with matter and then trying to explain how consciousness appeared as a rare and very localized phenomenon on planet earth, panpsychism has the advantage of providing a smooth and continuous interpretation of nature in terms of the same fundamental stuff, namely, sentient experience. There is no jump between living and non-living. Living organisms and consciousness emerge from the same type of stuff rather than from something that is utterly different and shares no properties. Mind or consciousness is a higher order of sentience in which there is an awareness of the contrast between what is in fact and what might be.

Panpsychism is not a scientific theory; it cannot be tested empirically, and it does not make any predictions, but this is also true of mechanistic materialism. Both stand as conflicting theories offering a metaphysical foundation for science, and while each has advantages and disadvantages, panpsychism at least provides a basis for plausible explanations in addressing the problems identified above where materialism and mechanism fall short, especially in biology.

A.N. WHITEHEAD'S PHILOSOPHY OF ORGANISM

Alfred North Whitehead is most famous for his work with Bertrand Russell on the foundations of mathematics, the *Principia Mathematica* (1910–1913). This work was a defense of logicism, the thesis that all of mathematics can be derived from basic logical notions; its notation and deductive procedure were enormously

[6] Some important publications of this trend include Brüntrup and Jaskolla's *Panpsychism: Contemporary Perspectives*, David Skrbina's *Panpsychism in the West* and Skribina's *Mind That Abides: Panpsychism in the New Millennium*.

influential in the development of modern mathematical logic. He then turned his attention to physics to formulate his own version of relativity theory as an alternative to Einstein and finally generalized this work to form a metaphysical theory based on the concept of process. In doing so, Whitehead drew upon his vast knowledge of many sciences and the history of philosophy to create a comprehensive system that he hoped would then illuminate fields of inquiry beyond physics. This is what he called the test of "applicability of its results beyond the restricted locus from which it originated" ([1929] 1978, 5). His metaphysics attempts to answer the question of how emergence and novelty are possible in the universe.

For the purpose of this essay, I will focus on three aspects of Whitehead's metaphysics, or what he called the "Philosophy of Organism" ([1929] 1978, xi): (1) The most fundamental elements of the universe are units of experience rather than units of matter such as sub-atomic particles. They are micro-organisms Whitehead called "actual occasions." (2) The actual occasions arise from the whole network of actual occasions in the immediate past by the manner in which the occasions actively select the data of their predecessors. (3) The organizational activity of the occasions gives rise to aggregates that form the material world in complex arrangements of "social order" whereby organisms exist within organisms within organisms and so on.

As Whitehead sought to communicate his unique vision, he found ordinary language inadequate to express the dynamic and processual nature of reality and therefore found it necessary to develop neologisms such as "actual occasion", "prehension", "concrescence", "nexus", "society", to express his views. Instead of working within the restrictive confinement of the dictionary, Whitehead felt that speculative philosophy provided the opportunity to extend the dictionary and the human mind's ability to explore novel conceptions ([1938] 1968, 173).

ACTUAL OCCASIONS AND THE CONCEPT OF ORGANISM

Whitehead's project in *Science and the Modern World* was to overthrow the concept of matter as the foundation of nature with the concept of organism ([1925] 1967, 75). His protest was that nature conceived as insentient bits of matter standing in purely external relations to one another and simply located in space and time led to explanatory incoherence. Later in *Process and Reality*, he referred to this view as a world of "vacuous actualities" ([1929] 1978, xiii). It served well the limited purpose of mechanical explanations in Newtonian physics, but it could not be generalized for all scientific explanation. Whitehead writes: "the whole concept of materialism only applies to very abstract entities", namely, instantaneous configurations of matter as treated in mathematical physics ([1925] 1967, 79). For Whitehead, this is an example of what he called "the fallacy of misplaced concreteness", namely, mistaking the abstract for the concrete. What we actually experience is events and processes in a much richer, diverse and holistic context. Moreover, any philosophy of nature that fails to account for the characteristics of

life in nature – self enjoyment, creativity and aim – is untenable. As he makes the point in his essay "Nature Alive," he wrote:

> Science can find no individual enjoyment in nature: Science can find no aim in nature: Science can find no creativity in nature; it finds mere rules of succession. These negations are true of natural science. They are inherent in its methodology. The reason for this blindness of physical science lies in the fact that such science only deals with half the evidence provided by human experience ([1938] 1968, 154).

So, Whitehead attempts to solve the problem by starting in a different place. Beginning with mind or matter – the two radically different and irreconcilable substances – and then trying to derive one from the other is the mistake of philosophers espousing the two extremes of materialism and idealism. What we need rather is to find something more basic in our experience that is common to all nature. Whitehead called the clear and distinct elements of our experience "presentational immediacy", namely, clear-cut sense data such as our keen visual perceptions. But as he made it clear in *Science and the Modern World*, it is not simply a generalization from consciousness but rather a generalization from *embodied* psychological experience where we discover the key to what is basic to nature more generally ([1925] 1967, 73). The vague and inarticulate feelings of our total bodily experience more accurately capture that commonality, a dull throb of existence or a basic feeling of emergence from the immediate past. He called this element in human experience "causal efficacy" and sufficiently generalized causal efficacy identifies the essence of all actual occasions.

Actual occasions are events rather than substances; the basic units of existence become, contribute their novel synthesis and perish ([1929] 1978, 22). In contrast to the traditional substance ontology which for the most part has served as a basis for materialistic and reductionist explanations in science, an event ontology such as advanced by Whitehead is more adequate for biological explanations where processes such as genetic inheritance, metabolism, development and life cycles are of utmost importance. Nothing living exists as a bit of matter at an instant of time.

Dorothy Emmet has suggested that when Whitehead began working towards a generalized view of organism as a unifying concept for physics and biology, it looked as if physics might be swallowing up biology, but in his later writings such as *Process and Reality*, it is biology, or rather psycho-physiology, that is swallowing up physics (1996, 112). The basic principles are not to be found in the high abstractions of human consciousness, but rather in the basic organic functions of lived psycho-physical experience. Our dim semi-conscious experience of half sleep or visceral feelings of well-being, mostly ignored in our everyday experience, are more representative of what is going on in some rudimentary way in the rest of nature. Whitehead is therefore stretching the concept of experience, as Emmet

notes, "upwards and downwards; upwards into cognition, called here 'conceptual feelings,' and downwards into the physical world, whose ultimate constituents have sentience, however, 'low-grade'" (1996, 113). It is interesting to note how this concept of low-grade sentience plays out in *Process and Reality* when Whitehead turns his attention to the natural world:

> 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 upward towards 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 ([1929] 1978, 176–177).

In other words, nothing of the full conscious experience of human beings or other mammals with a dominant single-line nexus is apparent in the most basic experiences of flora and fauna, but there is every reason to infer sentience in its basic form. Nature is alive with feeling.

While Whitehead did not use the term "panpsychism" to describe his position, the philosophy he embraced clearly espouses the omnipresence of sentience in a creative universe[7]. It should also be clear that Whitehead was not a pure idealist in the tradition of Berkeley or Bradley; nonetheless there are strong connections with idealism in his final synthesis[8]. For example, as he advanced what he called "the reformed subjectivist principle", he wrote: "apart from the experiences of subjects there is nothing, nothing, nothing, bare nothingness" ([1929] 1978, 167). And again: "'Actual entities' – also termed 'actual occasions' – are the final real things of which the world is made up. There is no going behind actual entities to find anything more real" ([1929] 1978, 18). Whitehead avoided the term "panpsychism" because of its literal meaning that all is psyche or consciousness. Consciousness, for him, is rare in the overall scheme of things. In *Process and Reality*, Whitehead thus distinguished between:

- Subjectivity (ascribed equally to all actual occasions in the immediacy of becoming);
- Mentality (ascribed to all actual occasions by the degree to which they can originate novelty);
- Consciousness (ascribed only to a very specific type of actual occasions based on their capacity for "intellectual feelings").

[7] Also see my "Whitehead's Panpsychism as the Subjectivity of Prehension", in *Process Studies*, 24, 1995, pp. 1–2.

[8] In my *Whitehead and Bradley: A Comparative Analysis* (1992), I explore Whitehead's connection to idealism, including the doctrine of experience, internal and external relations, eternalistic vs process conceptions of time and the consequent nature of God.

PREHENSION OF THE PAST

As noted above, actual occasions are the fundamental ontological units of Whitehead's system. Actual occasions create themselves by their "prehensions" of predecessor actual occasions, literally seizing or grasping of what was previously created. The process of forming a novel unity is what Whitehead calls a "concrescence." As such, the occasions can be analyzed into their genetic components which reveal the data from multiple lines of inheritance. When an actual occasion begins its process of concrescence it prehends or selects the data from its immediate past compatible with its aim and rejects the data incompatible with its aim. A completed concrescence is an occasion that has become concrete in physical time. And once objectified, it now becomes data for the prehensions of actual occasions in its future. To put this another way, what is present is always subject, or as Whitehead says, it is "subjectively immediate". Experience is what is now and privately entertained. What we call "matter" is what results from the process of self-completion once an object appears and becomes publicly shared; it is always past. So, subject becomes object in the process of concrescence.

As the actual occasion becomes there is a passage characterized by a passive reception of the antecedent universe to an active selection of the data from which it forms the novel individual. The multiplicity of data from the past enters the present actuality and becomes elements of the present concrescing occasion. The initial phase is said to be "passive" or "conformal" to express the way in which the multitude of data enters into the subjective immediacy of the occasion without any selection that affects the final outcome. This phase is merely receptive as the past merges into the present. At this point, the initial prehensions merely conform to what is settled in the past. The following supplemental phase, on the other hand, is an active process of self-creation. From the multitude of data felt in the conformal phase, the occasion now molds itself by selection and elimination ([1929] 1978, 211–215). The data that are "positively prehended" are taken into the constitution of the present actuality as compatible with its subjective aim. Such elements have value for the occasion and become the essential ingredients. Those elements that are not part of this selection are called "negative prehensions". They are eliminated from this particular determination even though they may be positively prehended by other contemporaries. The main point for any one occasion, however, is that the achievement of its aim will always involve elimination. This gives the occasion its particular character and makes possible a novel individual in the universe ([1929] 1978, 41–42). The vast majority of actual occasions that compose the physical universe and provide for stability and repetition of objects do very little beyond the "passive" or "conformal" stage of the concrescence. In other words, there is very little opportunity for novelty in these occasions.

The data that are positively prehended by an actual occasion obtain "objectification" in that occasion. The individual facts absorbed into the internal

constitution of the subject achieve an "objective immortality" beyond their perishing in the immediate past. They are, so to speak, reenacted in the life of the present moment. This is essentially what Whitehead means when he says, "The philosophy of organism is mainly devoted to the task of making clear the notion of 'being present in another entity'" ([1929] 1978, 50). The theory of prehension proposes a view of causation in which the past, as objectified actual occasions, pushes into the present, and the present concrescing occasion by virtue of its subjective aim pulls into the future. But crucially it is the present that is picking up and passing on by selecting from the past. What is and what might be are decided in the activity of the present.

According to this theoretical construct of how novelty emerges in the temporal process, it seems that Whitehead has generalized the basic idea of genetic inheritance but he has injected teleology into the process by giving actual occasions a goal directedness that is absent from orthodox biological explanations. It is exactly this view that will be most controversial for acceptance of Whitehead's views in science since purpose in nature was banished from the scientific revolutions in physics and biology and any suggestion of returning to Aristotle's teleological explanations will be viewed as a decisive step backwards.

THE THEORY OF SOCIETY – ORGANISMS AND ENVIRONMENT

As part of his metaphysics, Whitehead formulated a mereological theory that he called "the theory of society" ([1929] 1978, 89). This theory of whole-part relations accounts for the order of nature in what he called "the extensive continuum". He used the general term "nexus" to designate a special togetherness of the basic entities of his system. A "society" is a macroscopic object. It is a nexus that has what Whitehead calls "social order". Social order is a common element of form among the entities that belong to any specific society and the imposition of reproduction among the members of that society so that one generation of entities after another reproduce the same pattern. The extended universe is a system of societies embedded in societies embedded in societies. For example, the society of electrons is embedded in the society of atoms, which is embedded in society of molecules, and so on.

This very broad notion of "society" involves the idea of a character that endures over time given the manner in which the constituent members inherit and modify the defining characteristic. This new metaphysical meaning extends the usual meaning so that a philosophy of process accounts for *things*. A society, for Whitehead, is defined by the massive average objectification of the dominant characteristics or, in his terminology, the eternal objects in the actual occasions forming the society. A structured society is one that includes sub-ordinate societies and sub-ordinate nexūs (plural of nexus) with a definite pattern of structural inter-relations. A molecule, a cell, a planet, a solar system and a galaxy are all

examples of structured societies. Each society is an organism that is harbored within the environment of another larger society, which serves as an organism for another, and so on ([1929] 1978, 99). The special sciences – such as physics, chemistry, biology, geology, astronomy – study some layer of society or organisms and their environment – subatomic particles, atoms, molecules, cells, … plants, animals… planets and galaxies. Cosmology, the study of the large-scale structure and evolution of the universe, is an investigation of the most general features of organism at the very limits of observation.

When Whitehead introduced the idea of a structured society, he wrote:

> A structured society consists in the patterned intertwining of various nexus with markedly diverse defining characteristics. Some of these nexus are of lower types than others, and some will be of markedly higher types. There will be 'subservient' nexus and the 'regnant' nexus within the same structured society. This structured society will provide the immediate environment which sustains each of its sub-societies, subservient and regnant alike ([1929] 1978, 103).

A cell, for example, is structured in the sense that it is a society that harbors the existence of lower, more specialized societies – at one level molecules, at another level atoms, and so on. So the higher society, the cell, is regnant, and functions as an environment for the lower level, the molecules, while the lower societies are subservient and function as organisms for the higher level. This reciprocity of whole and parts applies throughout the various levels of order in the extensive continuum – working outward in terms of environments or inward in terms of organisms. In this way, all societies are enmeshed in a system of ever-widening characteristics and influence. The wider environment always provides the necessary conditions for the survival of the more special organism.

"A 'structured society' may be more or less 'complex' in respect to the multiplicity of its associated sub-societies and sub-nexus and to the intricacy of their structural pattern" ([1929] 1978, 100). It may be inorganic – crystals, rocks, planets, sun – or organic – cells, plants, human beings. There is no absolute gap between these two categories; the distinction merely serves certain purposes where life may be important or unimportant ([1929] 1978, 102). For instance, in the first category of material bodies life is unimportant for the science of dynamics. But up and down the continuum we find that many apparently inorganic societies sustain the organic ones, and organic societies include subordinate inorganic ones. For example, the solar system sustains the planet earth, and living animals and plants sustain their arrangements of molecules and atoms.

Most societies with which we come into contact are "democracies" in the sense that their subordinate societies function together without some central unified mentality. Certain cell colonies, plants, ecosystems and most lower forms of multicellular animals are democracies. These organisms react to stimuli, but there is

no central direction or unified control. Higher animals, however, are those with a dominant living nexus of personal order. In the case of the vertebrate animals, the nexus of occasions with a dominance of the mental pole arises out of the complex nervous system – here defined as a system of neural occasions eventually forming the neurons. And the intensity of this experience, we must presume, varies from species to species.

For Whitehead, a human being is an organic structured society in which the dominant nexus is a purely temporal, single-line inheritance of actual occasions known in James' terminology as the "stream of consciousness" (1891, 224) – or what Whitehead calls the "crown of experience" ([1929] 1978, 267). This results from a certain intensity of the subjective form in the nexus.

Regarding this last point, Whitehead's view of the human mind and brain stands in opposition to materialist interpretations, many of which have found stimulus from computational models of cognition and neuroscience. From his point of view, the materialist merely operates within a limited region of structured societies, i.e., the brain and sub-societies such as molecules and nerve cells. But it is never quite clear how consciousness could evolve from the inert and essentially lifeless base of matter. Whitehead's view, as noted above, begins with one type of stuff, of which consciousness is the most sophisticated end of a continuum beginning with the most rudimentary sentience.

What makes Whitehead's philosophy an organic view of nature is this central idea of nested hierarchies of societies, of smaller units of organisms nested in the larger ones, and the interdependence of wholes and parts. But in accordance with the one-way dependence of the temporal process, certain exchanges take place between the organisms and their environments in order that higher, more complex organisms can evolve from lower, simple ones. That is, the wholes and parts function together such that the parts are modified in accordance with the plan of the whole, and the whole is modified by its internal constituents. Whitehead, on this matter, locates two sides of the mechanism involved in the development of nature. He says that: (i) a given environment dominates its subordinate societies such that the organisms adapt themselves to it, and (ii) the organisms create their own environment by a certain cooperation among themselves in producing the desired effect ([1925] 1967, 111–112). On the first point (i), an individual organism of whatever level is liable to have aspects of the larger pattern dominating its own being and thus experiences modifications of the larger pattern reflected in itself. Obviously, such reactions to changing circumstances in the wider environment are of utmost importance for natural selection where adaption becomes crucial. But also (ii), organisms can change and mold the environment that defines them. To take a simple case, body cells, for example, alter their extracellular environment by exchanging chemicals, generating heat, and so on. The environment must therefore have a certain plasticity such that over a longer period of time a higher organism can evolve from changes that take place in the subordinate organisms. Changes at the lower level produce an

increase of complexity, thus allowing the evolution of novel and more sophisticated organisms[9].

C.H. WADDINGTON'S THEORETICAL BIOLOGY

Waddington was a polymath of wide learning who successfully crossed the boundaries of what C.P. Snow called the "two cultures" of the arts and sciences. It is rare to find one who made important contributions to the advance of science and writes with such a general understanding of philosophical issues. In this regard, Waddington would most certainly qualify as a "Natural Philosopher" in the Enlightenment sense of the term. He was the founder of epigenetics and proposed a model of genetic assimilation to compete with Darwin's theory of evolution by natural selection. Waddington was one of the founders of the Theoretical Biology Club at Cambridge in the 1930s whose members advanced a philosophy of biology, "organicism," that would offer an alternative to the reductionism of mechanistic materialism and the obscurity of vitalism in coming to terms with the dynamic, interdependent and purposeful character of life. This view was also embraced in one form or another by E.S. Russell, John Scott Haldane, C. Lloyd Morgan, Lawrence J. Henderson, C.D. Broad and Alfred North Whitehead. Waddington, in particular, sought to integrate genetics, development and evolution within the context of theoretical biology. Like Whitehead, who believed that ordinary language was inadequate to express the dynamic nature of reality, Waddington was a prodigious coiner of neologisms, e.g., "epigenetics," "epigenetic landscape," "genetic assimilation," "homeorhetic," "canalization," "chreod," and "epigenotype."

Waddington discovered Whitehead's work as an undergraduate at Cambridge. He said he paid more attention to Whitehead's writings than the textbooks in the subjects he was meant to read for his exams (1975, 3). Whitehead had such an impact on him that he abandoned geology and applied for the Arnold Gerstenberg

[9] Contrary to Whitehead's organic teleological conception of nature, the orthodox view in biology is expressed in the Modern Synthesis or Neo-Darwinism, a mid-twentieth century synthesis of some aspects of Darwinian theory with a newer population-oriented view of Mendelian genetics. The Modern Synthesis, with its emphasis on random mutation, is a purely mechanistic foundation of biology since random processes are by definition goalless. Teleology plays no role whatsoever in the theory. The term "Modern Synthesis" originated from the title Julian S. Huxley's 1943 book, *Evolution: The Modern Synthesis.* According to Noble and Noble, the Modern Synthesis has four main pillars: "(1) that changes in the structure and function of organisms in one generation could not be passed on through the germ line… the gene-centric dogma; (2) that organisms could not alter their genes, so causation was held to be a one-way process, from gene to organism functionality; (3) that the organism was best viewed as a passive vehicle for retaining genes in a 'gene pool' and, most significantly, that the behaviour and function of organisms was controlled to this end … ; (4) that evolution occurs through small random changes in genes (gene mutations) that are passively selected in the process of natural selection" (2023, ix).

Prize in Philosophy in 1929 which he won with his essay, "Philosophy and Biology". In this essay, Waddington focused on Whitehead's view of events and process as the fundamental constituents of the world and argued that physiochemical descriptions of living things fall short of grasping their essential nature (1929). It was at this time that he changed his interest to study "'live' biology rather than fossils" (Robertson, 1977, 578).

In his "Autobiographical Note" in *The Evolution of an Evolutionist*, entitled "The Practical Consequences of Metaphysical Beliefs on a Biologist's Work", Waddington acknowledged the influence of Whitehead on his scientific work (1975, 3). He also wrote an essay for a volume based on a talk he gave at Bellagio, Italy in June, 1974, "Whitehead and Modern Science" where he explains this influence in more detail. Whitehead, he says, provided a new way of looking at the problem created by the dilemma of mechanism and objective vitalism (or reductionism and anti-reductionism), and a new vocabulary with which to express the processual and relational nature of experience (1977, 143; 1962, 19–20). As for the question – Can living things be treated as if they are nothing but mechanisms constructed of mere material components? – the mechanistic biologists and reductionists answered in the affirmative while the objective vitalists and anti-reductionists answered in the negative. Whitehead, he thinks, resolved this dilemma by rejecting the whole conceptual framework in which the problem was framed. Living things cannot be accounted for in concepts that were formulated for the non-living world.

Organicists such as Waddington held that an organism does not exist at an instant, nor is it a bag of chemicals, each of which is produced by the influence of some particular gene. It is rather a process spread out in time and the explanation of its functioning requires more than the atomistic account of genes on heredity. Also, it is essential to an organism that its overall form and the properties of its component parts are a result of the reciprocal play of all the components on one another (1962, 53–54). The very concept of organism is therefore much more compatible with the sort of holism advocated by Whitehead.

So, not only did Waddington embrace metaphysics at a time when orthodox biology rejected such speculation as unscientific, he also embraced Whitehead's metaphysics against the status quo – a view of nature as alive and purposeful[10]. In his view, it wasn't a question of whether to engage in metaphysics or not; the orthodox view had accepted a metaphysical view without acknowledging it as such, a materialistic reductionism of the Democritean-Cartesian variety that Waddington called a "lousy philosophy" (Peterson, 2011, 316). His whole point, he said with

[10] See, for example, Erik Peterson's "The Excluded Philosophy of Evo-Devo? Revisiting C.H. Waddington's Failed Attempt to Embed Alfred North Whitehead's 'Organicism' in Evolutionary Biology" wherein Peterson argues that Waddington's explicit allegiance with Whitehead's metaphysics was one reason why Waddington's views did not have more impact on the Modern Synthesis (2011, 303).

respect to his Whiteheadian orientation was "to illustrate the fact that metaphysical presuppositions may have a definite influence on the way in which scientific research proceeds" (1975, 10). A metaphysical view that informs a scientist's work is not a mere epiphenomenon. In Waddington's case, he said that Whitehead's metaphysics had a definite and ascertainable influence on both his research agenda and on the experiments that he conducted in support of his theories (1975, 1). This included the fundamental ontology of process, which proposed events or occasions of experience as basic, the concept of organism, and the importance of both atomic and continuum theories for understanding development and evolution (1975, 4–5; 1962, 53–54)[11].

Waddington was also a proponent of panpsychism. He was more of what I would call a "closet panpsychist" by avoiding explicit mention of the term and he often skirted around the concept of goal orientation in nature by suggesting that something more than mechanisms is needed to explain development and evolution, namely "quasi-finalistic properties" (1962, 98). When, however, he argued with Whitehead that "you have either got to have consciousness or at least something of that general kind, everywhere; or nowhere" it is clear that he meant "everywhere, presumably mostly in a very rudimentary form" (1969, 114). Something, he wrote, "must go on in the simplest inanimate things which can be described in the same language as would be used to describe our self-awareness" (1962, 121). For his approach to theoretical biology, Waddington is sometimes referred to as a Whiteheadian organicist (Bard, 2017, 2).

DEVELOPMENT AND EVOLUTION

Waddington's most important scientific achievement was the concept of embryonic development as a highly integrated series of canalized pathways. Whitehead used the term "concrescence", to describe the process of coming together to create a novel entity which essentially invokes the concept of a subjective aim that drives the process to its endpoint. Waddington said that when he began working in embryology, he adopted a Whiteheadian perspective that development depended on activities of a very large number of genes which were brought together to result in some relatively unified type of action to form the different types of cells (1977, 143–144). A "creode" describes the path of change determined by initial conditions that once entered upon cannot be abandoned. It is

[11] Understanding development required both atomic and continuum theories; genes are the basic atomic units of hereditary material further analyzed into chromosomes, proteins, amino acids, and DNA into nucleotides, and the continuum is addressed by the biological processes by which development occurs, i.e. canalized pathways (1962, 36–37). In Whitehead's metaphysics, actual occasions atomize the extensive continuum. Actual occasions are analyzed into prehensions, eternal objects, subjective forms, etc. Continuity is addressed in terms of nexūs, societies, i.e., events, fields and matter formed from the prehensive activity of actual occasions ([1929] 1978, 20–30).

his biological term for Whitehead's concrescence, or what Waddington called "gene-concrescence" (1975, 9–10)[12]. As Waddington wrote in *The Nature of Life*: "We can say then that the heredity materials with which an organism begins life define for it a branching set of creodes. Different parts of the egg will move along one or other of these creodes, so that they will after a long process of progressive changes, finish up as one or other of a number of different end-results, as it might be a heart, muscle, nerve, kidney and so on" (1962, 64). The differentiating cells will thereby reach their endpoints unless there are powerful influences that divert the pathway and the cell or the developing organ ends up in an abnormal condition or a mutation. 'Canalization' is the property of developmental pathways to produce standard phenotypes despite environmental or genetic influences. The phenotype is the actualization of the potential in the genotype given a normal developmental pathway.

The epigenetic landscape is Waddington's visual representation of the different pathways a cell, an organ or an organism can take during embryological development. He used the term "epigenotype" to describe the complex interactions of genes and interactions between genes and the environmental factors that result in the phenotype. The development is represented as a topology of valleys with balls moving along the paths, each representing canalized pathways traversed by cells, etc. The usual pathways of change through which an organ develops produce a normal result. An interference in this process, as for example by an environmental stress induced by temperature or a chemical stimulus, is represented by a manipulation in a slope that leads to one channel being taken rather than another (1975, 53). In the case of Waddington's experiments with *Drosophila* larvae, the heat shock resulted in the bithorax phenotype or in changes to the structures of the wings (1975, 50–51)[13].

Waddington thought the epigenetic landscapes represented morphogenetic fields in which physical forces mold developing tissues into organs (1962, 69–71).

[12] Peterson notes that: "Waddington was trying to depict convincingly the Whiteheadian notion of concrescence as biological phenomena. Potentialities become actualities within a possibility space that allows for a great degree – though by no means total – freedom" (2011, 311).

[13] See Noble, 2015 for Waddington's experimental success in his approach by discovering in a population under study the forms of developmental plasticity that already exist and then altering the environment in such a way to find a path that evolution could have taken. For example, in Waddington's 1956 paper published in *Evolution*, "The Genetic Assimilation of the Bithorax Phenotype", he reported on the Bithorax mutant, a four-winged fruit fly, *Drosophilia*, with two thorax segments that was the product of experiments that changed the environmental temperature or used a chemical stimulus. In the case of a pregnant woman exposed to a teratogen such as thalidomide or paroxetine, the pathway of normal development of the embryo is altered and results in a birth defect. There are also different starting points that produce different outcomes, such as genotypes different from the XX female chromosome and the XY male chromosome – XO, XXY and XYY. These would be represented by a different spin on the ball at the start of the process and result in the probability of a path other than the main ones for XX and XY. In the case of the abnormality XO, for example, the result is a female with small stature, amenorrhea and infertility.

The developing systems are pushed from the past and pulled into the future toward their endpoints[14]. Here we recall Whitehead's view of the prehensive process in which the present is active in picking up data in the past and pulled into the future by the subjective aim. When Whitehead used the term "canalization," in reference to the philosophy of organism, he wrote: "The canalization of the creative urge, exemplified in its massive reproduction of social nexus, is for common sense the final illustration of the power of stubborn fact" ([1929] 1978, 129). His example is finishing a sentence because we have begun it. The actual occasion is set on its pathway, from what is given as stubborn fact in the immediate past and molds itself from that data to form its own creative synthesis. Waddington found this notion of being canalized suggestive of what is happening in embryonic development. It is a "homeorhetic" rather than a homeostatic process whereby an organism maintains a certain trajectory, i.e., "stabilized flow rather than stabilized state" (1975, 221).

With regard to Whitehead's influence on Waddington's view of evolution, he wrote: "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" (1977, 144). He said in *The Evolution of an Evolutionist* that he put his Whiteheadian outlook to actual use in particular experimental situations (1975, 11). For example:

> … when I started doing experiments on *Drosophila* evolution, in the '40s and '50s, I treated even that insect as a developmental system, and by manipulating the environment in which it develops was able to uncover the rather novel process of genetic assimilation. Thus my particular slant on evolution – a most unfashionable emphasis on the importance of the developing phenotype – is a fairly direct derivative from Whiteheadian-type metaphysics (Robertson, 1977, 597).

The Neo-Darwinist view focused on the genotype rather than the phenotype in explaining inheritance. In fact, Neo-Darwinism specifically excludes the inheritance of an acquired characteristic, i.e., Lamarckian inheritance. Against biological orthodoxy, Waddington sought to challenge this view by showing how embryos can respond to an abnormal environmental situation by producing a new character, i.e., a new phenotype, initially without genetic change. But then after exposure of subsequent generations to the same environmental change, selection occurs, and a genetic basis for the character will be found in the population without the environmental change. A "soft" inheritance, namely, a change in phenotype in one generation, then becomes "hard" inheritance as that characteristic is programmed into the genotype of succeeding generations. This is what Waddington called "genetic assimilation," which is the origin of epigenetics, namely, the study of

[14] Sheldrake specifically describes Waddington's view of embryonic development as goal-directed and connects Waddington's notion of the pathways in the epigenetic landscape to Whitehead's view of prehension (2020, 143–145).

heritable phenotype. The Greek prefix *epi-* "over, outside of, around" in "epigenetics" implies features that are "on top of" or "in addition to" the traditional genetic basis for inheritance.

As Waddington wrote in *The Nature of Life*: "We have considerable grounds for believing, then, that mentality in the broad sense, or at least behavior (biologists tend to be very timid about mentioning mind), is a factor of importance in evolution. Lamarck's insistence on the 'Will' is not wholly unjustified" (1961, 91). As Denis Noble commented on Waddington's position, he wrote: "He did not describe himself as a Lamarckian, but by revealing mechanisms of inheritance of acquired characteristics, I think he should be regarded as such" (Noble, 2015, 817).

Genetic assimilation is a revolutionary development because one dogma of the Modern Synthesis contends that causation only works one way from the genotype to the phenotype, but Waddington showed that organisms can alter their genes and thus causation also works from phenotype to genotype, a two-way causation (Noble and Noble, 2023, ix, 1–2, 28). Moreover, purpose in nature implied by the inheritance of acquired characteristics is a direct challenge to blind chance in random mutations. What Waddington demonstrated, contrary to the Modern Synthesis, is that acquired characteristics can be inherited. This is a major problem for the Modern Synthesis, but the anomaly has yet to be fully realized in any sort of an adjustment of the theory or a decisive refutation.

WHAT IS LIFE?

Erwin Schrödinger's 1944 classic *What is life?* proposed the idea of a code-script for reproduction in a heredity molecule ([1944], 1967, 21–23). The culmination of this line of work was Watson and Crick's double helix model: living things make variant copies of their parent organisms through DNA. In "The Process of Evolution and Notes on the Evolution of Mind", Waddington wrote: "biological systems work by means of the programs or instructions incorporated in their components" (1977, 70). He continued:

> 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. (1977, 71)

For all the brilliance in these scientific advances into understanding life in terms of heredity, DNA, and code-scripts for reproduction, Whitehead's protest that something essential to what we understand by life is neglected: self-enjoyment, creativity and aim. It was in this connection that he viewed any entity that is purposeful as having an inside or what he called a "subjective aim" or "feeling." Moreover, if the foregoing account of agency is correct and the central activity is located in the organism rather than in the genes, then organisms are not merely vehicles or passive systems carrying the genes to the next generation. The genome is rather a tool orchestrated by the organism (Noble and Noble, 2015, 1–4, 10–11).

A biological organism is a living process, not a static substance. This living process must in part be explained by choice at some very rudimentary level. The conception of a living organism as a machine has some obvious problems. Machines do not develop, nor do they reproduce. Moreover, machines do not depend on their relations to other machines whereas organisms do form complex interrelations with other organisms. As Dupré and Nicholson made this point they argued:

> In addition to legitimating and encouraging the recourse to machine analogies in the living world, mechanicism has permeated modern biology in another, more subtle way, namely by popularising the view that living systems can be explained by describing the causal mechanisms that are said to be operating within them…. Although it is undeniable that the elucidation of biological phenomena in terms of mechanisms has proven to be an enormously productive scientific strategy, mechanistic explanations are inherently limited in what they can tell us about living systems … mechanisms in biology are more appropriately understood as heuristic explanatory devices – as idealised spatiotemporal cross-sections of living systems that conveniently abstract away the complexity and dynamicity of their biotic and abiotic surroundings, and pick out only the causal relations that are taken to be most relevant for controlling and manipulating the phenomena being investigated… To suppose that mechanisms are the ontological building blocks of living systems is to commit what Whitehead famously called "The Fallacy of Misplaced Concreteness" (2018, 23–24).

CONCLUSION

Whitehead's concept of organism, generalized in his process metaphysics, had a profound influence on Waddington's theoretical biology and more specifically on his scientific research in development and evolution. Purpose in nature appeared to be banished from orthodox science beginning with the scientific revolution that dethroned Aristotelian teleology. While the mechanistic and materialist models remain indispensable to scientific explanations of natural phenomena, Whitehead and Waddington have shown the limitations of any such reductionism. But more to

the point, both Whitehead and Waddington accepted some form of panpsychism as a foundation for understanding the natural world. It is not panpsychism in its literal meaning since neither Whitehead nor Waddington proposed that mind or consciousness is fundamental but rather some rudimentary form of sentience in nature that drives the creative advance.

Waddington saw in Whitehead's metaphysics the power of generalization that produced basic concepts of process, creativity and organicism which he usefully applied to heredity, development and evolution. Whitehead drew upon many sciences – physics, chemistry, biology, cosmology, psychology – when he formulated his metaphysical principles. He claimed in *Process and Reality* that success would be measured by the extent to which the generalities of his process metaphysics pass the test of applicability beyond the restricted locus from which they originated, whether they illuminate our experience of the world, have broad explanatory power and provide unifying concepts for the sciences ([1929] 1978, 5). Waddington's biological work might be one of the best examples of this success. Like Whitehead, Waddington sought to explain fundamentally how novelty is possible.

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