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LIFE AND PROCESS

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TOWARDS A NEW BIOPHILOSOPHY

PROCESS THOUGHT

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Process Thought

Edited by
Nicholas Rescher, Johanna Seibt, Michel Weber

Volume 26

Life and Process

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DE GRUYTER

A Fourth Variable in Evolution

JOHN B.COBB, JR.

I cannot contribute to the discussion of evolution as a scientist, and I cannot claim to have read the literature widely or thoroughly. Accordingly, I am only reporting as a Whiteheadian on what I have learned through a conference on evolution and religion and by working on the papers to develop them into a book.[1]

Most of the conferences on science and religion take these two areas of thought as more or less given and then consider how they relate. Our Whiteheadian approach is quite different. We assume that revisions are needed on both sides. I thought that it would be appropriate in the context of this section to report on my conclusions as to the sort of revision that is needed on the side of evolutionary theory.

1. The activity of organisms as a main factor in evolution

The evolutionary theory that requires revision, I call neo-Darwinism. It is so widely accepted, that most biologists feel no need to give it a special label. At our conference the strongest representative of this mainstream theory was Francisco Ayala. He agreed to write additional material for our book so that the thinking of the majority of working biologists would be well represented. The book as a whole, however, is an argument against the adequacy of his formulation of evolutionary theory.

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[1] The Center for Process Studies received a small grant from the Metanexus Foundation, which emphasizes discussion of the relation of science and religion. We have held three conferences. The first conference, on evolution and religion, took place in October 2004. I had primary responsibility for organizing it and also for developing the book *Back to Darwin* from it.

Ayala is not a neo-Darwinian in the full sense. He believes that there are ways of knowing other than science. Accordingly, he does not draw from his evolutionary theory the full range of neo-Darwinian conclusions. He represents a widespread way in which peace is established between science and religion, that is, an epistemological dualism. However, I am not reporting here on the ways of dealing with the relation of science and religion - only on the science. I begin by quoting two passages from Ayala, so that you will know exactly what position I want to revise.

> "I argue in this paper that science encompasses all of reality and that we owe this universality to Charles Darwin, who completed the Copernican Revolution by extending to the realm of life the Copernican postulate of the natural world as matter in motion governed by natural laws. The Copernican Revolution had left out the diversity and configuration of organisms, because organisms and their parts manifest to be designed. Natural selection acting on spontaneously arising mutations can account for the diversity of organisms and their design. Evolution is a creative process owing to a fruitful conjunction of contingent and deterministic processes" (2008a, 50).
>
> "Natural selection does not strive to produce predetermined kinds of organisms, but only organisms that are adapted to their present environments. Which characteristics will be selected depends on which variations happen to be present at a given time in a given place. This in turn depends on the random process of mutation (broadly understood), as well as on the previous history of the organisms (i.e., on the genetic make-up they have as a consequence of their previous evolution). Natural selection is an 'opportunistic' process. The variables determining in what direction it will go are the environment, the preexisting constitution of the organisms, and the randomly arising mutations" (ibid. 72f).

It is my impression that these quotations express views widely held by contemporary evolutionary biologists. They are quite standard formulations. They lead to the conclusion that everything is to be explained by chance and necessity. Actually, the "chance" is usually not thought to be, finally, pure chance, since it is assumed that physical laws apply. These may be regarded as statistical laws, allowing for some small element of indeterminacy, but this is not what is meant when mutations are said to be random or matters of chance. The point is instead that mutation is not in any way purposeful or influenced by purpose, divine, human, or natural.

As a Whiteheadian, I find this explanation of evolution implausible, not because of what it includes but because of what it omits. It includes the organisms, understood as the multicellular plants and animals. It includes the environment of these organisms. And it includes the genes.

It omits the environment of the genes in the DNA molecule, the environment of that molecule in the cell, and the environment of the cell in the body. Instead it speaks of the randomly mutating gene as unaffected by its environment. Except for the selection of genetic mutations for survival, the standard theory omits the influence of the environment on the phenotype, that is, the multicellular organism. It omits the effects of changes in the phenotype in determining the adaptiveness of mutations. And finally, it omits the activity of the multicellular organisms and therefore the influence of this activity in determining both the adaptiveness of genetic mutations and the environment that selects.

If we consider the environment of genes to be composed of tiny organisms, then we can regard most of what is omitted as consisting of the activities of organisms at many levels. To simplify, I will emphasize here the activity of multicellular organisms, but in fact eucaryotic single-celled organisms, bacteria, viruses, and proteins are also important factors in evolution. I intend for my fourth variable to include all these even though I do not develop the argument here.

Mainstream biologists know that there is evidence for all of the relationships they omit from their formulations of the mechanics of evolution. Ayala refers to much of this. The problem is not ignorance. My complaint is that, despite his rich knowledge and that of other biologists, as a group they see no need to include any of this in their standard explanations of evolution. In this short paper I will review some of the evidence and consider the reasons for its neglect.

The phenomenon most widely recognized by evolutionary theorists that points directly to the role of the activity of multicellular organisms, in this case animals, is called the Baldwin effect or genetic assimilation. Baldwin showed that there is considerable evidence that animals find new adaptive modes of behavior and that these lead to the selection by the environment of different phenotypes, and through them, eventually, of genes. Thus animal activity not determined by genes influences nature's selection among the randomly mutating genes. It functions as a variable alongside those

identified by Ayala. Although this is widely acknowledged, it is generally regarded as a minor factor, and it is ignored in more summaries of the causes of evolution.

I was curious to learn how Ayala would respond to this, and I appreciated his writing a section on the Baldwin effect for the book. He wrote that this effect is fully recognized by neo-Darwinians and has been integrated into their theory. This has been possible, I gather, because his account of the Baldwin effect does not include any reference to the activity of organisms. I quote again:

> "Simply stated, the hypothesis asserts that the environment affects adaptively the phenotype of an organism, that is, its configuration, so that the organism can survive and reproduce under conditions that are unusual or even extreme, and that such adaptive modifications may later become genetically fixed by natural selection" (Ayala 2008b, 193).

I was struck by two things. First, Ayala seems to accept the idea that the priority of the effect of the environment's influence on the organism is widespread rather than occasional. This is quite different from the usual picture, in which selection of adaptive mutations of genes is not mediated by prior changes in the phenotype. I quote the paragraph with which Ayala concludes his discussion of the Baldwin effect.

> "The Baldwin effect has been ascertained in many other instances, including cast-determination in social insects (ants, termites and honeybees) and the affinity of hemoglobin for oxygen. Indeed, the Baldwin effect has been generally involved in the origin of evolutionary novelties.[3] Evolutionary novelties are reorganizations of preexisting phenotypes, which first arise in response to environmental challenges (given that all genotypes have enormous plasticity, that is, a wide norm of reaction), but eventually become genetically determined if the particular environmental challenges persist and the adaptation importantly contributes to survival and reproductive success. Kirschner and Gerhart explain in considerable detail that the genetic changes that account for evolutionary novelty involve gene control circuits (numerous but very short DNA sequences), rather than changes in the enzymes encoded by genes" (ibid. 195).

If I understand this correctly, then, contrary to the impression given by most evolutionists when speaking to the public, changes of phenotypes in

response to environmental conditions are a *major* factor in evolution. Subsequent selection among random genetic mutations functions to stabilize changes that have arisen in other ways. The Baldwin effect, instead of being a peripheral oddity, is of enormous importance for evolution. If so, evolutionary theory and its presentation to the public should be reformulated to make that clear. Instead of the environment selecting those randomly mutated genes that happen to produce phenotypes with survival advantage, the selection is of genes that support changes in the phenotype that have previously been selected for their superior adaptiveness.

An even more radical priority of phenotypes over genes seems probable. Among contributors to our conference and to the book developed from it is Dorion Sagan. He emphasizes the physical basis for evolutionary phenomena and with respect to the origin of genes he writes as follows:

> "Genes themselves likely appeared secondarily, after metabolically sustaining energy systems. It was their ability to further stabilize already relatively continuous centers of energy degradation, favored without natural selection by the second law that allowed genes the chance to arise in the first place. Consider an effective replicator hobbling its reproductive success by growing a great, protein-studded body. Why would such a replicator shoot itself in the foot? Nonmetabolizing replicators would easily replace it. This thought experiment proves that thermodynamic complexity, in the form of relatively stable but not yet fully replicative metabolizing bodies, must have appeared before naked DNA, or the (popularly postulated) RNA world" (Sagan 2008, 148f.).

In an article entitled "A Unified View of the Gene, or How to Overcome Reductionism", Peter Beurton provides an extended account of the emergence of genes in biological terms. He summarizes thus: "Not only are the selective values of genes emergent properties, but the genes *themselves* are emergent particles resulting from the interactive processes of populations" (2000). In short genes came into being through the Baldwin effect.

Second, I was also struck by the fact that much of this can be acknowledged without giving up what neo-Darwinians consider central to their theory. This is that the only agents in evolution are the genes and the environment. What can be assimilated by neo-Darwinists, despite its invisibility in their formulations, is that the effect of the environment on the pheno-

type precedes genetic change. This leaves the genes and the environment as the active agents, with the preexisting condition of the organism as the object of their action. However, the assimilation of the Baldwin effect into neo-Darwinism is only partial. The evidence for the operation of the Baldwin effect where the activity of organisms is a causal factor is ignored.

There are then two issues with neo-Darwinism. First, if the evidence now indicates that the Baldwin effect, broadly understood, identifies the primary pattern of evolutionary change, the standard explanation of evolution should make this visible. It does not suffice to assure the public that this effect can be interpreted in neo-Darwinian terms, meaning that it can be explained without adding any third agent of activity to the genes and the wider environment.

Second, the evidence that the *activity* of multicellular organisms plays a role in at least some instances of the Baldwin effect should also be directly considered rather than ignored. It is hard to see how one can deny the role of animal activity altogether. The codling moth once laid its eggs only on apples. But some codlin moths began laying their eggs on walnuts. These have developed into a distinct species. However one explains this change in host selection, I do not see how one can avoid the fact that the activity of moths was involved. Ignoring such facts is not a good scientific way of maintaining a theory that cannot account for them. Genetically unprogrammed activity of organisms *is* a distinct variable explanatory of evolutionary developments. Yet the prejudice against including the activity of organism as a variable in directing the course of evolution is so great that even sexual selection is rarely mentioned.

This role of the activity of organisms in indirectly determining the selection among genes is complemented by its role in modifying the environment. Richard Lewontin has recently emphasized the importance of this activity and complained about its neglect by evolutionists (2000). That neglect encourages, and is encouraged by, its omission from evolutionary theory. We saw that the quote from Ayala above, as well as his account of the Baldwin effect, depicts organisms as passive in relation to their environment as well as to the genes. But it cannot actually be doubted that organisms affect their environments. Further, the changes they effect in their environment certainly also affect what is adaptive both for themselves and for other organisms.

This is so obvious that it seems unnecessary to illustrate it. If a new predator enters an ecosystem, it certainly changes the environment for its prey. Habits that may previously have been adaptive may no longer be so.

Indeed, the effects of the activity of organisms go far beyond that. Billions of years ago, organisms that generated oxygen made the atmosphere poisonous for many creatures and radically redirected evolutionary development. There is now considerable evidence that the biosphere as a whole regulates the climate of the planet. These are surely not minor matters easily relegated to the periphery of theory.

Symbiosis describes an activity of organisms that dramatically changes their environments. Symbiotic relations lead to genetic changes. Ayala does not question that there is lateral transfer of genes as a result of such relations. The emergence of the eucaryotic cell, perhaps the single most important event in biological evolution, is now recognized as an instance of symbiogenesis rather than of mutation of genes.

I hope that these brief comments are sufficient to convince anyone who pays attention to what is going on in the world, that the activity of organisms plays a distinct and important role in evolution. Neo-Darwinists cannot realistically deny this, but if they cannot, then continuing to omit this activity from their accounts of evolution is surely unjustified. Hence, my thesis is quite simply that alongside the three variables listed by Ayala: the genes, the environment, and the extant state of the organism, we need a fourth: the *activity of organisms.*

2. Organisms as experiencing subjects

If there is as much evidence as I believe for the role of this activity, we must ask why it is systematically neglected by evolutionists. I suggest that we can find the answer in a now famous quote from the biologist who, himself, protested the neglect of this activity: Richard Lewontin.

> "Our willingness to accept scientific claims that are against common sense is the key to an understanding of the real struggle between science and the supernatural. We take the side of science [...] because we have a prior commitment, a commitment to materialism. It is not that the methods and institutions of science somehow

> compel us to accept a material explanation of the phenomenal world, but, on the contrary, we are forced by our a priori adherence to material causes to create an apparatus of investigation and a set of concepts that produce material explanations, no matter how counterintuitive, no matter how mystifying to the uninitiated. Moreover, that materialism is absolute, for we cannot allow a Divine Foot in the door" (1997).

For Lewontin, as for many biologists, this means that we cannot allow subjectivity of any kind to play an explanatory role. From his point of view, since nature is purely material, subjective experience is "supernatural". Lewontin thinks that he can affirm the importance of the activity of organisms and still exclude any role for animal experience. However, most biologists recognize that this proves difficult. Organisms seem to act so as to obtain food, to be safe, and to have pleasure. This seems to be because of their subjective desires. Given their sense organs it is hard to doubt that they have visual and auditory experiences and that their actions are influenced by these. It is hard to doubt that their actions are purposive. Once we allow that animal activity significantly influences the course of evolution, it is difficult to exclude a role for animal purposes. Rather than allow an important role for animal activity and then argue that it is exhaustively explained by randomness and law, chance and necessity, most biologists prefer to ignore the activity even at the expense of leaving out of consideration a great deal of empirical evidence.

Lewontin is clear that he argues as he does because of his metaphysical commitment. Would that neo-Darwinists in general were that honest! We may respect such honesty and such commitment, but it leads to a shift in the debate. If science is understood to be a dispassionate search for truth, then science does not support neo-Darwinism. If science is limited to acknowledging only what fits with its *a priori* metaphysics, neo-Darwinism may be good "science," but there is then no reason to privilege "science" over other ways of interpreting the evidence.

In 1938 Whitehead addressed this question perceptively:

> "Science can find no individual enjoyment in nature: Science can find no aim in nature: science can find no creativity in nature; it finds 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. It divides the seamless coat - or, to change the metaphor into a happier form, it examines the coat, which is superficial, and neglects the body which is fundamental" (211).

For Whitehead subjective experience and what is perceived objectively belong together in a single world. The actual course of evolution is a product of both working together. There is extensive evidence for this. The problem is a view of science that excludes the subjective from its purview. The problem is greatly intensified when scientists, have excluded the subjective, still claim that their explanations, based only on what can be perceived objectively, that is, by an outsider, are complete.

Obviously, it is my view that the adoption of a Whiteheadian metaphysics enables one to accommodate the evidence more inclusively. It is also my view that more scientists should be willing to allow the evidence to trump their metaphysical commitments. If in one way or another, the activity of organisms is recognized as an important factor in evolution, then it becomes possible to view human beings as part of the evolutionary process without supposing that we are nothing but matter in motion.

Honest scientists, in my view, have two choices. They can continue to restrict themselves to a methodology that limits science to the study of what is purely objective and then recognize that there are other factors at work that they cannot include. This means that they will acknowledge that scientific explanations are inherently incomplete. Or they can expand the study of science to include subjective aspects of the nature they study. They will then be able to include the purposive character of living things in their explanations.

I will conclude by mentioning one example of what has happened when science is expanded in this way. I should acknowledge that this example has no direct relation to evolutionary theory.

Charles Hartshorne, a leading Whiteheadian philosopher, was also an ornithologist. His special interest was birdsong. The usual explanation of birdsong is that birds sing only to attract mates and defend territory. Hartshorne believed that, in addition to these purposes, birds sing because they enjoy singing.

He wanted to test this hypothesis. He reasoned that if he was correct, birds with very simple songs would wait longer between songs. Quick rep-

etition would be boring. On the other hand, birds with more elaborate repertoires would pause less. He gathered extensive evidence, and it strongly supported his hypothesis. His book, *Born to Sing,* has had a good reception among ornithologists. Allowing for investigations of this kind does not destroy science, as some scientists, such as Lewontin, seem to fear.

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No Need for Dualism in Evolutionary Theory. A Comment on John B. Cobb's "A Fourth Variable in Evolution"

ANDREW PACKARD

I welcome this opportunity to comment on John B. Cobb's essay. Our editor has asked me to write for philosophers and scholars who are interested in philosophical problems of life rather than writing for philosophers of biology.

That will not be easy. Cobb is tackling aspects of the philosophy of biology and since I am a biologist, though of a generation now mostly retired, whatever I say will need to stand the test of other biologists looking over my shoulder. More importantly it will need to be true to my own experience of living entities.

1. Reflections on Cobb's criticism of a fragmented science

1.1. Cobb's fourth variable is a Trojan horse

When Cobb writes that he finds Francisco Ayala's "explanation of evolution implausible, not because of what it includes[1] but because of what it omits" he is implying that *technical formulations of evolution suffer from the same limitations as technocratic solutions to problems in the real world.* His Fourth Variable[2] exposes weaknesses in the Neo-Darwinian edifice and of all attempts to embrace within it a guiding role for the activities of organisms - if only because of the unpredictable nature of the phe-

[1] See Ayala's summary [in Cobb's chapter] this volume.

[2] Cobb's Fourth Variable is a set of other relationships contributing to the mechanics of evolution in the real world. It includes activities of the phenotype covered by the so-called "Baldwin Effect".

notype. Simple appeals to random mutation or other single factor certainly can not bear the weight the "Baldwin effect" would put upon them.

Spyridon Koutroufinis (this volume) describes some of the problems of modelling self-organising systems without at the same time pre-setting the many variables that in life can dramatically alter the behaviour of the system.[3]

In a review of the (confusingly named) "Baldwin Effect" and the issues it raises for Darwinian evolution, Patrick Bateson (2004) examines four proposals for "ways in which an animal's behaviour could affect subsequent evolution".

The debate on whether or not there can be laws in ecology and what part mathematical models play in ecological theory is also relevant here (see Cooper 2003).

1.2. Evolutionary theory and practice of most professional biologists essentially uncoupled

There is an enormous literature in evolutionary epistemology.[4] Some of it considers the issues raised by Cobb. This literature is better known to philosophers, and to students doing courses in philosophy of biology, than to most biologists. Evolutionary theory and the practice of "most biologists"

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[3] "It is typical of all mathematical accounts of self-organized behaviour, with which I am familiar - whether in physics, chemistry, or biology - to *essentially depend on a high number of externally set parameters'"* Koutroufinis (this volume, see sections 1.4 and 1.3).

[4] From this large literature, I mention the following: Gregory Cooper (1988) examines the philosophical status of Neo-Darwinism; Erkki Haukioja (1982, see below); Gabriel Dover (2000) "exposes the naively deterministic view of selfish genes" from within the establishment of modern molecular genetics; Robert G.B. Reid's innovative evolution (Reid 2007) substitutes self-amplifying "natural experiment" for natural selection - taking place under the "big top" of a 3-ringed circus where development, physiology and behaviour, environment, continually interplay. Many of the authors of this literature, and most of the public they are writing for, are not biologists. Biologists constitute only 5 of the 25 essayists contributing to a recent book (Grafen and Ridley, 2006) celebrating 30 years since the publication of Dawkins's *Selfish Gene.* Authors are exclusively from the USA, UK, Canada, Australia and New Zealand.

are on different planes steeply inclined to one another.[5] Practising biologists are rarely if ever required to submit their findings to any litmus test of Neo-Darwinism - or vice versa. This does not stop biologists referring to theory when writing up results - often in an uncritical and politically correct lip service to a highly reduced version. We tend to allude, in the Discussion section of our papers, to the potential (but not objectively demonstrated) "selective advantage" of a particular process, or trait, that we have examined. Less innocently, when experimental observations appear to be at variance with theory, authors can resort to all kinds of intellectual contortions in order to remain faithful to prevailing *cultural expectations* that have no connection with the science.[6]

1.3. Ratiocination and the technical expectations of society

A comment of Alfred North Whitehead in conversation with Lucien Price of the *Boston Globe* can perhaps help us see what is happening here. "Many of the people, including prominent ones, who are now regarded as scientists are little more than technicians" (Price 1954, 67).

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[5] Fitness equations have a short-term *future* projection which can rarely if ever be tested against facts of evolution *past and present.* Most of the Neo-Darwinian literature is *self-referent.* Gregory Cooper (1988), quoting Alexander Rosenberg, points out that "the biological fields which typically study the ways in which selection pressures originate in the organism/environment complex are not in fact part of the theory of natural selection at all".

[6] The entrenched nature of a cultural assumption ("self-interest") in certain quarters, and of its role in evolutionary theory, is illustrated by a recent scientific article on cooperation among microorganisms (Wingreen and Levin 2006). Opening with the statement: "One of the organizing principles of life on earth is that cells cooperate", the Discussion section then seeks to explain the principle by reference to (effectively opposite) anthropomorphic ones unrelated to the findings: "Is cooperation best understood as the convergence of the immediate self-interest of multiple parties? Or can evolution lead to stable cases of short-term altruistic behaviour, providing long-term benefit for all?" For a brief list of authors (from Empedocles to Wheeler) who have treated cooperation as fundamental principle in nature, see W.C. Allee (1938, Chapter 2). In Packard (2006), I summon basic physiological facts in an attempt to remedy its curious neglect in modern biology. However, facts alone can not counter the force of indoctrination over reasoned argument.

Seventy years on, we have all become technicians. Specialisation distances us from each other and from the understanding of the whole. The age is increasingly dominated by sophisticated (and often expensive) techniques of one kind or another. Despite its welcome emphasis on process, even much-trumpeted *Systems Biology* is yoked to *biotechnology:* to exploiting the processes and accompanying desire to *control.* The persistent danger is that students and workers in the Life Sciences, in line with the technological expectations of society and its cultural distortions, fail to recognize that technocratic solutions can only solve technical problems. To be successful such solutions must be complete. Simulations of an overarching theory of evolution suffer the same limitation. They can never be satisfactorily complete.[7] Life is too elaborate.

To recover a proper view of the self-regulatory whole, which accords due place to its intrinsic controls, will require a major programme of re-education.

1.4. Troubles with the (Anglo-American) school of evolutionary biology

The (Anglo-American) school of Neo-Darwinism is largely concerned with the science of prediction - notably with modelling population dynamics and the prospective fate of genes, traits and behavioural stratagems - requiring not inconsiderable knowledge of one kind of mathematics.[8] Moreover, some of the apologists for current formulations infer that biology (a largely descriptive science) can be considered mature and professional

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[7] Tragically, as we know from the rates at which marine ecosystems are being degraded (by shrimp and salmon farming practices, for instance (Molyneaux 2007)), the inverse is equally true. Technical solutions applied to the complex fruits of evolution can never completely reflect biological realities.

[8] Darwinism itself is now called a science. Student entry requirements for certain courses of evolutionary biology include the mathematics of Neo-Darwinism. The well is deep and can fill a lifetime. However, recent enormous strides in understanding the *activities of genes in the environment of the genome* have made some of the assumptions of the fundamental fitness equations look decidedly silly (see Dover 2000). Reid (2007) writes of the "mindset that regards evolution as no more than the differential reproduction of genes".

only if it has theories and laws that can be expressed mathematically: that it is better to have simplicity and clarity - even though the theory may be erroneous, flawed, or not apply in the case under consideration - than *not* to have a law or a theory. Sometimes even the best of these apologists trip themselves up on the skirts of their own convictions. In *Darwinism and its Discontents* (Ruse 2006), the historian and philosopher of Darwinism Michael Ruse traces the 20th century development of "a proper and professional evolutionary theory" and its relation to philosophy. The book has something of the grandeur of a Faustian struggle for the soul. A runaway - perhaps tongue in cheek - flirtation with scientism in Chapter 10 notes the selective advantages of a mathematical mind.

> "In a move that is now obvious, the Darwinian assumes simply that the rules of mathematics and logic, the basic beliefs about causality and the like, the epistemic values or principles [...] are at some level ingrained in our biology [...] One thinks mathematically because one is biologically disposed to do so, and one is attracted to simple and elegant theories for the same reason" (Ruse 2006, 242).

7.5. *Biological science and the scientist's perception of what science is*

Although John Cobb may be correct to infer that most practitioners "restrict themselves to a methodology that limits (biological) science to the study of what is purely objective" he is referring not to the science, but to the scientist's (technician's) perception of what science is. Subordination to techniques, reliance on "model" organisms and/or obedience to the received view that this is the only way to proceed, have confined the imagination. But biology as *science*[9] is not so restricted.

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[9] A recent editorial of the online journal *PLoS Biology* eloquently describes the situation in North American universities: "Not so long ago, virtually every major university had a department of biology, or perhaps bookend departments of zoology and botany, which complemented physics, chemistry, mathematics, and possibly geology to form its science foundation. Biology was, at least compared to the field today, an integrated discipline, from the molecular and cellular to the ecosystem, firmly resting on Darwinian principles. Weekly colloquia drew biologists from across the spectrum, whether the topic was the genetic code, the nature of the synapse, or the Cambrian Radiation. But biology has seen its own radiation and is just starting to catch up with this explo-

Let us see what Whitehead goes on to say:

> "[...] The trouble with creators of today is that they try to substitute a mental idea for the aesthetic experience. They think: 'Look here, wouldn't it be exciting to try it this way: a way no one else has ever tried it before?' But the novelty is of no significance. All that has any significance is the depth and validity of an experience out of which the art comes; and if it comes out of mere consciously clever ratiocination, it is foredoomed" (Price 1954, 67).

I belong to a tradition in which Whitehead's remark is as true of science as of art. Creators of biological knowledge are *not limited* to what can be objectively measured (by us technicians) in line with objective criteria (incorrectly assumed to be) suitable to the requirements of the mathematical and physical sciences. The *non-technical ingredient* out of which the science comes is the depth and validity of experience. All living entities, all living relationships, analysed by objective methods received their *names* and the *attention* devoted to them as a result of subjective processes. My commitment to naturalistic (rather than strictly materialist) explanation includes both the subjective and the intersubjective in the scientific process.

1.6. The positive side

While I realize that this is not what most Whiteheadians have in mind, the following will illustrate something of what is meant here.

- *The Origin of Species* presenting Darwin's evidence for natural selection is a work of literature: nonetheless science. The tradition continued

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sion. The amazing pace of advance in our understanding of biology has, perhaps unavoidably, engendered increasing specialization. Much of that advancement has involved the development of new tools, both in the laboratory and in computer models, and this has been dependent on the migration into biology departments of tools and people from physics, mathematics, chemistry, and elsewhere. These new collaborators have catalyzed rapid progress on specific problems, but they often have little interest in the broader scope of biology. Even traditional biologists with broader interests may not have the time to indulge outside of their own research areas because of the speed of scientific progress in those areas and the competitive nature of contemporary science" (Levin 2006, 300).

through Darwinism, the modern synthesis and Neo-Darwinism right up to the present day. Literary formulations of evolutionary theory - relying on metaphor - may fail as spectacularly as technical formulations, but they do not have the technical constraints of the latter (such as how many variables can be considered).

- Darwin's ideas - as he continually testifies - were born of subjective experience. He was above all a relentless observer. Theory was forced on him by observation and in turn forced him into further observation and experiment. The imaginative process goes all the way back to the infant's need to *make sense of the world* (Donaldson 1978). In Richard Gregory's definition of perceptions as hypothesis formation (Gregory 1966, 1980, 1997, 1998), it is difficult to say which comes first during the fact-forming process: the realities perceived, or the brain's value-based proclivity to perceive in certain ways. Creators of biological knowledge make great use of the comparative method (see below). Choosing what to study and what to compare are subjective processes. As to *inter subjectivity,* the facts of mimicry amongst butterflies in the South American jungle recorded by Fritz Mueller in the 19th century and Konrad Lorenz's observations that so advanced the science of ethology in the 20th, were the fruits of experiences shared with subjects in the insect and the avian[10] and canine worlds.
- Two 21st century contributions to biological theory will illustrate that Darwin's reciprocal procedure of passionately assembling experimental facts about "organisms" while continually meditating on their relation to the whole is still alive and well in some of today's scientists. The first overthrows a 100-year old theory about the transport of water in tall trees (Zimmermann et al. 2004). (Though having little to do with evolutionary epistemology, it is an instructive example of how long [largely because it was simple) a bad theory - the Cohesion Tension theory, barely supported by bad measurements - can be uncritically "accepted" by the biological community at large and taught in schools). The second is of an integrating principle operating amongst arrays of large molecules at the cellular and subcellular levels. *Conformational spread* (Bray and Duke 2004) is an intuitive leap that has enormous po-

[10] Lorenz's 1935 classic is entitled "The companion in the world of birds".

tential for the better understanding of self-organization, both generally and in evolution.

Finally, here is a less earth-shaking recent publication from the online journal *PLoS (Public Library of Science) Biology* - on cooperative hunting between fish of two different species (Bshary et al. 2006) - which treats of intersubjectivity in the underwater world. (In line with ruling paradigms the title of this work is neutral; the authors at several points apply the null hypothesis to their "purely objective" findings. Nevertheless, to have recognized in the first place that what they were seeing was cooperative behaviour is - while not stated - like Mueller's and Lorenz's an intersubjective experience).

1.7. Two populations of biologists: two biologies

It will be seen from the above that I am trying to *deflect* the choice that Cobb offers biologists.[11] Not because I do not think that biologists need to put their own house in order - the societal need is desperate[19] - but to provide a perspective that extends to the Enlightenment and beyond.

Cobb seems to be suggesting that the choice is between science and something to be added to science. I prefer to see the alternatives as a choice between the science of those professional biologists who already include "subjective aspects of nature" and "purposive character of living things in their explanations", and a reduced science of those who do not. Historically, biology is more the former than the latter (and lesser). When he writes: "Mainstream biologists know that there is evidence for all of the

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[11] Cobb says: "Honest scientists, in my view, have two choices. They can continue to restrict themselves to a methodology that limits science to the study of what is purely objective and then recognize that there are other factors at work that they can not include. This means that they will acknowledge that scientific explanations are inherently incomplete. Or they can expand the study of science to include subjective aspects of the nature they study. They will then be able to include the purposive character of living things in their explanations".

[17] Unlike the medical profession, the professional bodies of most biologists do not have deontological rules regulating our relationships with the objects of study or that regard them as subjects. Such rules as exist, are imposed upon the profession from outside.

relationships they omit from their formulations of the mechanics of evolution" he is really referring to two populations of individuals - one making the science the other making certain "standard" formulations.

1.8. Truth is indivisible

I personally do not feel a need to subscribe to the full Whiteheadian explanatory principle of all nature as "occasions of felt experience" (Delafield-Butt 2007). In what amounts to a second essay, I shall nevertheless now try to show from my own experience how questions of evolution amongst the "higher" animals (as well as some traditionally "lower" creatures) can be approached by biologists with a metaphysical commitment to naturalism and without resort to dualism. Many biologists of similar tradition could no doubt tell a similar story of their careers, into which the "subjective" would always intrude as essential partner in the process of creating knowledge.

2. A different way of thinking

> "Biological facts, from genetics to neuropsychology, show that living systems can properly be said to act in pursuit of certain aims. Each tries to achieve certain standards appropriate to its way of life. The result of this continual striving, choosing and deciding, through millions of years, has been a progressive accumulation of information about how best to live. Contrary to what is often said the facts of biology show both purpose and progress in life" (Young 1978).
>
> "Biologists know that animals and even plants are not puppets, manipulated by the environment. They are *agents,* provided with targets and a remarkably strong inner motor tendency that causes them continually to strive to achieve the aim of remaining alive" (Young 1987, 7-8).[13]
>
> "It is the essence of life that it exists for its own sake, as the intrinsic reaping of value" (Whitehead 1934).

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[13] This quotation is from the 1982 Shearman Memorial lecture series. Its original title, *Philosophers Use your Brains!,* was born of Young's experience that philosophers of mind did not take into account the exciting advances in anatomical and physiological knowledge of brain functioning marking much of his productive life.

In this second section I describe a way of thinking about the activities of animals - i.e. their physiology and behaviour operating through processes of pattern recognition - which grounds explanations of their evolution in principles applying to self-evaluating wholes.

2.1. The power of the comparative approach

Even though he claimed not to understand the philosopher's writings, it is evident from the two quotations above that J.Z. Young (1976) was something of a Whiteheadian. The background to the thinking is described by Peter Medawar (pupil of Young and eight years his junior). "Biology's central discipline [...] comparative anatomy has many of the virtues traditionally associated with the classical education called for by the humanities" (Medawar and Medawar 1983, 60). Its chief aim is the tracing of *homologies* - which embody both persistence and change during evolution. When linked to a pre-university schooling[14] in the humanities, we have a powerful combination. A contemporary influence was the Oxford "ordinary language" philosopher Gilbert Ryle. Ryle disdained mind-body dualism, putting it down to muddled thinking.

The octopus story. Young was very successful in studying the brains of octopuses and squids (cephalopods). These animals are almost as far genetically from our own line of descent as one can get, and therefore of special value for comparisons.

When I joined the small band of biologists and psychologists investigating their perception and learning abilities in Naples, I was able to point to the part they had probably played in their evolution from simple mollusk. The story is straightforward. When I look at an octopus which is looking at me[15],

[14] The home page of Marlborough College, which both Young and Medawar attended as schoolboys, describes it as "a community where scholarship is cherished, creativity is celebrated, diversity is evidenced, and conversation - the means by which knowledge is elevated into wisdom - is paramount".

[15] Much of my (also of Young's) understanding of biology was acquired from working on the octopus. I think it is not distorting the evidence to state that a critical part of that understanding came from establishing an *inter subjective relationship* with the animal.

I see that its eye is like mine. To find out what kind of scientific validity can be placed on this notorious instance of evolutionary convergence (or parallelism), I chose (subjectively) to measure (objectively) some parameters relating to functioning of eye and brain. I find a fish-eye lens, working on principles identical with those of its underwater compeers, feeding to an enormous brain whose circuit diagrams recall my own. Interest is quickened by finding that the sophisticated defense and camouflage repertoire of this dynamic and resourceful creature - epitome of *Metis* for the Greeks[16] - can regularly outclass my own search-and-find abilities.

Fortunately cephalopods have a long fossil history. Thanks to the good preservation of their shells, one can follow changes of behaviour over hundreds of millions of years every bit as radical as those traceable in the vertebrate skeleton.[17] The morphological parallels in the end-points of the two lines of descent were traditionally explained as the result of similar selection pressures from a common physical environment. As this explanation did not take functions into account, it did not convince me any more than it convinces Cobb who wishes to see a role for the activities of the phenotype in natural selection. I checked for records of predator/prey relationships between individual cephalopods and individual vertebrates now and in the past - and of other processes well-known to influence survival in a hostile world - and concluded that the remarkable parallels in dynamic life style were the result of competitive interactions in a "behaviour space" dominated by vision and centred upon food (Packard 1972). Convergent evolution (between cephalopods and vertebrates) is evolution of behaviour and is driven by behaviour. Metaphorically, one eye had "produced" the other.

2.2. Emotions: their "luring or driving value" - a neuro-ethologist's synthesis

To relate this to an evolutionary epistemology that takes us away from the collapsed (Ayala) explanation with its ratiocination about genes and point

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(N.B. We are talking here about a relationship, not with a dog or a cat or other mammal - which even hard-headed scientists would readily concede have feelings - but with a mollusk!)

[16] *Metis* was the first wife of Zeus and goddess of ingenuity.

[17] Coupled with conservatism in the tissues of which the two are built.

mutations, without at the same time losing sight of the individual, I choose Erkki Haukioja's *Theory of Living Entities* (1982) which emphasizes the process of living (POL).[18] Haukioja's *"criterion for success of a living entity (automaton) is its functioning at the moment of evaluation""* rather than hypothetical future reproductive "success". It introduces self-evaluation as explanatory principle.

In her 2-volume *work Mind: an essay in human feeling* Suzanne Langer explores the role that feelings play in animal behaviour.

> "The basic assumption here proposed is the constant guidance of overt animal action by feeling [...] This bars any explanation in terms of social "usefulness" or prevision of future conditions. All the conditions are 'now' and the guidance, from the total impulse to consummation of the fully elaborated act, is by the agent's own feeling. The motivation of a behavioral act has to be conceived as a felt element in the situation from which it arises, that is, as something with a luring or driving value for the performing organism, not only as an inherited reaction established by 'natural selection' for the good of the species" (1972, 141).

For Whitehead (1934) the emotions have a time-transcending vector relationship to the process of living: they both proceed from and they aim towards.

It would have been impossible for Charles Darwin to have introduced the "felt element" into his mechanisms of evolution; his task was to explain the origin of species. But he did as much as any scientist before or since to

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[18] POL assumes that life is a continuing of functioning which can not be defined by looking at structures. The criterion for success of a living entity (automaton) is its functioning at the moment of evaluation. On Haukioja's definition operational information (OI) for running automata can be divided into two logically different compartments: maintenance information (MI) and reproductive information (RI). By information is meant not the code, but the instructions produced when the code is translated. The emphasis is plainly on context and present action; continuity is important, not how many survive. This ecologist's experience of the evolution of life-history strategies had taught him that the genotype can "foster" the tactics and traits of any of a number of phenotypes "depending on developmental pathway and variable environment" (Haukioja and Jokela 2000, 180). (For the concepts of traits, tactics and strategies in Life History theory see Southwood 1977). (According to several Web based citation indices this carefully argued evolutionary theory (Haukioja 1982) has been cited less than 10 times in the past 30 years).

establish the primacy of the emotions in organic existence, first by demonstrating their commonality - his love of dogs (creatures originating a hundred million years apart from us) served him well in this; second by equating action with feeling;[19] third in being free from hang-ups about their place in science.

Without trespassing on the philosopher's sacred domain of qualia, it is nowadays much easier for the biologist to bring these thoughts into line with the facts. The analytical protocol adopted belongs equally with the animal psychologist,[90] ecologist,[91] physiologist and comparative morphologist - Darwin was all four.

The various forms that behaviour takes introduce directed changes into the ecosystems of which they are a part and alter their information content - the directional element being present in pattern recognising processes from the beginning of life. Evolution harnesses these changes, in turn altering the processes and enabling the evolutionary machinery itself to evolve. Special interest focuses on predators as selective agents and on the expanding power of the brain.

First predation. Predation is the most dramatic way in which one living entity can affect the survival of another[99] - simply by terminating the proc-

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[19] In the Introduction to *Expressions of the Emotions in Man and Animals* written many years after publication of the *Origin of Species,* Darwin reflects on what one might call the "Darwin/Spencer law" that "feeling, [passing a certain pitch,] always vents itself in bodily action" (square brackets mine). "Man himself cannot express love and humility by external signs, so plainly as does a dog, when with drooping ears, hanging lips, flexuous body, and wagging tail, he meets his beloved master" (Darwin 1872, 12).

[20] In ethology, the recognized terms are motivation and drive *(Stimmung).*

[91] Morphologist and physiologist as author of *A Monograph on the Sub-Class Cirripedia* (1851-54), *The Movements and Habits of Climbing Plants* (1875), and *The Various Contrivances by which Orchids are Fertilized by Insects* (1877); one of the founders of ethology as author of *The Expression of the Emotions in Man and Animals* (1872), and of ecology with *The Formation of Vegetable Mould, through the Action of Worms, with Observations on their Habits* (1881).

[99] Cobb writes: "This is so obvious that it seems unnecessary to illustrate it. If a new predator enters an ecosystem, it certainly changes the environment for its prey. Habits that may previously have been adaptive may no longer be so".

ess of living. It is never a random process (see Curio 1976). The recognition processes which enable a prey item to be singled out from a population of potential prey range from simple and specific "innate releasing mechanisms" to complex interactions whose outcome depends heavily on the individual experience both of the predator (or predators) and of the prey. Such acts ("selection by the phenotype") are guided by feeling in the higher animals and are quite different from selection by physical characteristics of the environment.

The critical "survival events" (Packard 1988) may be very brief. The visual strike of a young herring at its first food item conditions all future strikes.[23] Ethologists speak of a "search image". Octopuses attack and eat crabs recognising them by sight, but only if the crab is moving. Not surprisingly, crabs of the genus *Carcinus* keep very still, or move very slowly once they have been observed. They defend themselves with their claws: holding them outstretched as warning display; if attacked, they use them to deliver a nip *painful* enough to cause a small soft-bodied octopus to withdraw (Packard 1988)[24]. The claws of the crab are here acting as *teaching* aids in a one-trial learning session that inhibits further attacks for a while - a result that momentarily benefits other members of the local crab population.

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[23] Rosenthal (1969). Larval herrings, at hatching, are programmed to swim straight ahead; activity is conditioned by the "motivational" state of the fish (once the yolk supplied in the egg has been exhausted) and by olfactory cues; if potential prey is encountered a larva swims more slowly; the strike itself is preceded by a visual fixation lasting about 1 sec, with the body in a tight S-shape; this is the critical moment when an individual prey item is identified and selected or rejected and spared. Some form of imprinting seems to be at work; in experimental conditions, individual larvae tend to continue feeding on the prey species of their first successful encounter.

[24] The claws of the crab *Carcinus mediterraneus* (species commonly preyed on by *Octopus vulgaris)* are not adapted to pierce or to sever; the tips are blunt and produce localized pressure through the sustained contraction of large specialised "catch" muscles specifically adapted to evoke *nociception.* (The pain - experienced by anyone prepared to be nipped by a crab - has a special quality associated with capsacin). Immobility, "claws display", "catch" muscles, blunt claws for delivering pain, are all "coadapted *traits* that together make a *tactic*". In the innate defence strategy of *Carcinus,* the tactic is to promote learning through punishment of the predator.

During the trial and error experiments for training octopuses in the laboratory (see Young 1961, Sanders 1975), the negative reinforcement in such "teaching" is an electrical shock. The positive reinforcement (or "reward") signal is the *taste* of food: in both cases, a *feeling*. These things are encoded in their brains.

The brain as symbol of emergent evolution. The behaviour of an automaton - considered as that part of its activities in communication with the outside world - can be crudely represented by the dimensions of its growing brain: or, more meaningfully, by *brain/body weight proportion.* In some lines of animals (e.g. crabs) brain/body weight ratios have changed little over the last 300 million years; in others they have changed at accelerating rates always associated with increased capacity to deal with the environment and to learn. For Allan Wilson, the ascending curve - proceeding at a rate greater than exponential - is itself evidence of an autocatalytic process. He coined the terms "pressure to evolve" and "cultural drive" to encompass the idea that "the brain of mammals and birds is the major driving force behind their organismal evolution" (Wilson 1985).[25] When I came to look at the brain/body weight ratios of various cephalopods (squids, cuttlefish and octopuses) I found the log-log curves describing them (Packard 1972) to lie amongst those of higher fishes. The operational information (OI) acquired by an octopus during its lifetime takes up space. Genome size is little or not affected.

[25] Alan C. Wilson (1985) plotted relative brain sizes of vertebrates (Jerison's data) against the times of origin of the tetrapod groups on the palaeontological scale. The resulting curve gives an accelerated rate of change amongst higher vertebrates even faster than that for other morphological changes plotted in the same way. The finding is particularly dramatic coming from a molecular biologist since the rates of molecular change over the same period, whether measured as mutation rates (rates of substitution of base pairs in DNA) or as rates of change in other macromolecules, has altered no more than two- or three-fold. (However, if any term from physics is to be employed to describe the brain's consequencies for evolution it should perhaps be "power" - the rate of doing work - rather than a force such as "pressure"). Wilson proposed a mechanism by which one particular form of learning - imitation by conspecifics - can speed up the evolutionary process, by altering the rate at which mutations become fixed. A trait which spreads laterally through a population by being imitated will produce conditions in which mutations favouring or improving that trait will be more likely to be fixed.

Perception as evaluation. Ensembles of classifying cells of the deep retina situated on the first step of the visual pathway - whether of my eye or the octopus's - report the biologically relevant abstract properties of the visual world: appearance/disappearance, contrast, relative movement, etc. They do not signal absolute levels of illumination (see Figure 1) or illuminating wavelength - or mass displacements of the visual field occurring because my head turns.

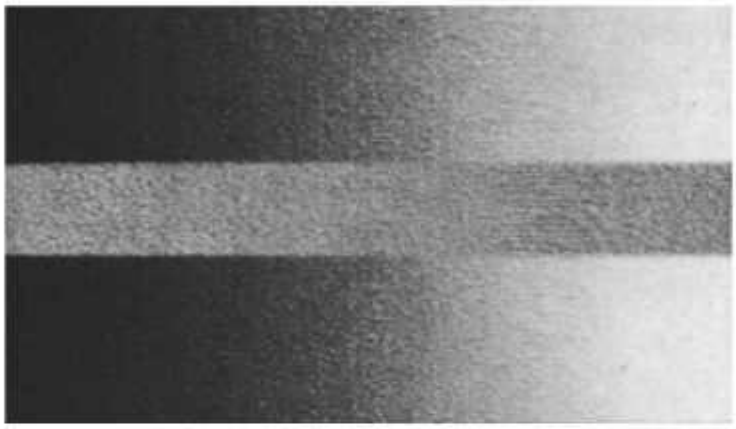

Fig. 1: *Simultaneous contrast illusion.* It is a measure of the generality of the information-processing involved in the illusion, that the neurophysiological basis of the process - lateral inhibition - was first discovered in the compound eye of an invertebrate animal: the horseshoe crab *Limulus* (Hartline et al. 1956). In humans, also, it takes place within the eye (see Asher 1951) and cannot be consciously suppressed. To perceive the central strip as of one mean grey level, it is necessary to mask the flanking strips; the combination of luminance and texture in this illustration seem to enhance its effect. (Source: Frisby, J. (1979).*Seeing: Illusion, Brain and Mind.* Oxford: Oxford University Press.)

Each subsequent step on the visual pathway performs further abstractions. Ballard, following Barlow (1972), referred to visual cortical cells as "value units" (see Ballard 1986 and associated commentaries). The extent to which each is tuned to (i.e. fits) derivatives of the scene encoded in their firing frequency, is a quantity that can be measured. Equally important is the finding that such "fit" is the result of feedback from the environment during development; the process in "higher" animals takes many months or years. Perhaps physiologists would do better to write of "meaning-making" rather than "information-processing".

In a brilliant investigation of the tuning of binocular cells of a kitten during POL - considered as a model for learning at the cellular level - Wolfgang Singer (1987) placed the process of evaluation actually inside the cell. The "reward" signal received by these units, generated by behaviour that has achieved its object, reaches the cortex by way of ascending pathways from brainstem areas close to neurochemical centres associated with mood and emotions.

Habitat selection by sessile marine organisms - such as bryozoa, tubeworms, barnacles, mussels, oysters, and many coelenterates - is a prime example of a means by which living entities assess their fitness to survive in a particular location of *proven value* (Buss 1979). For most of their lifetime they are found encrusting rocky shores above and below the tide line and have little or no power of independent movement. Many are gregarious. The swimming larvae (or dispersal phase) of such creatures actively choose the spot on which to spend the rest of their lives. After a period in the plankton, if appropriate conditions are not encountered when they are ready to settle they can prolong the search for days or weeks. A barnacle cyprid larva is equipped with a barrage of sense organs and responses tuned to this end; it first searches widely, then closely and then inspects the site before cementing itself into a place to metamorphose and grow up - amongst other barnacles (Crisp 1976).[26]

The path of a salmon off the east coast of Scotland seeking to spawn in the stream in which it was born is an enlarged version of that taken by the spat of a barnacle seeking a specific site on which to settle. The address of the home stream is imprinted in salmon as smolts and can be recorded electrophysiologically either at the single neurone level or at the level of the enormously increased EEG (electroencephalogram) and swimming activity it triggers. Seawater not smelling of the home stream is ignored and the fish proceeds on up the coast until it encounters water that does. Once it has entered the river and moves upstream, the selection process reiterates as it samples its tributaries. The interest of this example is that the mechanism enables a salmon to recognize a habitat (or refuge) of proven worth

[26] The adhesive organ of cyprid larvae is able to recognise the surface properties of the tanned protein arthropodin present in the cuticle of other barnacles (Crisp 1976).

(value) for its offspring through direct reference to the encoded experience of the parent when a juvenile: fitness being inferred from survival of the fish to date.[27] Though the accompanying feelings can not be recorded, at least the drive component can.

All biology is pattern recognition of one kind or another (Roederer 1979). Cell biologists, investigating the sorts of *relationships* that John Cobb says are missing from Ayala's account of the evolutionary mechanism, explicitly acknowledge this in their everyday use of the words "recognize" and "recognition" to describe interactions taking place between macromolecules at the cell membrane.

Towards the other end of the spectrum of relationships characterizing the living world - in the part called *sociality* - subjects (or automata) are continuously recognizing the evaluation process and its conveyed intentions in the actions and expressions of other subjects (for discussion see Emery and Clayton 2009). One day, the role that feelings play in this implicit *understanding* between subjects and their contribution to the history of the biosphere will doubtless find a formal place in evolutionary theory.[28] [90]

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[97] Buss (1979) has examined the relation of such events to the concept of "Neo-Darwinian fitness" and introduced the name *refuge* for those sites that fulfil the requirements for future survival and growth of the adult. He defines refuges as "spatial positions on marine hard substrata where the fitness of an individual is high relative to other spatial positions". Since larvae are actively recognizing refuges, this definition corresponds with Haukioja's criterion of fitness.

[28] Cobb writes: "For Whitehead subjective experience and what is perceived objectively belong together in a single world. The actual course of evolution is a product of both working together". Here I am placing emphasis on the experience of subjects in the living world, rather than of the scientist whose subjective experience of that world is engaged in studying it (see above).

[29] The above examples of behavioural processes which recognize and store the memory of causal relations in the environment, are taken from an unpublished essay written more than twenty years ago ("The Role of Behaviour in Evolution: a Metaselection Theory Rooted in Pattern Recognition" - running title "Evolution by Metaselection" (available on request)). Instances of the "Baldwin effect", it is the details that count. Metaselection theory has still to be axiomatised. It leads ultimately to the abstraction that behaviour is the stable bloc upon which the genome is slipping. Understanding of motives and intentions provides a teleonomic machinery *(metaselection)* for "innovative" evolution which is recognising its own processes in other living entities. (The

3. Summary and conclusions

I have tried to deflect John B. Cobb's criticism of the simplified (Anglo-American) version of Neo-Darwinism by pointing out that most of those who "accept" it are not required to test it. Its place in current teaching reflects cultural expectations and realities: reliance on technical solutions to complex problems, the fashion for emphasis on the competitive in daily life to the detriment of the associative, the reductive "numbers game" in economics, etc.

Second, while evolutionary theory is expanding just as rapidly as other areas of thought, all Neo-Darwinian formulations predicting the fate of genes or populations have a future reference: uncoupled, therefore, from the work of "most biologists" concerned with living processes in the present - or the story of evolution in the past.

Third, there is a long tradition of Darwinian biologists who attribute to behaviour and the activities of the phenotype an important role in directing the course of evolution. These can include "subjective aspects of the nature they study".

The second half of the chapter develops this Whiteheadian message by drawing on my own experience of psycho-physics and of the forms taken by pattern-recognition in the life histories of aquatic organisms. It incorporates the ecologist Erkki Haukioja's little known Theory of Living Entities which emphasizes the process of living (POL) and places self-evaluation at the heart of evolutionary dynamics.

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word "metaselection" was coined independently in an unpublished essay by Tony Smith (1993) http://www.meme.com.au/theoria/metaselection.html)

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Response to Andrew Packard

JOHN B.COBB, JR.

I am deeply appreciative of Dr. Packard's response to my essay. I interpret it to express full agreement with me that the neglect of the activity of the phenotype in evolutionary theory is a mistake. Indeed, he has documented the role of this activity richly in many different contexts.

Further, he agrees with me that when we consider the activity of animals we cannot avoid considering their subjective side. He recognizes that animals have sensations and emotions and purposes. He sees no reason to exclude these from the account of animal activity. He reminds his readers that there is a long tradition of Darwinian evolutionists who have paid attention to animal activity and have not excluded the subjective dimension of animal experience. I named a book I edited recently Back to Darwin in order to emphasize that Darwin was open to much richer paths than the one taken by Neo-Darwinians.

So far as I can tell, Packard agrees with me also that Neo-Darwinists do neglect the activity of animals and systematically exclude consideration of their subjective experience. So I assume he agrees that Neo-Darwinism is inadequate by virtue of its omission of what I called "the fourth variable".

I am truly pleased by these extensive agreements. Nevertheless, Packard thinks of his paper as deflecting my criticism. I think one of his points is that I imply that the mainstream of evolutionary biology is committed to the Neo-Darwinism I criticize. He thinks I am wrong in this, that even though many biologists give lip service to the Neo-Darwinian formulation, their actual work ignores it and takes much into account that Neo-Darwinism ignores. I hope he is correct.

Nevertheless, I do not consider it a healthy situation when the textbooks that introduce students to biology affirm an inadequate theory that most practicing biologists ignore. That theory is, unfortunately, not ignored by high school teachers of biology, and it is a cause of quite serious, social friction, which, if Packard is correct, is quite unnecessary. It would be a

great benefit to society if those numerous biologists who do not in fact believe the Neo-Darwinian theory of evolution would speak up. Giving them voice as Packard does in this paper is a valuable contribution. But until they undertake to improve the textbooks and the public face of evolutionary biology, some of us outsiders will need to continue to criticize. Since there is very little activity in this direction among practicing biologists, it is hard for the outsider not to suppose that Neo-Darwinism is the dominant theory and that most biologists accept it. Perhaps we could have a campaign to have Erkki Haukioja's "Theory of Living Entities" taught in courses in biology.

Packard follows Whitehead a long way, but not all the way. His limits are probably of two sorts. Whitehead considers that every actual entity is, in its moment of existing, a subject, acted on by past entities and involved in its own self-constitution. Packard seems to limit subjectivity to living things. From a Whiteheadian perspective, this introduces the dualism that Packard rightly wants to avoid. But since our essays are about living things, I will not pursue this here.

Secondly, while Packard is open to some features of subjectivity, he may not be open to all. Donald Griffin, in The Question of Animal Awareness, drew up a list of terms dealing with subjectivity (58). It begins with those that are widely used by students of animal behavior and goes to those that are most avoided. It ends with "consciousness" that is, Griffin states, taboo. The most acceptable term is "pattern recognition". In between he includes terms such as affect, spontaneity, intention, feeling, and awareness, in that order of increasing reluctance. Griffin thinks that the working principle is to see how far one can go in explaining animal behavior without including subjectivity and then introduce only those that are amenable to research methods (55). Probably Packard would follow some such policy.

I suspect that, for many of those who allow some terms referring to subjective states but avoid others, the issue is how easily it may be supposed that these aspects of subjectivity are directly explicable physiologically. As long as they can be explained in this way, the subjective term can be regarded as shorthand designation of the physiological state that is the real cause. If this is the deeper explanation, the scientist has not really broken the bounds of what is regarded by many as an essential feature of science, that is, that physical things are explained by other physical things in a

closed circle. By the "physical" here is meant that which is accessible, or thinkable, as object of experience rather than as subject.

In principle this would mean that a physicalist determinist, that is, one who understands all subjective states as epiphenomenal or supervenient on physical ones, could use any subjective terms with equal comfort. Packard's frequent identification of an animal with an automaton would fit this pattern, but I do not understand this reductionism to be his intention. If I am wrong, then, of course, the apparent similarity of our views would disappear.

Packard does not tell us explicitly the nature of the dualism he wishes to avoid. However, it is my assumption that it is one that allows a separate causal efficacy to subjective states. If the vast majority of science succeeds in finding causal explanations in the objects of experience, and then, in dealing with animals and human beings, we posit that the subjects of experience also exercise causal efficacy, that would indeed introduce a special kind of dualism.

Whitehead avoids that dualism in a different way. As David Hume showed long ago, and as strict empiricists have all agreed, there are no necessary relations of the causal sort between the objects of sense experience. One patch of color may be succeeded by another, but it does not cause the other. Of course, one can describe complex patterns that regularly recur, but regular recurrence says nothing about where causality is located.

Our certainty that there is real causality arises, not through these observations, but in personal experience. Strong pressure on my finger causes me pain. I experience my pain as caused by the pressure on my finger. The pain causes me to pull my hand away from the source of pressure. Or I may experience my anger as caused by the hurtful words of another. I may relieve the anger by lashing out at the one who caused it. The strong belief that we live in a causal world comes from experiences of this sort.

For Whitehead, all causality is the effect of some actualities on other actualities. The cause, in its moment of existence, is a subject receiving the causal influences of its past. As it completes its self-constitution it becomes an object for subsequent subjects. In this capacity it exercises its causal efficacy in their self-constitution. There is a vast variety of causes, but in this vision, there is no dualism of types of cause. There is, obviously, no exclusion of subjects from a role in this process.

There is a great deal in Packard's essay that breaks out of the narrow bounds of Neo-Darwinism and of materialistic science in general. Like Packard, Whiteheadians understand themselves to be naturalists but not materialists. We can read Packard's account with extensive agreement and great pleasure. Since, at the same time, Packard makes it clear that he does not want to go all the way with Whitehead, I have tried to guess what sorts of limits he posits and where he draws the line. If he really wants to avoid dualism, I would encourage him to remove the lines altogether. By removing the lines, Whitehead has overcome the dualisms Packard opposes. But I do realize that it may be too much to ask of a scientist to overcome fully the suspicion of the subjective sphere that has been endemic to science since it took its materialist turn in the seventeenth century.

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Erkki Haukioja to the Rescue?

ANDREW PACKARD

John Cobb's call for those practicing biologists who feel as I do, to club together "to improve the textbooks and the public face of evolutionary biology" does not fall on deaf ears. At a time when the ruling paradigms in so many arenas - political, financial, environmental - are being questioned as never before, such change would slip naturally in with the others that are hopefully to come. Visceral belief in selfish genes drew heavily on the language of market forces and the now discredited stock market - hence the title of this reply.

It will be tough going. Item: we are in 2008; a 2-day conference entitled "The Driving Forces of Evolution", held in the meetings room of the Linnean Society on the 150th anniversary of the reading of the famous Darwin-Wallace paper, did not include the role of Behaviour! My comment: "Driving forces without a driver!"

Though not explicitly touched on, my broad agreement with John Cobb goes beyond such sins of omission. I am not a theologian. The need for a formulation to replace ruling Neo-Darwinism derives from a "natural theology" that sees man's - and therefore also the biologist's - relationship with the universe as a moral one. In Naples some years ago, I organized a "Conversation" at the Italian Institute for Philosophical Studies to explore the abstract relationship between the Logic and the Ethic of the Life Sciences. We focused on a question put by Emilios Bouratinos: *can a science be considered ethical if it does not have a logic adequate to its subject matter?*

Within the framework of evolutionary theory - and, by extension, of the material products of evolution - the issue can be simply stated. *Ought* (Neo-Darwinian) genetic determinism to be governing our relationship with the biosphere? To take an extreme example: the physicist Freeman Dyson, fascinated by the potential "benefits" of biotechnology, suggests that one third of the earth's forest cover be bio-engineered in order to lock

up carbon and so reverse climate change! Is this to be treated as a moral question, or only as an intellectual, technical and political one?

Erkki Haukioja asks his own intriguing question (whose inferred double negative implies interesting states of denial which we have no space to discuss). "Do we really have good reasons why the evolutionary theory is not based upon a sound theory of life and living organizations?" (Haukioja 1993, 14). Answer: "[...] we do not have in wide use any explicit theory of organizations which live". Without claiming to replace it, he invalidates the logic of the theory at fault: a) by supplying a (missing) definition of the living units in which evolution is seen to take place, b) by needing to see them as products of functioning, which are all the time being tested by the process of living (his POL, tantamount to Cobb's "fourth variable"), before any examination of how genetic dynamics may be ruling their functioning, c) by calling for an understanding, in cybernetic terms, of the general principles of living organization and the constraints they set upon evolution, and d) placing the replication of multicellular organisms (lineages) in a separate box from the rest of POL.

Haukioja's Theory of Living Entities (1982) has recently been incorporated into ecology (autecology) by Gimme Walter (2008). Both practical ecologists point out the persistent (and pernicious) blurring of two distinct things: the self-evaluating functioning of individuals and small populations on one hand, the details (such as genes) that are helping to achieve functioning on the other. Haukioja concludes that a "Neo-Darwinian theory (which) views everything via changes in gene frequency [...] has made it unnecessary, perhaps even uninteresting, to analyze the logic of living" (Haukioja 1993, 24). Philosophically, we are confronted with the fallacy of misplaced concreteness, empirically, with research programmes so different that it is difficult to see where there can be conjuncture. One programme researches populations in which individuals become theoretical abstractions, the other individuals (whether unitary or modular) in which populations become abstractions.

On attitudes to consciousness raised by Cobb, I have two practical points to make. The present ascendancy of cognitive sciences has left few items on Griffin's thirty-years-ago list of taboos constraining behaviour studies. Moreover, the mainstream Neo-Darwinian theory under attack has not been built on data from the behavioural sciences. Admittedly, nor has

Haukioja's. (He only briefly alludes to subjective experience at the end of his 1993 paper - not to dismiss it, but to argue for his theory equally in the nuanced human context.) I too baulked at the word "automaton" when I first encountered it in Haukioja's writing. But for the purposes of his argument that the entities known to evolve are self-evaluating individuals (automata) using *information* for functioning - not "vehicles" for transporting genes in time - it was not relevant whether the information is built-in, acquired socially, subjectively, unconsciously, or consciously. None is excluded.

The second practical point obliquely touches on whether I personally am a dualist or an emergentist. Awed by the miracle that *anything* works, I find consciousness rather overrated! Consciousness fails, and errs during POL, in a way that unconsciousness does not. (Consider, moreover, the prospect that man, through the exercise of consciousness, is precipitating a collapse of the biosphere and the products of evolution to date, matching in its scale any of the catastrophic "events" of the past 500 million years.) Fortunately consciousness is held in check by the unconscious. Falling asleep is a beautiful example of Haukioja's cybernetic functioning. Tuned by POL in its myriad branches throughout that 500 million years, this universal (and stereotypical) adaptive mechanism does not fail during an individual's life.

Are the minds that have unravelled the multiple cause-effect relationships underpinning physiological sleep closer to Hume's framework of reasoning on causation or to Blaise Pascal's, I wonder?

Perhaps John Cobb - and the wider readership in this interesting exchange - will be disappointed that my response should be about technicalities. I hope not. I feel more at home in his company than I do with evolutionary theorists who chose to ignore Haukioja's ideas over the past quarter century, and than the metaphorical millions of colleagues who in their teaching of evolution keep in circulation a pre-emptive language and logic of "fitness" and "success".

Over to you, John.

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