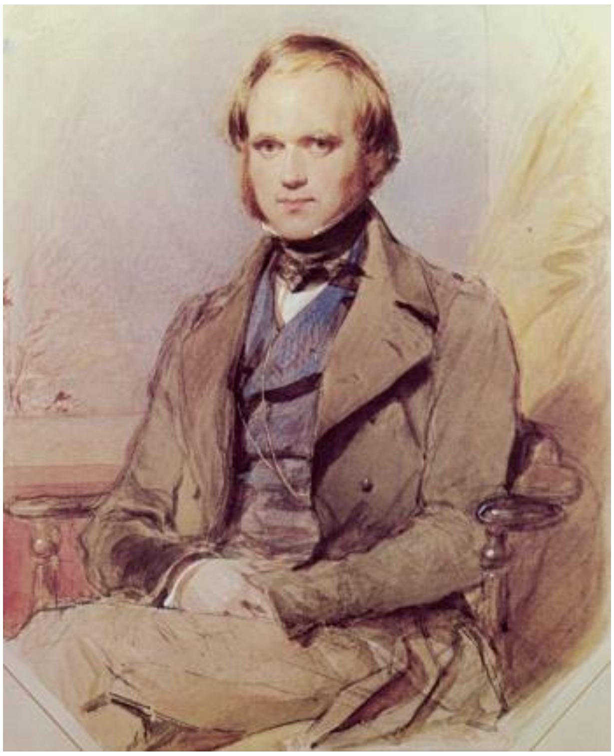
Classic Text 22 - Philosophy of Biology: Darwinism



A Young Charles Darwin (1809 - 1882) in 1840 – Watercolour by George Richmond.

In Classic Texts 10 and 13 we examined two texts that were written as popular biological science both of which had important implications for philosophy. In this study unit we turn to the relatively new field of Philosophy of Biology as a subject in its own right. We shall be using Alex Rosenberg and Daniel McShea's (2008) textbook *Philosophy of Biology - A Contemporary Introduction* as a guide, the introduction and first chapter of which are available for free download here. (Under South Africa copyright law individual chapters may be reproduced for educational purposes.) The authors assume a working knowledge of Biology at matric level. What follows is an annotated summary. For conformity the section headings below are the same as those of the text.

Philosophy Asks Two Kinds of Questions

During the Classical Age of ancient Greece philosophy encompassed all of what counted as knowledge, as opposed to opinion or rhetoric. Indeed, for about two millennia since philosophy and science were regarded as synonymous. However beginning with Euclid c. 300 BC, various disciplines have been "spinning off" from philosophy to become independently established subjects in their own rite. It wasn't until the 17th Century that physics became established as distinct discipline followed by chemistry and biology in the late 19th Century. To provide an alternative analogy to "spinning off", it is as if philosophy has been a seedbed for the germination of ideas, theories and, when established, wide-ranging subjects. As the various sciences "spun off" from philosophy historically or "took root" independently, the authors ask: "Do the sciences leave anything to philosophy… and, if so, why do they leave unfinished business to philosophy?" (p. 1)

As to the first question, the authors propose that "Each of the sciences leaves to philosophy issues that they might be expected to answer but have not". In the example of numbers that follows, we believe that it is not so much a matter of leaving behind as expediency. The meaning, nature and existence of numbers has perplexed philosophers even before Plato, who believed they were ideal forms that existed in a realm beyond the senses but in which the rational mind could participate. (See Classic Text 20)

Although 20th Century mathematicians have succeeded in giving an account of numbers via set theory that is consistent, (see Critical Reasoning 18) their efforts have been contrived to make the theory fit the properties of numbers, rather than to explain their ontological status. The truth is, beside that rare beast, the number theorist, mathematicians cannot afford the luxury of philosophical speculation about numbers when their primary focus is to conduct mathematical researches and disseminate their findings. Not that they are uninterested, it is just that philosophy of mathematics is not a bread and butter issue.

The same is true of time, which appears in many equations of physics, from the most basic definition of velocity in Newtonian mechanics as displacement over time and acceleration as change in velocity over change in time. Although Einstein proved that our ordinary notion of space and time are not adequate for a relativistic understanding motion and gravity, the question however of what time is has been left to philosophy. Nevertheless in addressing that question philosophers have turned to the laws of physics to make sense of it all. Time, for example, *appears* to have a direction pointing from the past to the future which can be explained by the second law of thermodynamics; however in every other respect classical and quantum mechanical equations are symmetrical with respect to time. So there is some theoretical back-and-forth between physics and the philosophy of physics.

Biology too has its own philosophical questions that are also of interest to psychologists, sociologists, legal experts as well as philosophers. For example, although biologists have given us an account of what life is and the chemical mechanisms that sustain it, they have not addressed the philosophical questions of the value of life or whether life is “nothing but” its underlying chemistry. The way these questions are posed and answered have implications for our view of human nature, society, and our relation to other species.

Biology, like all other natural sciences, relies on observation and experimentation and as such it is fallible. That is not a matter for despair, for as long as a science is falsifiable, it can be improved upon, subject to revision and further experimentation. However just which scientific methods are the right ones is a matter for dispute, given that biology is a special science with different experimental designs and standards of evidence to physics. Of course, these are questions for the philosophy of science; however most biologists are acutely aware of them, perhaps more so than in other natural sciences.

According to the authors, questions about the scientific method, including its justification as well as the scope and limits of biology, lie outside of biology and within the field of philosophy of biology. If biologists themselves are engaged in such debates then they are engaged in a philosophical discussion. Finally for the first question, the metaphor of subjects “spinning off” from philosophy and leaving questions behind overlooks the emergence of new philosophical questions thrown up by novel discoveries within biology. For example, questions about the ethics and desirability or creating human-animal chimeras or genetically engineering germline cells only became pressing when we already had the biotechnology to do so.

As to the second question: “If there are questions that the sciences cannot answer, why do such questions exist?” The authors propose that this question should be construed as a question about the limits of science. It is well known that many people reject the findings of natural sciences from geology to biology because they do not sit comfortably with their beliefs, especially their religious beliefs. For these religious fundamentalists, questions such as the origins of life or the evolution of humans lie outside of biology and the onus is on them to validate their claim as a philosophical one. The same is true of those who claim that natural science can have no bearing on questions of ethics, value or aesthetics.

The authors briefly outline the five main branches of philosophy that by now will be familiar to the reader: metaphysics, ontology, epistemology, ethics (including moral and political philosophy) and aesthetics. Since Darwin, evolutionary biology has inspired the hope of finally putting ethics on a scientific foundation, thus having at least some philosophical questions decided by science. Then there are recent developments in the field of experimental philosophy or "X-Phi" which uses empirical methods, often in cognitive science, to supplement the more traditional tools of analytic philosophy in assessing philosophical hypotheses. (See Critical Reasoning 27) These include X-Phi of action, language, mind, ethics, epistemology, metaphysics and indeed the foundations of X-Phi itself.[1]

According to the authors' working definition of philosophy of biology:

> the philosophy of biology addresses those questions that arise from biology but that biology cannot answer, at least not yet, and the further questions about why biology may be unable to answer these questions. (p. 3)

In the light of recent developments we find this definition too restrictive as it ignores all the collaborative, interdisciplinary research that philosophy and biology have been engaged in. Nevertheless the authors do describe their definition as a "working definition", therefore we free to take on the definition, provisionally and then amend it as needed.

Philosophy and Language

The authors single out six candidate questions that are raised by biology but that they believe biology cannot address. They are:

1. Is life a purely physical process? Are biological processes "nothing but" complex physical and chemical ones? If so, what does this mean for the science of biology as an independent discipline?

2. Does evolution have any goal or purpose, perhaps one that might give our existence meaning or intelligibility?

3. Is there any such a thing as evolutionary progress? Is complexity increasing in evolution? If so, is that increase inevitable? And what, if anything, does increasing complexity say about values? Are more complex organisms somehow better than, or higher forms of life than, less complex ones?

4. Does the theory of natural selection conflict with theism, and, if so, how can we rationally choose between them?

5. What is human nature? Which of our traits are essential to us? Are some traits innate? Do any determine our characters more than others? Are they fixed or not? Are socially

[1] At the time of writing there we at least 50 Masters and PhD programs in experimental philosophy at various universities across the world.

important human traits more the result of heredity, nature, and our genetic programs than the result of learning, nurture, and our environments?

6. To what extent are humans adapted in the biological sense? To what environmental conditions are we adapted, and at what level does this adaptation occur — the individual human, the family or the lineage, the whole population, or perhaps the species? (p. 3 - 4)

None of these questions has an unambiguously right answer. As with most questions in philosophy they depend very much on the meanings assigned to the terms involved. These include 'life', 'purpose', 'progress', 'complexity', 'theism', 'genetic program', 'adaptation', 'species' *etc.* However their meanings cannot be "Humpty Dumpty" or relative, for then we would have neither biology nor philosophy of biology. (See Classic Text 17) Fortunately philosophy excels at clarifying concepts and meanings. Sometimes it does so by showing that a fundamental term such as 'life' or 'adaptation' can have more than one meaning that is being interpreted ambiguously or conflated with some other term.

Of course, terms for scientific concepts are bound up with the theories in which they feature; therefore it may be unhelpful simply to look them up in a dictionary which usually offers a variety of options. The word 'set' for example has some 464 definitions listed in the Oxford English Dictionary. The example the authors offer of asking what it is that positively charged protons have that negatively charged electrons lack, reflects the ignorance of the would be inquirer concerning the use of positive and negative charge in elementary physics. Similarly, in order to not ask such "silly" questions, the philosopher of biology must be at least as well versed in the theories of biology under discourse as the biologist. This in turn requires an understanding of the domain of a theory which it purports to explain and predict, as well as the experimental techniques that are employed to test the theory. According to the authors, many of the questions of the philosophy of biology are about the domain of a theory and its appropriate methods of investigation. Question 6 above is just such an example about the domain of adaptation by natural selection. Can it explain human social phenomena and how far might that extend?

The authors emphasise that the process of clarifying the meanings of scientific terms needed to make philosophical questions unambiguous is not separable from the development of scientific theory itself. If they differ, it is a matter of degree rather than kind. Of course, philosophers seldom undertake field work or laboratory studies, rather they concern themselves with more abstract issues but again the difference in these pursuits lies on a continuum. One activity at which philosophers (and theoretical physicists) excel is the thought experiment in which a "science fiction" like scenario is imagined in order to explore the logical relations, implications and compatibility between scientific theories and data as well as among other theories.

For example, in one of Einstein's most famous thought experiments, that he started thinking about at age 16, he imagined chasing down a beam of light. If you could catch up to the light then presumably it would appear frozen in space. However if light were frozen in space it wouldn't be light, therefore light cannot be slowed down and must always be moving at the speed of light. Later he realised that what was changing in the imagined scenario was time itself, which was one of the conceptual underpinning of his special theory of relativity, proposed in 1905.

Thought experiments therefore have the dual advantage of being able to conceptually “try out” ideas before empirical data become available as well as broadening the domain of those theories in which they feature. Of course thought experiments if they are to be useful to science must ultimately generate and then give way to testable hypotheses that can be incorporated into such theories.

Suppose that matters of terminology are settled. The question(s) may still remain unanswered; however we would still have to decide on what counts as a legitimate question and a satisfactory answer. According to the authors, not every grammatical interrogative sentence expresses a *bona fide* question. For example, the question, “When it is 9 a.m. in Cape Town, what time is it on the Sun?” is both grammatical and an interrogative. However, once we understand the meaning of the terms it expresses we see that it is only a pseudo-question. Time at a point on Earth is dependent on its position relative to the Sun; however it obviously makes no sense to ask, “What is the position of the Sun relative to the Sun?” Therefore such questions can simply be disposed of, needing no answers.

Then there are some scientists who hold the view that all genuine questions, including those of philosophy, will ultimately be answered by science, given enough time and money and that the rest will turn out to be pseudo-questions.[2] However, if philosophy concerns itself with those questions that cannot or cannot *yet* be answered by science then scientist who believes that there are only questions answerable by science and that there is effectively no such subject as philosophy, will have to proceed in one of two ways. The first piece meal approach is to take on every apparently unanswerable question and show how either something is wrong with it so that it can be disposed of or show how it might be answered in principle. The second is to show that, in principle, there are no real questions beyond science. But as the authors point out, both approaches are philosophical; therefore anyone who asserts that every real question will eventually be settled by science owes us a philosophical argument that justifies their belief. Since that argument is still outstanding we can take it that there are real questions that science raises but that science alone cannot answer and that these questions are the fitting concern of the philosophy of science.

The Agenda of the Philosophy of Biology

Darwinian theory which is central to the philosophy of biology is supported by a considerable body of evidence and, contrary to creationist claims, has not been refuted in any detail even once - a claim that cannot be made by any other theory arising from the social or behavioural sciences. Of course, tests of outcomes predicted by Darwinian theory cannot rival those of the physics and chemistry for precision. Particle physicists, for example, demand a level of confidence of 5 sigma or 5 standard deviations before they accept an observation of an event as significant. According to the authors however, for all the well-established atomic theory that stands behind the organisation of the periodic table and the chemical properties of the atoms of our bodies, it cannot answer questions about human nature, human behaviour, human institutions, or human history. For what Darwinian theory lacks in precision it makes up for in relevance to questions about ourselves.

[2] Interestingly, Ernest Rutherford took the most extreme view of all when he declared “All science is either physics or stamp collecting”, meaning that all other sciences simply collect facts the way stamp collectors collect stamps. Wikiquotes - Ernest Rutherford

Other theories in the social and behavioural sciences that purported to explain (and predict) human behaviour, including cultural and historic processes, have been on offer since the late 19th Century. These include Freud's psychodynamic theory, Skinner's behavioural learning theory, Durkheim and Weber theories of social structure and function, Marxist economic theory, classical, Keynesian, and neoclassical economic theory and so on. None of these has been confirmed or acquired general acceptance among scientists today. Indeed they read like a list of casualties of war or creatures recently gone extinct. Had any of them been confirmed we might have relied upon them to explain human nature and affairs even partly as well as Darwinism which has received general acceptance in biology as well as other disciplines.

According to the authors, Darwin's theory of natural selection and its subsequent scientific developments combine explanatory relevance to human affairs and independent scientific confirmation in a way that no other theory in science has achieved. And this is what has made it a potential source for public controversy, whether deserved or imaginary. Some see it as a threat to religion, theism in particular. Others, armed with the phrase "Survival of the fittest" coined by Herbert Spencer in his *Principles of Biology* (1864) after reading Darwin's *On the Origin of Species*, justify some of the worst excesses of capitalism. Still others are fearful that it might undermine the very essence of our humanity and the values and meaning on which our lives depend. Diametrically opposite are those who believe that Darwinian theory and its biological understanding provide a substantiated basis for moral concern with all living beings on our planet, including ourselves.

Whether Darwinian theory implies any such view(s) is a question that, for now, lies outside of biology but within the purview of the philosophy of biology. Outside of philosophy the question has become a hot topic, particularly in the United States where an increasingly vocal minority of Creationists has brought the matter before the courts and state legislatures raising constitutional issues of Church and State. We will not become embroiled in that debate, if only because the matter has already been settled in South African schools in favour of compulsory teaching evolutionary biology. Instead we shall follow the authors' lead in exploring some of the narrower scientific and philosophical questions on which the larger issues turn.

Like most works on the philosophy of biology, the authors quote the evolutionary biologist and Eastern Orthodox Christian Theodosius Dobzhansky's title of his 1972 presentation, "Nothing in Biology Makes Sense Except in the Light of Evolution". In his presentation Dobzhansky criticised anti-evolutionary creationism, instead espousing a version of theistic evolution. (Dobzhansky, 1973) Taken at face value, Dobzhansky's title as a statement is in need of some explanation and qualification. The idea of evolution, which includes decent with modification as well as decent from a common ancestor, is broader than that of Darwin's theory of natural selection. The latter is a proposed mechanism of change that explains how decent with modification occurs. Secondly, the authors feel, the statement "overreaches somewhat". There are for example some questions of biology, such as the crystallographic nature of the otoliths in the inner ear of vertebrates that involve evolution only indirectly. On the other, hand it could be argued that the reason for this is because such a question is posed as one for crystallography and not biology directly. Nevertheless we believe the statement to be true as a claim about shared ancestry, as well as natural selection.

1 Darwin Makes a Science

Overview

Biology from the Greek word βίος, (bios) for 'life' and the suffix -λογία, (-logia) for 'study of' can be traced back to the study of Natural Philosophy as early as the ancient civilizations of Mesopotamia, Egypt, the Indian subcontinent, and China. However, credit is usually given to Hippocrates (ca. 460 BC - ca. 370 BC) for introducing the formal study of medicine and to Aristotle (384 BC - 322 BC) for the development of biology. Medieval scholars of the Islamic world produced treatises on botany, anatomy, physiology and medicine. Then there were Anton van Leeuwenhoek who's improvement of the microscope opened up a new world teeming in a drop of water, William Harvey who first described the circulation of the blood and Carl Linnaeus who devised the system of classification of living things and the binomial nomenclature still used today. (Wikipedia: Biology)

However for the authors, there is an important sense in which biology, as a science, only began with Darwin's theory of natural selection, worked out in the 1830's but not published until 1859. Until such time the careful observations of natural philosophy, anatomy, physiology and microscopy as well as the classification of living things could not have been organised with explanatory power into anything that resembled a science. However, Darwin's theory explains more than just common descent and shared ancestry; it also provides a causal mechanism that produces the adaptations that we see in nature. In the rest of the chapter the authors consider the above argument and discuss some controversies, some of which are based on misunderstandings and others which are genuine.

Teleology and Theology

By the end on the 19th Century most major fields of natural science had succumbed to explanation; first by Newtonian mechanics, then by electro-magnetism and thermodynamics and soon after atomic theory. Everything physical, it seemed, could be accounted for by the mindless operation of causal properties, including mass, velocity, momentum, force, acceleration, electric and magnetic charges and fields and by point-like molecules that feature in kinetic theory. And with this knowledge came the ability to tame agriculture and invent new means of production and manufacture that were the hallmark of the industrial revolution. However before Darwin, philosophers such as Kant (1790) lamented that "There will never be a Newton for the blade of grass", meaning that biological phenomena would never be explained by such processes.

Aristotle identified four forms of causation. In particular he distinguished efficient or moving causes from final causes. With **efficient causation**, prior events interact in such a way as to bring about physical changes that we are familiar with in physical explanations. **Final** or **end causes** on the other hand concern purposes, goals, or ends that explain what it is for the sake of which a thing is what it is. For a sailing boat, it might be sailing, for a ball at the top of a hill it might be in order to come to rest at the bottom, for the heart it is to pump blood so that it might circulate around the body. What is unusual about final or end causes is that they concern future goals, ends or purposes without reference to the prior causes that bring them about. (Wikipedia: Four causes)

Consider the authors' example of the cotton plant and the cowpea:

> Take a cotton plant: it moves its leaves throughout the day to track the sun, and it does so *in order to* maximize the amount of sunlight that falls on its petals. Even more impressively purposeful or goal directed is the cowpea plant. When well-watered plants of this species move in a way that maximizes the amount of sunlight to fall on their leaves, they do so apparently *in order to* produce starch from water and CO_2 through a chemical reaction catalysed by chlorophyll. And the plant produces starch *in order to* grow. But when the surrounding soil is dry, these same plants move their leaves *in order to minimize* their exposure to sunlight so that they retain water that would otherwise evaporate. (p. 13)

Biological explanations such as the ones above are clearly of the sort that Aristotle would have classified as final or end causes and therefore count as **teleological** explanations, from the Greek word τέλος (télos) for 'the fulfilment of or completion of anything'. If we ask a teleological question such as why the heart pumps blood, the answer typically cites something in the future to explain something in the past, be they structures, processes or events. If so, how is it possible for something in the future to bring about something in the past or present? Circulation is the effect of the heart's pumping and so explains it teleologically even though the circulation happens afterwards as a result of each pumping stroke.

Biology is replete with teleological terms. Consider the author's list of nouns: codon, gene, promoter, repressor, organelle, cell, tissue, organ, fin, wing, eye, coat, stem, chloroplast, membrane. Each of these is explained by what it *does*, or more precisely, what it is supposed to do when working normally. Of the many things that a heart does, pumping blood, making a "lub-dub" sound in the chest, creating alternating electric fields in the body, releasing various hormones, occasionally skipping a beat and so on, only one or two of these counts as a *function*. In other words, a heart is something an animal has "in order" to pump blood. One obvious question then is who or what brought it about that a heart provides this function? The same question can be asked in a meaningful way of almost anything biological in a way that does not seem to arise for purely physical entities like electrons or photons.

As noted above, teleological explanations are problematic because they cite future effects that prior causes will potentially lead to (and in some cases may never lead to. Think of the hundreds of millions of sperm cells that swim up the uterus "in order to" fertilize an ovum but never do). Obviously something in the future, which does not yet exist or may never exist, cannot lead to anything in the past. Aristotle was aware of this problem and argued that final causes were **immanent**, meaning that they have to have something already represented or embodied in their prior state that leads them towards their final goal.

Teleological explanations are unproblematic when beliefs and desires underwrite "in order to" explanations that involve actions. Why do you always empty your change into that compartment of your car? Because I always used to be short of change to pay for parking and this way I won't have to look for any when I need it. By making such beliefs and desires explicit the teleological explanation for my action becomes a non-teleological explanation in terms of past causes and my intended effect. Before Darwin however, a similar strategy for turning statements about purposes, goals, ends and the means to achieve them into causal relations that could bring them about simply did not exist. Questions such as, "why does the heart beat?" might have been answered, "In order to circulate blood". But this was really just shorthand for "desires" and "beliefs" of God: "Because God willed it so that blood should circulate around the bodies of some of his creatures".

There are several problems with invoking God to explain some or every natural phenomenon. Firstly, the move changes the subject from natural science to theology. Secondly, the acceptability of divine teleological explanations will depend on the success of arguments for the existence of God. As we have seen in Classic Text 03 no one such argument is without its problems. Thirdly, invoking God to explain every biological phenomenon is all too easy. In Voltaire's *Candide*, Dr. Pangloss explains why the nose has a bridge, namely in order to support spectacles. Of course, we see adaptations everywhere in nature and come up with Panglossian explanations that lead us no closer to the truth. The same is true of theistic explanations. God, being omnipotent, could have arranged anything any way he or she chose. And yet all the adaptations that we see are tightly constrained to one or more functions as well as by the physical and chemical nature of matter. Therefore if God were also so constrained in the creative act, he or she wouldn't be omnipotent.

Making Teleology Safe for Science

According to Richard Lewontin's (1978) statement of Darwinian theory, three conditions need to obtain for adaptation to proceed.

1. There must be reproduction with some inheritance of traits in the next generation.
2. There must always be some variation in each generation, among the traits so inherited.
3. The inherited variants must differ in their fitness, in their adaptedness to the environment.

These three conditions allow for adaptation in a variety of contexts, not just biological; however let us follow the authors' example of the giraffe's neck because for a long time before and for a time after Darwin the exact mechanism of such adaptation was hotly disputed. So why do giraffes have such long necks? Clearly, to reach the topmost succulent leaves of trees that other browsers cannot reach. More precisely, the giraffe's long neck is an *adaptation*, the *function* of which is to reach the topmost succulent leaves of trees that other browsers cannot. If we refer to Lewontin's conditions, we see that giraffes reproduce with some inheritance of the trait for long necks in the next generation, *i.e.* long-necked giraffes tend to have long-necked offspring. Of course, giraffe offspring do not have uniformly long necks. Some are longer than others, some shorter, others more or less the same length of theirs as their parents; hence the variation in this heritable trait. Sometime in the ancestry of giraffes the long-necked variation must have conferred an advantage over shorter necked individuals that gave the long-necked individuals a slight reproductive advantage, because presumably they were able to reach more succulent and nutritious food than the shorter-necked individuals. In other words, the hereditary trait of having a slightly longer neck was "fitter" in the giraffe environment allowing them to "out-compete" their shorter-necked individuals for scarce resources. Over many generations the slight reproductive advantage of being able to access superior resources would have resulted in a higher representation of longer-necked in the giraffe population.

The above scenario is by no means the last word on the evolution of the giraffe neck. However, it does illustrate how Darwin's theory of natural selection is able to explain how giraffe populations came to be dominated by long-necked individuals by identifying the causal mechanism responsible without having to invoke any special agency acting "in order to" provide superior nourishment for giraffes. There might have been other environmental pressures that favoured long-necks as an adaptation for giraffes; however what we are interested in here is the *process* that Darwin dubbed "Natural Selection". The choice of the name is somewhat unfortunate because it misleadingly suggests that agent choice or desire, that feature in theological accounts, somehow operate in picking the best and the fittest in each generation. Since what is happening in natural selection is a passive process, the authors suggest that "environmental filtration" might be a better label for the way the environment prevents less fit individuals from "passing through" offspring to subsequent generations.

Of course, what is adaptive in one environment may be maladaptive in another. The long thick hairy coat of the Woolly Mammoth that was adaptive in the extreme climate of the last Ice Age became a limitation once the ice began to retreat. This example puts paid to the notion that natural selection always generates continuous improvement and that later organisms are somehow always better adapted than their ancestors. In fact, Darwinian theory makes no commitment to the long-term "progress" of any lineage. Adaptation will always operate in response to the local and present environment.

Another potential source of misunderstanding that the authors point out is that the theory of natural selection requires that heritable traits must vary to some degree in each generation and that this variation must be "random". The theory itself says nothing about the mechanism of inheritance or the source of variation, indeed they have turned out to be quite different from what Darwin supposed in his day. However the theory does rule out variation guided by future causes in individuals that bear it, hence Darwin's use of the phrase "random variation". It is not that the appearance of new traits are undetermined by prior causes, only that such causes are independent of or unconnected with the factors that determine their adaptedness. Thus the randomness of variation is "with respect to" adaptation and not a statement about its ontology. In other words, the usefulness of a trait in a given environment is not among the causes for its appearance. Indeed, since Darwin, goals, ends or future causes in general are superfluous in biology.

Although today we know a great deal about the causal mechanisms of genetic mutation, some of which are truly random, such as those caused by quantum processes, contemporary texts prefer the word "blind" rather than "random" because this emphasises that variation is *blind* to the need of the individual or to that of the environment. Donald Campbell's (1974) description of natural selection as "blind variation and selective retention" is quite apt because it emphasises that process itself has no foresight.

Lewontin's list of conditions above need not apply exclusively to the individual organism or indeed to any living thing. The theory of natural selection may apply to macromolecules capable of replication, genes, viruses, organelles or even prions, none of which is "alive" in the ordinary sense. Industrial chemists even use a process similar to natural selection to generate tens of thousands of different molecules which are then tested for desirable properties. Those that are identified are retained go on for further rounds of differentiation, retesting and selective retention. Of course, industrial processes are goal directed and are therefore better described as **artificial selection**. However, in general, natural selection "must be expressed as a general claim about the evolution of reproducing things with heritable variation and differential fitness or adaptedness". (p. 19)

David Hull (and, independently, Richard Dawkins whom we met in Classic Text 10) introduced the terms “replicator” and “interactor” (“vehicle” for Dawkins) to express the generality of natural selection as a mechanism. For Dawkins (1982) a replicator is any entity in the universe of which copies are made. Meanwhile a “vehicle” is defined as any relatively discrete entity, such as an individual organism, which houses replicators… and which can be regarded as a machine programmed to preserve and propagate the replicators that ride inside it. Together these terms provide the theory of natural selection with the generality it requires. We have already seen how Dawkins used the terms to speculate about the molecular origins of life without knowing the exact details but also about the origins of altruistic behaviour driven by genes acting in their own “selfish interest”. (Dawkins, 2006)

Misunderstandings about Natural Selection

One of the most common reactions to hearing or reading about natural selection for the first time is sheer bewilderment. How could a theory based on blind variation and selective retention explain the origins of all the splendour of life? When we see a hereditary variation in nature it is either slight or in rare cases almost totally incapacitating, if not fatal. How is it that environmental selection acting on such slight variations could produce such spectacularly complex organs such as the eye or the brain, whether insect, cephalopod or human? Darwin himself acknowledged the problem when he wrote:

> To suppose that the eye, with all its inimitable contrivances for adjusting the focus to different distances, for admitting different amounts of light, and for the correction of spherical and chromatic aberration, could have been formed by natural selection, seems, I freely confess, absurd in the highest possible degree. (Darwin, 1859 p. 186)

The sceptic may concede that evolutionary changes can be brought about by selective breeding in the laboratory or in domesticated animals over hundreds of generations, but then these changes are usually quite small. Besides, which the experimenter or breeder begins with an animal or plant that is already highly adapted and sophisticated. What the sceptic demands of Darwinian theory is an uninterrupted account that begins with a random assortment of prebiotic molecules in the primordial ooze some 3,5 billion years ago down to present day creatures like lettuce, mice and men. Of course, the biologist should not take the bait - no such account is possible. What the evolutionary theorist does wish to show is that natural selection, specifically random variation and environmental filtration, is the only known mechanism that can bring about *adaptation* - that which answers to the myriad “in order to” characterisations of the features of organisms.

Typically, there is some equivocation concerning the use of the word “randomness”. The sceptic may insist that no random process such as natural selection could ever produce such complex features as the insect or avian wing, let alone the human brain. In one sense, natural selection is random in so far as variation is random; however environmental selection, the differential survival and reproduction of the variants that are better adapted, is anything but random. The problem of complexity is another matter. Wings, eyes and brains did not spring into existence as single adaptations. Instead they are the products of a series of cumulative adaptations, each building on earlier adaptations that allow complexity to be ratcheted up incrementally. At times however, some complex adaptations or speciation events can be driven by sudden and large mutations or **saltations** interspersed by periods of **stasis** during which relatively little evolutionary change takes place during the history of a species.

The evolution of powered flight among vertebrates (at least twice over) occurred as a series of complex adaptations over hundreds of millions of years from fin to weight baring limb to wing, each serving different functions. As the authors point out, “A wing is not a better fin or even a better leg. [Each] is something entirely different…” If all you look at are the endpoints of their evolution, the gap between fin, walking limb and wing can seem impossibly great. One reason is that we no longer see any intermediary forms. Occasionally however we are lucky enough to uncover a fossil of a transitional form such as the Urvogel (German for ‘original bird’) *Archaeopteryx* complete with forelimb bones and feathers. More often we rely on **homology**, the anatomical similarity in parts, numbers, and spatial relations of different structures to one another. This was one of Darwin’s earliest arguments for natural selection. Today we can extend this to molecular similarities in DNA sequences and the genes they encode, say for forelimb development in fish, amphibians, reptiles and birds. Homology and molecular biology are just two sets of tools for uncovering the tracks that evolution has hidden, “so that adaptations begin to look expectable instead of miraculous”. (p. 21)

The notion of directionality, a drive ever onwards and upwards towards greater complexity, is also problematic. Admittedly, the evolution of an extremely simple organism, must at some point explore slightly more complex adaptive spaces once the nearby extremely simple adaptive spaces have been occupied; however there is no such general tendency in evolution. Quite often more evolved species opt for less complex adaptive solutions: free living species lose most of their senses and nervous system when they become endoparasitic; some birds have become flightless and cetaceans have lost their weight baring limbs since they have returned to the water. Clearly complexity is reversible with natural selection favouring whatever adaptive opportunities that arise.

Evolutionary biologists frequently use the language of engineering to talk about “design problems” or “design spaces” as metaphors for natural selection “as if had it had foresight”. Of course, natural selection is blind and there is no designer; however arguments from design try to infer the existence of a Divine Designer from the apparent existence of design in nature. (See Classic Text 03) Solving a metaphorical “design problem” comes down to being fitter than competing lineages faced with the same environmental challenges. Humans consciously favour designs that are elegant and efficient; however often variations will emerge that “solve design problems” in a way that is “quick and dirty” so long they confer an immediate advantage on offspring who possess the “problem solving trait”. A “better but slower to emerge” solution may appear but then it will have to compete with the “quick and dirty” solution which may place it forever out of reach. (p. 22)

The authors mention several such “suboptimal solutions”: The giraffe’s long neck makes it excellent at browsing tree tops but makes it difficult to drink; the human alimentary canal intersects with the airway in such a way that makes it possible to choke on our food; the vertebrate eye has a “blind spot” where the optic nerve connects at the front of the retina – the cephalopod eye has no such “design flaw” as their optic nerve connects at the back of the retina. It is now no longer possible for the vertebrate eye to evolve into the more elegant cephalopod design, given that its various parts are now too deeply interdependent to permit major rearrangements. Besides which, what little vision has been lost to the blind spot has been compensated for by the *fovea centralis* responsible for sharp central vision. According to the authors, “The lesson is that while natural selection explains adaptations, apparent perfections of design, it also explains some of the imperfections of design we see in organisms". (p. 23)

Is Darwinism the Only Game in Town?

Before Darwin, Jean-Baptiste Lamarck (1809) proposed a theory of heredity based upon use or disuse of various characteristics acquired during an organism's lifetime. According to **Lamarckian inheritance**, the long neck of the giraffe can be explained by the cumulative strivings of many generations of giraffe stretching their necks to reach the highest and most nutritious leaves of tall trees, passing this trait on to their descendants. In truth, this was only a small, hypothetical illustration of heredity as part of Lamarck's much larger theory of evolution towards "perfection". Nevertheless the, "theory" and the name Lamarck have been entrenched in textbooks ever since. (Ghiselin, 1994) Therefore by Lamarckian inheritance we shall informally mean inheritance of acquired characteristics.

Darwin himself was partly taken in by some aspects Lamarckian theory. Indeed Lamarckian inheritance, in particular, has the virtue, shared by natural selection, of being based entirely on past causation. Unfortunately, all the available evidence militates against it. For example, for millennia in China, girl's feet were tightly bound to modify the shape of their feet and yet the size of the feet of their offspring at birth remained the same. (The practice has since been outlawed.) Moreover, today we know that only changes to the germline (those cells they may pass on their genetic material to their progeny) can produce changes to the genetic makeup of offspring. If Lamarckian inheritance were true then there would have to exist some causal mechanism by which the stretching of giraffe necks could make changes to the heredity material (*i.e.* DNA) of germline cells in reproducing giraffes. No such mechanism is known, either in theory or observation. In fact, the whole scenario is incompatible with everything we know about the modern genetic theory of heredity, which has been so strongly corroborated.

There are some other "out-of-this-world" accounts of the adaptedness of organisms to their environment here on Earth. Could it be that a technologically advanced alien species has engineered life on Earth to be the way it is? Although we might balk at the idea, we cannot rule it out on the basis of any known physical laws. Even if this were so, and we have no way of knowing for certain that it is, we would still have the question of the adaptedness of the aliens, including superior intelligence and sophisticated technology, to account for. Another "out-of-this-world" account known as **panspermia** (from the Greek πᾶν (pan) for 'all' and σπέρμα (sperma) for 'seed') proposes that life on Earth, or at least the pre-biotic organic building blocks of life, originated elsewhere in the universe and "hitched a ride" to Earth on the back of a comet, meteoroid, asteroid or interstellar dust, which then "seeded" Earth with life or its precursors. Once again, we cannot rule out this hypothesis on physical grounds alone. However, the problem with both alien and panspermia accounts is that they simply postpone the questions of evolutionary adaptiveness and the origins of life rather than answering them. Instead we would have to address the selfsame questions somewhere in outer space, we know not where.

Of course there could be a planet out there on which Lamarckian genetic mechanisms produce extremely elegant adaptations, but that planet is not this one and we have no idea how such mechanisms could have emerged. The fact that we see everywhere in nature the "quick and dirty" adaptations in our world suggests that only Darwinian natural selection could account for them. In the same vain, if God really had created every living thing, then why, being omnipotent, did he or she go to such trouble to make them look that they had been cobbled together (imperfectly) by natural selection, rather than creating them anatomically and functionally perfectly formed from the start? But that question takes us into the realm of theology, not the philosophy of biology. So it seems that as the authors declare, “Darwinism seems to be “the only game in town”, not just the best explanation of adaptation but the only physically possible purely causal explanation, the only one consistent with what we already know about the physical laws (the laws of special and general relativity, quantum mechanics, thermodynamics) that govern the universe”. (p. 25)

For some, such a strong claim is unwarranted when all that is required is a more limited theory about the Earth over the last 3,5 billion years or so. If such a theory is simply a specific claim about the natural history of the Earth then the evidence we need to test it is finite and decidable. On the other hand, limiting the theory in this way undermines some of its explanatory power, even for terrestrial adaptation. (p. 25 - 26)

Of course, as the authors point out, “arguing that the only way adaptation could have arisen is by natural selection is not the same thing as claiming that adaptive evolution was inevitable on Earth or anywhere else”. If any one of Lewontin’s conditions had been too slow, too variable or too extreme, adaptive evolution by natural selection might never have gained a toehold or might have simply “fizzled out”. Therefore the claim that Darwinism is “the only game in town” is not an inevitable one, only that *when* adaptive evolution did occur, it did so by random variation and environmental filtration. We should be wary of elevating natural selection to some kind of universal law. After all, Newton’s law of universal gravitation turned out to be only a limiting case for objects moving much slower than the speed of light. There may be other places in the universe in which other forms of adaptation have arisen, only we don’t know about them if they do exist.

On the other hand, we should be encouraged by the way Darwinian mechanisms have featured in the fields of psychology, sociology, anthropology, economics and linguistics in explaining the appearance of apparently purposeful phenomena in these and other disciplines. B. F. Skinner’s work on operant conditioning, in which laboratory animals (and humans) were able to produce apparently purposeful behaviour based only on blind variation and selective retention, is a form of natural selection operating ontogenetically (within the development of an individual) rather than phylogenetically (down its evolutionary history). Similarly, synaptic pruning, which includes both axon and dendrite pruning, has been shown to selectively eliminate of the overabundance of neurons in the developing brain, beginning early in childhood and completed around the time of sexual maturity. Meanwhile selective retention of functionally appropriate neurons proceeds along the lines of **Hebb’s rule**, often summarised by the misattributed catch phrase “cells that fire together, wire together”. More formally, “When an axon of cell A is near enough to excite a cell B and repeatedly or persistently takes part in firing it, some growth process or metabolic change takes place in one or both cells such that A’s efficiency, as one of the cells firing B, is increased”. (Hebb, 1949 p. 62) This represents another form of ontogenetic evolution, this time *within* the brain.

Philosophical Problems of Darwinism

Given that natural selection can be used to explain so many phenomena in so many diverse disciplines it is not surprising that the attempt to extend it beyond biology into the behavioural and social sciences has proven controversial. Even within biology, the claim that adaptation explains every feature of every organism at all times is questionable. Adaptive explanations seemingly cannot account for why the animal kingdom is divided into those with radial and those with bilateral symmetry or why some rhinoceroses have one horn and others have two. Similarly, adaptive explanations fail to account for many of the watershed evolutionary events such as the **Cambrian explosion**, an event some 538.8 million years ago in the Cambrian Period lasting 13 - 25 million years during which most of the modern multicellular animal phyla appeared. On the other hand, many forms of human behaviour and socialisation appear to be non-adaptive or even apparently counter-adaptive in so many ways. According to the authors, the debate appears to be about the range of the theory's application and the limits of selective explanation. (p. 27)

Then there is the very real but vexing problem of **genetic drift** which is a mechanism of evolution in which there is a change in the frequency of an existing allele within a population over time due to chance. Genetic drift occurs in all populations but more often in smaller populations, especially at population bottlenecks, typically after population crashes. Genetic drift may involve the total loss of an allele in a population or the total replacement by one allele at a particular locus. There is no adaptive rhyme or reason for genetic drift except that it can be regarded as an instance of random sampling by organisms. (Wikipedia: Genetic drift)

Some critics question the application of the theory of natural selection to human beings. In particular those who advocate radical social chance and who think that adaptationist explanations of human traits such as gender and sex roles, intelligence, violence or criminality undermine their programme. These again are disputes about the domain of the theory's application. But, as the authors point out, "there can be no agreement on the theory's range of application so long as there is no agreement on precisely what the theory says". Although philosophers could help in disambiguating the theory of natural selection and in identifying its logical implications for the various domains of application, it is unlikely that any group with such a preconceived social agenda would be open to persuasion. (p. 28)

Among those who deny the theory of natural selection are a nebulous group of religious thinkers including less than 5% of scientists for whom the theory threatens their belief that God created life as part of his or her divine plan. Some denialists have claimed that the theory is tautologous or circular and therefore has no explanatory force. Relying on the concept of fitness and the peremptory phrase "survival of the fittest", popularised by Herbert Spencer, these individuals claim that the theory of evolution predicts an increase of "fitter" individuals in the population who out compete less "fit" individuals. But, these critics claim, when biologists define the term "fitness" they do so in terms of survival and reproduction, therefore the terms "survive", "reproduce" and "are fitter" mean the same thing. So according to the theory of natural selection, those who survive and reproduce are the ones that survive and reproduce, which is manifestly circular and therefore of no explanatory value.

As we saw in Classic Text 17 there is a distinction between ordinary substitution and substitution *salva veritate,* so that we should not be taken in by such a cheap trick. Darwin never used or endorsed the use of the phrase “survival of the fittest”, therefore we shall have to come up with a noncircular definition of fitness if the theory of natural selection is to do any explanatory work.

Finally, there is the relation between the biological and other natural sciences including physics, chemistry and geology. During the 1880’s Lord Kelvin argued that Darwin’s theory of natural selection could not be true because of the immense timescale it would take for evolution to occur. According to Kelvin’s calculations the Earth could not be more than 40 million years old. Today we know the age of the Earth to be some 4.5 billion years old with the oldest fossils appearing as early as 3.77-billion years ago. (Gramling, 2017) Also, as we saw in Classic Text 13, the chemical and physical machinery of living organisms, including reproduction, protein synthesis, and general metabolism were not known until the mid-20th Centaury.

Task

What are some of the *philosophical* questions that emerge from the theory of natural selection? Are there any that can be dismissed out of hand and are there others that can, in principle, not be answered? What, according to the authors, is a prerequisite to any such task?

Feedback

Firstly, it is important to distinguish between scientific and philosophical questions relating to natural selection. How did humans evolve in Southern Africa during the last 3 million years is a question for the *science* of palaeoanthropology. Whether natural selection is theoretically possible in a world of physical causes that have no ends, goals or purposes is a distinctly philosophical one. Of course, the two disciplines are not neatly segregated, so that there is always a fertile region of interdisciplinary overlap. There are no genuine philosophical questions around natural selection that are in principle unanswerable; although philosophers will, for example, have to answer questions such as why the theory is not tautologous. There are numerous questions about the scope of the theory and just how much it purports to explain. Similarly, there are questions about how natural selection relates to other theories such as physics, chemistry and geology and to what degree they are consistent. Finally, there are questions about what, if any, is the relation between natural selection and the behavioural and social sciences. All of these questions require an unambiguous statement about just what the theory says and means. (p. 29)

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