The gospel of inevitability

Was the Universe destined to lead to the evolution of humans?

Life Evolving: Molecules, Mind, and Meaning
by Christian de Duve
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Towards the end of *Life Evolving*, de Duve states that his message "does not oppose the view that places humankind on top of the tree (for now) and sees the attainment of this position as a significant, perhaps even necessary, step in the unfolding of biological evolution". From the scientific point of view, his main agenda seems to be to attack what he calls "the gospel of contingency" — in which evolution unfolds as a series of events crucially littered by chance, ultimately leading to extremely improbable states such as the human population — as expressed by George Gaylord Simpson, Ernst Mayr, Stephen Jay Gould and Jacques Monod among others. But there is another agenda: with admirable frankness, de Duve sets out to prove that many hidden or expressed assumptions of religion, illustrated by those of the Catholic Church (the faith in which he was raised), are clearly untenable from the viewpoint of contemporary biology.

According to the Bible, humankind had to come because God saw it fit. According to the adherents of the 'anthropic principle', the Universe, for whatever reason, is fine-tuned in such a way that led to evolution, culminating in an intellect that can reflect on it and on itself. The details of evolution are therefore irrelevant. But de Duve does not buy either of these explanations; instead he offers his own, portraying biological evolution as almost determined by itself to climb up towards the human race. The devil is in the details of evolution. In an imaginary play, Lamarck would embrace de Duve, whereas Darwin (I suspect) would not. Setting this aside, does de Duve prove his case? I do not think so.

He offers a wide overview ranging from the origin of life to the ascent of humans, from biotechnology to the autoevolution of the human race. Many of the topics are treated with obvious competence, although I would have appreciated some explanatory diagrams throughout. Yet there are topics where I disagree with de Duve. For example, although it is true that the first RNA could not have made itself (this is true, by the way, for any first unit of evolution), and that we cannot prove for sure that there was an RNA world, the metabolic competence of ribozymes is presented in a way that is biased against the case. Another example: the treatment of the origin of language (announced on the jacket) is too short to capture the complexity of the problem and misses many of the recent advances in the field. Here de Duve argues cogently that consciousness is a real thing, and offers some kind of an explanation by saying that it "represents some sort of physically energized state and that the particular configuration of neurons in the cerebral cortex serves as generator and supporter of that state". If this does not strike you as enlightening then you are not alone.

Let me return to the main theme. In a chapter entitled "The Arrow of Evolution", de Duve distinguishes between two directions of evolution: horizontal and vertical, which roughly coincide with micro- and macroevolution, respectively. The claim is that the first is littered with contingency, whereas the latter is self-guided along certain trends towards increasing complexity. The main reason for this is that in microevolution the population can respond by many alternative mutations to the same selective challenge, whereas in macroevolution the range of genetic changes is severely limited.

According to de Duve, "it is self-evident that the universe was pregnant with life and the biosphere with man", and he maintains that claims to the contrary are logically fallacious. "The universe has given life and mind. Consequently, it must have had them, potentially, ever since the Big Bang." I think that de Duve confuses (if I may borrow a phrase from Jacob) the possible with the actual. Any married couple could be said to have had the potential to give birth to their actual children, but knowing the chance elements in marriage, in meiosis and in fertilization, they can be said to have had in their potential, for all practical purposes, a countless number of different children. Having those, and even their actual children, was by no means inevitable. Yet the genetic constitution of their children is important and will critically determine many aspects of family life.

I share the belief with de Duve that life had to originate in some more or less straightforward manner, but without a convincing scenario we cannot calculate probabilities and cannot know, therefore, whether this belief is true or not. I am inclined to use contingency exactly opposing de Duve. The point that increasingly complex organisms have relatively few permissible genetic changes (not opposed by negative selection) does not reduce, but instead increases, contingency in the set of possible lineages. Although the alternatives for future evolution are reduced in number, alternatives of existing forms are more markedly delineated from each other, as a result of the constraints of previous turns. To use Lewis Wolpert's example, one cannot evolve angels with wings from humans, because of the past evolution of the relevant developmental mechanisms.

This increased contingency would lead to inevitability only in the extreme case when, from the level of bacteria upwards, say, the number of options at major steps was reduced to a minimum, preferably one. In any other case, previous turns exclude many feasible alternatives in the future. The fact that there are no asexual gymnosperms is possibly due to the condition that the egg delivers the mitochondrion and the pollen provides the

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plastids. The lack of parthenogenesis in mammals may be partly explained by the existence of genomic imprinting. It is not too hard to figure out what genetic changes would be needed to allow for the appearance of asexual variants; it is just highly unlikely that the genetic systems could produce them at once.

Some of the major transitions in evolution (such as the origin of the genetic code, or the eukaryotic cell) could be truly unique, not because of some chance bottleneck, but because either the required genetic variations, or the selective conditions, or both, were extremely unlikely. Given 1,000 Earth-like planets with the same initial conditions, and a period of 8 billion years (to be on the generous side), how many of the planets would evolve eukaryotes? Or deuterostomes, primates or humans? It seems that de Duve's tacit position is that most would have humans. If this case could be proven, it would be the most important discovery in evolution — more important even than the idea of natural selection.

However, de Duve does not offer a proof. Regarding the importance of the asteroid impact at the Cretaceous–Tertiary boundary, he says: "Perhaps mammals were bound to supplant dinosaurs at some stage for reasons linked to the intrinsic properties of the two types of animals, and the asteroid only precipitated an event that would have occurred sooner or later." Yes, perhaps. But if de Duve wants to supplant divine or anthropic determinism by an evolutionary one, a much stronger case has to be made. Without that, neither physicists, biologists nor the Church will be convinced. ■

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Universal values

The Constants of Nature
by John Barrow
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The description of natural phenomena through the differential equations of physics has three separate aspects. First, of course, is getting the correct equations and description. The second has to do with understanding the boundary conditions to these equations without which it is often impossible to select relevant solutions. And finally, one would like to understand the origin of the constants and parameters that occur in the equations.

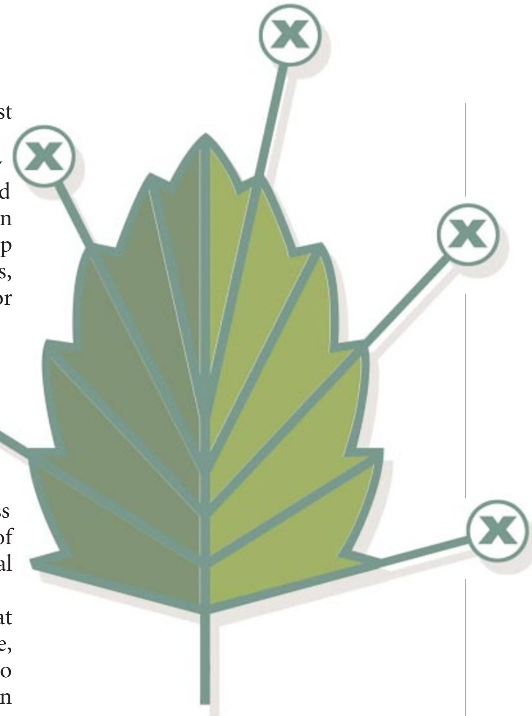
Although most effort goes into the first task, one should not underestimate the importance of the other two — especially the third. Broadly speaking, one would have expected the number of constants in the equations describing nature to keep reducing as our knowledge increases. This, unfortunately, does not always happen. For example, the fundamental theory describing electroweak interactions has more than a dozen parameters, with their associated constants. One is, therefore, led to questions such as: Why do the constants in the equations have the values they do? Why do dimensionless ratios have some specific values? Are some of the constants of nature more fundamental than others?

These questions, of course, assume that one has a choice in the matter. For example, one might have thought *a priori* that the ratio of the masses of the muon and the electron (which is still undetermined even though we believe we understand the physics of leptons) or the fine-structure constant, a measure of the strength of electromagnetic attractions, could have been ten times as large or as small as observed. Is this really true? One argument — called the anthropic principle — attempts to address this question by stressing that for us to be able to discuss such questions at all, the Universe necessarily evolved in a manner allowing the formation of fairly complex organisms. There have been several attempts to show that if some of the constants of nature had significantly different values, the evolution of the Universe would have been very different and complex organisms could not have originated.

Advocates of the anthropic principle claim that this is the only paradigm currently available to discuss the issue. Opponents criticize the anthropic view for having no predictive power and for introducing a subjective bias (related to the existence of complex organisms) into science.

Another question is whether the constants are truly constant. Laboratory observations cover an insignificant span of time compared with the time over which the Universe has existed in a form familiar to us. If some of the 'constants' actually vary with time at a very slow rate, then laboratory experiments cannot determine this, although such a variation can have significant cosmological consequences.

John Barrow discusses these and other related issues in his fascinating book *The Constants of Nature*. In 13 chapters, sprinkled liberally with quotations from many different sources, he discusses the role of constants of nature, the historical quest to understand them, the role of the anthropic principle as a guiding philosophy and some recent evidence suggesting that some of the constants of nature are probably not



constants at all. The major strength of the book lies in the diversity of topics discussed.

Although there are very few equations in the book, it certainly uses a language that is a notch more technical than a non-specialist reader may be accustomed to. For example, graphs are drawn in logarithmic units and the 'powers of ten' notation is consistently used to describe large numbers without much explanation.

I found the discussion of the anthropic principle and the description of the theory of the fine-structure constant most impressive. This is to be expected, as Barrow was directly involved in developing these ideas. In a few other places, however, the discussion is somewhat simplistic. For example, in the discussion of the historical evolution of units of measurement, there is no mention of the oriental heritage and discussion is biased towards the ideas of Western civilization. The description of how real advances in understanding physics occur is also far too naive, and the discussion does not merge coherently with the rest of the book. And a typographical error that could be confusing to the reader is a missing factor 'c' in the first equation on page 86.

The book is liberally sprinkled with human-interest stories. But to do this properly one should be a historian of science. Otherwise there is a risk of introducing factual errors that have a tendency to propagate themselves. One example here is the mistaken statement that Paul Dirac was the youngest winner of a Nobel Prize for Physics; that honour goes to Lawrence Bragg. Such mistakes rather shake one's faith in the other stories and reduce them to enjoyable bits of gossip, which may or may not be true. ■

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