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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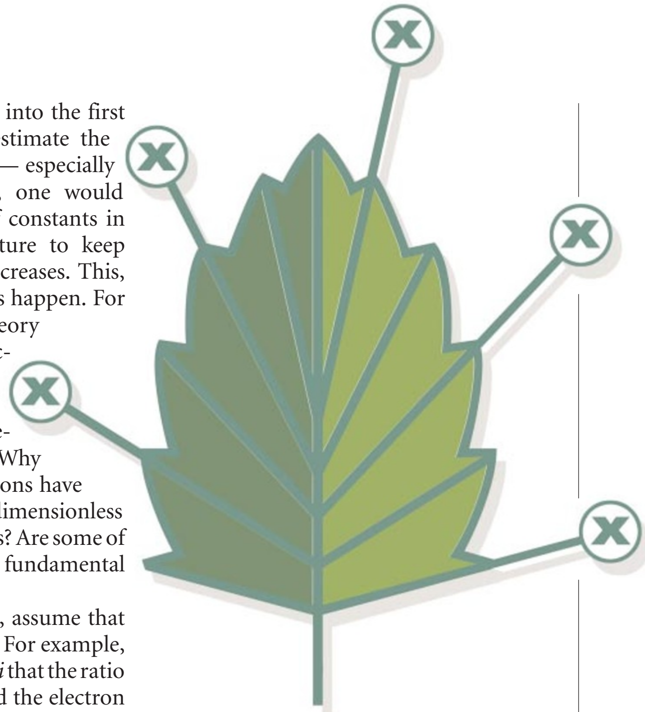
The description of natural phenomena through the differential equations of physics has three separate aspects. First, of course, is getting the correct equations and description. The second has to do with understanding the boundary conditions to these equations without which it is often impossible to 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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