no combination of the currently understood mechanisms of evolution is capable of producing them. An extreme version of the argument claims that no other form of natural process is capable of doing so either. Secondly, it is argued that the nature of the features in question represent conclusive evidence that they must have been purposefully designed by some intelligent entity or entities.

Modern advocates of Intelligent Design base their arguments on some of the intricate biochemical systems discovered over the last fifty years, and they insist that these arguments, besides being conclusive, are also completely scientific. At the heart of the arguments lie two key concepts of complexity which some of these biochemical systems are purported to exhibit.

Irreducible Complexity

The first of these, *irreducible complexity*, was defined by Michael Behe, a professor of biochemistry at Lehigh University in Pennsylvania, as follows:[2] "By *irreducibly complex* I mean a single system [necessarily] composed of several well−matched, interacting parts that contribute to the basic function, wherein the removal of any one of the parts causes the system to effectively cease functioning". The word "necessarily" did not appear in the original definition. It was added later in response to various criticisms.

Prof. Behe contends that cells contain many irreducibly complex biochemical systems, and that it is impossible for such a system to be produced *directly* by any mechanisms, like those of Darwinian evolution, which operate by making successive, small modifications to the system's parts. He admits that such mechanisms might produce any given irreducibly complex system by what he calls an "indirect, circuitous" route, but contends that this possibility is effectively ruled out because the probability of that happening is practically infinitesimal.

Regardless of the rest of the argument's merits, the last assertion is based on two statistical fallacies which are fatal to any resulting inference that irreducibly complex systems cannot be produced by Darwinian evolution. The first of these is the mistaken presumption that whenever some set of circumstances has been observed to occur, and there is only an exceedingly small *prior* probability that those particular circumstances would result from a particular hypothetical process, then it can be concluded that the circumstances in question were not produced by this process. Appeals to this fallacy appear to result from a misunderstanding of certain genuine techniques of statistical inference known as *significance tests*, regarded as valid by one school of statisticians (but not by others).

The second fallacy lies in the grotesquely inadequate form of statistical model used to estimate the prior probabilities that the systems under discussion would have arisen by evolutionary processes. Even if the calculation of these estimates *could* be used in a proper statistical significance test, all that can be concluded from the failure of such a test is that the *statistical model* used to calculate the estimates should be rejected. But when the model is already so poor that it could have been rejected out of hand in the first place, mere confirmation of that fact by a statistical significance test doesn't really tell you very much.

Specified Complexity

The second form of complexity, called *specified complexity*, was introduced by a mathematician and philosopher, William Dembski, currently professor of the conceptual foundations of science at Baylor University in Texas. Roughly speaking, an observed phenomenon is said to be *specified* with respect to some statistical hypothesis about its causes, if it conforms to some pattern which, according to the hypothesis in question, is "independently given". According to Prof. Dembski, this property would guarantee that the prior probability assigned to the phenomenon by the hypothesis could be used as the basis for a valid test of statistical significance.

The phenomenon is called *complex* with respect to the hypothesis in question if its probability under the hypothesis is so small that the hypothesis can reasonably be rejected. Finally, the phenomenon is said to exhibit *specified complexity* if it is both specified and complex with respect to "*all relevant*" statistical hypotheses that might be used to explain its occurrence.

The idea behind this definition is that if an observed phenomenon can be shown to exhibit specified complexity, then for *every* plausible "naturalistic" explanation of its occurrence there must be a valid statistical significance test which enables that explanation to be rejected. Prof. Dembski and his followers assert that specified complexity is a perfectly reliable indication of intelligent design, and that it is exhibited by many human artifacts and cellular biochemical systems.

However, Prof. Dembski's formal definition of what it means for a phenomenon to be specified turns out to be ambiguous when one tries to apply it in practice. For the property of being specified to serve as an indicator of a valid statistical significance test, one particularly narrow interpretation of the definition must be rigidly adhered to. In practice, this makes it effectively impossible to confirm that any of the phenomena claimed by advocates of Intelligent Design to exhibit specified complexity are indeed specified in the required sense with respect to any reasonable statistical hypothesis.

When one carefully inspects the examples claimed by Prof. Dembski to exhibit specified complexity, it becomes evident that he has given his definition a much looser interpretation than necessary. This means that the procedures he follows are by no means guaranteed to be valid statistical significance tests.

The upshot is that nearly all of his declared examples of specified complexity suffer to some degree from the first of the two statistical fallacies mentioned above.

But *even using his much looser* interpretation of what it means for something to be specified, it is *still* effectively impossible in practice to show that it exhibits specified complexity, because it has to be shown to be specified and complex with respect to *all* relevant statistical hypotheses. For all the examples cited by the Intelligent Design movement, the most obviously relevant statistical hypotheses are so complicated that even very crude estimates of the relevant probabilities are well beyond the capabilities of any currently known computational techniques. Typically, assertions that these examples exhibit specified complexity amount to nothing more than question begging−−−they are simply declared to do so with no attempt whatever to justify the declaration by performing the necessary calculations.

In other cases, just as with irreducible complexity, some completely inadequate statistical model is used to calculate an essentially meaningless probability, which is then taken as justification for declaring the example to be one of specified complexity. Finally, in some of the few examples which Prof. Dembski has indeed shown to be complex with respect to a reasonable statistical hypothesis, it is very easy to come up with an equally reasonable hypothesis with respect to which the example is *not* complex and which demonstrates that it cannot possibly exhibit specified complexity.

In short, advocates of Intelligent Design have failed dismally to show that *any* of the phenomena they have hailed as examples of specified complexity do in fact satisfy its formal definition, and I see very little prospect of their doing so in the foreseeable future.

Conclusion

In view of the inadequacies outlined above, the concepts of irreducible complexity and specified complexity present no credible challenge to the theory of evolution. I therefore see little point in further examining claims that they provide conclusive evidence of design by intelligent agents. These claims turn out to be based on specious attempts at inductive generalisation taken over holus−bolus from natural theology, and are no more convincing now than they were when the philosopher David Hume demolished them 250 years ago.

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For further information on the Australian Skeptics and their journal, *The Skeptic,* connect to www.skeptics.com.au

Information on Intelligent Design

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What is Intelligent Design?

According to one of its principal advocates, *Intelligent Design* is[1] "three things:

- a scientific research program that investigates the effects of intelligent causes;
- an intellectual movement that challenges Darwinism and its naturalistic legacy; and
- a way of understanding divine action."

However, the literature produced by the first of these seems to contain little more than specious arguments against biological evolution and in support of the view that design by an intelligent agent must have somehow been instrumental in the development of life. The most notable activity of the second seems to be a concerted political campaign to have US school students exposed to these arguments during their science classes.

In broad outline, the arguments produced by the Intelligent Design movement are little different from those which have been used to attack Darwin's theory of evolution ever since *The Origin of Species* was published in 1859. They purport to establish two main conclusions. First, it is argued that some features of living organisms are so extraordinary that