

Design, Yes.

Intelligent, No.

Were we designed by an intelligent creator? In our last issue Todd Moody described Intelligent Design theory as a scientific alternative to Darwinian evolution. Here, Massimo Pigliucci takes a more critical view of 'ID'.

A new brand of creationism has appeared on the scene in the last few years. The so-called neocreationists generally do not believe in a young Earth or in a rigidly literal interpretation of the Bible. While still mostly propelled by a religious agenda and financed by mainly Christian sources such as the Templeton Foundation and the Discovery Institute, the intellectual challenge posed by neocreationism is sophisticated enough to require detailed consideration.

Among the chief exponents of Intelligent Design (ID) theory, as this new brand of creationism is called, is William Dembski, a mathematical philosopher and author of *The Design Inference*. In that book he attempts to show that there must be an intelligent designer behind natural phenomena such as evolution and the very origin of the universe (see Pigliucci 2000 for a detailed critique). Dembski's most recent argument is that modern science ever since Francis Bacon (1561-1626) has illicitly dropped two of Aristotle's four types of causes from consideration altogether, thereby unnecessarily restricting its own explanatory power.

Aristotle's four causes in science

Aristotle identified *material* causes, what something is made of; *formal* causes, the structure of the thing or phenomenon; *efficient* causes, the immediate activity producing a phenomenon or object; and *final* causes, the purpose of whatever object we are investigating. For example, let's say we want to investigate the causes of the Brooklyn Bridge. Its *material* cause would be encompassed by a description of the physical materials that went into its construction. The *formal* cause is the fact that it is a bridge across a stretch of water, and not either a random assembly of pieces or another kind of orderly structure, such as a skyscraper. The *efficient* causes were the blueprints drawn by engineers and the labor of men and machines that actually assembled the physical materials and put them into place. The *final* cause of the Brooklyn Bridge was the need for people to walk and ride between two landmasses without getting wet.

Dembski maintains that Bacon and his followers did away with both formal and final causes (the so-called *teleonomic* causes, because they answer the question of why something is) in order to free science from philosophical speculation and ground it firmly on empirically verifiable statements. That may be so, but things certainly changed with the publication of Darwin's *Origin of Species* in 1859. Charles Darwin was addressing a complex scientific question in an unprecedented fashion: he recognized that living organisms are clearly

designed in order to survive and reproduce in the world they inhabit; yet, as a scientist he worked within the framework of naturalistic explanations of such design. Darwin found the answer in his well-known theory of natural selection. Natural selection, combined with the basic process of mutation, makes design possible in nature without recourse to a supernatural explanation because selection is definitely non-random, and therefore has 'creative' (albeit non-conscious) power. Creationists usually don't understand this point and think that selection can only eliminate the less fit; but Darwin's powerful insight was that selection is also a cumulative process – analogous to a ratchet – which can build things over time, as long as the intermediate steps are also advantageous.

For example, if we were to ask within a Darwinian framework what are the causes of a tiger's teeth, we would answer in the following manner. The material cause is provided by the biological materials that make up the teeth; the formal cause is the genetic and developmental machinery that distinguishes a tiger's teeth from any other kind of biological structure; the efficient cause is natural selection promoting some genetic variants of the tiger's ancestor over others; and the final cause is provided by the fact that having teeth structured in a certain way makes it easier for a tiger to procure its prey and therefore to survive and reproduce – the only 'goals' of every living being.

Therefore, design is very much a part of modern science, at least whenever there is a need to explain an apparently designed structure such as a living organism. All four Aristotelian causes are fully reinstated within the realm of scientific investigation, and science is not maimed by the disregard of some of the causes acting in the world. What then is left of the argument of Dembski and of other proponents of ID? They, like William Paley (1831) well before them, make the mistake of confusing natural design and intelligent design by rejecting the possibility of the former and concluding that any design must by definition be intelligent.

One is also left with the lingering feeling that Dembski is being disingenuous about ancient philosophy. It is quite clear, for example, that Aristotle himself never meant his teleonomic causes to imply intelligent design in nature. His mentor Plato had already concluded, in the *Timaeus*, that the designer of the universe could not be an omnipotent god, but at most what is called a Demiurge, a lesser god who messes around with the universe with mixed results. Aristotle believed that the scope of god was even more limited, essentially to the role of prime mover of the universe, with no additional direct

interaction with his creation. In other words he was one of the first deists. In his *Physics*, where he discusses the four causes, Aristotle treats nature itself as a craftsman, but clearly one devoid of forethought and intelligence. A tiger develops into a tiger because it is in its nature to do so, and this nature is due to some physical essence given to it by its father (we would call it DNA) which starts the process out. Aristotle makes clear this rejection of god as a final cause when he says that causes are not external to the organism, as a designer would be, but internal to it (as modern developmental biology clearly shows). In other words, the final cause of a living being is not a plan, intention, or purpose, but is simply intrinsic in the developmental changes of that organism. Which means that Aristotle identified final causes with formal causes as far as living organisms are concerned. He rejected chance and randomness (as do modern biologists) but unlike Dembski did not invoke an intelligent designer in its place. We had to wait until Darwin for a further advance on Aristotle's conception of the final cause of living organisms and for modern molecular biology to achieve an understanding of their formal cause.

Irreducible complexity

There are two additional arguments proposed by ID theorists to demonstrate intelligent design in the universe: the concept of 'irreducible complexity' and the 'complexity-specification' criterion. Irreducible complexity is a term introduced in this context by molecular biologist Michael Behe in his book *Darwin's Black Box* (1996). The idea is that the difference between a natural phenomenon and an intelligent designer is that a designed object is planned in advance, with forethought. While an intelligent agent is not constrained by a step-by-step evolutionary process, the latter is the only way nature itself can proceed given that it has no planning capacity (this may be referred to as incremental complexity). Irreducible complexity then arises whenever all the parts of a structure have to be present and functional simultaneously for it to work, indicating that the structure was designed and could not possibly have been gradually built by natural selection.

Behe's example of an irreducibly complex object is a mousetrap. If you take away any of the minimal elements that make the trap work it will lose its function; on the other hand, there is no way to assemble a mousetrap gradually for a natural phenomenon, because it won't work until the last piece is assembled. Forethought, and therefore intelligent design, is necessary. Of course it is. After all, mousetraps are indeed human products; we know that they are intelligently designed. But what of biological structures? Behe claims that, while evolution can explain a lot of the visible diversity among living organisms, it is not enough when we come to the molecular level. The cell and several of its fundamental components and biochemical pathways are, according to Behe, irreducibly complex.

The problem with this statement is that it is at least partially contradicted by the available literature on comparative studies in microbiology and molecular biology, which Behe conveniently ignores (Miller 1996). For example, geneticists are continuously showing that biochemical pathways are partly redundant. Redundancy is a common feature of living organisms where different genes are involved

in the same or in partially overlapping functions. While this may seem a waste, mathematical models show that evolution by natural selection has to imply molecular redundancy, because when a new function is necessary it cannot be carried out by a gene that is already doing something else, without compromising the original function. On the other hand, if the gene gets duplicated by mutation, one copy is freed from immediate constraints and can slowly diverge in structure from the original, eventually taking over new functions. This process leads to the formation of gene 'families', groups of genes clearly originating from a single ancestral DNA sequence, that are now diversified and perform a variety of functions. An example of such a family is the globins, which vary from proteins allowing muscle contraction to those involved in the exchange of oxygen and carbon dioxide in the blood. As a result of redundancy, mutations can knock down individual components of biochemical pathways without compromising the overall function – contrary to the expectations of irreducible complexity. (Notice that creationists, never ones to miss a chance, have also tried to claim that redundancy is yet another evidence of intelligent design, because an engineer would produce backup systems to minimize catastrophic failures should the primary components stop functioning. While very clever, this argument once again ignores the biology: the majority of duplicated genes end up as pseudogenes, literally pieces of molecular junk that are eventually lost forever to any biological utility.)

To be sure, there are several cases in which biologists do not know enough about the fundamental constituents of the cell to be able to hypothesize or demonstrate their gradual evolution. But this is rather an argument from ignorance, not positive evidence of irreducible complexity. William Paley in 1831 advanced exactly the same argument to claim that it is impossible to explain the appearance of the eye by natural means. Yet today biologists know of several examples of intermediate forms of the eye, and there is evidence that this structure evolved several times independently during the history of life on earth (see Gehring and Ikeo 1999). The answer to the classical creationist question, "what good is half an eye?" is "much better than no eye at all"!

However, Behe does have a point concerning irreducible complexity. It is true that some structures simply cannot be explained by slow and cumulative processes of natural selection. From his mousetrap to Paley's watch to the Brooklyn Bridge, irreducible complexity is indeed the hallmark of intelligent design. The problem for ID theory is that there is no evidence so far of irreducible complexity in living organisms.

The complexity-specification criterion

William Dembski uses an approach similar to Behe to back up creationist claims, in that he also wants to demonstrate that intelligent design is necessary to explain the complexity of nature. His proposal, however, is both more general and more deeply flawed. In his book *The Design Inference* he claims that there are essentially three types of phenomena in nature: 'regular', random, and designed (which he assumes to be intelligent). A regular phenomenon would be a simple repetition explainable by the fundamental laws of physics, for example the rotation of the earth around the sun. Random phenomena are exemplified by the tossing of a coin. Design enters any

time that two criteria are satisfied: complexity and specification (Dembski 1998b).

First of all, leaving aside design for a moment, the remaining choices are not limited to regularity and randomness. Chaos and complexity theory have established the existence of self-organizing phenomena (see Shanks and Joplin 1999), situations in which order spontaneously appears as an emergent property of complex interactions among the parts of a system. This type of phenomenon, far from being a mere figment of mathematical imagination as Behe maintains, is real. Tornadoes, for example, are neither regular nor random but are the result of self-organizing processes.

But let us go back to complexity-specification and take a closer look at these two fundamental criteria, allegedly capable of establishing intelligent agency in nature. Following one of Dembski's examples, if SETI (Search for Extra Terrestrial Intelligence) researchers received a very short signal that could be interpreted as encoding the first three prime numbers, they would probably not rush to publish their findings. This is because even though such signal could be construed as due to some kind of intelligence, it is so short that its occurrence can just as easily be explained by chance. But, says Dembski, if the signal were long enough to encode all the prime numbers between 2 and 101, the SETI people would open the champagne and celebrate all night. Why? Because such a signal would be both too complex to be explained by chance and specifiable, meaning that it is not just a random sequence of numbers, but an intelligible message.

The specification criterion needs to be added because complexity by itself is a necessary but not sufficient condition for design. To see this, imagine that the SETI staff receive a long but random sequence of signals. That sequence would be very complex, meaning that it would take a lot of information to actually archive or repeat the sequence (you have to know where all the 0s and 1s are), but it would not be specifiable because the sequence would be meaningless.

Dembski is absolutely right that plenty of human activities, such as SETI, investigations into plagiarism, or encryption, depend on the ability to detect intelligent agency. Where he is wrong is in assuming only one kind of design: for him design equals intelligence. Although he admits that the intelligent designer *might* be an advanced extraterrestrial civilization, his preference is for a god, possibly of the Christian variety.

The problem is that natural selection, a natural process, also fulfills the complexity-specification criterion, thereby demonstrating that it is possible to have unintelligent design in nature. Living organisms are indeed complex. They are also specifiable, meaning that they are not random assemblages of organic compounds, but are clearly formed in a way that enhances their chances of surviving and reproducing in a changing and complex environment. What, then distinguishes living organisms from the Brooklyn Bridge? Both meet Dembski's complexity-specification criterion, but only the bridge is irreducibly complex. This has important implications for the consideration of design.

Some of Dembski's critics have asked why God would do such a sloppy job with creation that even a mere human engineer can easily see where the flaws are. For example, why is it that human beings have haemorrhoids, varicose veins, backaches and foot aches? If you assume that we were 'intelligently' designed, the answer must be that the designer was

rather incompetent – something that would hardly please a creationist. Instead, evolutionary theory has a single answer to all these questions: humans only began walking with an erect posture very recently, and natural selection has not yet fully adapted our body to the new conditions. Our closest primate relatives, chimps, gorillas and the like, are better adapted to their way of life, and therefore are less 'imperfect' than ourselves!

In response, Dembski has claimed that intelligent design doesn't necessarily mean optimal design. In this he is of course correct. As much as the Brooklyn Bridge is a marvel of engineering, it is not perfect, meaning that it had to be constructed within the constraints and limitations of the available materials and technology, and it still is subject to natural laws and decay. The bridge's vulnerability to high winds and earthquakes, and its inadequacy to bear a volume of traffic for which it was not built can be seen as similar to the back pain caused by our recent evolutionary history. However, the imperfection of living organisms, already pointed out by Darwin, does do away with the idea that they were created by an omnipotent and omnibenevolent creator, who surely would not be limited by laws of physics that he himself made up from scratch.

The four fundamental types of design and how to recognize them

Given the considerations above, I would like to propose a system that includes both Behe's and Dembski's suggestions, while at the same time showing why they are both wrong in concluding that we have evidence for intelligent design in the universe. Essentially, I think there are *four* possible kinds of design in nature which, together with Dembski's categories of 'regular' and random phenomena, and the addition of chaotic-self-organizing phenomena, exhaust all possibilities. Science recognizes regular, random, and self-organizing phenomena, as well as the first two types of design described below. The other two types of design are possible in principle, but I contend that there is neither empirical nor logical evidence that they actually occur.

The first kind of design is *non-intelligent-natural*, and it is exemplified by natural selection within earth's biosphere (and possibly elsewhere in the universe). The results of this kind of design, such as all living organisms on earth, are not irreducibly complex, meaning that they can be produced by incremental, continuous (though not necessarily gradual) changes over time. These objects can be clearly attributed to natural processes for two other reasons too: they are never optimal, in an engineering sense, and they are clearly the result of historical development. That is, they are full of junk, non-utilized or under-utilized parts, and they resemble similar objects existing now or in earlier eras, as we can tell from fossils. Some scientists and philosophers of science feel uncomfortable calling this 'design' because they associate the term with intelligence. But I see no reason to accept this limitation. If something is shaped over time – by whatever means – so that it fulfills a certain function, then it is designed and the question is simply of how such design happened to materialize. The teeth of a tiger are clearly designed to efficiently cut into the flesh of its prey and therefore to promote the survival and reproduction of tigers bearing such teeth.

The second type of design is *intelligent-natural*. These artifacts are usually irreducibly complex, such as a watch designed by a human. They are also not optimal, meaning that they clearly compromise between solutions to different problems and they are subject to the constraints of physical laws, available materials, designer expertise, and so on. Humans may not be the only ones to generate these objects, as the artifacts of any extraterrestrial civilization would fall into the same broad category.

The third kind of design, which is difficult, if not impossible, to distinguish from the second, is what I term *intelligent-supernatural-sloppy*. Objects created in this way are essentially indistinguishable from human or E.T. artifacts, except that they would be the result of a Demiurge, a god with limited powers. Alternatively, they could be due to an evil omnipotent god who just amuses himself with suboptimal products. The reason intelligent-supernatural-sloppy design is not distinguishable from some instances (but by no means all) of intelligent-natural design is Arthur C. Clark's famous third law: from the point of view of a technologically less advanced civilization, the technology of a very advanced civilization is essentially indistinguishable from magic (such as the monolith in his *2001: a Space Odyssey*). I would be very interested if someone could suggest a way around Clark's law.

Finally, we have *intelligent-supernatural-perfect* design, which is the result of the activity of an omnipotent and omnibenevolent god. These artifacts would be both irreducibly complex and optimal. They would not be constrained by either trade-offs or physical laws – after all, the designer created those laws him/herself. While this is the kind of god many Christian fundamentalists believe in (though some do away with the omnibenevolent part), it is quite clear from the existence of human evil as well as of natural catastrophes and diseases, that such a god does not exist. Dembski recognizes this difficulty and, in answering his critics (personal communication), admits that his intelligent design could even be due to a very advanced extraterrestrial civilization, and not to a supernatural entity at all.

Conclusions

In summary, it seems to me that the major arguments of Intelligent Design theorists are neither new nor compelling. (a) It is simply not true that science does not address all the Aristotelian causes, whenever design needs to be explained. (b) While irreducible complexity is indeed a valid criterion to

distinguish between intelligent and non-intelligent design, these are not the only two possibilities, and living organisms are not irreducibly complex. (c) The complexity-specification criterion is actually met by natural selection, and cannot therefore provide a way to distinguish intelligent from non-intelligent design. (d) If supernatural design exists at all (but where is the evidence or compelling logic?), it is certainly not of the kind that most religionists would likely subscribe to, and is indistinguishable from the technology of a very advanced civilization.

Therefore, Behe's, Dembski's, and other creationists' claims that science should be opened to supernatural explanations and that these should be allowed in academic as well as public school curricula is unfounded and based on a misunderstanding of both design in nature and of what the neo-Darwinian theory of evolution is all about.

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- Behe, M.J. (1996) *Darwin's Black Box. The biochemical challenge to evolution*. Free Press, New York.
- Darwin, C. (1859) *The Origin of Species by means of natural selection: or, the preservation of favoured races in the struggle for life*.
- Dembski, W.A. (1998) *The Design Inference*. CUP
- Gehring, W.J. and Ikeo, K. (1999) Pax 6, mastering eye morphogenesis and eye evolution. *Trends in Genetics* 15:371-377.
- Miller, K.R. (1996) The biochemical challenge to evolution, web page, biomed.brown.edu/faculty/M/Miller.
- Paley, W. (1831) *Natural Theology: or, Evidences of the existence and attributes of the Deity, collected from the appearances of nature*.
- Pigliucci, M. (2000) Chance, necessity, and the new holy war against science. A review of W.A. Dembski's 'The Design Inference'. *BioScience* 50 1, January, pp.79-81.
- Shanks, N. and Joplin, K.H. (1999) Redundant complexity: a critical analysis of intelligent design in biochemistry. *Philosophy of Science* 66.

