In Explaining Life's Complexity, Darwinists and Doubters Clash

By KENNETH CHANG

At the heart of the debate over intelligent design is this question: Can a scientific explanation of the history of life include the actions of an unseen higher being?

The proponents of intelligent design, a school of thought that some have argued should be taught alongside evolution in the nation's schools, say that the complexity and diversity of life go beyond what evolution can explain.

Biological marvels like the optical precision of an eye, the little spinning motors that propel bacteria, the cascade of proteins that cause blood to clot, they say, point to the hand of a higher being at work in the world.

In one often-cited argument, Michael J. Behe, a professor of biochemistry at Lehigh University and a leading design theorist, compares complex biological phenomena like blood clotting to a mousetrap: Take away any one piece — the spring, the baseboard, the metal piece that snags the mouse — and the mousetrap stops being able to catch mice.

Similarly, Dr. Behe argues, if any one of the more than 20 proteins involved in blood clotting is missing or deficient, — as happens in hemophilia, for instance, clots will not form properly.

Such all-or-none systems, Dr. Behe and other design proponents say, could not have arisen through the incremental changes that evolution says allowed life to progress to the big brains and sophisticated abilities of humans from primitive bacteria.

A DEBATE OVER DARWIN

Evolution or Design?

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Advocates of design point to complicated bacteria as evidence.

These complex systems are "always associated with design," Dr. Behe, the author of the 1996 book "Darwin's Black Box," said in an interview. "We find such systems in biology, and since we know of no other way that these things can be produced, Darwinian claims notwithstanding, then we are rational to conclude they were indeed designed."

It is an argument that appeals to many Americans of faith.

But mainstream scientists say that the claims of intelligent design run counter to a century of research supporting the explanatory and predictive power of Darwinian evolution, and that the design approach suffers from fundamental problems that place it outside the realm of science. For one thing, these scientists say, invoking a higher being as an explanation is unscientific.

"One of the rules of science is, no miracles allowed," said Douglas H. Erwin, a paleobiologist at the Smithsonian Institution. "That's a fundamental presumption of what we do."

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Darwinists and Doubters Clash Over Explaining The Complexity of Life

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That does not mean that scientists do not believe in God. Many do. But they see science as an effort to find out how the material world works, with nothing to say about why we are here or how we should live.

And in that quest, they say, there is no need to resort to otherworldly explanations. So much evidence has been provided by evolutionary studies that biologists are able to explain even the most complex natural phenomena and to fill in whatever blanks remain with solid theories.

This is possible, in large part, because evolution leaves tracks like the fossil remains of early animals or the chemical footprints in DNA that have been revealed by genetic research.

For example, while Dr. Behe and other leading design proponents see the blood clotting system as a product of design, mainstream scientists see it as a result of a coherent sequence of evolutionary events.

Early vertebrates like jawless fish had a simple clotting system, scientists believe, involving a few proteins that made blood stick together, said Russell F. Doolittle, a professor of molecular biology at the University of California, San Diego.

Scientists hypothesize that what happened is that at some point, a mistake during the copying of DNA resulted in the duplication of a gene, increasing the amount of protein produced by cells.

Most often, such a change would be useless. But in this case the extra protein helped blood clot, and animals with the extra protein were more likely to survive and reproduce. Over time, as higher order species evolved, other proteins joined the clotting system. For instance, several proteins involved in the clotting of blood appear to have started as digestive enzymes.

By studying the evolutionary tree and the genetics and biochemistry of living organisms, Dr. Doolittle said, scientists have largely been able to determine the order in which different proteins became involved in helping blood clot, eventually producing the sophisticated clotting mechanisms of humans and other higher animals. The sequencing of animal genomes has provided evidence to support this view.

For example, scientists had predicted that more primitive animals such as fish would be missing certain blood clotting proteins. In fact, the recent sequencing of the was actually designed?

"If we've defined science such that it cannot get to the true answer, we've got a pretty lame definition of science," said Douglas D. Axe, a molecular biologist and the director of research at the Biologic Institute, a new research center in Seattle that looks at the organization of biological systems, including intelligent design issues. Dr. Axe said he had received "significant" financing from the Discovery Institute, but he declined to give any other details about the institute or its financing.

Stephen C. Meyer, director of the Center for Science and Culture at the Discovery Institute, compares the design approach to the work of archaeologists investigating an ancient civilization.

"Imagine you're an archaeologist and you're looking at an inscription, and you say, 'Well, sorry, that looks like it's intelligent but we can't invoke an intelligent cause because, as a matter of method, we have to limit ourselves to materialistic processes,' " Dr. Meyer said. "That would be nuts."

He added, "Call it miracle, call it some other pejorative term, but the fact remains that the materialistic view is a truncated view of reality."

William Paley, an Anglican priest, made a similar argument in the early 19th century. Someone who finds a rock can easily imagine how wind and rain shaped it, he reasoned. But someone who finds a pocket watch lying on the ground instantly knows that it was not formed by natural processes.

With living organisms so much more complicated than watches, he wrote, "The marks of design are too strong to be got over."

Mainstream scientists say that the scientific method is indeed restricted to the material world, because it is trying to find out how it works. Simply saying, "it must have been designed," they say, is simply a way of not tackling the hardest problems.

They say they have no disagreement with studying phenomena for which there are, as yet, no explanations.

It is the presumption of a designer that mainstream scientists dispute, because there are no artifacts or biological signs — no scientific evidence, in other words — to suggest a designer's presence.

Darwin's theory, in contrast, has over the last century yielded so many solid findings that no mainstream biologist today doubts its basic tenets, though they may argue about particulars.

fish genome has shown just this.

"The evidence is rock solid," Dr. Doolittle said.

Intelligent design proponents have advanced their views in books for popular audiences and in a few scientific articles. Some have developed mathematical formulas intended to tell whether something was designed or formed by natural processes.

Mainstream scientists say that intelligent design represents a more sophisticated — and thus more seductive — attack on evolution. Unlike creationists, design proponents accept many of the conclusions of modern science. They agree with cosmologists that the age of the universe is 13.6 billion years, not fewer than 10,000 years, as a literal reading of the Bible would suggest. They accept that mutation and natural selection, the central mechanisms of evolution, have acted on the natural world in small ways, for example, leading to the decay of eyes in certain salamanders that live underground.

Some intelligent design advocates even accept common descent, the notion that all species came from a common ancestor, a central tenet of evolution.

Although a vast majority of scientists accept evolution, the Discovery Institute, a research group in Seattle that has emerged as a clearinghouse for the intelligent design movement, says that 404 scientists, including 70 biologists, have signed a petition saying they are skeptical of Darwinism.

Nonetheless, many scientists regard intelligent design as little more than creationism dressed up in pseudoscientific clothing. Despite its use of scientific language and the fact that some design advocates are scientists, they say, the design approach has so far offered only philosophical objections to evolution, not any positive evidence for the intervention of a designer.

Truncated View of Reality'

If Dr. Behe's mousetrap is one of the most familiar arguments for design, another is the idea that intelligence is obvious in what it creates. Read a novel by Hemingway, gaze at the pyramids, and a designer's hand is manifest, design proponents say.

But mainstream scientists, design proponents say, are unwilling to look beyond the material world when it comes to explaining things like the construction of an eye or the spinning motors that propel bacteria. What is wrong, they ask, with entertaining the idea that what looks like it was designed

A Debate Over Darwin

This is the second in a series of articles examining the debate over the teaching of evolution. The first article looked at how scholars at the Discovery Institute are mounting a politically savvy challenge to evolution. The next article will look at scientists' religious beliefs. Coverage of the Discovery Institute and the arguments over intelligent design: nytimes.com /evolution.

The theory has unlocked many of the mysteries of the natural world. For example, by studying the skeletons of whales, evolutionary scientists have been able to trace the history of their descent from small-hoofed land mammals. They made predictions about what the earliest water-dwelling whales might look like. And, in 1994, paleontologists reported discovering two such species, with many of the anatomical features that scientists had predicted.

Darwin's Finches

Nowhere has evolution been more powerful than in its prediction that there must be a means to pass on information from one generation to another. Darwin did not know the biological mechanism of inheritance, but the theory of evolution required one.

The discovery of DNA, the sequencing of the human genome, the pinpointing of genetic diseases and the discovery that a continuum of life from a single cell to a human brain can be detected in DNA are all a result of evolutionary theory.

Darwin may have been the classic scientific observer. He observed that individuals in a given species varied considerably, variations now known to be caused by mutations in their genetic code. He also realized that constraints of food and habitat sharply limited population growth; not every individual could survive and reproduce.

This competition, he hypothesized, meant that those individuals with helpful traits multiplied, passing on those traits to their numerous offspring. Negative or useless traits did not help individuals reproduce, and those traits faded away, a process that Darwin called natural selection.

The finches that Darwin observed in the Galápagos Islands provide the most famous example of this process. The species of finch that originally found its way to the Galápagos from South America had a beak shaped in a way that was ideal for eating seeds. But once arrived on the islands, that finch eventually diversified into 13 species. The various Galápagos finches have differently shaped beaks, each fine-tuned to take advantage of a particular food, like fruit, grubs, buds or seeds.

Such small adaptations can arise within a few generations. Darwin surmised that over millions of years, these small changes would accumulate, giving rise to the myriad of species seen today.

The number of organisms that, in those long periods, ended up being preserved as fossils is infinitesimal. As a result, the evolutionary record — the fossils of long-extinct organisms found preserved in rock — is necessarily incomplete, and some species appear to burst out of nowhere.

Some supporters of intelligent design have argued that such gaps undermine the evidence for evolution.

For instance, during the Cambrian explosion a half a billion years ago, life diversified to shapes with limbs and shells from jellyfish-like blobs, over a geologically brief span of 30 million years.

Dr. Meyer sees design at work in these large leaps, which signified the appearance of most modern forms of life. He argues that

genetic mutations do not have the power to create new shapes of animals.

But molecular biologists have found genes that control the function of other genes, switching them on and off. Small mutations in these controller genes could produce new species. In addition, new fossils are being found and scientists now know that many changes occurred in the era before the Cambrian — a period that may have lasted 100 million years — providing more time for change.

The Cambrian explosion, said David J. Bottjer, a professor of earth sciences at the University of Southern California and president of the Paleontological Society, is "a wonderful mystery in that we don't know everything yet."

"I think it will be just a matter of time before smart people will be able to figure a lot more of this out," Dr. Bottjer said. "Like any good scientific problem."

Purposeful Patterns

Intelligent design proponents have been stung by claims that, in contrast to mainstream scientists, they do not form their own theories or conduct original research. They say they are doing the mathematical work and biology experiments needed to put their ideas on firm scientific ground.

For example, William A. Dembski, a mathematician who drew attention when he headed a short-lived intelligent design institute at Baylor University has worked on mathematical algorithms that purport to tell the difference between objects that were designed and those that occurred naturally.

Dr. Dembski says designed objects, like Mount Rushmore, show complex, purposeful patterns that evince the existence of intelligence. Mathematical calculations like those he has developed, he argues, could detect those patterns, for example, distinguishing Mount Rushmore from Mount St. Helens.

But other mathematicians have said that Dr. Dembski's calculations do not work, and that they cannot be applied in the real world.

Other studies that intelligent design theorists cite in support of their views have been done by Dr. Axe of the Biologic Institute.

In one such study, Dr. Axe looked at a protein, called penicillinase, that gives bacteria the ability to survive treatment with the antibiotic penicillin. Dr. Meyer, of the Discovery Institute, has referred to Dr. Axe's work in arguing that working proteins are so rare that evolution cannot by chance discover them.

What was the probability, Dr. Axe asked in his study, of a protein with this ability existing in the universe of all possible proteins?

Penicillinase is made up of a strand of chemicals called amino acids folded into a shape that binds to penicillin and thus disables it. Whether the protein folds up in the right way determines whether it works or not.

He calculated that of the plausible amino acid sequences, only one in 100,000 trillion trillion trillion trillion trillion — a number written as 1 followed by 77 zeroes — would provide resistance to penicillin.

In other words, the probability was essentially zero.

Dr. Axe's research appeared last year in The Journal of Molecular Biology, a peer-reviewed scientific publication.

Dr. Kenneth R. Miller, a professor of biology at Brown University and a frequent sparring partner of design proponents, said that in his study, Dr. Axe did not look at penicillinase "the way evolution looks at the protein."

Natural selection, he said, is not random. A small number of mutations, sometimes just one, can change the function of a protein, allowing it to diverge along new evolutionary paths and eventually form a new shape or fold.

One Shot or a Continual Act

Intelligent design proponents are careful to say that they cannot identify the designer at work in the world, although most readily concede that God is the most likely possibility. And they offer varied opinions on when and how often a designer intervened.

Dr. Behe, for example, said he could imagine that, like an elaborate billiards shot, the design was set up when the Big Bang occurred 13.6 billion years ago. "It could have all been programmed into the universe as far as I'm concerned," he said.

But it was also possible, Dr. Behe added, that a designer acted continually throughout the history of life.

Mainstream scientists say this fuzziness about when and how design supposedly occurred makes the claims impossible to disprove. It is unreasonable, they say, for design advocates to demand that every detail of evolution be filled in.

Dr. Behe, however, said he might find it compelling if scientists were to observe evolutionary leaps in the laboratory. He pointed to an experiment by Richard E. Lenski, a professor of microbial ecology at Michigan State University, who has been observing the evolution of E. coli bacteria for more than 15 years. "If anything cool came out of that," Dr. Behe said, "that would be one way to convince me."

Dr. Behe said that if he was correct, then the E. coli in Dr. Lenski's lab would evolve in small ways but never change in such a way that the bacteria would develop entirely new abilities.

In fact, that is what appears to have happened. Dr. Lenski said his experiment was not intended to explore this aspect of evolution, but nonetheless, "We have recently discovered a pretty dramatic exception, one where a new and surprising function has evolved," he said.

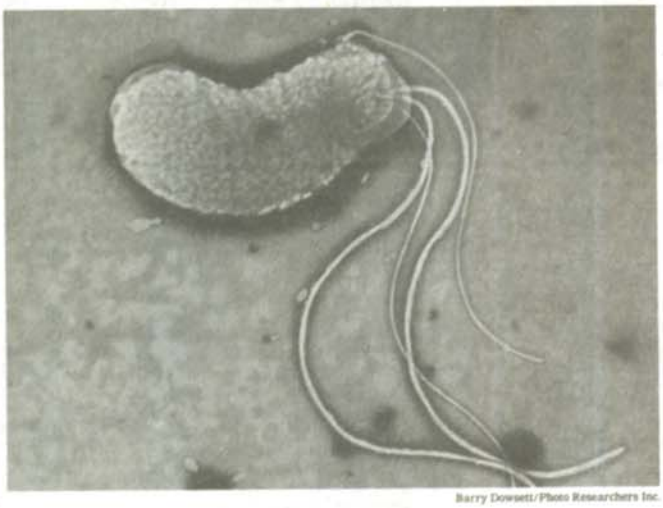
Dr. Lenski declined to give any details until the research is published. But, he said, "If anyone is resting his or her faith in God on the outcome that our experiment will not produce some major biological innovation, then I humbly suggest they should rethink the distinction between science and religion."

What's Wrong With Evolution?

The proponents of intelligent design do not claim to have a coherent scientific theory about how life actually changed over time on earth. They offer arguments about what evolution could not do, and then conclude that a designer is the best hypothesis.

Irreducible Complexity

THE CRITICISM The parts of a mousetrap do not catch mice unless they are put together. Much of the biological machinery in cells, like the motor-driven tails, or flagella, at the back of the bacterium Helicobacter pylori (below) and other bacteria, is similarly complex. Taking away one piece breaks the machine. Because evolution makes slow, incremental improvements, it would not have produced all these separate pieces that would have had no use until they were assembled into the final, working mechanism.

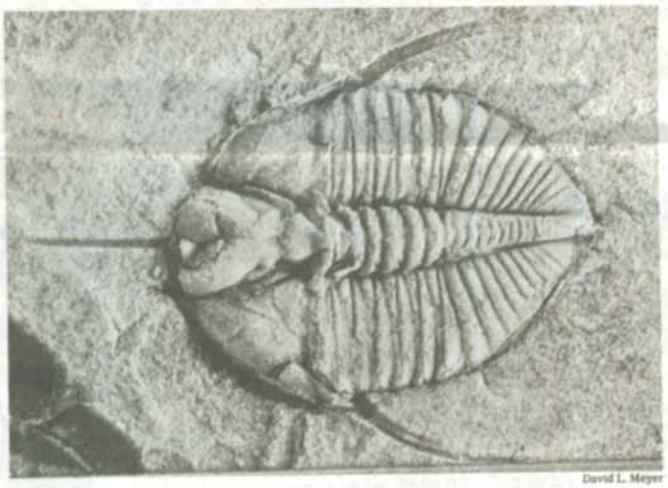


Barry Dowsett/Photo Researchers Inc.

THE RESPONSE Evolutionary biologists agree that evolution would never have produced the biological structures all at once. Rather, what likely happened is that evolution borrowed existing structures for new purposes, like taking the spring of a clothes pin for use in a mousetrap. For example, there exists a microsyringe inside some bacteria that consists of about 10 of the proteins found in the flagellum.

The Pace of Change

THE CRITICISM Since natural selection deals with small changes in DNA, which in turn alter proteins the cell produces, it cannot create fundamentally new body shapes and new forms of life, as occurred during the Cambrian explosion a half a billion years ago, or during the rise of mammals after dinosaurs went extinct about 65 million years ago. The trilobite fossil, below, lived half a billion years ago in what is now Wales. The crablike trilobite, which lived on the ocean floor, is one of the major groups of advanced animals that appeared suddenly in the Cambrian.

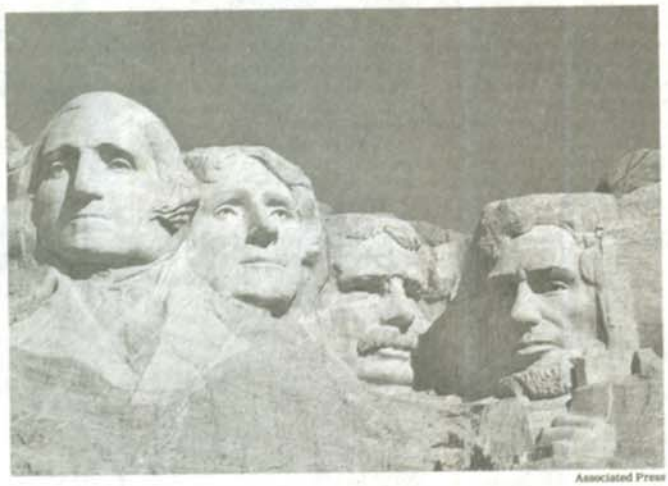


David L. Meyer

THE RESPONSE Some very powerful genes control what other genes do. These control genes switch on and off early in the life of embryos and mutations in these genes can make major changes, giving rise to new animal species. More and more fossils from the era leading up to the Cambrian are being discovered and studied, and other evidence shows that Earth's environment might have been undergoing major changes, like a rise in oxygen levels, that for the first time made more complex life possible. Further, the changes leading up to the Cambrian may have taken up to 100 million years.

Information Theory

THE CRITICISM Look at Mount Rushmore and you think that it must have been carved. Look at a cell and you should think it must have been designed. Scientists who won't consider this are doing the same thing as looking for erosion and tectonic explanations for Mount Rushmore.



Associated Press

THE RESPONSE Mount Rushmore is an exception. It is the only place among all of earth's mountains where the faces of four presidents appear. A cell that had the faces of four presidents on it, while other cells did not, would no doubt prompt scientists to look for a designer. But the point of science is to discover how natural processes work. Moreover, intelligent design theorists have failed to show calculations that can convincingly differentiate a designed object from a naturally occurring one.