IN DEFENSE OF EVOLUTION

Dr. Kenneth Miller is as familiar as anyone in the scientific community with the intelligent-design movement and its attempts to undermine the theory of evolution. A professor of biology at Brown University and coauthor (with Joe Levine) of the standard high-school textbook *Biology*, Miller testified at the Dover trial as an expert witness for the plaintiffs, the Dover parents who brought suit against their town's school board. Here, Miller, who stresses that he is also a man of faith, talks about why evolution matters, what flaws he sees in the intelligent-design argument, and why the Dover decision hardly means the end of the controversy.

FAITH AND REASON

Q: Why is evolution so controversial?

Kenneth Miller: I think one of the reasons why evolution is such a contentious issue, quite frankly, is the same reason you can go into a bar and start a fight by saying something about somebody's mother. Evolution concerns who we are and how we got here. And to an awful lot of people, the story of evolution, the story of our continuity with every other living thing on this planet, that's not a story they want to hear.

They favor an entirely different story, in which our ancestry is separate, our biology distinct, and the whole notion of our lineage traceable not to other organisms, but to some sort of divine power and divine presence. But it's absolutely true that our ancestry traces itself along the same thread as that of every other living organism. That, for many people, is the unwelcome message, and I think that's why evolution has been, is, and will remain such a controversial idea for many years to come.

Q: Where do you come from personally on this topic?

Miller: I think that faith and reason are both gifts from God. And if God is real, then faith and reason should complement each other rather than be in conflict. Science is the child of reason. Reason has given us the ability to establish the scientific method to investigate the world around us, and to show that the world and the universe in which we live are far vaster and far more complex, and I think far more wonderful, than anyone could have imagined 1,000 or 2,000 years ago.

Does that mean that scientific reason, by taking some of the mystery out of nature, has taken away faith? I don't think so. I think by revealing a world that is infinitely more complex and infinitely more varied and creative than we had ever believed before, in a way it deepens our faith and our appreciation for the author of that nature, the author of that physical universe. And to people of faith, that author is God.

Now, I'm a scientist and I have faith in God. But that doesn't make faith a

scientific proposition. Faith and reason are both necessary to the religious person for a proper understanding of the world in which we live, and there is ultimately no necessary contradiction between reason and faith.

"Whether God exists or not is not a scientific question."

Q: What's wrong with bringing God into the picture as an explanation?

Miller: Supernatural causes for natural phenomena are always possible. What's different, however, in the scientific view is the acknowledgement that if supernatural causes are there, they are above our capacity to analyze and interpret.

Saying that something has a supernatural cause is always possible, but saying that the supernatural can be investigated by science, which always has to work with natural tools and mechanisms, is simply incorrect. So by placing the supernatural as a cause in science, you effectively have what you might call a science-stopper. If you attribute an event to the supernatural, you can by definition investigate it no further.

If you close off investigation, you don't look for natural causes. If we had done that 100 years ago in biology, think of what we wouldn't have discovered because we would have said, "Well, the designer did it. End of story. Let's go do something else." It would have been a terrible day for science.

Q: Does science have limits to what it can tell us?

Miller: If science is competent at anything, it's in investigating the natural and material world around us. What science isn't very good at is answering questions that also matter to us in a big way, such as the meaning, value, and purpose of things. Science is silent on those issues. There are a whole host of philosophical and moral questions that are important to us as human beings for which we have to make up our minds using a method outside of science.

Q: Can science prove or disprove the existence of a creator, of God?

Miller: Whether God exists or not is not a scientific question.

EVOLUTION IN A NUTSHELL

Q: What is evolution exactly?

Miller: Well, everyone knows that evolution, in a sense, is change over time. But what few people understand is how straightforward the nature of this change is. It's important to understand, first of all, that individuals don't evolve. I'm not evolving into something else, and my dog isn't evolving into something else. I'm going to remain a human being, he's going to remain a dog. That's the way things are going to work. What changes over time are populations of individuals, for very straightforward reasons.

Number one, every species shows variation among individual members of that population. Number two, individuals in a population show what biologists call differential reproductive success. Some individuals leave more offspring than others. Some people have no children; some people have big families. Finally, one of the factors that influences differential reproductive success is how well-suited individuals are to the present environment in which they find themselves—how good they are at obtaining food, defending themselves against their enemies, resisting disease, and finding and meeting a member of the opposite sex and raising offspring. All these things matter.

What Darwin appreciated is that nature herself selects from variants in the population for those that are best able to succeed in this race for differential reproductive success. Over time, and given a steady input of new variation into the population, that can change the average characteristics of a species, and it can split one species into two. Those species, those two groups, can then go

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on changing in different directions. That's what leads to the formation of yet more new species. Nature herself automatically selects for favorable variations, and this is the driving engine of evolutionary change. That, in a nutshell, is what evolution is.

Q: Why is evolution important? How does it affect people in their everyday lives?

Miller: We should care about evolution because it concerns who we are, where we came from, why we are the way we are, and maybe even where we're going. The whole notion that biology is wrapped up in the idea of evolution is extremely important to experimental biologists, because otherwise, to paraphrase another scientist, biology is nothing but stamp collecting. It's an exercise in which you say, "Here's a worm and here's how worms work, and here's this type of cell and here's how this cell works. And here is a plant, and here is how plants work."

If they're all completely unrelated, then biology is not a unified science. But we know from a half century of biochemistry and molecular biology that all these living organisms, no matter how diverse they are, share certain common features, and those common features include the way in which they store and transmit and evolve information, and these common features tie all of life together. They help us to understand our own bodies and our own genomes in the light of the bodies and genomes of other organisms. So what evolution really does is to make sense of biology, and what biology does is to help us make sense of ourselves, our own lives, and the planet on which we live.

INTELLIGENT DESIGN

Q: What is intelligent design?

Miller: My understanding of intelligent design is that it is the argument that the structures, features, organs, and biochemical pathways that we find in living cells are so complex that they could not have been produced by natural processes such as evolution and that they would require the intervention of an intelligent designer outside of nature to bring them into existence.

> "I often hear people say that they're not descended from monkeys. Well, they're right."

Q: [Phillip Johnson, the father of the intelligent-design movement] likens this process to flipping a coin: if it lands and it's not heads, it must be tails. He says that evolution can't account for the diversity of life, therefore it's got to be something else. The only other thing it could be is an intelligent designer.

Miller: It's a negative argument in the sense that their proof of the existence of a designer is the alleged inadequacy of evolution to account for these complex features. What's wrong with that explanation is that it's a contrived dualism. It's an argument that says, "Either evolution can explain everything, or we can invoke an intelligent designer." What it amounts to, for example, is the claim that the moon is made of green cheese, and someone else says, "No, I think it's made of granite." Then we go to the moon, we bring back samples of rock, and we say, "You know what? They're not made out of granite." Does that mean we now have definite proof for the green-cheese explanation? Of course not.

The whole idea of intelligent design is a confession on the part of its advocates that they actually can't get any evidence at all in favor of a designer. So what they resort to is the notion that it's either evolution or it's design. And if evolution right now, today, cannot explain everything, that lack of a complete explanation amounts to evidence for the other side.

Well, it doesn't. What it really points out would be the current inadequacy of

science to explain everything. And science, as any realist knows, is necessarily incomplete. On the day when we have a complete scientific explanation for everything in nature, it'll be time to close every science department of every research institution in the world, because all questions will have been figured out. I don't expect to see that day. But that doesn't mean that the incompleteness of science is an argument for a supernatural alternative like intelligent design.

Q: What's the harm in introducing intelligent design into a science classroom?

Miller: One could very well say that a God, a designer, a supernatural force was responsible, let's say, for an event that happened in your life or my life, or was responsible for our ability to meet the challenges of life. I don't see anything wrong with that, and it might be a valid explanation in many cases. But pretending that that explanation is a scientific one is a violation of everything we mean and understand by science.

Bringing that idea into the school classroom seems innocuous enough, because all you would do is tell students, well, there's either the evolution explanation or the design explanation. But consider the implications of that. If we present the idea of intelligent design as an alternative to evolution, students, who are very bright, are going to understand something right away, and that is, basically, you've got your atheist theory over here and you have your Bible or God-friendly theory over there.

What it does is to falsely cast evolution in light of an inherently atheistic idea. This is the goal of the intelligent-design movement, indirectly to tell students that either you turn your back on the faith that you've been brought up with in order to embrace the scientific mainstream, or to be true to your faith you have to reject modern science. That's a false choice. It does disservice to religion, and it does disservice to science, and I think it is a terrible way to proceed with scientific education.

COMMON ANCESTRY

Q: People often say, "I'm not descended from a monkey." What's the true relationship there?

Miller: Well, I often hear people say that they're not descended from monkeys, and they would defy me or anybody else to show that they are. Well, they're right, they're not descended from monkeys. They're not descended from chimps or monkeys or gorillas or any other living organism.

The essential idea of common ancestry is that ultimately all living things on this planet share common ancestors if we go far enough back into the past. So, for example, to take the case that people talk about all the time, we share a common ancestor with all primate species. This means that we're related, by having a single ancestor somewhere in the past, to monkeys, gorillas, chimpanzees, and so forth.

But the idea of common ancestry goes way deeper than simply saying we're related to monkeys. We're in fact related to all mammals. You go farther back, we are related to all vertebrates. And, ultimately, we are related, if you go far enough back, to every living thing on this planet. The almost universal nature of the genetic code, the fact that all life depends upon DNA, all of these things are evidence of this commonality of ancestry, if we go far enough back in time.

Q: One of the lines of evidence that you pointed out at the Dover trial is the organization of our own chromosomes. How is that evidence for common ancestry?

Miller: We've known for a long time that we humans share common ancestry with the other great apes—gorillas, orangs, chimps, and bonobos. But there's an interesting problem here. We humans have 46 chromosomes; all the other

great apes have 48. In a sense, we're missing a pair of chromosomes, two chromosomes. How did that happen?

Well, is it possible that in the line that led to us, a pair of chromosomes was simply lost, dropping us from 24 pairs to 23? Well, the answer to that is no. The loss of both members of a pair would actually be fatal in any primate. There is only one possibility, and that is that two chromosomes that were separate became fused to form a single chromosome. If that happened, it would drop us from 24 pairs to 23, and it would explain the data.

> "The closer we look at our own DNA, the more powerful the evidence becomes for our common ancestry with other species."

Here's the interesting point, and this is why evolution is a science. That possibility is testable. If we indeed were formed that way, then somewhere in our genome there has to be a chromosome that was formed by the fusion of two other chromosomes. Now, how would we find that? It's easier than you might think.

Every chromosome has a special DNA sequence at both ends called the telomere sequence. Near the middle it has another special sequence called the centromere. If one of our chromosomes was formed by the fusion of two ancestral chromosomes, what we should be able to see is that we possess a chromosome in which telomere DNA is found in the center where it actually doesn't belong, and that the chromosome has two centromeres. So all we have to do is to look at our own genome, look at our own DNA, and see, do we have a chromosome that fits these features?

We do. It's human chromosome number 2, and the evidence is unmistakable. We have two centromeres, we have telomere DNA near the center, and the genes even line up corresponding to primate chromosome numbers 12 and 13.

Is there any way that intelligent design or special creation could explain why we have a chromosome like this? The only way that I can think of is if you're willing to say that the intelligent designer rigged chromosome number 2 to fool us into thinking that we had evolved. The closer we look at our own DNA, the more detailed a glimpse we get of our own genome, the more powerful the evidence becomes for our common ancestry with other species.

THE PROCESS OF EVOLUTION

Q: What do gaps in the fossil record represent vis a vis evolution? Why are such gaps not a problem for evolutionary theory?

Miller: It's important to appreciate that all historical records are necessarily incomplete. We don't have complete data for any historical process. I've tried to trace my own ancestry, and after about four generations, we lose bits and pieces of it. I don't think that means I don't have any ancestry. I think it means that some of the evidence is missing.

The same is true for the study of history. We know, for example, when and where the Battle of Gettysburg took place in the Civil War. We know the opposing generals on both sides. But we don't know exactly what every soldier, by name, was doing at every moment during the Battle of Gettysburg. That doesn't mean Gettysburg didn't take place. It doesn't mean that the Union forces didn't win. It simply means we have more to learn about that battle.

The same is true for the fossil record. We have an enormous amount of information as to what life was like in the past. That information tells us that life changed, that it changed in a particular pattern, and that the history of change is complete, with one example after another of descent with

modification, an ancestor-descendant relationship between organisms. And in a few lucky cases, we can trace almost step by step the evolution of key organisms in the history of life. [See Fossil Evidence.]

Q: What about the claim that no one's ever seen a new species form?

Miller: Right now new species are literally in the process of forming in the state of California. For years David Wake of the University of California at Berkeley has studied different species of salamander that surround the Central Valley in California. When you look at the range of these species, what you discover is that the local variations at the very ends of the range are now so different from each other that if you capture them both and you put them side by side in a cage, any biologist would agree that they are distinct and separate species. Nonetheless, they have been produced in recent times simply by the spreading of salamanders over a geographic range.

Many opponents of evolution will sort of retreat and say, "Well, okay, but those species are really similar to each other. Show us a species that is dramatically different." But that initial splitting, that's the phenomenon that actually drives evolution. You shouldn't expect to see a cat suddenly give birth to a dog or something along those lines. At the moment when one species splits into two, you should see two distinctly different species that still show the similarities that previously united them within a single classification. We see this happen all the time.

The people who say that macroevolution, by which they mean really big evolution, has never been observed, inevitably cannot give you a strict and rigorous definition of what macroevolution is. They'll simply say it's the formation of new categories or evolutionary novelties. They're loath to put specifics on that idea, to tell you what percentage of the genes or how many base pairs of DNA have to change, because I think they know very well that once they make specific what they mean by macroevolution, some darn biologist is going to go out into the field or into the lab and follow exactly that rate of change and show that macroevolution really does occur.

Q: Another criticism often made is that all this couldn't just have happened by random chance.

Miller: One of the great mischaracterizations of evolution is that it's driven by random chance, that things just happen. People like to say, "I don't like to believe that I'm just an accident." Well, you're not. What evolution says is that the variation that crops up in a species is indeed unpredictable. We can't be sure what will happen next. But that doesn't mean it's random.

To me, the word "random" means anything can happen. But the reality is that evolutionary change is restricted. It's restricted by the laws of physics and chemistry. It's restricted by the nature of molecular biology. It's restricted by the constraints of developmental biology during development. Most importantly, evolutionary change is governed by natural selection, and natural selection is not a random process at all. Natural selection selects for successful phenotypes, for successful combinations of characteristics that actually work, and that's not random at all.

> "Any theory that can stand up to 150 years of continuous testing is a pretty darn good theory."

Q: I have heard critics say that mutation doesn't create information, it destroys it.

Miller: That notion is at variance with the facts. Four or five million years ago, for example, the Antarctic Ocean, which was warm at the time, froze over as a result of a kind of climate change on this planet. Well, to this day, there are fish that swim in the oceans of Antarctica. One of the interesting things about

those fish is that even though the saltwater is actually below the freezing point—our own blood would freeze solid in that cold water—these fish don't. The reason they don't freeze solid is because their blood contains an antifreeze protein, sort of the biological equivalent of ethylene glycol in antifreeze.

Well, how did they get it? It turns out that the antifreeze protein that is found in the blood of Antarctic fishes was the result of a digestive enzyme that was mutated, retargeted to the bloodstream, and then mutated again and again to enhance its antifreeze properties. All of these changes were the result of mutation.

Now, that Antarctic fish has a kind of biological information that its ancestors didn't have. It has the ability to make a completely new protein that enables it to survive in very cold waters by preventing its blood from freezing. That's novel information, and it's information that was produced by the process of mutation.

THE TEST OF TIME

Q: How do you answer the charge that evolution has never been tested?

Miller: Evolution is tested every day in the laboratory, and it's tested every day in the field. I can't think of a single scientific theory that has been more controversial than evolution, and when theories are controversial, people devise tests to see if they're right. Evolution has been tested continuously for almost 150 years and not a single observation, not a single experimental result, has ever emerged in 150 years that contradicts the general outlines of the theory of evolution.

Any theory that can stand up to 150 years of continuous testing is a pretty darn good theory. We use evolution to develop drugs. We use evolution to develop vaccines. We use evolution to manage wildlife. We use evolution to interpret our own genome. Every one of these uses of evolution is a test, because if the use turns out to be inadequate, we would then go back and question the very idea of evolution itself. But evolution has turned out to be such a powerful, productive, and hardworking theory that it's survived that test of time.

Q: So when they talk about teaching the strengths and weaknesses of evolution, what are the weaknesses?

Miller: Evolution has great strengths in that it unifies biology and gives us a coherent explanation. Its only weakness is that it hasn't explained everything yet.

For example, we have great doubts as to what the evolutionary purpose of sex is. Now, sex is everywhere, not just in us, but also in trees and flowers and microorganisms. It's very difficult to understand exactly how sex first evolved, why there are only two sexes, and why things work the way they do. Evolution hasn't completely explained that yet.

We also don't understand where the first living cell came from or how prebiological evolution took place. But most of us in science don't regard the inability of science to explain everything as weakness. We regard that as the unexplored territory that's going to keep most of us busy for the rest of our careers.

A COMPLEXITY THEORY

Q: What is irreducible complexity?

Miller: Irreducible complexity is a term that was first used on behalf of the intelligent-design movement by Michael Behe, a biochemist at Lehigh University. What Behe observed is that living cells are filled with complex biochemical systems and that these systems have multiple parts. Dr. Behe has

argued that systems like that are irreducibly complex. He says that all these parts are required for the system to function, and if you take even one away, it stops working. That means its complexity is irreducible. In other words, you need all the parts.

If that were true, it would indeed be a powerful argument against evolution, because what evolution can only do is to produce these complex systems by putting together a few parts at a time. And if there is no function until all the parts are assembled, evolution's in trouble. That's the argument from irreducible complexity.

In reality, these supposedly irreducibly complex systems are cobbled together by evolution from individual systems that have functions of their own.

Q: Dr. Behe has pointed to the bacterial flagellum as a good example of irreducible complexity. Can you explain why you think it isn't?

Miller: Well, the bacterial flagellum is this marvelous little machine that consists of about 30 or 35 individual proteins, and the argument is if you take even one part away, the flagellum doesn't work anymore. So evolution couldn't possibly have produced it, because evolution is blind. Evolution couldn't say, "Well, we've got 20 parts for the flagellum. Next year we'll evolve the 21st part, and then 22 and then 23, and maybe in 10 million years, we'll get the 30th part, and everything will start working." Evolution doesn't work that way.

When you look at the experiments that biologists and biochemists have done on the bacterial flagellum you discover that little clusters of proteins in the flagellum, in other bacteria that don't have flagella, are busy doing other functions.

> "Not a single scientific paper has been published that supports the notion of irreducible complexity."

For example, about 10 of those proteins in the base of the flagellum form a little machine called the Type 3 Secretory system. It's kind of like a molecular syringe that bacteria use to pump poisons into cells they're attacking. This system, this little syringe, is found in bacteria that don't have flagella.

The very existence of this little subset of parts, just 10 parts, with a perfectly good function of their own, shows that the idea of irreducible complexity is wrong. And when you take the flagellum apart, you discover that virtually every protein in there is related to another family of proteins that performs a different function somewhere else in the cell.

So the prediction of evolution, which is that these complex systems are actually slapped together by scavenging pieces of different systems, turns out to be true. And the prediction made by irreducible complexity that none of these proteins would have any function until they're all put together and all work, that prediction turns out to be wrong.

In the 10 years since Professor Behe first advanced the idea of irreducible complexity, not a single scientific paper, even from his own lab, has been published that supports the notion of irreducible complexity for any of the systems that he described, and that's why the scientific community simply has not embraced this idea.

Q: In the trial, both Michael Behe and Scott Minnich [a microbiologist at the University of Idaho who is a proponent of intelligent design] claim that intelligent design is testable, but then they say that they don't conduct those tests. What does that indicate to you?

Miller: One of the biggest problems with intelligent design is it's not empirical. It doesn't feature any testing. The advocates of intelligent design are not

experimentalists. They're not going out in the lab and doing experiments to see this. Both Michael Behe and Scott Minnich have said that one could disprove intelligent design by taking a bacterium in the laboratory that didn't have a flagellum and evolving a flagellum in it.

Well, that's a ridiculous proposal for an experiment for two very simple reasons. First of all, the experiment would probably take 10 to 100 million years to carry out, and it's kind of hard to get funding for that long. The second reason is that what they propose is to retrace the path of an existing sequence of evolutionary changes. Evolution doesn't repeat itself like that. So even if we were absolutely certain the flagellum had been produced by evolution, we wouldn't expect the same sequence of events to happen again. That's a critical point.

A better test for the whole notion of irreducible complexity is just to compare various bacterial genomes and see if their arguments are correct. Their arguments are that none of the genes that produce the proteins of the flagellum are used for any other purpose in any other organism. Well, that test has been done, and it turns out their premise is not correct, that these individual proteins and individual genes are used for other purposes in other organisms, which is the direct prediction of evolution.

In essence, when one looks closely at the arguments that are raised of intelligent design, these are not arguments that are raised to advance science, because if they were, the advocates of intelligent design would be busy in the laboratory and they'd be producing research papers. What they're really busy doing is raising a series of arguments against evolution. The purpose of these arguments, quite frankly, is to prop open the schoolhouse door long enough to get a religiously inspired doctrine into the science classroom under the pretense that it's authentic science when it's not.

SEEKING A DESIGNER

Q: Critics of evolution say that the search to understand design has gotten us a long way. Was that what Isaac Newton was kind of all about in a way?

Miller: I think it's a gross mischaracterization to take a scientist in the past who was a person of faith—and Newton is a good example—and say that he worked on the basis of a hypothesis of design. Well, it's true that he certainly believed in a creator, and he believed that that creator was the architect of the universe he investigated.

But Newton never proposed God as a cause in any of his theories. In other words, he didn't seek to explain the way in which the prism broke light into many different colors by saying, "Well, it happens that way because it is God's will, and I will stop investigating."

He sought a physical explanation, and his explanation was that white light is composed of many colors and what the prism does is to bend each color by a different amount. That's not a divine explanation. That doesn't use intelligent design. That's an explanation based on the principles of physics.

What Newton and other scientists did was to assume that the universe made sense because it had a designer, and then to use what we would call ordinary material scientific methods to investigate that universe. That's just what science does today. What intelligent design pretends to be is in the tradition of Newton. What intelligent design actually is, to be perfectly honest, is in the tradition of the Middle Ages, where they stop investigation by saying, "We cannot answer this mystery; it is the work of God the designer."

In short, Newton's on *our* team.

"No idea should be inserted into the science classroom by

force of law unless that idea can first win a place for itself in the scientific community."

Q: Phillip Johnson argues that determining intelligence from non-intelligence is within the purview of science, specifically forensic science. That is, forensic scientists can determine whether someone died of natural causes or was killed.

Miller: It's true that we can detect the actions of an intelligent agency scientifically. We can look for fingerprints. We can look for a purposeful arrangement of parts, as the advocates of intelligent design say. But the heart and soul of their argument, that you can detect intelligent action in biological systems, rests on a premise that the way you identify intelligent action in living systems is by showing that evolution couldn't have done it. So the heart of their argument is basically a claim that evolution can't do this, can't do that.

Q: Some people charge that positing material causes for everything has removed God from life, taken away meaning and purpose. How do you see it?

Miller: I think with all due respect that people like Phillip Johnson have it wrong, that they have taken the position that we can't find meaning and value and purpose to our lives except in those areas of scientific ignorance, that we have to find significance in the sort of dark recesses of what science cannot explain.

I take an entirely opposite view, that we should find our being, our value, and our meaning as human beings not in the darkness but in the bright areas of knowledge that science illuminates. I think understanding evolution gives us a fundamentally more optimistic and open view of the world than can those who have placed their faith in the claim that science isn't going to figure out these key questions.

The ultimate project of the intelligent-design movement is much grander than simply trying to displace evolution. It's a project that is basically designed to bring the supernatural into science. And that kind of introduction would destroy both science and religion.

DOVER AND BEYOND

Q: What was at stake in the Dover trial?

Miller: One of the things that the Dover trial brought to a head was the idea that the intelligent-design movement represented a genuine alternative, something very different from the creation-science movement that took hold in several states in the U.S. in the early 1980s. The advocates of intelligent design disavow any connection with creationism or creation science. They say their ideas are purely scientific and have nothing to do with religion.

In the trial, documents regarding the formation of the intelligent-design movement, the construction of the intelligent-design textbook that was recommended for use in the Dover schools, came to light. And it was very clear that intelligent design represented nothing more than an intentional effort to relabel creation science by taking all the same old arguments and putting a new label on them.

The second thing that was very much at stake in the trial was religious freedom. Religious freedom in this country is based on two great and essential principles. One is that the government shall not interfere with the free exercise of religion, and the other one is that the government shall not endorse or establish a religion. What the Dover board was doing very clearly, by their own statements, was trying to establish an official religion for the school district of Dover and trying to get science teachers to advance the Dover board's view of that religion.

Now, the members of the Dover board are perfectly entitled to hold all these

religious views and to hold these views about intelligent design and evolution and everything else. But what they're not entitled to do, under our Constitution, is to use the force and power of the state to foist those ideas on young people. That would have been a very dangerous precedent if they'd been able to get away with it.

Q: Was it wrong, in your view, for the Dover school board to try to get their ideas into the science classroom?

Miller: No idea should be inserted into the science classroom by force of law unless that idea can first win a place for itself in the scientific community. The real problem that happened in Dover was not intelligent design being a bad idea or anything else. The real problem was the use of a government agency to pick up an idea that science itself had rejected and to say, "We're going to put this idea in the science classroom regardless of its inability to win any following within science itself."

They did this for religious reasons. That's why they lost the case. But the general idea of not allowing science to work was at the heart of what was wrong about Dover.

> "Not a single scientific society has made a statement or claim in support of intelligent design. In fact, quite the contrary."

Q: So is this over? Are we beyond intelligent design yet?

Miller: I'd love to think that this battle is over. It's not. The war is going to go on. Intelligent design as anything resembling a scientific theory has been shown fundamentally to be intellectually bankrupt, and it's also been shown to be an idea that is religious in character, simply cloaked in the language of science. I think that came out of the trial at Dover. The evidence that was presented, and even the testimony from the other side, showed that beyond any shadow of a doubt.

But the people behind the intelligent-design movement will do what they've always done. They will move on, they'll change terms, they'll come up with a new label, and they'll continue to fight this fight against evolution and against scientific rationalism.

One of the legacies of the Dover trial is that the term *intelligent design* has almost become a kind of intellectual poison, and its advocates are running around saying, "No, no, no, no. We don't want to teach intelligent design in the schools." They'd better not, especially after the Dover trial. Instead, they say, "What we want to do is we want to teach critical analysis of evolution, or we want to teach the controversy surrounding evolution."

Ironically, when you look at what they actually would like to teach, it is simply the collection of anti-evolution arguments that were always part and parcel of intelligent design in the first place. So it is simply relabeling the intelligent design critique of evolution. And this idea of teaching the controversy is built upon a false premise, that there is a controversy within the scientific community on the issue of evolution. Well, there isn't. Evolution is, in fact, mainstream science.

Q: Critics of Darwinism often say that evolution is a theory in crisis. How do you see it?

Miller: Evolutionary theory has never been more active in terms of an area of inquiry and an area of scholarship than it is right now. Evolution as an idea has never been more useful than it is right now, because we use evolution everyday to interpret genomes, to develop drugs, to prolong the useful lifetime of antibiotics, to grow genetically modified crops—all these things have

components of evolution in them.

If you look at the major scientific societies in the United States and around the world, not a single scientific society has made a statement or claim in support of intelligent design, in support of scientific creationism. In fact, quite the contrary. Every major scientific organization that I'm aware of that has taken a position on this issue has taken their position four-square in favor of evolution. So the notion that evolution is in some sort of crisis is just not true. ■

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