

SCIENCE



FRICTION

*Creationists are pushing intelligent design in the classroom.
Scientists are pushing back.*

At the turn of the 18th century, a debate erupted among Europe's leading thinkers over the question of whether the world as it existed was the best of all possible worlds. This debate revolved around such enduring issues as the role of evil, possible limitations on the Divine powers, human ability to understand God's hidden plan through critical analysis, and why the world was created as it is. Points of departure not only were traditional religious doctrine, but also growing scientific insights into the workings of nature. First and foremost was the view that an invisible force played a critical role in ordering the universe: the law of gravity. Equally revolutionary were the era's emergent disciplines of botany, biology and comparative anatomy. The physical world became multiple, diverse and changeable. It was governed by unseen laws.

German mathematician and philosopher Wilhelm Leibniz added fuel to the best-of-all-possible-worlds debate. The world as it currently exists, he reasoned, does not tell the full story because without the possibility of change beyond prescribed boundaries, it would limit God's potential as Infinite Creator. The principle of plenitude, Leibniz argued, mandated an accounting of potentially different worlds, different species and different types. Each thing in the constituted world had value and the right to realize its individual value fully within the system to which it was attached. This world he declared to be the only one that could ever conceivably exist because it allows for change and for the growing perfection of the parts and of the whole.

While not yet within the realm of a Darwinian theory of evolution, Leibniz's version of "intelligent design" clearly points forward toward evolutionary and co-evolutionary theory. The human mind he then likened to the mind of God, the realm of eternal verities. Human understanding is designed to explore without hindrance how the world functions, the place of humankind in it, and the role that reason plays in advancing God's ultimate design.

Much has been written on the subject since 1700. What Leibniz had to say about diversity, plenitude, interacting sub-systems, possible worlds, and the creatively analytical thrust of human understanding as a god-like operation retains

its value for examining the relationship between critical inquiry and religious belief within the context of institutions of higher learning 300 years later.

Last fall I served as organizer and moderator for a panel discussion at Vanderbilt addressing the role of reason and faith in the pursuit of science and understanding the place of humanity in the world. I invited Father Edward Malloy, PhD'75, president emeritus of the University of Notre Dame, to join Vanderbilt faculty from several disciplines in the discussion, in which participants were asked to address, either directly or indirectly, the current battles over evolution prompted by advocates of intelligent design. Not surprisingly, given recent media attention to the subject, a standing room-only crowd turned out.

The event was sponsored by the Vanderbilt University Faculty Senate, the Center for the Study of Religion and Culture's Project in Religion and Science, and the Metanexus Templeton Research Lectures in Religion and Science program at Vanderbilt.

Included here are edited versions of the five panelists' remarks. Each was free to view the constraints, challenges and opportunities posed by the intersection of religion and critical inquiry from her or his own perspective.

— *John A. McCarthy, professor of German and comparative literature and chair of the Vanderbilt Faculty Senate*

Randomness Followed by Selection Is the True Genius of Creation

By WALLACE LESTOURGEON
Professor of molecular biology

I am one of many biologists who fears that someday, non-scientists and politicians will tell us what science really “is” and exactly how science should be taught.

I’ll start by describing the day I fear might come true: In this scenario I am halfway through the semester, teaching advanced molecular genetics to a class of 60 students—bright young women and men who have studied the sciences for many years. They hope to someday use evolutionary principles to defend us from pandemics and to develop genomic therapies for diseases we cannot treat today.

Imagine on this day I say, “Students, today we are going to learn the truth. First, you must forget what you have learned in physics and in chemistry. You must forget what you have learned in geology and about plate tectonics. You must forget what you know about the fossil record. You must forget astronomy. You must forget all you have learned in biology, biochemistry and especially genetics.

“The truth is this: Everyone in this room and everyone on the face of the Earth today can trace their ancestry to a man named Noah. And according to some of the people who claim to know about Noah, he lived about 4,000 years ago.

“So, students, what we know about genetic diversity in humans must be some kind of mean trick because Noah’s children’s children would have had to mate among themselves for generation after generation after generation. Yes, I know, this is inconsistent with the existence of the Chinese, and the Africans, and Europeans, and Aborigines. But the truth is the truth.”

My predicament as a biologist is that, if limited to this so-called truth, I might as well teach that the earth is flat. As

a biologist, when I hear people talk about intelligent design, my first thought is how little they know about the molecular mechanisms of life.

I could point to seeming mistakes like male nipples, or a little thing called an appendix, or the fact that humans’ lower backs are not well designed to support our thoracic weight, or the fact that like other mammals, our internal organs are suspended from our backs. But I’d like instead to offer the example of the piloerector muscle.

Every hair on the body has a small muscle attached just under the skin. It is called the piloerector muscle. Each piloerector muscle is innervated by a neuron from the sympathetic nervous system. If I place a mouse or a chimpanzee outside when it is freezing, the hair will fluff up and it will not freeze to death. That is the piloerector muscle at work.

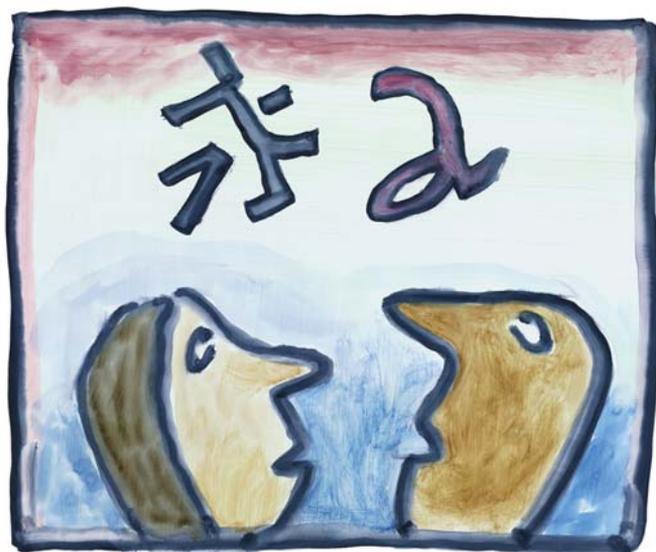
My predicament as a biologist is that, if limited to the so-called truth of intelligent design, I might as well teach that the earth is flat.

The same thing happens if I stand out in the cold: Every hair on my arm will stand up, and I will see goose bumps caused by contraction of the piloerector muscles. But I am not warmed by the hair standing up on my arm, and I will freeze to death. Does that sound like an intelligently designed system? It just doesn’t work. Think of all the wasted genes, wasted enzymes, wasted muscle energy, wasted nerves—a total waste.

Evolutionary theory predicted long ago that as generations pass through time, we retain our ancestral genes. In other words, the major mechanism of evolutionary change is gene over-duplication followed by divergence. This is now confirmed in the sequenced genomes of both humans and chimpanzees. We can look directly at how our genes and the genes of chimpanzees are organized and evolved in our chromosomes.

Scientists want evidence, we want facts, and we want to understand the how and why. Without this kind of knowledge, there is nothing we can do to design new therapies.

Here is an example of randomness followed by selection at the molecular level, another example of an inefficient system that questions the argument that all life is designed by an intelligent creator: The biochemical conversion of the compound lanosterol to cholesterol takes 19 high-energy reactions. The entire process consumes massive amounts of energy. The end product, cholesterol, differs from lanosterol only by a couple of protons and carbon atoms. Today a good organic chemist could convert lanosterol to cholesterol in about six reactions. So not only is this an example of random reactions, but it does not seem especially intelligent.



I could provide hundreds of examples of life depending on random events followed by selection. DNA replication is totally dependent on this process. The point is that many millions of years ago, animals that could make cholesterol had enhanced survival value. Any mutation that inactivates any of these 19 enzymes is lethal. This is the mechanism of genomic conservation: Animals that can make cholesterol survive, and those that do not can't survive.

Even at the molecular level of life, we see clear examples of randomness followed by selection. It is the true genius of creation. It not only led to the origin of life on this planet, but it continues to create today. From this biologist's perspective, evolution based on randomness and selection is the best argument today of an "intelligent design."



Every Pursuit of Truth Is a Potential Path to God

By FATHER EDWARD A. MALLOY, PHD'75
President emeritus, University of Notre Dame

Last summer when the Vanderbilt Board of Trust, of which I'm a member, gathered in Colorado, we had the opportunity to hear presentations by a number of faculty members. It gave us an appreciation of the cutting-edge research going on at Vanderbilt and also helped us recognize how difficult it is to find a common language by which we could interact and ask appropriate questions. The more specialized the research, the more difficult it is to communicate even to colleagues, let alone enlighten a broader audience.

I believe in a unified theory of knowledge that presupposes that every form of inquiry, whether highly sophisti-

cated or not, has value in and of itself. To use theological language, every pursuit of the truth is a potential path to God, wherein the discovery of beauty can illuminate the wonder and brilliance of God's creation. To make a claim like that is not to assert that at any given moment, any one of us as particular limited human agents can fully compre-

No matter what our path of inquiry, whatever our level of confidence about the truth we've discovered, we should have a humility about other paths to the same reality.

hend the full nature of the integration of that knowledge, or even the particular path that we're pursuing at the time.

Much of human history is taken up with efforts within particular faith traditions to account for the creative order, to ascribe creation to a kind of agency, and to give that agency a name. It is an effort to recognize in the unfolding of history a sense of time and a sense of development that accounts for the future—either in hope or despair.

One part of that inquiry is a preoccupation methodologically with the created natural order, the social structures within which human life takes place, and all the subdisciplines by which we account for things.

When I was a sophomore undergraduate at Notre Dame, I remember taking a philosophy course in which I read a book that introduced me to the "nothing but" fallacy—the idea that all of reality is reducible to economic dynamics, to some psychological perspective, to the biological workings of the human organism, or something else. It has always seemed curious to me that, in the history of ideas, when someone is considered a genius in one realm of understanding, that same person is often thought of as all-encompassing, like the old Renaissance scholar. The assumption is that one human agent can be so wise in all things, in knowledge and in wisdom, that he or she alone among all human agents has something special to say. Albert Einstein, for example, one of the greatest physicists in human history, had attributed to him an understanding about other areas of human inquiry that seems in retrospect utterly naïve.

A perspective that I find helpful is the question, What is a door? If you ask that question of an architect, or a carpenter, or a poet—you can fill in the blank—each will give you a different understanding of what a door is. Some answers will be symbolic or indirect, appealing to a different dimension of human perception. And each can be appreciated on its own terms without necessarily being contradictory.

Those of us who are not scientists, for example, need to be open to the very best understanding of the world as we know it, according to the methodologies and tools available to us at a given time in history.

If you were to go on an archaeological dig to someplace like the Middle East and you visited a tel—the mound that results from people living on the same site for hundreds and thousands of years—you would find that archaeologists cut into it at an angle. They know that in the future there will be more sophisticated ways of trying to unpack the nature of the civilization that lived there at different times in history. It’s an implicit recognition of the limits of what we know today.

It seems to me that no matter what our path of inquiry, whatever our level of confidence about the truth we’ve discovered, we should have a humility about other paths to the same reality. There is, in addition to a pragmatic sense of things, a mythic sense of reality that appeals to something in human nature, which religious traditions have provided.

“Mythic” is not to say false. It’s simply another way of trying to come to grips with the complexity, the beauty and the wonder of things.

I’m passionate about what I do, and I appreciate the passion, dedication and training required in order for the scientific community to discover ever more about the world in which we live. But I would caution against an excessive level of confidence or a predisposition to think that one’s path to the truth is the only relevant or credible point of discovery of the beauty and the wonder of the world around us.

Intelligent Design: Unbiblical and Unscientific

By DOUGLAS A. KNIGHT
Professor of Hebrew Bible and director of the
Center for the Study of Religion and Culture

I will begin my examination of the notion of “intelligent design” by asking why the word “intelligent” is used. Is it an anthropomorphic projection? In a sense, it appears as a narcissistic inversion of the notion of the “image of God”—that if humans are made in God’s image, and if humans are intelligent, then God must be intelligent as well. The problem is that it doesn’t logically follow. Does one want to accept that all other attributes of humans, such as various limitations or malicious intents, are also attributes of God?

While I am no theologian, it strikes me that orienting the concept of a deity to a human attribute must be theologically suspect. The Hebrew Bible, it is true, does associate wisdom with God, although the Hebrew word for “wisdom” is in many instances also used to designate a practical human skill—for example, being skillful in building (Exodus 31:6), in conquering other lands (Isaiah 10:13), in keening (Jeremiah 9:17), or in advising a monarch (2



Samuel 20:16). When wisdom in the Hebrew tradition is attributed to God, it generally denotes an understanding of the deeper workings of things, at a level not known to humans unless God reveals it to them.

Wisdom is present with God when the universe is being created (Jeremiah 10:12; Psalm 104:24). However, in the Hebrew Bible creation is not a matter of devising an evolutionary scheme but of establishing order and coherence where once there was chaos—separating light from darkness, dry land from the seas, birds from sea life, large animals from small, man from woman, the Sabbath from

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the rest of the week. An orderly world, so seems to be the message, is a more manageable place for humans to live.

Yet, dissent on this point is also expressed. Job protests that the system of just deserts hasn’t worked for him. Ecclesiastes doubts that we can realistically understand very much about the workings of the world, so it’s best to follow a course of moderation in all things, even in the practice of religion: “Do not be too righteous, and do not act too wise; why should you destroy yourself?” (Ecclesiastes 7:16).

Intelligence and wisdom are not identical. Wisdom has to do with judiciousness, skill, considerable experience in some field, contemplation, insight and understanding while intelligence corresponds more to knowledge and reasoning. Why didn’t the ID folk use the term “wise design” instead of “intelligent design”? Are we supposed to imagine that the world was the result of a supreme being with a perfect IQ score, however high that might be?

My second point has to do with intelligent design as a

When John T. Scopes Came to Peabody

On April 1, 1970, I reported to work as I always did, with intermingled feelings of boredom and dread, taking my seat in the claustrophobic office I shared with 16 teletype machines. Fred Moen, czar of the Associated Press in Nashville, noted my arrival and shouted instructions above the clatter of the news: “Gaillard! John T. Scopes is speaking at Peabody. Get out there and do an interview.”

I must have stood frozen for nearly a minute, trying to take in what he had said. I couldn’t have been more stunned if he had told me to interview Abraham Lincoln. *John T. Scopes*. Was this some kind of April Fool’s joke? As a history major fresh out of Vanderbilt, I knew a little about the famous “monkey trial”—the trial of the century, many people said—and 45 years later, that description still seemed to apply.

But was it possible that Scopes was still

alive—that this biology teacher from Dayton, Tenn., this apostle of science and academic freedom, was still a living, breathing human being? The answer to the question turned out to be yes, for there was Scopes on the Peabody campus—a twinkly-eyed man then 70 years old, with thinning gray hair and a dark, rumpled suit, speaking to a group of biology students.

It was his first appearance in a Tennessee classroom in 45 years—one of four appearances he made that day, followed in order by a luncheon with the president and leaders of the college, a press conference, and a final lecture to an overflow crowd at one of the auditoriums on campus. Until I went back and looked up the clippings, I couldn’t remember very much of what he said, just the dominant impression he made, not only on me, but apparently on everybody who heard him.

He was self-deprecating about his role in the trial, seeing himself as a bit player in history. “I did little more than sit, proxylike, in freedom’s chair that hot, unforgettable summer,”

he had written. “No great feat, despite the notoriety it has brought me.”

To many of us that day at Peabody, Scopes’ humility took us by surprise, though I’m not quite sure what we were expecting. Maybe Clarence Darrow or William Jennings Bryan.

The flamboyant Darrow was known as the greatest trial lawyer of his day, folksy and caustic, defender of the leaders of organized labor and criminal defendants nobody would touch. He came to Dayton to defend John Scopes, but more than that to attack the foolishness of fundamentalism, that pernicious doctrine, as he understood it, that was an affront to the intellect and common sense. In Darrow’s view, nowhere was fanaticism more apparent than in Bryan’s crusade against the theory of evolution.

Bryan, meanwhile, was regarded by many as a national treasure—a former presidential candidate and secretary of state, who had campaigned for peace, women’s rights, and economic justice for American workers. He was also a deeply religious man who had aimed his

eloquence, in the latter years of his life, at the issue of evolution.

Partly, he simply had doubts about the science, but in the survival-of-the-fittest theories of Charles Darwin he perceived a cruel and dangerous understanding that was already being used in human society to justify the oppression of the weak.

He had come to Dayton as a special prosecutor, and with Darrow as lead attorney for the defense, John T. Scopes was the man in the middle. At the age of 25, Scopes was a popular first-year teacher, hired in Dayton to teach mathematics and coach football. He wasn’t even sure he had taught evolution, though he had spent a few days subbing for a biology teacher who was ill, and thought he must have touched on it somewhere.

In any case, he was offended by the new law in Tennessee, passed in March 1925, making it a crime “to teach any theory that denies the story of the Divine Creation of man as taught in the Bible.” As Scopes made clear, both at the time and during his later visit to Peabody, it

was not the theory of evolution that concerned him, so much as the freedom to teach and to learn.

“Education is something that is to mold the individual,” he told his student audience at Peabody, free from the “contamination of state interference.”

His depth of feeling seemed to be undiminished, despite his self-imposed absence from the classroom. He had made the decision right after his trial (a conviction followed by a \$100 fine, later overturned on a technicality) that he wanted to step back from the evolution limelight. He pursued a career as a man of science, an oil company geologist prospecting for a time in the jungles of South America. But his stand for academic freedom was not a fluke.

At his Peabody press conference, he declared his pleasure that the law he had challenged in 1925 had finally been repealed in 1967. “Better late than never,” he quipped. But he also seemed to understand clearly that the issue was likely to come up again.

As he had written earlier in his autobiogra-

phy, “The cause defended at Dayton is a continuing one that has existed throughout man’s brief history and will continue as long as man is here. It is the cause of freedom for which each man must do what he can.”

He said essentially the same thing in Nashville, and Steve Smartt was one of the students who heard him. Smartt was president of Peabody’s student government (today he is Vanderbilt’s assistant provost for graduate education and research), and he served that day as Scopes’ student host, marveling at the gentle humility of the man, but also at the passion that still seemed to burn.

It was a feeling that many of us shared that day. And looking back on it, it seemed appropriate that in one of the last appearances Scopes would ever make (he died unexpectedly the following fall), he would stand before a group of future teachers and defend, as he had much earlier in his life, what Steve Smartt called “the fundamental right of man to ask questions.”

—F RYE GAILLARD, BA’68

substitute for God. “Intelligent design” is not a biblical notion, nor is it a doctrine in the history of theology. Rather, something devious is afoot, and it doesn’t take a very suspicious mind to sense it. Choose your own imagery: smoke and mirrors, under the radar, Trojan horse. It is a deliberate effort to circumvent the Constitution’s protections and the Supreme Court’s decisions regarding the First and the 14th Amendments.

It’s naïve to suppose that, for its proponents, intelligent design doesn’t imply intelligent designer—a supreme being that is effecting the design work. The next question is obvious: Which god, or whose god? Or for that matter, which gods? There’s nothing in the phrase “intelligent design” that requires there be only one divine designer.

The religions of the world are filled with creator deities. Each was immensely important for the religionists who worshiped them. I suggest that wherever intelligent design is taught and a supreme “designer” is discussed, any and all of these great deities deserve equal billing with the Christian God.

Finally, there is the fundamental problem of theodicy—reconciling a benevolent and omnipotent God with reality. What about natural disasters, cancers, the bird flu, the meanness of many humans? Are all of these phenomena, plenti-

fully evident in the history of the world, also the result of “intelligent design”? Or are they design flaws?

Is the Supreme Being all-powerful but not fully good? Or thoroughly good but not powerful enough to suppress all that is destructive and evil? It’s an ancient dilemma, experienced by most of us at one time or another in our lives. A common manner of resolving it is to adopt a dualistic view, whereby good and evil are played off against each other—for example, by picturing God vs. Satan in constant battle.

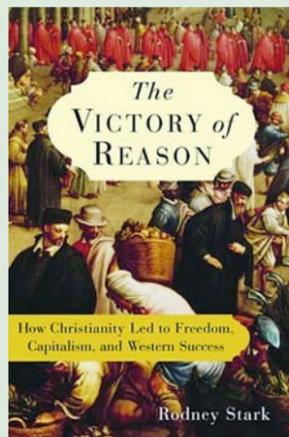
Yet, even this approach leaves the ultimate question of theodicy still open. In intelligent design tends to downplay this importance of the meaning, purpose and morality of the universe, emphasizing instead that the world and all life are simply crafted in an “intelligent” manner. Why, however, are the realities of the world presented so callously and remotely? Rather than advance the abstract notion of “intelligent design,” why not propose the concept of a “just design” or a “compassionate design”?

The notion of intelligent design, I would argue, is unbiblical, unclear, unhelpful, uninformed, unscientific and, quite likely, unconstitutional.

Faith in Reason Is Intrinsic to Faith in God

Rodney Stark is a plain-spoken provocateur, a former journalist who writes prolifically and gets to the point. He has a knack for sniffing out conventional wisdom in his world of the sociology of religion, then defying it.

Where others argue that organized religion has held back science and enlightenment, Stark says monotheism led to the rise of science and the end of slavery. The title of his latest book plainly announces his view: *The Victory of Reason: How Christianity Led to Freedom, Capitalism and Western Success*. The medieval world, he says, was not a dark ages but laid the foundation for sci-



entific discovery, free enterprise and belief in progress, belief in the accumulation of knowledge. Anti-Catholic bias among generations of scholars has distorted the historical record.

“There shouldn’t be a need to make these arguments, yet still they do need to be argued,” he said recently.

In his book he writes: “During the past century, Western intellectuals have been more than willing to trace European imperialism to Christian origins, but they have been entirely unwilling to recognize that Christianity made any contribution (other than intolerance) to the Western capacity to dominate.”

Working at the intersection of religious thought and economic change, Stark, 71, is a hot ticket in sociological scholarship these days. In February and March he came to Vanderbilt to give a series of lectures on a subject dear to

him: a “market approach” to understanding religion. Religion works rather like a supply-and-demand economy, he says. Religious producers (denominations) compete for consumers (lay people). Throughout history, religions have risen or declined based on their competence at meeting the public’s demand for spirituality.

Religious “monopolies”—state-subsidized faiths, whether in ancient Egypt or modern Europe—inevitably wither. They’re flawed because they repress religious pluralism and force only one “brand” on people. Also, they get lazy. Since their salaries are guaranteed, rather than tied to success in the field, they lack motivation and lose touch with consumer needs.

A free-wheeling system of competing faiths—the American scene—keeps religious “capitalism” in balance. In *The Churching of America 1776–2005: Winners and Losers in Our Religious Economy* (co-written with Roger Finke), Stark says American religious life became vibrant only after freedom of belief—and religious competition—became national habits.

Science Is a Living Enterprise, Not a Finished Book

By LENN GOODMAN

Andrew W. Mellon Professor of Humanities and professor of philosophy

Evolutionists need not get defensive and circle the wagons over intelligent design. Instead, we need to delve into it and understand the motives of those who make the argument for teaching intelligent design. I think the issue offers an opportunity for teaching more about evolution and more about related issues of law and religion, public policy and poetry. There’s something from which all of us can learn.

The fact is that there are gaps in the evolutionary account of the origin of living species by natural selection. Some of these gaps will not be filled by new empirical discoveries but will require new conceptual ones. Darwin himself found that natural selection did not explain everything. He expanded his realm of models, his realm of hypotheses, to include sexual selection. He also, erroneously, leaned on Lamarck’s idea of the inheritance of acquired traits. Humility and intellectual honesty call on us to recognize that science is a liv-



ing, growing enterprise, not a finished book.

Stephen Jay Gould, an accomplished and original evolutionary biologist, worked for decades, until his death in 2002, seeking to develop new naturalistic lines of explanation that would enrich our understanding of evolution. His work suggests that intelligent-design advocates who point to the areas not yet explained by natural selection may be performing

In colonial America only 17 percent identified with an organized faith, he says (based on neglected census data). Colonists brought their lax worship habits with them from Europe, where state-run religion was the norm. By the Civil War the rate was up to 37 percent, as new energetic denominations sprang up to attract new believers. By 1980 the rate of religious adherence had topped 60 percent. Stark thinks it’s been hovering there ever since.

Born in North Dakota, Stark got his Ph.D. at Berkeley and spent three decades at the University of Washington teaching sociology and comparative religion. He personally continues to be a spiritual searcher, declaring no particular congregational affiliation. But in his latest book, *The Victory of Reason*, he happily gives Christian faith the credit for the rise of Europe’s technological superiority in the last millennium.

The reason is reason: Centuries ago, Christian theologians “taught that faith in reason was intrinsic to faith in God,” he says. Intellectual rigor and logic became worthy guides to theol-

ogy, biblical interpretation and individual rights. This spiritual style had worldly consequences, Stark says. It founded medieval universities, stimulated the pursuit of science, and applied natural laws to economics. It stirred early capitalism along the Mediterranean and on Catholic monastic estates—some 600 years before the Protestant Reformation. The usually accepted version of history gives the Reformation credit for sparking a work ethic that made free enterprise bloom.

When Stark is not rummaging through historical records to reassess the received wisdom about previous epochs, he is watching current spiritual shifts. He’s as blunt about the present as the past. He explains the declines in mainline Protestant church memberships by their fixation on (liberal) politics and neglect of a demanding traditional faith.

Conservative churches are outperforming them in the spiritual marketplace, he says. Churches that preach sin, salvation, hell and hope—churches that still “hold church”—do well. “If you forget to hold church, people won’t come,” he says.

—RAY WADDLE, MA’81

Rodney Stark’s Vanderbilt visit was hosted by the Center for the Study of Religion and Culture and financed by the Templeton Research Lecture Grant, which will bring at least \$270,000 to Vanderbilt over three years to fund a research group, speakers, publications and a major conference.

The grant was awarded by the Metanexus Institute, which advances research, education and outreach on the engagement of science and religion. It runs some 300 projects in 30 nations, including the Templeton Research Lectures funded by a grant from the John Templeton Foundation.



a heuristic role. For science does not advance without criticism. Any model we use will be incomplete, and all are susceptible to improvement.

Intelligent design presents itself in part as a lawyer's brief—not surprisingly, since Phillip Johnson, one of its chief advocates, is an attorney by trade. The aim is to shift the burden of proof to one's adversary. But in formal terms the move is fallacious. The advocate challenges evolutionists by pointing to "irreducible complexities" that natural selection has not explained, and then urges that what has not yet been explained is in principle *impossible* to explain—that is, naturalistically.

But science need not be adversarial. Here the burden should be shared. We should all assume some part of it. That means that the poet who celebrates the beauty and complex-

Intelligent design theorists who point out gaps in the evolutionary account of nature may be performing a heuristic role. Science doesn't progress without criticism.

ity of life has a place at the table alongside the scientist, whose explanatory work celebrates the same beauty and complexity in quite a different way.

I think it's a mistake both tactically and strategically for theists to rely on intelligent design: tactically, because they will find themselves on the defensive, open to refutation as new cases are found and new explanations worked out; and strategically, because it depends on a "god of the gaps." God becomes the explanation only of what's inscrutable, and as science advances God then retreats into ever narrower and

darker corners. A more hopeful strategy, which I am trying to pursue in my work, is to explore the compatibilities of science and religion, creation and evolution.

As for the question of whether evolution or intelligent design should be taught, I think the question itself is based on a misunderstanding of what teaching is—as if teaching meant the same inculcation or indoctrination. As I see it, intelligent design presents an educator with an opportunity, that is, the opportunity to teach the controversy, analyze and discuss the issue, open up a dialogue between the sciences and the humanities, and ask ourselves, What kind of explanations can science offer? What kind of explanations go beyond what science can offer? Where is the right way of relating these areas of human experience? Are there things in nature that can't be explained mechanically? What do we see that can't be explained? This is a fruitful arena for conversation in which dogmatists on both sides will be very much hampered by their dogmatism, but people with open minds will find they have much to say to each other.

Wandering in a Dark Labyrinth

By VICKI GREENE
Associate professor of physics

My role in the mission of higher education is that of science teacher. My statement about intelligent design and creationism focuses on science education because the intelligent-design debate has revealed a deeper problem about the teaching of science.

A recent Pew poll shows that 67 percent of white Christians favor teaching creationism along with evolution. No significant differences on this matter exist among evangelicals, mainline Protestants and Catholics. Among those who believe in evolution by means of natural selection, 62 percent believe that creationism should be taught along with evolution.

Why do so many people without either scientific or religious predilection favor the teaching of creationism in the science classroom? We infer from the poll results that many people in this country do not understand science, neither as a body of knowledge nor as a process of discovery. The resulting vacuum allows many unfortunate ideas to rush in.

For the moment, physics teaching is removed from the controversies attending the life sciences classroom. However, physics has many pedagogical, structural and cultural attributes in common with these other sciences. Thus, the physics classroom is an excellent place to explore the various contributions that scientists and science teachers often make to popular misunderstandings of science. There are several possible reasons many people don't understand science well enough to classify descriptions of nature as scientific or nonscientific.

Among these are the construction of private universes, bad science teaching, bad translations, scientific arrogance, the “science as religion” problem, and general complacency on the part of scientists.

People have their own theories about how the world works. This set of theories forms a person’s “private universe.” This personal cosmology can be as firmly held as any religious conviction, more elaborate than epicycles and very, very wrong.

A well-known videotape shows recent Harvard graduates, Boston city high-school students, and at least one tenured professor at Harvard struggling to explain why it is warmer in the summer and colder in the winter. All have similar, incorrect explanations for this phenomenon. It is extremely hard for a teacher to help the students replace this picture with the correct explanation that seasons come from the tilt of the earth’s axis relative to its orbit around the sun.

Much of bad science teaching can be summed up in the words of physicist Wolfgang Pauli: “This isn’t right. This isn’t even wrong.” Explicit definitions of science in science textbooks range from reasonable to nonexistent. One example



in an elementary physics textbook shows a high-speed photograph of a water balloon shortly after being popped with a pin. The photograph shows that the water inside retains the shape of the balloon briefly before collapsing. The caption explains that the photograph provides evidence refuting the theory that liquid does not retain its shape when removed from its container. In fact, there was no such theory to contradict. The photograph shows that the water has conformed to the shape of the container as expected.

Another problem is the difficulty of translating physical concepts from the mathematical language of science. So many people are averse to math, and innumeracy is culturally acceptable in our culture. In the words of Galileo: “Philosophy is

written in this grand book, the universe, which stands continually open to our gaze. But the book cannot be understood unless one first learns to comprehend the language and read the characters in which it is written. [The universe] is written in the language of mathematics, and its characters are triangles, circles and other geometric figures without which it is humanly impossible to understand a single word of it; without these one is wandering in a dark labyrinth.”

The arrogance of proponents of science also increases the difficulty with which many people willingly integrate scientific understanding into their everyday thinking. Philosopher Daniel Dennett said, “To put it bluntly but fairly, anyone today who doubts that the variety of life on this planet was produced by a process of evolution is simply ignorant—inexcusably ignorant.” This sort of thinking is not likely to leave the reader with an open mind towards science.

Some scientists concatenate their scientific beliefs into their spiritual ones or simply substitute one for the other. In “The One That Got Away,” a 1997 *Science* magazine article, Gary Taubes wrote an account of a Yale professor of

Many people in this country do not understand science, either its definition or as a process of discovery. The resulting gaps leave space for many unfortunate ideas to rush in.

physics, Jack Greenburg, who spent years trying to reproduce evidence for a new particle he thought he had discovered. His analyses were based on throwing out any data that didn’t look right. Decades of wasted funds and lost careers later, a colleague explained: “Jack was on this Nobel Prize hunt. Jack was so convinced from his GSI data that it had to be there, it was like a religion with him.”

Scientific explanations are built on observations, hypotheses and theories. But ID advocates want to redefine science, giving rise to the practical problem that we can’t arbitrarily redefine science and simultaneously maintain our dependence on technology. Those of us who are teachers and practitioners of science need to counteract the various problems I have outlined. We also need to educate our students about the process of scientific inquiry and teach them the nature of scientific proofs. We need to distill the statistical arguments on which evolutionary biology depends so that students can still recognize the scientific method within these arguments. When the public can make informed decisions about what does and does not constitute a scientific argument, we will not have to worry about pseudoscientific controversies such as the intelligent-design debate. ▼