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such as Michael Behe, William Dembski, and Phillip Johnson), and Darwin took him very seriously.

Contrary to what modern creationists like to claim, Darwinism was also vigorously challenged within the scientific community after its alleged rise to the status of biological "dogma." Bowler (1983) recounts in detail the story of how, for example, neo-Lamarckism¹ was very much alive and well in scientific circles, both in Europe and the United States, well into the twentieth century. Many professional scientists at the time saw Darwin's theory in decline and the future of biology uncertain. But the rediscovery of the laws of genetics—and their incorporation into the theories of natural selection and descent with modification—led to the so-called neo-Darwinian synthesis of the middle part of the twentieth century (Mayr and Provine 1980). Though modern creationists refuse to take note of this remarkable scientific fusion, the theory of evolution is now as much in doubt in biology as quantum mechanics is in physics (which, of course, doesn't guarantee that either of them is "true," since science can by its nature only provide provisional answers).

Ever since the defeat of scientific neo-Lamarckism at the turn of the twentieth century, therefore, creationists and "intelligent design" (ID) proponents (better thought of as neo-creationists, as Eugenie Scott points out in this volume) have fought a battle that at best was based on a barely viable philosophical position and at worst has simply been a stubborn exercise in attempting to impose one's parochial religious ideology on the rest of the world. Furthermore, with the exception of the Scopes "monkey trial," this battle has been set back throughout the twentieth cen-

Introduction: The Problems with Creationism

THIS BOOK IS ENTITLED *Scientists Confront Intelligent Design and Creationism*, yet it is clear from looking at the contents that this isn't just about science. Indeed, the three major sections of the book are a good summary of the issues: creationism has deep historical and cultural roots in the United States (part I), it is of course an alleged challenge to a scientific theory (part II), and it involves complex questions of philosophy and science education (part III). In other words, creationism is not a single problem but rather a panoply of loosely connected threads, all of which continue to pose a threat not only to science funding but, more important, to the quality of education and ultimately even to free speech in modern liberal societies.

Historically (part I of this book), of course, creationism has preceded evolutionary theory (despite some interesting speculations from materialist philosophers in ancient Greece). Most important, natural theology was the dominant paradigm when Charles Darwin published *The Origin of Species* in 1859. In fact, Darwin spent a considerable amount of time directly answering the arguments of those such as William Paley (1802), who attributed features of the natural world to the actions of a purposeful designer. Paley was a first-rate naturalist (unlike, one cannot help adding, modern proponents of "intelligent design"

1. It was Jean-Baptiste Lamarck's view that environmental change created "needs" in organisms that responded by differential usage of organs. In response, the organs grew or shrank, and evolution occurred as this intragenerational modification experienced by the parents is inherited by descendants. In contrast, Darwinian models are based on differential survival and reproduction of those who possess favored variations, and evolution occurs as the environment "tests" these variations, allowing some to leave descendants that also have these features and producing modifications in the proportions of certain variations among future generations.

tury by an endless stream of legal defeats. At the local level, however, creationists have been doing much better, shamelessly bypassing laws and regulations and successfully intimidating school boards and teachers into avoiding or watering down “the issue.” This is part of the reason books like the one you are about to read are much needed. (Another reason is that if one does an online search for books using the keyword *evolution*, one finds mostly creationist propaganda, much of it directed to children.)

Scientifically (part II), as I have noted, creationists and ID supporters don’t have a leg to stand on, but they nevertheless manage to make a lot of noise. One of the recurring tricks I have experienced when talking with creationists is that they like to portray the debate as one concerning the “science of origins.” Don’t waste time looking up any “Origins Science” Department at the local college or university; like much else associated with creationism, it is a pure rhetorical device. The “origins” (plural) to which creationists refer are three: the origin of humans (sometimes extended to the origin of any species, though an increasing number of creationists allow for some “micro-evolution” within vaguely defined “kinds” of living organisms), the origin of life, and the origin of the universe.

Even a superficial acquaintance with science reveals that these three subjects actually belong to three very distinct disciplines (evolutionary biology, biophysics, and cosmology), and that only the first one has anything to do with the theory of evolution proper. Darwinian mechanisms cannot get going until after life originates on a planet, and, last time I checked, planets and galaxies were not making babies that could be subjected to natural selection. In other words, to put it in terms of “origins” is misleading at best, which once again clearly reveals the thin veneer of science thrown over the creationist Trojan horse.

This is not to say that the current version of the theory of evolution does not face serious unanswered questions from a genuinely scientific perspective. Of course it does. So do other dominant theories in science. For example, even though quantum mechanics is by all accounts the single most successful sci-

tific theory ever produced (because it accounts for so much, and with such a high degree of accuracy in its predictions), physicists still do not know how to reconcile it with Einstein’s theory of relativity. The two theories make conflicting predictions in certain cases (for example, the behavior of a black hole), yet they both seem to be correct (Greene 1999). Clearly, something is amiss, but this has *stimulated* physicists to look for new and broader solutions, such as “superstring theory,” not to give up and say, “Well, it must be that God did it, let’s leave it at that.”

In the same way, evolutionary biologists are still working to determine how new patterns of development arise through the history of life on earth (for recent discussions of some of the relevant issues, see Schlichting and Pigliucci 1998; Wilkins 2002; West-Eberhard 2003). There will be questions that perhaps will never be answered, simply because it is unlikely that we will ever uncover enough evidence—the great diversification of invertebrate life at the beginning of the Cambrian period, more than 500 million years ago, being one possible example. But to claim from this that something is profoundly wrong with the theory of evolution is to fundamentally misunderstand, or willfully ignore, the very nature of scientific inquiry—which brings us to the third component of the problem, philosophy (part III).

As much as scientists, by and large, don’t particularly enjoy musing about philosophy, science itself is based on fundamental philosophical assumptions, and creationists have tried to make the most of this alleged “weakness.” For example, in order for science to work, one has to assume (as a methodological tool) “naturalism”—that is, that all we need in order to comprehend nature is a solid understanding of the laws and processes that we can observe and test in the natural world. The supernatural cannot be called forth, simply because it cannot provide us with any “explanation” in the sense of a useful and testable set of statements. But then again, all of us—including creationists—make the same assumption in most of our everyday dealings. While it is true that some people hold to such an extremely religious view of

life that they think that God is directly responsible when they find a parking place at the mall, we can't actually function as human beings in modern technological societies if we go around attributing everything to the supernatural.

For that matter, both scientists and creationists make even more radical—and philosophically questionable—assumptions, such as “realism,” the idea that there is a physical world out there, and that everything is not just in our (or God's) mind. Plenty of idealist and skeptical philosophers have repeatedly pointed out that there is not and cannot be any *proof* of realism: one has to accept it “on faith.” Then again, those same philosophers apparently had no trouble setting aside their qualms about reality when they went to the grocery store. Bertrand Russell once said that sometimes one wishes that philosophers who question reality would get into a car and drive into a wall at a speed proportional to their disbelief in the existence of said wall.

Philosophy of science is no laughing matter, and scientists would do well to read up on it, especially if they wish to counter creationism in the public arena (and they ought to do so, as professional researchers and educators). Alas, it turns out that to try to understand what the scientific method is and how it works is not trivial (Chalmers 1999). Scores of philosophers have managed to give partial, more or less correct accounts of it. Beginning in the seventeenth century with discussions of induction by Francis Bacon (2000) and John Stuart Mill (1851), through the concepts of falsification of Karl Popper (1968) and the influence of “paradigm shifts” examined by Thomas Kuhn (1970) in the twentieth century, philosophers of science have tried to formulate the general principles of the scientific method based on the ways in which science is practiced by scientists.

Why not ask scientists themselves, then? After all, they are the ones *doing* the job. But that is like asking a football player how he gets a touchdown, or a painter what her latest canvas *really* means. In all of these cases, you will hear a lot of blabbering nonsense and very little useful information. That is because all these activities (science, sports, and arts) share an interesting commonality

that is seldom explicitly acknowledged by scientists: they require long years of apprenticeship. One does not become a professional player by reading manuals on how to handle the ball. Rather, one has to start with some degree of natural talent and then practice constantly while learning from watching and interacting with people who know how to play well.

It is no different in science, which is why we have graduate schools where we *train* PhDs. It is hard to convey to a creationist the idea that getting a PhD by working in a laboratory for years is not “brainwashing”; it simply is the best way we know to produce the new crop of scientists. Of course individual scientists are going to be “biased”—in the general sense that they will have a point of view when they approach any particular scientific problem, and such point of view is likely to have been influenced by their PhD advisers (though it is common to see students take positions diametrically opposite to those of their mentors).

That being the case, where does the alleged scientific “objectivity” come from? Philosopher Helen Longino (1990) has convincingly argued that there are two sources of (long-term) objectivity in science: (1) the fact that the scientific community is made up of a culturally diverse group of people, with both men and women, members of different racial and ethnic groups, and individuals who espouse all sorts of ideological and religious positions; (2) the fact that there is a real world with which any scientific theory, sooner or later, has to come to terms. It is entirely possible—and it has happened several times in the history of science—that scientists will temporarily fall for the wrong explanation of a class of natural phenomena (for example, phrenology—the idea that one's character can be surmised by the shape of one's head). But eventually the facts will simply stubbornly refuse to comply with our preconceptions, and we will be forced to move on or give up our quest to understand nature.

How does creationism measure up to Longino's two criteria? On the one hand, creationists tend to represent a very narrow sample of human backgrounds and opinions: most of them are religious fundamentalists (often Christians or Muslims, but

including Orthodox Jews and others). More important, the few testable statements that have come out of creationism (for example, the occurrence of a worldwide flood about four thousand years ago) have been tested, and clearly rejected! Yet, as in the case of other pseudosciences such as astrology, its followers refuse to bow to the judgment imposed on their theories by the real world. It is philosophy of science that condemns creationism and ID as inviable options, for the basic reasons that—contrary to science—they are not rational enterprises, and they don't "work."

I will close with a note about the fourth problem with creationism, though it is treated also in part III, together with philosophy. It concerns science education, which is where the front line of the evolution–creation controversy lies. This is a battle over the minds of our children, and too many educators simply have not been doing their job, partly because—ironically—they don't *know* how to do it (Pigliucci 2002).

The problem is too complex to attempt even a superficial summary here, but let me at least provide a couple of obvious pointers. In the best Catholic tradition, I can start with a *meta-culpa* and admit that too many scientists don't know how to teach and largely don't care about it. We don't know how to do it because we get no training in it. Or, rather, the only exposure we have to teaching is usually of the worst kind. During graduate school, we are thrown into a lab classroom with very little idea of what to tell the students and with the mandate to "get it done" and return as soon as possible to our *real* jobs, doing research. That trend continues when we are professional scientists, working in departments that put a high premium (understandably) on publication and, especially, grant writing. Teaching? Well, that's something you can *buy yourself out of* if you have a grant, or are encouraged to do in the most "efficient" way possible: little preparation, no research into alternative teaching techniques, and as little contact with the undergraduates as possible.

Our pre-college teachers fare little better, unfortunately.

Many of them don't know enough about the science they are supposed to teach, because too often they didn't receive anything more than superficial training in it. Those who do know the science are overwhelmed by the amount of material they must cover (which keeps increasing steadily, since science is a cumulative enterprise, unlike—say—creationism), or they are too busy simply keeping their students' attention focused longer than the duration of an MTV sound bite. Is it any wonder that most of our high school and undergraduate students are ignorant of the intricacies of the theory of evolution and do not understand how science itself works?

The outlook, however, is not as bleak as I have hinted at so far. More scientists, philosophers, and educators are becoming involved in the evolution–creation controversy and are striving to promote better teaching of science and development of critical thinking skills. This is a major positive shift. Lately, even several professional scientific societies have timidly started to come out of the ivory tower and become involved in sponsoring symposia on teaching, as well as a variety of public outreach activities. This change will take years, probably decades, to yield measurable effects, but, ironically, it is a positive trend to which creationism has unwittingly contributed.

Take my own case, for example. Before 1996, I had never written a word about creationism, nor was I particularly interested in teaching methods or in talking to the public. But then I accepted a job at the University of Tennessee and immediately witnessed an attempt by the Tennessee legislature to pass an anti-evolution law. This shock was a wake-up call. It helped channel the energy of some of my colleagues and graduate students toward doing something about the problem. We felt we had to give back to the community simply because, after all (as creationists never cease to remind us), the public pays for our salaries (if one works at a public university) and for most of our research money (even if one works at a private institution). Engaging in public outreach and fighting against irrational nonsense is not merely an option

to fill our spare time, it is also our moral obligation as members of a free society.

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