Introduction:

Evolutionary Science and Society: Saving Lives and Promoting Prosperity

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Nations and cultures sustain greatness by sustaining unity while promoting diversity and through a willingness to encourage freedom of intellectual thought and rational inquiry. At the same time, they nurture these aspirations through their young people, from one generation to the next. Not surprisingly, the formal education system serves as the primary medium for that historical continuity.

Rational inquiry and the growth of knowledge itself result from a process we call science (in its broadest sense): ideas are proposed that attempt to explain, or account for, some problem or observation in the natural world, and then they are tested against additional observation. Some years back the well-known biologist John A. Moore called this science as a way of knowing. He knew that rational- and empirical-based inquiry applied much more broadly to human knowledge than just to science. Ideas—call them hypotheses, theories, conjectures—can come from almost anywhere, but they will only have staying power if they have a firm foundation in the empirical world. In the end, we reject or provisionally accept ideas about how the world is, or how it works, through empirical study. This is the requisite nature of science as practiced by scientists and the essence of science as experienced by students.

Many people, however, dismiss science and its empirical framework, often with tragic results. Peoples of many cultures obtain their knowledge of the world from religiously inspired texts, from charismatic and inspirational leaders, or from mythical folklore, and although such knowledge is crucially important to people as they form spiritual, ethical, and moral views of the world, it is an inadequate basis for promoting human well-being and prosperity.

The more we discover about our world empirically, day by day, year by year, the more societies benefit. Although this would seem to be so commonsensical as to defy the need for discussion, we live in a world in which countless people believe, and many genuinely so, that we should be rejecting most of science outright in favor of faith-based knowledge, or that we can pick and choose which science we like or don't like on the basis of faith-based belief. Large numbers of people in all parts of the world, for example, don't want to take their sick children to medical doctors and rely instead on spiritual intervention to heal or save them. Many believe disease is ultimately due to spiritual causes rather than naturally functioning pathogens (it is not uncommon to hear that AIDS is God's way of dispensing punishment).

Throughout history, growth in knowledge about the natural world has been construed as threatening to some at the same time it is liberating and life affirming to others. In most countries, fortunately, people understand that science is the means through which we learn about the world and upon which we build the foundation for societal advancement. This is certainly true in the United States, which has the largest financial commitment to science of any country. Yet even here, many citizens are working furiously to undercut science through their opposition, primarily, to evolution. Indeed, the United States, compared with all other industrial countries, has the largest contingent of activist creationists who are trying to impose a specific religious viewpoint on the remainder of society. Although the young Earth creationists failed to convince the U.S. courts and the majority of the public that their view about how the world works is anything but religiously inspired, and

therefore illegal to teach as science in the public schools, they still have an audience for those who distrust science and equate evolution with atheism and other "societal ills." There is no question they remain a pervasive influence against science through churches, schools, writings, mass media, and even creation museums.

It is important to emphasize that no matter how much creationists focus attention on evolution, to them, all the sciences—not just evolution—are threats to "the inerrancy of the Bible" and are therefore to be resisted or biblically reinterpreted. This type of thinking—using evolution as a wedge to get to the other sciences—is flat-out dangerous for the future well-being of Americans. The latter depends on a scientifically accurate and pedagogically sound science education. Creationists are antagonistic to sciences in general because most are evolutionary. Astrophysics, chemistry, geology, and biology, for example, are concerned with natural systems that change over periods of time and that document a deep history for the universe, Earth, and Earth's biological diversity and organization.

The United States is falling behind in science. Relative to the comparably sized European Union, the United States no longer leads in the number of scientific publications, PhDs awarded, or patents. Although it would be unfair to place all the blame for this on creationists, can there be any doubt that the antiscience, anti-evolution atmosphere pervading the United States at this time is contributing to the erosion of science? Teachers are running scared in many parts of the country as local creationist activists stir up a frenzy against evolution and the school districts and teachers who dare to teach it. We recently heard about a Midwestern principal who directed teachers to use a razor blade to remove all pages that referred to evolution from their biology textbooks—sadly, it is a true story, independently attested to. Unfortunately, this is just one of a litany of such stories we could tell. Thus, the destructive tendencies of creationism cannot help but spill over to all the sciences. Which brings us to "intelligent design" creationism.

Intelligent Design Creationism Is Not Bad Science, It Is *Not* Science

The political movement called intelligent design is sometimes called bad science by scientists who should know better. It is not bad science; it is not science. There is plenty of bad science in the world, but even in those cases investigators are following scientific methodologies and are not indulging in religious narrative or doctrine. They are trying to find naturalistic explanations for phenomena, and they are trying to do so by empirical study.

Intelligent design creationism is not science because it still relies on miracles to explain natural phenomena. The notion of a miracle is not a scientific concept; it is a theological concept. When advocates of intelligent design speak of an intelligent designer, they are transparently referring to a Christian God and they clearly mean that this Christian God directly interceded in the natural world multiple times. Such a view of explaining real-world phenomena is a theological construct, not one of modern empirical science.

Some followers of intelligent design wear their intentions on their sleeves and admit that their opposition to evolution is religiously inspired. Others use stealth and deception and hide that religious inspiration behind a quasi-scientific façade.

Intelligent Design Creationism Is a Political Movement

It should be obvious to everyone, including those state legislators, school board members, and textbook committees agitating for inclusion of intelligent design creationism in biology curricula, that this is a political movement and is not about having a debate among scientists or getting the best science to the students of America. The vast majority of those pushing intelligent design are doing so out of a fear of an increasingly secular society, which most interpret, mistakenly, as threatening their religious beliefs. Most, moreover, are not conversant with modern science, otherwise they would know that evolution has been so thoroughly tested and confirmed as to be uncontroversial within the scientific community. The basic reason for entertaining the teaching of intelligent design/creationism in the public schools is to apply a counterweight to something (evolution) that is perceived to be a threat to their worldview (and that of their children).

In some respects, it is difficult to understand why intelligent design creationism is taken so seriously since it is not science, and obviously so. The answer, it seems, is that a rather small number of advocates have launched a very effective campaign of propaganda, not unlike advertising, to convince the susceptible that there is room for religious "explanation" in the science classroom; indeed, there is a need for it lest

you want your children to lose all their moral values. This argument is not being made on scientific grounds, but is based squarely on religious belief. And people are responding to that all across the country.

Understanding Evolution and the Tree of Life Saves Lives and Promotes Prosperity: How Even Creationists Benefit From Evolution in Their Daily Lives

We scientists and educators are doing an inadequate job at meeting the creationists' challenge. We do not educate students early enough on the nature of science. We do not teach them about the boundaries between religious and scientific thought and how this bears on their understanding of the world and their place in it. Most important, we also do not teach adults about these distinctions. Scientists are ill trained in many cases to speak comfortably about religion even though large public-opinion polls show that the percentage of scientists holding religious beliefs is not very different from the public at large.

At the same time, we do not do an adequate job of teaching modern evolutionary biology. In particular, we do not teach why evolution is important to society. The public intuitively understands why molecular biology, chemistry, or physics is important in their lives, but they do not have that same perception about evolutionary science.

Over the past decade, evolutionary science and our increased understanding of the history of life have become essential tools in saving lives and promoting economic prosperity and well-being. Evolutionary principles are used to design flu vaccines, to understand disease transmission, to engineer new drugs, and to manage endangered species, among many other benefits to society. Because of the power of biological comparison within the framework of the tree of life, scientists are using newfound knowledge about the history of life to (1) search for new drugs, (2) identify new pathogens (e.g., West Nile virus, many other viruses), (3) predict new disease outbreaks, (4) identify and predict the hosts (e.g., rodents, insects) of pathogens, and (5) identify invasive species that threaten our ecosystems, among many others. It is ironic, therefore, that many fervent anti-evolutionists are unwittingly dependent on evolutionary science to keep their families safe: if they are adamantly opposed to evolutionary science, perhaps vaccines are not for them.

Teaching about Evolution

The chapters in this book were first presented in a symposium at the fall 2004 meeting of the National Association of Biology Teachers (NABT) in Chicago, Illinois. It was organized collaboratively by the American Institute of Biological Sciences (AIBS), BSCS, and NABT.

The purpose of the symposium and this publication is to provide science teachers and students with a general review of the philosophical issues surrounding the teaching of evolution (part 1), a broad update on current evolutionary science from the tree of life to how evolutionary mechanisms work (parts 2 and 3), and a detailed overview of how that science produces benefits to public health (part 4) and society (part 5). Applied evolutionary science is rarely taught. The chapters in this book, along with the teaching resources provided by a stellar lineup of educators, provide a framework for teaching and learning about evolution through numerous examples that show the power of evolution in solving societal problems. Thus, readers will find insightful summaries of evolution and its role in human health, agricultural productivity, forensics, and other important sectors of society.

The symposium and book would not have been possible without the hard work of many individuals. Most of the organizational details and management of the speakers fell to the staff of AIBS, particularly Richard O'Grady (executive director), Susan Musante (education and outreach program manager), and Gordon Uno (chairman of the Education Committee). At NABT, Wayne Carley (executive director) and the NABT board and staff arranged for the symposium to be held at the Chicago meeting and provided a magnificent venue and logistic support for the scientists and educators. Finally at BSCS, Barbara Perrin, Director of Publications; Barbara Resch, Editor; and Jennifer Phonexayphova, Project Assistant have guided this book through publication. To all these people, as well as to the teachers and students who attended the symposium and the scientists and educators who participated, we extend our gratitude and admiration.