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GAS PRESIDENT'S COMMENTS AND REPORT FROM THE ACADEMY COUNCIL

The 83rd Annual Meeting of the Georgia Academy of Science will be held Friday and Saturday, March 24-25, 2006 at Georgia Perimeter College, Lawrenceville, GA. Paper sessions will begin in the afternoon on Friday and continue until the luncheon on Saturday. This year Fernbank Science Center will be the site of the Friday night reception and attendees will have an opportunity to elect to attend a planetarium show or IMAX presentation.

One of the highlights of any Georgia Academy of Science meeting is always the student presentations. I sometimes think we all forget how important state academies are to the professional growth and development of undergraduate students. Recently, at a Botanical Society of America meeting, I had a chance to conduct an informal poll and ask how many of my colleagues presented their first paper at a state academy. More than half of them had presented the results of their first research project at a state science academy. Others who had not were in states without active science academies.

Presenting research at the Annual Meeting of the Georgia Academy of Science is only one step towards the "care and feeding" of undergraduate students. Having students prepare and publish their findings with their faculty advisors is another step in the professional training of undergraduates. Outstanding work presented at the Annual Meeting is often not published. I challenge all of us who actively engage undergraduates in research to consider publishing the results of that research in the Georgia Journal of Science.

The council has been exploring the possibility of joint annual meetings with other state science academies. By having joint meetings we are further expanding the visibility of both the Georgia Academy of Science and the research being conducted in our state.

John Aliff and the Local Arrangement Committee at Georgia Perimeter have an outstanding program planned for the 83rd Annual Meeting of the Georgia Academy of Science. I encourage everyone to consider submitting abstracts with, or without, students. The abstract submission forms have been included in the Call for Papers sent to you by your respective Section Chair. If you have not received this material, please visit the Academy website <http://www.gaacademy.org/> for your Section Chair's contact information.

Melanie DeVore, President

MEETING ANNOUNCEMENT

The 83rd annual meeting of the Georgia Academy of Science will be held Friday and Saturday, March 24-25, 2006 at Georgia Perimeter College, Lawrenceville, Ga. The meeting will begin with a council meeting at 11:00 am and continue Friday afternoon with paper presentations. Friday evening activities include a reception, a book signing by Dr. Barbara Forrest, co-author of "Creationism's Trojan Horse," and activities at the Fernbank Science Center. Paper presentations and poster presentations will continue Saturday morning, followed by a luncheon, guest speaker, and award presentations at noon.

CALL FOR PAPERS

The deadline for receipt of abstracts by section chairs is Friday, December 2, 2005. The abstract submission form and complete instructions for abstract submission are available from the academy website at the following www link:

http://www.GaAcademy.org/documents/GAS06abstract_submission_form.doc

Abstracts will be reviewed by section referees for adherence to the guidelines indicated on the abstract submission form. Accepted abstracts will be published in the conference issue of the Georgia Journal of Science. Competitive monetary awards will be given for oral student presentations at the conference. Travel directions to Georgia Perimeter College, fee schedule, conference activities, local accommodations, and other information about the conference are posted at the academy website.

CALL FOR NOMINATIONS

Specific officer duties are described in article V of the Georgia Academy Constitution at:

<http://www.GaAcademy.org/documents/constitution03.htm>

If you wish to nominate a section officer, contact the appropriate section secretary. If you wish to nominate an academy officer, contact the Academy President, Dr. Melanie Devore or your section Secretary listed at the Academy website above. The academy membership will receive ballots for section and academy officers prior to the conference; results of the election will be announced at the Saturday noon luncheon. All academy members are encouraged to participate in the election process.

TEACHING EVOLUTION AND THE CHALLENGE OF INTELLIGENT DESIGN: A SYMPOSIUM

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ABSTRACT

A symposium titled “Teaching Evolution and the Challenge of Intelligent Design” was presented at the 66th annual meeting of the Southeastern Society of Biologists, University of North Alabama, Florence, AL, April 16, 2005. The symposium was arranged, introduced and moderated by John V. Aliff. The advent of a “scientific theory of intelligent design” has created conflict in religious denominations, public school educators, and within the community of scientists who are being threatened by the imposition of a specific religious view. Intelligent Design theory is a new form of creationism that abandons the biblical inerrancy of the older scientific creationism in favor of a neutral position on the age of the earth. Intelligent Design theory is not a valid scientific theory for these reasons: 1.) Its hypothetical, intuitive and religious assumption of the intelligent design of complex systems is not testable or falsifiable using the scientific method, 2.) ID “theory” cannot develop hypotheses, and 3.) ID theory does not predict new discoveries as a true scientific theory does. More simply put, ID cannot explain natural phenomena beyond the intuitive and religious assumption that “God did it.” The participants in the symposium – Barbara Forrest, Massimo Pigliucci, Taner Edis and Keith Miller – have written and edited leading papers and books on the challenges of creationism to the teaching and practice of science. The author lists 14 deceptions commonly used by scientific creationists and ID creationists in their propaganda.

Keywords: Symposium, teaching evolution, intelligent design, creationists, Cobb County evolution stickers, supernaturalism, scientific method, scriptural inerrancy,

INTRODUCTION: CREATIONISM AS A RELIGIOUS MOVEMENT

I reflect back upon my own experience in arranging a similar symposium on “scientific creationism” at Emory University in Atlanta in 1980 that featured a scientist, a historian and a theologian. That symposium was a traditional academic reaction to the theological and purportedly scientific content of creationism and a response to a proposal in the Georgia legislature requiring the teaching of scientific creationism in the public schools. The proceedings of that symposium were distributed to the senate and house of the Georgia

Legislature who actually passed HB 690 slightly different versions of the bills. but failed to enact a compromise bill in joint session (1). Georgia legislators retired to their districts with a record of voting for God without the state having to defend their action in court as would happen later in Arkansas and Louisiana (see below).

A few days later a woman, who attended the last session at Glenn Memorial United Methodist Church in Atlanta, appeared at my office with some tapes she wanted to let me hear in an effort to convert me to scientific creationism. The tapes were oral chapters of John C. Whitcomb and Henry M. Morris, *The Genesis Flood*, (2), with Reverend Whitcomb reading. As one with a southern religious upbringing, I heard a powerful, mythological siren-like call to adhere to the simple proposition that the Judeo-Christian Bible is not only “God’s Word,” but scientific revelation as well. In a reaction to “blind faith,” the scientific creationists substituted a materialist definition of faith by demanding that science confirm scripture and scripture confirm science, while simultaneously attacking the materialism of scientific explanation. Also applying the principle of scriptural inerrancy to science, we now have young earth Islamic creationists (Harun Yahya) and old earth Islamic creationists on the internet (3a, b, c, d, e). Henry Morris, who entered a Ph.D. program in geological engineering with the express purpose of proving the scientific accuracy of the Biblical “flood” account (4), followed *Genesis Flood* with a series of books that blame the theory of evolution for a multiplicity of evils including Nazism, Communism, religious heresy, abortion, crime, gay rights and women’s liberation (5). And most biologists thought the theory of evolution was a useful theory to explain nature and not an attack on religion!

A “NEW” POLITICAL MOVEMENT: CREATIONISM DEVELOPS INTO INTELLIGENT DESIGN

Creationists (e.g., Tim LaHaye, Jerry Falwell and Henry Morris worked together in San Diego) believe that they are the forerunners of a political revolution that will save America (4). Their goals are to establish a theocracy. The passing of anti-evolution laws represents their first efforts politically. If this effort to teach religion in the public schools fails, I predict that the ID creationist political movement will attempt to abolish public education.

Scientific creationists have failed to pass laws requiring the teaching of a version of science subservient to a particular religious viewpoint coequal to the teaching of evolution. However, creationists have learned from their legal experience and now have started a political campaign to force the teaching of a “scientific theory of intelligent design” (ID) that is not directly linked to biblical inerrancy.

As Judge Overton said in the 1982 Arkansas decision overturning a law requiring the teaching of scientific creationism, “creation science” was a “religious crusade coupled with a desire to conceal this fact” (6). The new ID creationists, like their scientific creationist forebears, attempt to disguise their religious and political motivations. The curricula of ID creationism and the older

scientific creationism are remarkably alike. Supported by illogical arguments, they are crescendos of erroneous observations about the meanings of the terms evolution and theory, as Massimo Pigliucci, evolutionary biologist of S.U.N.Y., Stony Brook, pointed out. Dr. Pigliucci's book *Denying Evolution: Creationism, Scientism and the Nature of Science* (7) traces the roots of American creationism to populism, anti-intellectualism, and scientism (science as an exclusive ideology to explain everything in human experience) taught by some science teachers. See Dr. Pigliucci's paper below.

Offering only anecdotes and evidence by analogies (e.g., the irreducible complexity of the "designed" mousetrap conflated to apply to biochemical pathways), ID creationist publications, websites, and films use sophisticated propaganda designed to confuse the boundary established between science and religion by traditional academic disciplines (science, philosophy and theology) and the U.S. Constitution. The AAAS, AIBS, Association of Southeastern Biologists (sponsor of the symposium), the American Chemical Society, the American Physical Society, the National Academy of Sciences, the Georgia Academy of Science, along with many other professional societies, have gone on record opposing the older "scientific creationism" and the current ID creationism.

Barbara Forrest, professor of philosophy of Southeastern Louisiana University, has written and spoken extensively about the political machinations of the ID movement. Her book, *Creationism's Trojan Horse: The Wedge of Intelligent Design* (8) is an important contribution to the knowledge of the politics behind the ID movement. Dr. Forrest explained the scope of the ID movement and their political force, which in Kansas recently led to kangaroo courts (Darwin trials) that featured ID creationists. The "trials" were followed by a 6 to 4 vote of the elected members of the Kansas State Board of Education to forward the pro-ID revisions derived from the "trials" ("criticisms of evolution" in K.B.O.E. terms.) to a standards committee of science educators who will certainly not approve them (this review is legally prescribed). Never the less, the Board can approve and enact the ID creationist curriculum in September of 2005 (9, 10, 11) over the objections of the professional review board. At this time (September, 2005) the board of education of Cobb County, GA, using taxpayer money, are appealing the legal decision of U.S. Judge Clarence Cooper (January, 2005) to remove anti-evolution stickers from public school textbooks. These stickers read, "This textbook contains material on evolution. Evolution is a theory, not a fact, regarding the origin of living things. This material should be approached with an open mind, studied carefully and critically considered." The sticker's language, Judge Cooper also ruled, misused the scientific term theory by equating it with a "hunch" (12). See Dr. Forrest's paper below.

IS INTELLIGENT DESIGN SCIENTIFIC?

Taner Edis, associate professor of Physics at Truman State University (MO.) and research associate of the Lawrence Livermore National Laboratory,

explained how the theory of intelligent design is scientifically flawed. He pointed out that Darwinian evolution (natural selection) has taken root outside the confines of Biology by moving into physics. Dr. Edis explained how both chance and necessity, in addition to natural selection, are vital to creativity in general. He has authored an important book on the topic of the symposium: *The Ghost in the Universe: God in Light of Modern Science* (13), and he has edited, with Matt Young, *Why Intelligent Design Fails, A Scientific Critique of the New Creationism* (14). Please refer to Dr. Edis' paper below.

The existence of God and the belief in a Creator cannot be tested or falsified using the methodology of science (6). Keith B. Miller is a research geologist (paleontologist) at Kansas State University and a Christian who has defined and defended the roles of science and religion in society. Dr. Miller and I made clear the value of science to describe nature using the evidence provided by nature itself. As a board member of Kansas Citizens for Science, he is very active in efforts to preserve quality science education in Kansas and to oppose recent attempts by ID advocates to change the public school curriculum. Dr. Miller edited the book, *Perspectives on an Evolving Creation* (15), which reflects his activities with the American Scientific Affiliation who believe that the discoveries of science do not conflict with religion or faith. See a fuller explanation of Dr. Miller's position below.

ID creationists attack the scientific method as "naturalism." Surprisingly, ID creationists want to infuse "supernaturalism" into the science curriculum by considering the role of God in designing nature. Their chief proponent is Phillip Johnson -- a retired professor of law (16). Intelligent Design may explain nature intuitively and therefore, religiously; but not rationally, that is using the logic of the scientific method. The idea is powerful simply because most people already believe it to be true. But scientifically ID theory cannot create testable and falsifiable explanations (hypotheses; see also 6). The so-called "scientific revolution of Intelligent Design," cannot describe how God does things or attempt to predict what God will do with nature. The argument of complexity indicating design is an old scientific creationist argument resurrected. For example, the ID creationist analogy asserting the irreducible complexity of the "designed" ear is much better explained by the fossil evidence of evolving cranial bones. Applying Darwin's principle of descent with modification, evidence clearly shows how ear bones (ossicles) gradually developed from vertebrate jawbones.

The failure of ID creation theory as science is cleverly hidden behind a wall of politically motivated propaganda. Massimo Pigliucci described the logical fallacies ID creationists use to attack the theory of evolution (e.g., equivocating evolution with either Darwinism or atheism). The principal logical flaw of ID is this: the unexplained in science is an opportunity to do further research to explain natural phenomena, not scientific evidence of a designer. As the associate editor of GaJSci Steve Whittle points out, "The invention of every thing we have (machinery, drugs, electrical appliances, etc) was hindered

at one time by a lack of knowledge. ID “science” seems to suggest that an invention cannot take place through observation of nature and experiment, but rather it must await a decision by God to make it” (personal communication). Indeed, in spite of the smoke screen of propaganda, the assumption of a designer is intuitive. As such it is a wonderful religious idea and its believers should proclaim it as such. However, ID is a scientific non-starter according to Taner Edis or a “science stopper” according to Eugenie C. Scott of the National Center for Science Education (10). For instance, one would have to abandon the explanation of how horses came to be. They did not evolve. Natural selection (Darwinism?) could not have been involved. New structures could not have been added one at a time (descent with modification). God designed them. End of scientific discovery!

SALVAGING SCIENCE EDUCATION BY CORRECTING MISINFORMATION

The speakers’ presentations were followed by a panel discussion and questions from the audience. We concluded that the way science is taught has contributed to the public misconceptions that are being seized upon by the ID creationists. Science should be taught as a method of knowledge rather than a mass of facts alone.

We must understand the motivation of the creationists. They have a deep emotional response to any information that is perceived to threaten their understanding of religious scriptures. Although it may sound ridiculous to many, creationist suspicions about the “evils” of evolution and its effects on society must be addressed specifically. Instructors of evolution should avoid the battle of literalisms: scientific literalism vs. scriptural literalism. Science should not be taught as an exclusive way of explaining everything (scientism), as most people need a comfort zone for their spirituality. Scientific theories should be presented as concepts that not only describe a set of discoveries but also serve as a way of predicting new discoveries and formulating new hypotheses.

DECEPTIONS OF SCIENTIFIC CREATIONISM AND INTELLIGENT DESIGN CREATIONISM

After reading 25 years of creationist literature, I offer this list of the common deceptions and misrepresentations made by creationists.

1. They pretend that evolution is only a “theory” in the sense of hunch. They ignore the fact that the vast majority of scientists conclude that evolution of species has occurred in the history of the earth.

2. The scientific creationists demand that their scriptures are, using literal interpretations, scientific descriptions of nature while ignoring flat earth and other conflicting observations that are not supported by science or logic.¹

Although ID takes no formal position on the age of the earth Phillip Johnson wrote, “I have consistently said that I take no position on the age

of the earth, and that I regard the issue as not ripe for debate yet. I have also rejected all suggestions that I should denounce the YECs (young earth creationists) and instead have said that I regard high-quality YECs like Andrew Snelling (staff member of Henry Morris' Institute for Creation Research) as respected allies."² Johnson toured the United Kingdom in 2004, speaking at churches with Andrew Snelling.³

3. The scientific creationists want us to accept their idea that the earth was created 6-10 thousand years ago by criticizing evolution and avoiding the "creation research" that would overwhelmingly prove their point. This logic is similar to proving that UFOs are angels because some have soundly criticized the research techniques of the scientists delving into the reported phenomena. Therefore, the often repeated nostrum follows: "You must believe in either evolution or creation."

4. They pretend that their reactionary political-religious philosophy of teaching by indoctrination is an effort to "protect academic freedom." They justify this approach by saying that public education supports the indoctrination of a theory of evolution. [See reference 5.]

5. The ID and scientific creationists profess their ideas as a "scientific revolution" when they do most of the workshops and recruiting in churches. ID creationists, like their scientific creationist forebears, cannot get their ID articles published in peer-reviewed journals. [I can personally attest that the rejections are for reasons of scientific accuracy.]

6. In order to engage the rapidly rising populist anti-intellectualism of the industrialized world, they portray the theory and evidence of evolution as products of an atheist-humanist conspiracy.

7. They portray themselves as scientific when they don't allow for evidence to falsify their assumptions or otherwise apply the scientific method. By doing this, they practice pseudoscience.

8. They purport that the occasionally heated discussions of evolutionary principles among scientists mean that we privately agree that it is not a real phenomenon. They "cherry pick" statements (misquotes and out of context) to support that contention, making it appear that well known scientists (e.g., Dobzhansky, Gould, Eldridge and Patterson) support their position.

9. Henry Morris and his sons imply that since unconformities (so called out of sequence layers) occur in geological strata, geologists do not know what they are talking about. The same tactic is applied to radiological dating. See Ed Chatelain's excellent explanation of the unconformities of the Grand Canyon, (AZ) at http://www.valdosta.edu/phy/hist_geo_lab/.

10. The scientific creationists flagrantly assume to represent the philosophy of all Christians.

11. Creationists apparently believe that constant repetition of the ID creationist theme "Darwinism is dead" will make it so. The power of a simple propagandistic message is in its repetition. Accordingly, creationists believe democratic action will determine the conclusions made by science. This would be roughly equivalent to allowing a politically powerful lobby of

crystal healers to revise the curriculum of a California medical college.

12. By hammering at the naturalism of science, ID creationists hope to conceal the inadequacy of their “supernatural science.”

13. By asserting that evolution is a religion because it “requires belief,” they attempt to justify their position by confusing the issues. Propaganda, by definition, attempts to confuse issues by presenting misinformation.

14. Contrary to their moral instruction, creationists justify their unethical misuse of science and its findings by asserting that the evolutionists do the same thing.

15. To their “Christian” audience, the Institute of Creation Research accuses “evolutionists” of teaching “animal ethics” (hedonism).⁴

16. Scientific creationists (Gish) declare that there are no transitional fossils. Their reasoning works this way: when a fossil is found that has intermediate features such as Artiocetus, a walking whale or Archeopteryx, a flying reptile with a toothed, lizard-like skull and feathers; their tactic is to define it as one animal, a bird or a whale, respectively. That way they continue claiming that there are no transitional fossils.

¹The Chicago Statement on Biblical Inerrancy: “The truthfulness of Scripture is not negated by the appearance in it of irregularities [errors of] phenomenal descriptions of nature... or seeming discrepancies between one passage and another... Solution of them, where this can be convincingly achieved, will encourage our faith, and where for the present no convincing solution is at hand we shall significantly honor God by trusting His assurance that His Word is true, despite these appearances, and by maintaining our confidence that one day they will be seen to have been illusions.” <http://www.bible-researcher.com/chicago1.html>. Contrast this logic with the naturalism of science and Ockham’s Razor that yields: “What you see is what you get.”

²http://www.touchstonemag.com/blogarchive/2004_09_26_editors.html

³<http://www.darwinreconsidered.org/tournewstu.asp>

⁴<http://www.icr.org/index.php?module+articles&action=view&ID=71>

CONCLUSION: SAVING SCIENCE

Evolutionary theory is powerful. As Theodosius Dobzhansky said, “Nothing in biology makes sense except in the light of evolution” (16). Darwin’s thinking has led us to test the theory of evolution and go beyond his mechanism of natural selection to test new explanations of genetic change and descent with modification. A hopeful view is that the future will bring better knowledge if science maintains the freedom to discover what nature offers. Considering the attempted religious censorship of Bacon in the 1200s, the burning of the heliocentrist astronomer Bruno and the censure of Galileo in the 1600s,

and in the 20th century, Lysenkoist persecutions of scientists in communist Russia (18); specifically, science and human curiosity have a long history of resistance to the dictates of ideologies, be they secular or religious.

Personally, I have no commitment to a theory of evolution or Darwinism other than that allowed by objective evidence for it and its predictive value. But there is something even more precious to protect here: that is the freedom of science to explore, explain, and relate what nature offers as phenomena.

The future becomes dark indeed if religious zealotry, mutated and folded into a political movement built upon pseudoscience and promulgated by the President of the United States, acquires the political power to decide what scientists may explore or what our children may be taught. I recall the ancient accounts of a Roman soldier callously killing the great Archimedes and a mob of religious zealots flaying the skin of Hypatia, a renown pagan female mathematician and philosopher; similarly, scientific discovery and its transmission of knowledge are being threatened by an ideology preying upon a uniformed and misinformed public. The late Carl Sagan warned (19), "We have also arranged things so that almost no one understands science and technology. This is a prescription for disaster. We might get away with it for a while, but sooner or later this combustible mixture of ignorance and power is going to blow up in our faces."

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- It was revised and renamed in 1991 becoming *Christian Education for the Real World*. Cliché or not, the 1977 edition is the creationist *Mein Kampf*. This quote offers a good example of Morris' thinking: "Teaching is not the free pursuit of truth or the sharing of truth, it is indoctrination." See the book review at <http://www.asa3.org/ASA/BookReviews1949-1989/9-78.html>.
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INSIDE CREATIONISM'S TROJAN HORSE: A CLOSER LOOK AT INTELLIGENT DESIGN

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ABSTRACT

Intelligent design (ID) creationists at the Discovery Institute's Center for Science and Culture claim to be advocating good science and education. Although they promote ID as a "full-scale scientific revolution," it is really the newest variant of American creationism. Proponents have no scientific data to support their contention that a supernatural designer explains biological phenomena better than natural processes. They have waged a thirteen-year PR and political campaign to translate their religious views, which include religious exclusionism and anti-secularism, into public policy. Only six states remain exempt from their attempts to influence science standards, curricula, or textbooks. When approaching educational policymakers, they disguise their agenda with seemingly innocuous terminology co-opted from legitimate scientific and educational discourse. ID creationists work through local, state, and national religious organizations and religious/political operatives, including members of Congress. If they succeed, they will damage both science education and the separation of church and state.

Editor's Note: Barbara Forrest appeared on CNN's Larry King Live, August 23, 2005, defending the methodology of science against advocates of Intelligent Design "theory."

Keywords: Intelligent design, politics, Wedge strategy, legal decisions, Michael Behe, William Dembski, Phillip Johnson, Jonathan Wells, Center for Science and Culture, Discovery Institute, Intelligent Design and Evolution Awareness Center, Intelligent Design Network.

INTRODUCTION

In *Creationism's Trojan Horse* (1), Paul R. Gross and I explained the nature and strategy of the intelligent design (ID) creationist movement, which is headquartered at the Discovery Institute (DI), a conservative think tank in Seattle, WA. In 1996, DI established the Center for the Renewal of Science and Culture (CRSC), now called the Center for Science and Culture (CSC), to promote "intelligent design theory." Functioning as DI's creationist arm,

the CSC is advancing a religious agenda by cultivating political influence with state boards of education, local school boards, and members of Congress. Executing a twenty-year plan outlined in a document called “The Wedge Strategy” (a.k.a. the “Wedge Document”), ID creationists hope to drive a “wedge” between the concept of science and the naturalistic methodology by which science operates (2). This would foster in the public mind a pre-modern understanding of science in which God is invoked as a scientific explanation of natural phenomena. An early CRSC website announced that “new developments in biology, physics, and artificial intelligence are raising serious doubts about scientific materialism and re-opening the case for the supernatural” (3). ID proponents call this “theistic science.”

Law professor Phillip E. Johnson began his anti-evolution crusade in the late 1980s following his religious conversion (1). He and his tightly knit cadre of religiously motivated associates call themselves “the Wedge.” While they were formalizing the Wedge Strategy in 1996, DI added the CRSC to its roster of programs, guaranteeing that the Wedge would have a formal home and lucrative “research fellowships.” Johnson became a CRSC advisor. A student creationist group founded in the 1970s (37), Students for Origins Research, transformed itself into Access Research Network (ARN), a separate, auxiliary ID organization in Colorado Springs. ARN functions as a clearinghouse for ID “educational” and promotional materials.

The Wedge Strategy called for publication of thirty ID books by 2003, and the CSC has moved past that goal with books aimed at a popular audience. In 1991, Johnson had already published *Darwin on Trial*, in which he rejects science’s naturalistic methodology (4). In 1996, biochemist Michael Behe published *Darwin’s Black Box*, in which he stated that excluding the supernatural from scientific explanations is “an artificial restriction on science” (5). William Dembski, a philosopher, mathematician, and Christian apologist, followed in 1999 with *Intelligent Design: The Bridge Between Science and Theology*, explaining ID in overtly religious terms (6). In 2000, Jonathan Wells, the only founding Wedge member with a Ph.D. in biology, published *Icons of Evolution* (7), charging that science textbooks present fraudulent material about evolution to unsuspecting students. In 2003, philosopher Stephen C. Meyer co-edited *Darwinism, Design, and Public Education* (8), falsely advertised as a “peer-reviewed science book” (9). In addition to publication, the Wedge is executing virtually every aspect of the Wedge Strategy except the one they list as foundational to their program: “scientific research being done from the perspective of design theory” (2). Despite their protestations to the contrary, ID is a supernatural religious belief that its proponents attempt (unsuccessfully) to conceal behind their scientific pretensions.

Wedge leaders deny that ID is religion and, consequently, that it is creationism. Most worrisome is Meyer’s contention that the 1987 U. S. Supreme Court ruling, *Edwards v. Aguillard*, which outlawed creationism in public school science classes, “does not apply to design theory” since ID is science (13). Claiming that “intelligent design fits the bill as a full-scale

scientific revolution” (36), Dembski challenges critics: “Ask any leader in the intelligent design movement whether intelligent design is stealth creationism, and they’ll deny it” (1). Yet their own words show that ID is characterized by that hallmark of creationism, the rejection of evolution in favor of creation by a supernatural deity. Johnson has stated flatly, “Evolution is a hoax” (1). “Darwinism is not science,” insists Behe (10). DI president Bruce Chapman promotes the falsehood that “Darwinism is a theory in crisis” (12). And Dembski identifies ID as not only a religious but a sectarian Christian belief: “Intelligent design is just the Logos theology of John’s Gospel restated in the idiom of information theory” (11). Wells’ involvement, stemming from a different but equally anti-evolutionist religious affiliation, fulfills his obligation as a “Moonie,” a member of Rev. Sun Myung Moon’s Unification Church. At Moon’s urging, Wells earned a Ph.D. in molecular biology at the University of California-Berkeley, not to do science (he admittedly does no scientific research), but because “Father” Moon convinced him that “I should devote my life to destroying Darwinism” (1). And Wells himself, as a founding Wedge member, confirmed in 1996 that ID is creationism when, calling Johnson a “creationist,” he affirmed that “the most vocal advocates of design in the creation-evolution controversies, however, are creationists rather than theistic evolutionists” (1). (ID proponents reject theistic evolution, which holds that God shaped life through evolution, despite its acceptance by all mainstream Christian denominations. Catholic theologian John Haught is a prominent theistic evolutionist [38], as is scientist Francis Collins, director of the National Human Genome Research Institute [43].)

A telling piece of evidence that ID is not science is the total failure by Wedge scientists to produce original research supporting ID – even by Behe, a practicing biochemist who claims to have embraced ID for scientific rather than religious reasons. Declining to discuss ID at scientific meetings – “I just don’t think that large scientific meetings are effective forums for presenting these ideas” (1) – he chooses instead to discuss it in churches (14). After thirteen years of the Wedge Strategy (which Johnson says began in 1992 at a conference at Southern Methodist University [1]), Paul Nelson, himself a Wedge founder (and young-earth creationist), recently assessed ID’s current scientific status:

“Science in the Key of Design” if you will, is a melody that we’re going to have to teach others to hear and play. First, of course, we have to master it ourselves! ...

Easily the biggest challenge facing the ID community is to develop a full-fledged theory of biological design. We don’t have such a theory right now, and that’s a real problem. Without a theory, it’s very hard to know where to direct your research focus. Right now, we’ve got a bag of powerful intuitions, and a handful of notions such as “irreducible complexity” and “specified complexity” – but, as yet, no general theory of biological design. (15)

Despite ID’s admitted scientific sterility, the Wedge has a nationwide network of supporters and state-level organizations that do the political legwork

in states where the CSC tries to influence public school science standards, textbook selection, or curriculum development. After young-earth creationists initiated efforts leading to the Kansas Board of Education's deleting evolution from state science standards in 1999, ID creationists moved in and assumed the lead role when corporate lawyer John Calvert founded the Intelligent Design Network (IDnet) in Shawnee Mission, KS. Having played a pivotal part in promoting ID in Kansas, IDnet has affiliates in New Mexico and Minnesota and works closely with Science Excellence for All Ohioans (SEAO) to promote ID in Ohio. ID supporters on the Ohio Board of Education, with help from the CSC and IDnet, inserted an ID-friendly benchmark into state science standards and engineered the board's acceptance of a creationist lesson plan for that benchmark. Recognizing the need for recruits, the Wedge also has student supporters. The Intelligent Design and Evolution Awareness Center (IDEA) began as the student IDEA Club at the University of California-San Diego. Transformed into the IDEA Center after its founders graduated, the organization helps establish IDEA clubs at universities and high schools (1). The Intelligent Design Undergraduate Awareness Center (IDURC) is the student division of ARN. The Wedge Strategy also aims at higher education, and supporters among university faculty have used special courses outside required curricula to expose students to ID (16). ID proponent Jed Macosko, who teaches biophysics at Wake Forest University, taught such a class when he was a doctoral student at the University of California-Berkeley. He modeled his class after the one his father Chris Macosko, a chemical engineering professor at the University of Minnesota, taught as a freshman seminar at UM (1). Both courses awarded credit toward graduation, though not in science.

ID CODE WORDS, ALLIANCES AND RELIGIOUS EXCLUSIONISM

In the Wedge's early years, ID creationists candidly displayed their true identity and agenda; they needed to raise money and cultivate their support base, which the Wedge Document calls ID's "natural constituency, namely, Christians" (2). They did not shy away from the word "creationist" and were forthright in their references to the supernatural. However, as they have assumed a higher public profile, they have adopted euphemisms to disguise their aims to mainstream audiences (although they drop their linguistic façade when addressing religious supporters). (See note 45 for a list of ID creationist tactics that will enable parents, concerned citizens, and school officials to identify ID activity if it appears in their school districts.) In the wake of publications exposing ID's religious foundations and political ambitions, they have strategically altered their terminology, attempting to conceal their identity as creationists (1, 17). But their code words are clearly identifiable.

One ID tactic is to try to convince school boards to alter the way evolution is taught, as Darby, Montana, minister Curtis Brickley did in 2004. Brickley's proposal to add "intelligent design" to Darby's high school science curriculum was supported by three of five school board members. Both Calvert and CSC fellow David K. DeWolf, a law professor (13), addressed the board on

Brickley's behalf. After opposition by Ravalli County Citizens for Science (RCCS), Brickley altered his terminology, requesting the teaching of "objective origins" rather than "intelligent design." RCCS ultimately won: a new board scuttled the policy after the next election. But ID activity continues in other states, and ID code talk includes a variety of other euphemisms.

The CSC promotes "teaching the controversy," hoping to convince the public and educational policymakers that there is a raging debate over evolution in mainstream science. Stymied so far in efforts to get ID into science classes via the front door, ID creationists take the backdoor approach of proposing that the "strengths and weaknesses of evolution" be taught in order to encourage "critical thinking" or, as in the Ohio benchmark and lesson plan, "critical analysis" (17). They used the "strengths and weaknesses" approach in an unsuccessful attempt to influence the Texas Board of Education's selection of science textbooks in 2003 (12). ID creationists yet needed another euphemism for their attempt to evade the legal constraints of *Edwards v. Aguillard*, in which the U. S. Supreme Court outlawed creationism while acknowledging that "teaching a variety of scientific theories about the origins of humankind to schoolchildren might be validly done with the clear secular intent of enhancing the effectiveness of science instruction" (18). Viewing this as a legal loophole, ID creationists pronounced ID an "alternative theory," a scientific competitor to evolutionary theory (13). Even further, co-opting the language of civil liberties to disguise their reactionary agenda, they argue that teaching ID is protected by "a teacher's right to academic freedom" (13). One of the most effective terms in the ID lexicon is "fairness," used in constant appeals to allow children to hear "both sides" of ID's contrived controversy. According to Dembski, one of ID's favorite tactics is "to appeal to the undecided middle's sense of fairness and justice, especially its tendency to root for the underdog and its predilection for freedom of expression" (19). But the ID tactic that most conclusively identifies ID as religion is its rejection of "naturalism."

Parents, concerned citizens, and school officials must be able to recognize attempts by ID proponents to make inroads in their communities. Below is a list of their most frequently used tactics:

- Efforts to convince school boards to weaken the way evolution is taught.
- Use of euphemisms and code talk in an attempt to skirt court rulings against teaching creationism:
 - “Teach the controversy.”
 - “Teach the strengths and weaknesses of evolution.”
 - “Teach objective/balanced views of origins.”
 - “Teach alternative theories.”
 - “Teach students to critically analyze evolutionary theory.”

“Academic freedom/fairness requires that students hear ‘both sides.’”

- Objections to teaching “naturalism.”
- Attempts to influence science standards and curricula, using the above code terms.
- Attempts to influence selection of science textbooks, which may include objecting to the books’ instruction in evolution and/or to the exclusion of “alternative theories.”
- Accusations of fraudulent material in science textbooks.
- Proposals for disclaimer stickers in science textbooks and/or verbal disclaimers by science teachers or administrators.
- Efforts to pass ID-friendly legislation that incorporates the above code terms.
- Criticism of taxpayer funding for research in evolutionary biology, geology, and/or other related sciences.
- Involvement of local, state, and national Religious Right organizations.
- Presentations about ID as “science” to school boards, preceded or followed by presentations about ID in churches (where religious terminology is usually integrated into discussion of ID).
- ID proponents touting their scientific credentials. (ID proponents with genuine scientific credentials are usually engineers, physicists, chemists, etc., not biologists.)

ID’s anti-naturalism is central to the Wedge Strategy. Johnson conflates “methodological naturalism,” which is simply a fancy name for scientific method, with “philosophical naturalism,” a metaphysical view that reaches beyond science in its conclusion that the supernatural does not exist. Johnson wrongly but deliberately equates these terms in order to argue that teaching evolution, the product of science’s naturalistic methodology, is tantamount to teaching atheism in public school science classes (20). But his rejection of naturalism is merely a backhanded way of arguing that an appeal to the supernatural can suffice as a scientific explanation. In doing so, Johnson ignores the essential distinction between science and religion that constitutes an elementary understanding of science.

In addition to its strategic use of terminology, the Wedge employs other recognizable tactics intended to undermine the teaching of evolution. ID proponents have played a major role in disputes over science standards in New Mexico, Kansas and Ohio (1). With help from ID creationists such as University of Georgia chemist and CSC fellow Henry F. Schaefer III, the Wedge has been heavily invested in defending the Cobb County, GA, disclaimer stickers (21). Jonathan Wells calls for his readers to protest public funding of evolution research (7). In addition, awakened to the Wedge’s agenda by its aggressive

PR campaign, sympathetic lawmakers have introduced ID-friendly legislation. Among the most egregious was Missouri House Bill No. 911, introduced by Rep. Robert Wayne Cooper into the Missouri General Assembly in December 2003. This abominably written bill, called the “Missouri Standard Science Act,” would have required that “if scientific theory concerning biological origin is taught, biological evolution and biological intelligent design shall be taught and given equal treatment” (39). It would also have required that “willful neglect of any elementary or secondary school superintendent, principal, or teacher to observe and carry out the requirements of this section shall be cause for termination of his or her contract.” From 2001-2003, thirty bills were introduced in fourteen states, and such efforts continue (22). As of April 2005, ten anti-evolution bills had been promoted in state legislatures (23). So far, all such legislation has failed. But CSC creationists now have political influence in the nation’s capital; they used it in an attempt to co-opt the No Child Left Behind Act (NCLB).

In June 2001, Sen. Rick Santorum (PA) introduced a sense of the Senate resolution into NCLB. The “Santorum amendment” seemed innocuous to everyone except those familiar with the Wedge Strategy, who recognized its intent. Written by Phillip Johnson, it singled out “biological evolution” as a subject that “generates so much continuing controversy” that for the sake of “good science education,” students should be taught to “distinguish the data and testable theories of science from philosophical or religious claims that are made in the name of science” (1). The called-for distinction reflected ID complaints that naturalism is supposedly being used in public schools to chip away at students’ theistic beliefs (20). Pro-science and education organizations successfully lobbied to get the resolution removed from the bill, but ID supporters on the conference committee placed a slightly altered version in the legislative history, from whence ID supporters constantly invoke it as authoritative over educational policy. Although the Santorum amendment has no legal force over educational policy, Bruce Chapman and David DeWolf refer to it as “federal policy” with “the effect of law” (1). Influential members of Congress have signaled their agreement. In March 2002, Rep. John Boehner (OH) and Rep. Steve Chabot (OH) wrote a letter on congressional stationery to the president and vice-president of the Ohio Board of Education, incorrectly asserting, “The Santorum language is now part of the law.” In September 2003, Boehner, joined by Sen. Judd Gregg (NH) and Sen. Santorum himself, intervened in the Texas textbook dispute with a letter to Chapman, also on congressional stationery, endorsing DI’s interpretation of the amendment: “The Santorum language clarifies that public school students are entitled to learn that there are differing views on issues such as biological evolution” (24). This letter was distributed to the Texas Board of Education at the selection hearings (25).

Evangelical Christians are an essential support base for the ID movement. The Wedge has evangelical supporters in churches around the country, as well as in campus ministries such as InterVarsity Fellowship and Veritas Forum

(1). Prominent television evangelist Pat Robertson endorsed the teaching of ID on his 700 Club program (40). Prison Fellowship Ministries founder Charles Colson is one of ID's staunchest supporters (41). (There are also evangelicals, including scientists, who actively oppose ID [44].) Some of ID's most vocal supporters, however, are national Religious Right organizations and their state affiliates (1). The most prominent supporter on the Religious Right is James Dobson. Dobson's Focus on the Family (FOF) co-published a professional-looking creationist videotape, *Unlocking the Mystery of Life*, currently being sold by PBS as a science film in its online store. On its August 15, 2003, CitizenLink website, FOF announced that, thanks partly to this video, ID is "blowing Darwinism out of the water." Additional support comes from Religious Right leaders such as D. James Kennedy of Coral Ridge Ministries; Phyllis Schlafly of Eagle Forum; and Concerned Women for America, founded by Beverly LaHaye (whose husband Tim LaHaye co-authored the popular *Left Behind* books). All of these organizations reject church and state separation as a myth.

In addition to its religiously motivated anti-evolutionism, the ID movement has a more ominous side: its leaders attack the secularism and religious tolerance that are vital to constitutional democracy. CSC fellow Benjamin Wiker asserts that ID "directly contradicts the modern secularist intellectual trend that has so thoroughly dominated Western culture for the last two centuries" (26). He warns, "Soon enough, secularized culture will be compelled to realign." Dembski and Johnson promote a disturbing religious exclusionism. Displaying a penchant for military metaphors, Dembski calls ID "ground zero of the culture war" (27). By his own admission, Christian apologetics (the defense of Christianity against perceived attacks) forms the foundation of his work as a "design theorist" (28). For Dembski, ID goes hand-in-hand with an aggressive forward movement into secular society by defenders of Christian orthodoxy: "We are to engage the secular world, reproving, rebuking and exhorting it, pointing to the truth of Christianity" (1). Christianity, he says, has a "dark side" for "those who refuse to embrace this truth." He favors reviving the religious transgression of heresy: "Heresy remains a valid category for today" (1). Knowing that his Christian "mandate" will be unpopular, he asks rhetorically, "Can't we all just get along and live together in peace?" His reply is chilling: "Unfortunately, the answer is no" (1, 29).

Johnson has also exhibited a disturbing tendency to criticize fellow Christians who disagree with him. His unsettling comments have been at times quite personal: during a 2003 radio program, he criticized the religious faith of Brown University biologist Kenneth Miller, a Behe critic and, like Behe, a devout Catholic:

The only reason I have to believe that Kenneth Miller is a Christian of any kind is that he says so. Maybe he's sincere. But I don't know that. If he is, I can say this: you often find the greatest enemies of Christ in the church... [T]here is a kind of person who may be sincere in a way, but is double-minded, who goes into the church in order to save it from itself by bringing it into

concert with evolutionary naturalism... And these are dangerous people. They're more dangerous than an outside atheist, like Richard Dawkins, who at least flies his own flag. So I am not impressed that somebody says that he is a Christian... and believes that evolution is our creator.... [S]uch people often do a great deal of damage within the church. (30)

The religious exclusionism of ID leaders has at times taken on another facet: the criticism of non-Christian religious belief. In an interview about the ID movement with Christianity Today, Johnson, referring to September 11, 2001, spoke in the same breath of Muslim terrorists and Muslim students in American universities. He implied that Muslims worship a false god:

Now we're seeing how the country is almost cringing in fear of these Muslim terrorists from the Middle East. I see professors afraid to discuss the subject because they're afraid of what the Muslim students will do. They're afraid it won't keep the peace on campus. I never thought our country would descend to this level. We are afraid to search the truth and to proclaim it. We once knew who the true God was and were able to proclaim it frankly. (31)

In promoting ID for more than a decade, Johnson has repeatedly stressed his desire to move the country back toward what he considers its Christian foundation. Given his role as the catalyst for the formation of the Wedge and the sectarian Christian foundation upon which he and his fellow Wedge members have built their movement, such exclusionary sentiments can be understood as an integral part of the ID edifice.

CONCLUSION

Journalists have asked me how the Discovery Institute creationists, all well-educated and some with scientific credentials, can truly believe what they tell the public and educational policymakers about ID's purported scientific validity and evolution's impending demise. Although such puzzlement is inevitable if ID is isolated from its cultural, religious, and political framework, the ID movement is not puzzling at all when one views it within this context. It must be understood as part of something more than a strategy dreamed up by a relative handful of well-financed religious zealots: it is another column in the Religious Right's attack on public education and secular society, and the Wedge Strategy constitutes ID's logistical contribution to this attack. The aggressive campaign waged for more than a dozen years now by Wedge members and their supporters points to a troubled future for public education and constitutional democracy. Citizens who value both should understand what the ID agenda portends.

NCLB's 2008 deadline for nationwide, standardized science testing requires the revision of state science standards in time to meet this deadline. Having inserted themselves into the Kansas, Ohio, New Mexico, and Minnesota revision processes, ID proponents can be expected to target standards in other states. Given ID's aggressive recruitment of young supporters, we can also expect anti-evolutionism to become more broadly integrated into American politics. Moreover, the CSC crafted a legal strategy in anticipation of lawsuits

(13), reflecting another Wedge Strategy goal: “We will also pursue possible legal assistance in response to resistance to the integration of design theory into public school science curricula” (2). The first lawsuit over ID was filed in December 2004 against the Dover, PA, school district (32), and more lawsuits can be expected. Wells’ call for his readers to challenge public financing of evolution research could also prompt attacks on research in related sciences such as astronomy and geology (33).

The long-term results of ID proponents’ coordinated actions against teaching evolution, with the consequent diversion of time and money toward fending off its advances, will be the deterioration of science education, already threatened in many places by under-prepared and intimidated teachers. Fewer students who are properly educated about science will translate into fewer students who are qualified to become scientists. And the results of ID’s encroachment upon the public policy-making process include the further erosion of secular democracy, the bulwark of academic freedom that is the lifeblood of science. Separation of church and state may appear only distantly related to science education – until one remembers that we have only one Constitution to protect both. Science education is ID’s chosen vehicle for its role in the Religious Right’s broader attack on secular society. The undermining of church and state separation will mean the undermining of science education as well.

Qualified scientists such as my co-author, Paul R. Gross, have now deflated ID proponents’ scientific pretensions. Other prominent scientists, including Steven Pinker, E. O. Wilson, Francisco Ayala, and Nobelist Steven Weinberg have rejected ID as lacking in scientific legitimacy (42). Detailed accounts and analyses of the Wedge Strategy are available to anyone wishing to understand how it is being pursued (1). But the exhaustive scientific analyses and accounts of the Wedge’s agenda must not overshadow the personal damage ID proponents have done and will yet do. There is no sadder example than Darby, Montana, as recounted by resident and RCCS member Victoria Clark, who said, “The local impact has been huge” (34). Comments by Darby residents whom Clark overheard revealed that the animosity Brickley ID’s campaign stirred up extended not only into the public school where ID would have been taught (“My daughter stormed out of the classroom to avoid more trouble”), but into the business community (“The florist didn’t deliver when she saw my name on the bill”). According to Clark, Brickley’s “objective origins” policy “brought Darby nothing but grief and discord.” His success in turning neighbor against neighbor over the ID issue was reflected in the tension in encounters between citizens on opposite sides. Clark stated, “There [was] a strangeness and bristling up the back, sometimes mixed with hostility” and “a tendency to avoid public conversation.” ID proponents, purporting to defend “critical thinking, freedom of speech, and freedom of religion,” had swallowed ID misinformation whole, contending that “there exists valid scientific criticism of evolution” and that “evolution and God are mutually exclusive.” Fortunately,

the Wedge Strategy failed in Darby because concerned “Darbarians” rallied to the defense of their science curriculum and the Constitution. Both are safe there – at least until the next election. But Clark offers a hard-won lesson to communities who are potential targets of the Wedge Strategy: “[P]ay attention to local trustee elections, follow school board proceedings carefully, be aware of underlying agendas. Save your community from this malignancy.”

Fortunately, help is available. The National Center for Science Education is a clearinghouse for information and advice about ID. NCSE alerts members around the country so they can help resist Wedge efforts in their respective states and elsewhere. Organizations such as Georgia Citizens for Integrity in Science Education (GCISE) make valuable contributions to the anti-ID effort, and there are now other such pro-science organizations (35). Unfortunately, they work with small staffs – and small bank accounts. (See information about the Wedge’s financial largesse in Creationism’s Trojan Horse [1]). NCSE, like GCISE and its sister organizations, needs support from those who benefit, either as scientists, educators, parents, or simply as citizens, from the vital work it does. The beneficiaries of their efforts are invited to contribute manpower and financial assistance. Don’t wait until ID wedges its way into your schools.

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THE ALLEGED FALLACIES OF EVOLUTIONARY THEORY

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The neo-Darwinian theory of evolution is the currently accepted paradigm to explain the history and diversity of life on earth. Yet, since the publication of Darwin's *Origin of Species* it has been under attack on a variety of grounds. Some of these criticisms have been put forth in the philosophical arena, where evolutionary theory has often been accused of being incoherent or logically fallacious.

Perhaps the best-known philosophical criticism of evolution has been put forth by Karl Popper, who once claimed that "Darwinism is not a testable scientific theory, but a metaphysical research program" (1). Famously, Popper retracted his comments, once it was explained to him that there was quite a bit more to the theory of evolution than he had understood from a cursory examination of the subject: "I have changed my mind about the testability and logical status of the theory of natural selection; and I am glad to have an opportunity to make a recantation" (2).

Peter Williams (3) listed a bewildering array of eleven logical fallacies allegedly committed by evolutionary biologist Richard Dawkins in a variety of his writings. In what follows we reexamine each of the fallacies and comment on the extent to which Dawkins actually commits them. This article is not meant as a defense of Dawkins (who can surely take care of himself), but rather as a stimulating exercise tackling the logical framework of modern evolutionary theory and its real or perceived philosophical implications.

THE ALLEGED FALLACIES

1. Self-Contradiction – a statement that refers to and falsifies itself.

Williams quotes an open letter of Dawkins to his daughter, in which he advises her to think for herself, determine if a claim is being made on the basis

of evidence or authority, and ask for evidence whenever somebody claims to know the truth. The problem allegedly is that Dawkins is conflating evidence with empirical evidence, from which it apparently derives that Dawkins also equates knowledge with scientific knowledge. Since the latter position is not itself based on empirical evidence, it follows that Dawkins contradicts himself by suggesting a course of action to his daughter that cannot actually be backed up by the very methods proposed by Dawkins.

We feel Williams is reading too much into Dawkins' advice. Dawkins starts out by simply suggesting a sensible course of action to his daughter whenever faced with evaluating somebody's claim to truth; he is not saying that his advice is scientific, nor is he equating knowledge with scientific knowledge. As for what counts as evidence, the American Heritage Dictionary defines the latter as: "the available facts, circumstances, etc., indicating whether or not a thing is true or valid." From this perspective, most evidence is in fact empirical. The only exception would be mathematical or logical reasoning, although most people wouldn't think of this as 'evidence' so much as a 'reason' in favor of a certain conclusion. Finally, empirical (but not necessarily scientific) evidence for Dawkins' statement could be brought in: one only needs to compare the number of successful decisions that people make about, say, their finances based on reading their horoscopes vs. following the advice of a financial expert (if the latter is backed by empirical evidence on the performance of various portfolios).

2. Begging the Question - the fallacy of using the conclusion of an argument as one of the premises employed to establish that conclusion.

The problem here is that Dawkins seems to assume a naturalistic and gradualistic explanation for the diversification of life on earth. He claims that one can see that this must be true without stirring from one's chair, as any other explanation can be ruled out on first principles. Williams concludes that Dawkins must take this philosophical (not scientific) position because he wants to exclude intelligent design a priori.

Indeed, Dawkins should not have said that one can see the truth of Darwinian evolution without stirring from one's chair. Evolutionary biology is an empirical science, and it is only because of more than a century and a half of investigation that we have concluded that it is the best available explanation for the history of life on this planet. But there are two crucial distinctions that Williams fails to make: a) Darwinian gradualism is only one of a panoply of naturalistic explanations of evolution (others include Lamarckism, orthogenesis, and saltationism); while it is indeed the one currently most widely accepted by scientists, it is false to charge that it is the only game in town and is therefore accepted by default. b) Both Dawkins and Williams should make the all-important distinction between philosophical and methodological naturalism. Philosophical naturalism, the position that all there is to the world is natural phenomena, is indeed outside of science proper. But what all scientists espouse is methodological naturalism, the operational position

that the best way to find a testable explanation for a phenomenon is to assume that only natural laws are at work. While creationists make a big deal of this alleged 'bias', in fact all of us behave as methodological naturalists most of the time. We are willing to bet (and this is an empirically verifiable prediction) that the next time that Williams' car breaks down he will not go to church and ask his preacher to fix it; he will instead bring it to a mechanic, seeking a natural solution to the problem. Moreover, even if the mechanic should not find any remedy, Williams will not therefore turn to God, but will ditch the car assuming (reasonably) that the facts are simply insufficient to find the correct natural fix, and that he is better served by another means of transportation.

3. The False Dilemma - Two choices are given when in actuality there are more choices possible.

Williams quotes Dawkins saying that William Paley's supernatural explanation for the complexity of life and Charles Darwin's natural alternative are mutually exclusive. Williams cites Michael Poole as clarifying the difference between explanations in terms of agency and those in terms of mechanisms. The two do not have to be in contradiction, since a particular agent (say, God) could use a given mechanism (say, natural selection) to achieve whatever goal the agent sets forth.

We see two problems with Williams' position: first, he equivocates on Paley. Paley was not talking about God just being the agent determining biological complexity, he thought of God as also being the mechanism: in other words, it is anachronistic to see Paley as a theistic evolutionist, since he was defending the classical Christian doctrine that God created humans and everything else directly, not through the action of natural laws. Second, while at a more general level Poole is correct that agency and mechanism are not necessarily mutually exclusive, 'God did it' simply does not qualify as a scientific explanation because it doesn't add anything to the rational explanatory schema.

4. The Fallacy of Equivocation - a word is used in two different contexts and is assumed to have the same meaning in both contexts, when distinct meanings ought to be preferred.

Williams here takes Dawkins to task for shifting the meaning of the word 'designoid', coined to explain why the appearance of design in biological organisms is just that, an appearance. Dawkins says that there are natural objects that superficially look like the result of design, for example a rock looking a bit like the face of an American President. He claims that this is the same sort of phenomenon that induces people to think that, say, the vertebrate eye is designed. The problem is that the first type of 'designoid' is obvious (i.e., people immediately realize that the face was not actually carved), while the second is much more subtle and – Williams claims – therefore belongs to a different category.

We think Williams is partially right here: Dawkins did choose a bad example, and for fundamentally wrong reasons. The resemblance of a cliff outcropping to a human face is the result of entirely random causes (wind patterns, the consistency of the rock, etc.), while biological organisms are the outcome of two processes: mutation (which is indeed random) and natural selection (which is anything but random). That is why Dawkins' designoids don't cut it. However, Dawkins' fundamental point can be rescued by simply using a better analogy. There are natural, non-biological, processes that convey the impression of intelligent design and provide us with a more closer parallel to evolution. For example, on many rocky beaches, pebbles are sorted by size going from the waterline towards the interior, in a distinctly nonrandom pattern. This is not because somebody got all the pebbles out of the ocean, carefully weighed them, and then constructed the beach. Rather, the pattern was created by the joint action of two processes: the (random) action of waves and the (nonrandom) effects of gravity.

5. The Non Sequitur – Comments or claims that do not logically follow from what has gone before, but that are presented as if they do.

Williams here leaves the field entirely to a quote from Stephen Barr, who accuses Dawkins of attempting to defend science from allegations of being 'joyless' and 'arid', while not recognizing that 'the public' raises those objections to atheism, not to science itself. Apparently, Dawkins does not seem to see the difference between science and atheism.

It is a bit difficult to make sense of what exactly the charge is here, and especially of why this would be an example of non sequitur. We take it that Williams' intended target of criticism is the move from modern science's discoveries to the philosophical position of atheism. Dawkins does indeed often state that his atheism is reinforced by the scientific understanding of the world: the more science finds out about nature, the less room there is for a direct intervention by supernatural entities. Now, if what Dawkins means is that atheism is logically implied by evolution, then he is surely wrong. On the other hand, to deduce philosophical (moral, existential, etc.) conclusions from the best available knowledge of the world is certainly not illogical, and seems to be the rational thing to do. The important distinction, therefore, is between an atheism that is informed by science (which is plausible), and one that is made logically necessary by science (which is illogical).

6. Special Pleading (double standard) - the fallacy in which one criticises others for falling short of particular standards and rules, while taking oneself to be exempt, without adequately justifying that exemption.

The alleged fallacy here lies in the fact that Dawkins on the one hand rejects 'God' as an explanation, on the ground that there is no way to tell where God himself came from, while at the same time accepts natural selection as a valid explanation of the diversity of life on earth, even though natural selection itself cannot explain where life comes from.

We see three problems in William's position: First, natural selection was never meant as a theory of life's origins, while 'God did it' clearly is. Second, Dawkins would be engaging in special pleading if he had not provided an account of how natural selection (not life) began, since the explanatory principle parallel to 'God' here is selection, not life (life is what needs to be explained by either 'hypothesis'). But evolutionary biology does have an explanation for how natural selection comes into being: it happens as soon as there is a population of self-replicating, variable, molecules. No such explanation is available for God. Third – once again – 'God did it' is not an explanation, but a fancy way of admitting ignorance: an explanation is an account of mechanisms (such as natural selection), not a label to put on the facts.

7. Wishful Thinking - a fallacy that posits a belief because it or its consequence is desired to be true.

Williams comes really close to catching Dawkins (but not science in general) in flagrante delicto. Dawkins is cited by Williams writing that nobody knows how life on earth originated, but it must have been by natural causes.

If Dawkins is reaching that conclusion – as Williams alleges – because of his philosophical position of naturalism (i.e., atheism), then he is in fact engaging in wishful thinking (though no more than the other side when they say that life must have originated from an act of special creation). However, there is a more moderate interpretation of Dawkins' statement: he is just being a good scientist in accepting as a matter of methodology that the only way to find a scientific explanation for the origin of life is to tentatively assume that there is one that doesn't include supernatural intervention. One may not like the idea that science is limited to natural explanations, but it is hard to see what sort of experiments or testable hypotheses could possibly emerge from introducing a supernatural fiat into these matters. As an aside, we also point out that Williams' statement that there is "a large body of scientific evidence against" a naturalistic theory of the origin of life is simply false (see, for example, *The Emergence of Life on Earth: a Historical and Scientific Overview* by I. Fry, Rutgers University Press, 2000.)

8. The Red Herring - A Red Herring is an irrelevant topic or premise brought into a discussion to divert attention from the topic at hand. Usually, the irrelevancy is subtle, so that it appears relevant to those not paying close attention.

This is really another version of the objection raised under fallacy #6, but with a different twist. Williams claims that the real problem of evolutionary theory is to explain the origin of catalytic proteins (enzymes), and accuses Dawkins of distracting his readers from it by introducing natural selection as an explanation of how enzymes became more complex beginning from a simple molecule.

Once again, evolution by natural selection is not, and was never meant to be, a theory of life's origins. Ironically, it is the creationists who make a

red herring out of this issue, since they keep misinterpreting the scope of evolutionary theory. Natural selection is (demonstrably) perfectly capable of changing and improving the catalytic actions of proteins, which is all the theory claims. On the other hand, it is true that we still don't know how the first replicators originated; however, what is needed for a naturalistic theory of origins is that the first replicators were simple enough to originate randomly. This does not seem an inordinately unlikely supposition. Lastly, it is interesting that Williams introduces the concept of 'irreducible complexity' of proteins as if it were widely accepted in science. It is not.

9. Straw Man Argument - a type of Red Herring that attacks a misrepresentation of an opponent's position. That is called to burn a straw man. It is a surprisingly common fallacy, because it is easy to misunderstand another person's position.

The incriminating passage here is one in which Dawkins states that the difference between science and religion is that the former is based on evidence and 'gets results', while neither apply to the latter. Williams, curiously, takes this to be an attack on Christianity in particular, and responds that there has been a strong Christian tradition of valuing rationality.

First, Dawkins was taking aim at religion in general, not especially at Christianity. Second, the criticism was that religion is not based on evidence, which is not the same as accusing religious people of not valuing rationality. One can construe rational arguments in favor of the existence of God, but one cannot provide any evidence to back up such constructs. Science is an inextricable combination of rationality and evidence: without the latter, it would not be different from logic or philosophy. Lastly, while it is certainly true that there are great traditions of rational inquiry within Christianity, do we need to remind Williams that the Church always put very strict limits on such 'free inquiry'? Just think of Bruno, Copernicus and Galileo. The scholarly tradition of the Catholic Church is surely well represented by the Jesuits (for example, they run the Vatican astronomical observatory in Italy), and yet it was the Jesuits who opposed Galileo and famously refused to acknowledge the observational evidence he was providing through his telescopes. It is hard to think of a better example of how differently science and religion approach the relationship between rationality and faith.

10. Ad Hominem – the fallacy of attacking the individual instead of the argument.

Dawkins, in his characteristic bluntness, likens people who believe in God to children who believe in Santa Claus. Williams takes this to be an ad hominem attack, and hence a logical fallacy. Williams then goes on, somewhat curiously, to state that even children are sometimes right, and that therefore one cannot dismiss childish beliefs altogether.

We chastise Dawkins for his language, which is sure to inflame and certain not to gain him much sympathy. On the other hand, this hardly qualifies as

a fallacy because Dawkins is not using the ‘belief in God = childish thinking’ equation as an argument against the existence of God. On the contrary, he begins with the premise that God is a fairy tale and then deduces (in a perfectly logical manner, if one accepts the premise) that believing in God is as childish as believing in fairy tales. Of course children (or childish adults) can be right about certain things, but Socrates (in Plato’s *Meno*) convincingly argued that true belief without cause is nothing to brag about.

11. Poisoning the well - a form of ad hominem attack that occurs before the meat of an argument, biasing the audience against the opponent’s side before he can present his case.

Dawkins is once again taken to task for his language. In some of his writings, he alleges that no qualified scientist doubts the reality of evolution, the implication being that one should not pay attention to arguments advanced from people who do not believe in evolution, because they are not qualified on such matters.

As in other cases, we agree with the criticism of Dawkins’ language, which is clearly hyperbolic (heck, if one searches hard enough one can find qualified scientists who doubt quantum mechanics, by most accounts the best scientific theory of all time!). Dawkins can indeed reasonably be taken to be ‘poisoning the well’ here. However, we find Williams in turn to be rather disingenuous (and relying on an appeal to authority, a fallacy in itself) when he quotes three allegedly qualified and unbiased authors on his behalf: William Dembski, Jonathan Wells, and Thomas Woodward. All three are open Christian apologists, and therefore cannot seriously be considered to be ideologically unbiased (note that while Dawkins is an open atheist, there is a large number of religious people from many denominations among evolutionary scientists). Moreover, Dembski has degrees in mathematics and philosophy, Woodward teaches theology at a fundamentalist Christian school for ministers, and Wells has a degree in biochemistry and molecular biology. None of them are qualified to comment on evolution for the simple reason that their degrees are not in any of the organismal biological sciences. One of us (Massimo Pigliucci) has a Ph.D. in Botany, which is an organismal biological science, but he would hardly feel qualified to comment about the reasonableness of, say, quantum mechanics. Just because one has a Ph.D. one is not automatically qualified to pontificate on all topics, as much as one’s ego might incline one to think so.

SCIENCE, PHILOSOPHY, AND THE LIMITS OF LOGIC

This entire discussion is based on the concept of logical fallacies. But reasoning can be logical, and even correct, at the same time that it is strictly speaking fallacious. For example, one of the classical fallacies is the post hoc ergo propter hoc (after that, therefore because of that), where one infers that the cause of a certain effect is a particular event on the basis of the fact that the alleged cause preceded the effect in short time (e.g., I woke up with

a headache this morning; I drunk red wine last night; ergo the wine caused the headache).

It is important to realize in what (very strict) sense post hoc ergo propter hoc is a fallacy: if one wishes to say that it necessarily follows that if two events are temporally close to each other, then the first one causes the second one, this is obviously not true. We have plenty of examples of temporal sequences the elements of which are not causally connected (e.g., last night it also happened to be full moon, but that very likely had nothing to do with my headache this morning). However, it is perfectly rational to begin the investigation into causes based on correlations, which is exactly what science does. If I know that certain kinds of red wine (e.g., high in sulfites) are prone to cause headaches in certain individuals, and if I repeatedly observe that when I drink those kinds of wine I often develop a headache the following morning, then I am logically justified in tentatively concluding (pending further evidence) that my headaches really are caused by high sulfites levels in red wine (and I ought to stop drinking such concoctions).

It follows from all of this that science is inherently an approach that can lead only to tentative conclusions, while if one wishes Truth one is limited to the realm of logic and mathematics. Philosophy occupies an interesting middle ground between these two approaches: while a philosopher attempts to build bullet-proof logical arguments (i.e., she aims at logical truth of the formal kind), the premises of her reasoning can only be of two types (Hume's famous 'fork'). Either one starts with arbitrary or unfounded statements, in which case even logically tight reasoning leads nowhere; or one begins with empirical observations about the world, and philosophy therefore shares some of the limitations of science. A lot of ink and bad feelings would be avoided if people realized that human beings (with the exception of logicians) cannot attain Truth, but only more or less likely maybes.

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COUNTERING PUBLIC MISCONCEPTIONS ABOUT THE NATURE OF EVOLUTIONARY SCIENCE

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ABSTRACT

Challenges to modern evolutionary science are often rooted in fundamental misconceptions about the nature of science itself. Among the public, there is a widespread perception that the focus of science on natural cause-and-effect explanations is a thinly disguised effort to promote a godless worldview, rather than an inherent methodological limitation. Furthermore, the general public often view theories as merely unsubstantiated guesses, rather than as the unifying concepts that give our observations coherence and meaning. Theories within the historical sciences, in particular, are seen as being inherently untestable without an objective basis for assigning validity. Science for many is simply an encyclopedic accumulation of unchanging observational “facts.” The dynamic nature of science with the continual revision of theoretical constructs becomes for them evidence of the fleeting validity of scientific “truth.” The future of scientific literacy will depend on how we respond to these misconceptions as scientists and educators.

Key words: Nature of science, science teaching, evolution, methodological naturalism, scientific method, theory, philosophical naturalism, creationism, intelligent design

INTRODUCTION

Misunderstandings and fallacious understandings of the nature and limitations of science are widespread in our culture. They underlie much of the popular resistance to the conclusions of modern science, particularly historical sciences. Misunderstandings about the nature of science also lay at the foundation of most of the recent attacks on public science education by Intelligent Design proponents and traditional creationists. These efforts are expressions of deeply held, but entirely false, views of science that threaten many people’s religious world views.

Although the popular ignorance of the conclusions of modern science has been widely recognized, the false understandings of the nature and practice of science are more fundamental and present a greater obstacle to scientific literacy. This is particularly true for the “historical sciences” – those sciences that deal with the reconstruction of the past. Those who oppose the current



conclusions of the historical sciences commonly see scientific and theological descriptions of reality as being mutually exclusive and contradictory (1). A “warfare” view of science and faith is widely assumed. This view is supported by erroneous understandings of the nature of historical and theoretical science. A distorted understanding of the history of science also exacerbates this view.

Too many people in our society view science as simply the discovery of unchanging truths to be memorized and added to an encyclopedia of scientific knowledge. Theories are viewed as merely unsubstantiated guesses, rather than as the unifying concepts that give our observations coherence and meaning, provide us with a basis to make testable predictions, and ultimately to solve scientific problems. As a result, many people are unable to distinguish valid scientific conclusions from pseudoscience. The dynamic nature of science, with its continual revision of theoretical constructs, becomes evidence in the eyes of the public for mistrusting the validity of scientific “truth” and a basis for its outright rejection. Theories within the historical sciences, in particular, are seen as being inherently untestable and driven by a materialistic philosophical agenda (2).

The widespread public misperceptions of science are clear indicators that science educators have largely failed to communicate the processes by which scientific understandings of the natural world are obtained. Helping students to understand the nature and limitations of science is a fundamental part of science education. In recognition of this, the nature of science (NOS) is a prominent theme within all comprehensive science standards. This prominence is well articulated in documents such as Science for All Americans (3) and the National Science Education Standards (4). The NOS theme is also part of many state science standards, including those of Kansas.

The effective teaching of evolutionary science is also tied to the teachers’ understanding of the nature of science. For example, studies of both college students and science teachers have shown a clear relationship between the lack of understanding of the nature of science and low acceptance of the theory of evolution (5). Furthermore, middle and high school teachers have not been adequately prepared to teach the NOS. Too often the NOS is left to implicit inference through students’ science classroom experiences and reading, rather than being an explicit topic of instruction (6). This is especially the case when science is taught as a package of received factual knowledge to be learned, and where the emphasis is placed on the results of confirmatory laboratory assignments rather than on the dynamic process of inquiry itself.

Science teachers and educators need to be more aware of the popularly held erroneous understandings of science, and develop strategies to directly and effectively address them. Informing students and the larger public of how science really works, and what questions it does and does not address, is critical to combating the appeal of anti-evolutionary creationist arguments.

DISCUSSION

Misconceptions and obstacles to scientific literacy:

This paper will first present a number of the common public misconceptions of the nature of science, and briefly outline a response to each. This will be followed with some suggested educational remedies.

Science is a thinly disguised effort to promote a godless worldview.

Scientific and religious understandings of the origin and evolution of the universe, earth, and life are widely seen as being in tension if not outright opposition. Evolution in particular is seen as inherently atheistic and inseparably wedded to a worldview that denies God and objective morality. Evolutionary theory, often pejoratively referred to as “Darwinism,” is also perceived as denying purpose and meaning. As a result, the science of evolution and the theology of creation have become in the minds of many two mutually exclusive explanations. Such dichotomous thinking is also consistent with our cultural preference for simplistic answers to complex problems.

For traditional creationists and most Intelligent Design (ID) supporters, the conviction that evolutionary theory and orthodox Christian faith are in irreconcilable conflict is fundamental. It is also a central part of the political strategy of the ID movement. As stated by Phillip Johnson, one of the founders and leaders of the ID movement: “The objective [of the Wedge Strategy] is to convince people that Darwinism is inherently atheistic, thus shifting the debate from creationism vs. evolution to the existence of God vs. the non-existence of God.” (7)

The broader “warfare” view of science and faith owes much of its modern expression to a pair of widely influential 19th century works – John William Draper’s *History of the Conflict between Religion and Science* (1874) and Andrew Dickson White’s *A History of the Warfare of Science with Theology in Christendom* (1896). Such views have been perpetuated by simplistic and grossly inaccurate historical summaries. However, this warfare view has been thoroughly discredited by both theological and historical scholarship (8). Christian theologians (including evangelicals) have long recognized that a faithful reading of Scripture does not demand a young Earth, nor does it prohibit God’s use of evolutionary mechanisms to accomplish God’s creative will. Many evangelical Christians at the time of Darwin found no inherent conflict between evolutionary theory and scripture. In fact, several of the authors of the “Fundamentals” (the set of volumes that gave us the term “fundamentalist”) accepted some form of evolutionary theory. One of these was B.B Warfield, a theologian who argued forcefully for Biblical inerrancy, and who accepted the validity of evolution as a scientific description of origins. Probably the most prominent advocate of evolutionary theory in America in Darwin’s time was Asa Gray, a committed evangelical Christian (9). To the present day, Christian scientists and theologians have articulated this integration of evolutionary science and Christian faith within a broad range of theological traditions (10).

Although the conflict perspective continues to be promoted by some individuals within both the religious and scientific communities, its conflation of philosophical materialism or atheism with evolution must be rejected as philosophically, theologically, and historically false. As long as this false view is allowed to remain in students' minds, they (and by extension the general public) will be unable to accept the conclusions of science, no matter how well they are taught. The scientific enterprise is a limited way of knowing about the natural world. Scientific research proceeds by the search for chains of cause-and-effect, and confines itself to the investigation of "natural" entities and forces. This limitation of the scientific enterprise is sometimes referred to as "methodological naturalism." Science restricts itself to proximate causes, and the confirmation or denial of ultimate causes is beyond its capability. Science does not deny the existence of a Creator – it is simply silent on the existence or action of God. Methodological naturalism is not a prescriptive "rule", but simply describes what empirical inquiry is. It is certainly not a statement of the nature of cosmic reality. Science does not, and cannot, say that material things are all that exist, or all that matter. Science pursues truth within very narrow limits. Our most profound questions about the nature of reality (questions of meaning and purpose and morality), while they may arise from within science, are theological or philosophical in nature and their answers lie beyond the reach of science.

Some non-theists see God as an unnecessary addition to a scientific description of the universe, and therefore extend this to a philosophical exclusion. In fact, God is unnecessary, or rather irrelevant, for a scientific description, but a scientific description is not a complete description of reality. Scientific methodology excludes appeals to supernatural agents because it has no way to test for the action of such agents. To then use this methodological exclusion to support a philosophical exclusion is completely fallacious. That science does not make reference to God says nothing about whether or not God is actively involved in the physical universe or in people's lives.

One very important feature of the scientific enterprise is that it takes place within a multi-cultural and interfaith community of scholars. At a typical professional scientific meeting there will be participants from a wide range of nationalities, cultures, and religious traditions. Yet, those scholars can sit down together and productively discuss scientific questions, examine evidence and even reach consensus conclusions. They can do this because scientific knowledge is not tied to a particular religious or non-religious worldview – it is universally accessible. Any attempt to incorporate supernatural action into scientific description, or to declare that science is inherently atheistic, undermines this religious neutrality.

The methodological naturalism (MN) of science restricts the search for truth.

Many Intelligent Design (ID) advocates argue that MN arbitrarily and unjustifiably excludes supernatural agency from scientific explanation. They

believe that this exclusion of God from scientific description unnecessarily restricts the search for truth. Phillip Johnson has made this a prominent focus of his arguments.

“We [members of the intelligent design movement] are opposed by persons who endorse methodological naturalism, a doctrine that insists that science must explain biological creation only by natural processes, meaning unintelligent processes. Reference to a creator or designer is relegated to the realm of religion, and ruled out of bounds in science regardless of the evidence.” (11)

Note that MN is treated as a doctrine, a philosophical assumption, rather than a methodological limitation of scientific inquiry. In much of the ID and traditional creationist literature, MN is falsely presented as equivalent to philosophical naturalism or materialism. That is, the practice of science is seen as based on a philosophy that claims that the material universe is all that there is.

ID advocates believe that the exclusion of God from scientific description unnecessarily restricts the search for truth. It does nothing of the sort. If God acted in creation to bring about a particular structure in a way that broke causal chains, then science would simply conclude that: “There is presently no known series of cause-and-effect processes that can adequately account for this structure, and research will continue to search for such processes.” Any statement beyond that requires the application of a particular religious worldview. Science cannot conclude “God did it.” However, if God acted through a seamless series of cause-and-effect processes to bring about that structure, then the continuing search for such processes stimulated by the tentativeness and methodological naturalism of science may uncover those processes. Using an ID approach, the inference to “intelligent design” would be made, and any motivation for further research would end. Thus, ID runs the risk of making false conclusions, and prematurely terminating the search for cause-and-effect descriptions when one wasn’t already at hand. Furthermore, how would a gap in our knowledge be filled unless there was a continued effort to search for possible “natural” causes? Thus even the verification of gaps requires research conducted using MN assumptions.

In both the 1999 and 2005 Kansas science standards controversies, a single word has been the focus of a great deal of attention. That single word is “natural.” Scientists and science educators describe science as a human process of discovering natural explanations for the physical world around us. Creationists and ID supporters want to remove the word “natural” from the definition of science so that supernatural explanations can be admitted. However, an appeal to a supernatural agent does not provide any insight into how a particular event or process occurred. The intelligent design approach of “God did it” can explain anything, but doesn’t provide the cause-and-effect understandings of physical phenomena that are the proper subject of science.

Supernatural action is a legitimate subject of scientific inquiry.

Both traditional creationists and ID supporters have been seeking to have “non-natural” or supernatural action included as a legitimate part of scientific explanation. One way that this view is expressed is that science pursued under theistic assumptions must differ in its scientific conclusions from science as currently practiced. There is the strong desire to see scientific evidence for divine action, to have theistic arguments be part of science. William Dembski, a prominent ID advocate, has stated:

“... intelligent design is incompatible with what typically is meant by theistic evolution. Theistic evolution takes the Darwinian picture of the biological world and baptizes it, identifying this picture with the way God created life. When boiled down to its scientific content, however, theistic evolution is no different from atheistic evolution, treating only undirected processes in the origin and development of life.” (12)

Note that this statement implies that “Darwinian” evolution is inherently atheistic and must be in conflict with a theistic perspective. It also accepts uncritically that evolution denies the possibility of divine guidance or purpose.

As previously argued, the methodology of science is incapable of investigating supernatural action. Even what scientific research is conducted by ID advocates is conducted using MN. The genetic research of Michael Behe, for example, is entirely consistent with standard science using a MN approach. There simply is no way to incorporate the actions of non-natural agents into a scientific research program. What ID proponents typically do is to overlay philosophical and religious understandings on scientific conclusions. They invest particular scientific observations with theological meaning. It is entirely appropriate for anyone to apply his or her religious and philosophical perspectives to interpreting science. Theists as much as atheists can, and should, work toward a comprehensive integrated worldview. However, that does not make such philosophical perspectives themselves scientific. It is no more appropriate to argue that science can conclude that “God did it,” than to argue that science demonstrates that the natural world is all there is, or that natural process are divinely unguided and without ultimate purpose.

From the perspective of scientific inquiry, a supernatural agent is effectively a black box, and appeals to supernatural action are equivalent to appeals to ignorance. A supernatural agent is unconstrained by natural “laws” or the properties and capabilities of natural entities and forces. It can act in any way, and accomplish any conceivable end. As a result, appeals to such agents cannot provide any insight into understanding the mechanisms by which a particular observed or historical event occurred. Belief in the creative action of a supernatural agent does not answer the questions of “How?” “A miracle occurs here” is no more an answer to the question of “How?” than is “We don’t know.” The scientific community’s passion is to understand the “Hows” of the natural world. It is the gaps in our current understanding of the natural world – those black boxes – that draw the attention of scientists and drive new discovery and new theoretical insights.

True science deals with proven facts.

Many people see science as an encyclopedic listing of unchanging facts. Since scientific “facts” are equated with “truth,” once discovered they cannot change. This is an essentially static view of science, and very much at odds with the tentative nature of scientific conclusions and the dynamic process of scientific inquiry. It also elevates the discovery of observational “facts” as the fundamental objective of science. Theories on the other hand, are viewed as mere guesses and speculation. This is commonly expressed in phrases such as “Evolution is just a theory.”

However, science is not the mastery of a body of unchanging scientific “facts”, but a way of inquiring about our physical environment. It provides a way of understanding, explaining, and integrating our diverse observations of the natural world. Theories place our observations into an explanatory context and give them coherence and meaning. Although observations form the foundation of scientific description, serious theoretical inquiry is the essence of science. Observational “facts” by themselves are lifeless and do not yield understanding. Nothing could be more deadly to science than to divorce it from the unifying theories that give observations meaning. Theories also provide the predictions that suggest new observations and drive new discovery. Theories are the very essence of the scientific enterprise.

Scientific theories are not speculations or guesses but well-supported interpretations of the natural world. They are built up from many hypotheses that have survived repeated tests against new observations. However, no scientific theory can be proven in the sense of a mathematical or logical proof. Any accepted scientific theory is simply the best existing explanation for the observations already made, and rests on the continued success of the hypotheses that are generated from it. Science is a dynamic enterprise of understanding the natural processes operative in the universe. Scientists modify or even replace theories as new observations accumulate and improved explanatory models are developed. The very strength of scientific methodology is that ideas are subject to testing and verification.

The construction and testing of hypotheses is fundamental to scientific inquiry. Although different fields of scientific study have unique ways of approaching their subject, there are some basic elements that characterize scientific methodologies.

- 1) Observations are made of the natural world, whether directly or through the use of instruments.
- 2) Perceived patterns and regularities in these observations become the basis for proposing a hypothesis to explain them. This occurs within a set of already existing broader theoretical understandings.
- 3) A new set of observations not yet made is predicted deductively from the hypothesis.
- 4) The hypothesis can then be tested against these new observations. The original hypothesis may be supported, or the new observations may be found to be inconsistent or unexpected.

The above process may be followed very formally. However, it may also be followed in an informal, almost subconscious, way as a scientist generates and tests new ideas while working on a research problem.

Although hypotheses can be disproven by the methodology of science, they cannot be positively proved. Scientific conclusions are always tentative. However, the more the expectations generated by a hypothesis are confirmed, the more confidence the investigator has in that explanation. The success of hypotheses in turn lends additional support to the theories upon which those hypotheses rest.

There is no way to objectively select among “theories.”

If a “theory” is understood simply as a guess or speculation, then one person’s “theory” can be as good as another’s. This is particularly true if scientific theories are viewed as resting more on philosophical bias than objective observations. Any person’s idea becomes a “theory” with an equal claim to serious consideration. Arguments of any type and merit can then be seen as having equally valid claims to “truth.” For the public, selecting between competing theories is more a matter of choosing authorities than critically evaluating scientific claims.

Scientists constructing scientific theories, and their component hypotheses, are influenced by philosophical, religious and cultural assumptions. The investigator(s) may even be unaware of some of these influences. However, those hypotheses are subject to test, and will not become widely held by the scientific community unless their predictions are fruitful. The source or inspiration for an idea is irrelevant to its utility as a scientific hypothesis. The validity of the idea must stand or fall on its own.

Theories change and are modified over time as new discoveries are made and new more productive interpretive frameworks are proposed. Some are ultimately rejected by the preponderance of practicing scientists, and others remain at the fringes provoking critical examination. How do we distinguish a good theory from a bad one? How do we establish relative confidence in theories? Criteria for a good scientific theory include: 1) explanatory power, or the ability to integrate and explain a wide range of observations, 2) predictive power, or testable expectations; 3) fruitfulness, or the ability to generate new questions and new directions of research; and 4) aesthetics (eg. beauty, simplicity, symmetry).

It is important that the process of evaluating a scientific theory (and its component hypotheses) takes place within a community of trained practicing scientists. The scientific enterprise is fundamentally conservative, and any new idea must meet the challenge of demonstrating a greater ability to explain and integrate current knowledge and predict future observations than its competitors. Scientists meet that challenge through diligent research, and by presenting the new ideas for criticism by the scientific community through professional meetings and publication in peer-reviewed science publications. Most new ideas do not survive this process. However, having passed through

this process and won the consensus of the scientific community, a new idea is ready for widespread application in addressing outstanding questions in the field.

Biological evolution (descent with modification from a common ancestor), plate tectonics (the mobility and recycling of the Earth's crust), and the Big Bang theory are examples of extremely well substantiated theories that provide an interpretative framework for a vast amount of observational evidence. That is, they have great explanatory power. These powerful unifying theories continue to generate fruitful and testable hypotheses that drive new discovery.

The historical sciences are inherently untestable.

Creationists and ID supporters frequently claim that the historical sciences (cosmology, astronomy, geology, evolutionary biology, anthropology, archaeology) deal with unrepeatably events and are therefore not experimental. Furthermore, because past events and processes are not directly observable, theories of origins are deemed inferior or less certain than studies of present processes. This view commonly finds expression in statements like: "No one was there so we can never know what really happened." This view is false. The historical sciences are no less scientific, or testable, than the "hard sciences" (13).

Research in the historical sciences proceeds by an almost continuous process of hypothesis creation and testing. Predictions are continually tested against each new observation or analysis. Obtaining data from a newly analyzed sample or newly described locality is no different methodologically from obtaining data from a new experimental trial. In both cases, the new observations can be tested against expectations based on previous experience and theoretical predictions. If the predictions deduced from a hypothesis are not supported by new observations then that hypothesis is modified or rejected. Scientific research proceeds by an almost continual process of hypothesis creation and testing. Many past theories in the historical sciences have been discarded with the accumulation of new observations and the development of new theories of greater explanatory power.

Like all scientific disciplines, the historical sciences proceed by testing the predictions or expectations of existing models and theories. In geology, for example, the measurement and description of each new rock outcrop or subsurface core is a test of working hypotheses based on present understanding. If a specific rock unit is interpreted to be part of a meandering river system, then specific predictions can be made concerning the geometry of this rock body and the characteristics and distribution of associated sedimentary rocks. In modern meandering river systems a whole complex of sedimentary environments are present: channel and point bar deposits, levees, crevasse splays, overbank flood deposits, abandoned channels, freshwater lakes, etc. Each of these environments has its characteristic spatial relationships, sediment types, depositional features, and associated biota. If the original

hypothesis of a meandering river system was correct, then further exploration and sampling of the area should reveal the predicted geologic features and their predicted spatial and temporal relationships. If the new observations are contrary to these predictions, then the hypothesis must be modified, or if necessary, abandoned.

All “theories” have a right to a hearing in the public science classroom.

Because historical theories are viewed as untestable guesses, it is often argued that all “theories” have a right to a hearing in the public classroom. It is this fundamental public misunderstanding about the nature and centrality of theory in science, combined with the identification of evolution as a fruit of atheism or materialism, that provides the basis for the public call for the democratization of science. These misconceptions also underpin the public support for traditional creationism and intelligent design.

In the public mind, “fairness” demands that all voices have a right to be heard. However, few people have the skills to evaluate the validity of scientific claims. This includes those elected to local and state school boards. In the absence of critical thinking skills, marginal ideas, pseudoscience, and folk science may be favored because their conclusions agree with individuals’ worldviews. In this way ideas, however unsupported, get equal access to the public – bypassing the rigors of research and peer review.

Furthermore, many people have been led to believe that creationist or ID arguments have been excluded from the science curriculum for political or social reasons, rather than for their failure to explain or predict observations. As a result, determining the content of public science curricula is seen as a political, not a scientific, issue. Public opinion polls are viewed as a valid basis for determining the content of public science curricula. It becomes the public’s responsibility, not that of the community of trained scientists, to decide what qualifies as valid science.

However, good science is not determined by popular vote. Rather, it is the consensus of the community of science professionals that determines the currently best theories. That community includes individuals with a wide range of cultural and religious worldviews. The scientific enterprise is a human activity and thus imperfect. But it is the very diversity of the scientific community, and the incredible range of experience and knowledge of the natural world held by that community, that provides the best means of determining error and identifying the most practically useful and fruitful ideas. We do a great disservice to our children if we deny them the consensus understanding of that community.

Addressing public misconceptions as science educators:

As science educators, what do we do? From the discussion above, it is clear that scientific evidence and argument alone are not enough. The evidence will not persuade people if they hold fundamentally erroneous understandings of the scientific process. For many, the essence of science is not the process

of inquiry and theory construction, but rather a body of accepted “facts” to be accepted on authority. When science is further seen as resting on a philosophy of materialism or atheism, there is a powerful barrier to science education and public science literacy.

The nature of science (NOS) must be an important component of teaching science, and evolutionary theory in particular. The NOS is communicated implicitly to students in all science courses. However, the impression given through science instruction commonly reinforces popular misconceptions rather than countering them. Portrayals of the history of science in science textbooks are notoriously simplistic and commonly present science as a steady march of enlightenment culminating in our current understanding. There is little sense of the human dimension of the scientific enterprise and its cultural, political and philosophical context. This can often reinforce the perception of science as the accumulation of encyclopedic knowledge. Laboratory and classroom activities are often structured to focus on obtaining the correct results, rather than on the process of inquiry itself. Similarly, assessment is commonly focused on knowing science content rather than understanding science as a way of knowing. Such an emphasis leaves students without the tools to critically evaluate competing scientific claims, or to understand the incomplete and open-ended nature of scientific conclusions.

The NOS is rarely taught explicitly beyond a simplistic recitation of “the scientific method.” The understanding of the scientific method is often focused on a generic description of experimental method that really does not reflect science as it is actually done, especially in the historical sciences such as biological evolution. As found by Dagher and Boujaoude, such generic understandings do “not appreciate the distinctive nature of evidence, explanations, and predictions employed in evolutionary theory.” They therefore argue that teaching the nature of science must be embedded within the context of specific theories. The meaning of any abstract NOS without such context may become “vacuous,” and actually lead to the rejection of valid scientific conclusions. (14)

The NOS must be taught explicitly, and teaching strategies and lesson plans must be developed with understanding the NOS as their primary goal. As emphasized by Cough and Olson, “Teachers must play an active role in posing questions at strategic points to explicitly draw students’ attention to NOS ideas. Just as students rarely develop accurate science ideas from activities alone, accurate NOS ideas will not be learned simply by doing activities or reading/watching historical and contemporary accounts of science in action.” (15)

Students do not acquire an understanding of science as a process and a way of knowing through traditional science instruction. Teaching about the nature of science must be explicit, reflective, and taught within an applied context (16). The focus of science instruction must be the nature of science; it will not be passively learned or absorbed merely through the learning of science “facts.” Communicating the nature of science must include: teaching

the historical context and development of scientific theories, inquiry-based instruction, and explicitly teaching the methodological foundations of science within the context of specific theories.

Discussing the historical context of the rise of new scientific theories and models can be an effective way of presenting the human side of the scientific enterprise. Science becomes inherently more interesting when is seen as a truly human activity. Students can also better appreciate that, despite personal ambitions, personality conflicts, and political agendas, ideas that successfully resolve scientific questions and lead to further discovery rise to scientific consensus (even if that process is a long one). There are now many excellent historical treatments of important episodes and personalities in science that are accessible and historically accurate (17). Such accounts are particularly valuable in countering the popular “conflict” view of science and faith.

Having students become participants in scientific inquiry is an effective way to develop an understanding of the scientific process. In inquiry-based instruction, student problem solving focuses not on the solution but on the process of inquiry. This moves attention away from getting the right answer, to reflecting on the processes involved in trying to answer the question. Such inquiry-based instruction needs to be accompanied by explicit teaching on the nature of science. As discussed above, that teaching needs to be done within the context of a particular theory or hypothesis. Students need to know not only what the current scientific consensus is, but how that consensus was reached.

It can be legitimately argued that the structure and demands of current science curricula pose significant obstacles to implementing the suggestions above. Where can teachers find space in their teaching for this emphasis on the nature of science? While the pedagogical challenge should not be minimized, much of the teaching about the NOS can be embedded within the existing course content. Students already acquire a certain perception of what science is, accurate or not, during the course of their science education. The question then is not so much should we teach the nature of science, as how do we present science in such a way that the nature of science is accurately communicated.

CONCLUSIONS

Numerous fundamental misunderstandings about the nature, limitations, and practice of science underlie the public resistance to the conclusions of modern science. This is particularly true of evolutionary science, which has been falsely portrayed as an expression of an atheistic or materialist philosophy. Both traditional creationists and Intelligent Design supporters build their cases upon these false views of the scientific enterprise. Therefore, public challenges to the conclusions of science must be addressed not only by appeals to the evidence, but also by directly countering the widely-held erroneous views about the nature of science itself.

Public science education needs to be part of the solution rather than part

of the problem. As science educators we must be attentive to teach not just the content of our science, but its methodological foundation. The nature of science must be taught consciously and explicitly. The nature of science needs to be taught as part of the subject content, and currently accepted theories need to be understood as the result of a long process of rigorous testing and challenge within a diverse community of scientists. Students need to understand science as a dynamic, exciting, open-ended, and thoroughly human activity. Science is a process of developing explanations for how our natural world works, of making sense of our diverse observations of the world around us. It is a limited way of knowing about our physical reality; it complements rather than conflicts with other human endeavors that seek to answer other more profound questions. Rather than being perceived as a threat, the scientific enterprise should be seen as a vocation open to anyone with a curiosity about the workings of the natural world.

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WHY “INTELLIGENT DESIGN” IS MORE INTERESTING THAN OLD-FASHIONED CREATIONISM

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ABSTRACT

“Intelligent Design” (ID) creationism largely relies on long-discredited forms of argument to try and make a case against naturalistic evolution. However, it also includes some novel elements, such as William Dembski’s claim to rigorously identify a reliable signature of intelligent design and thereby establish ID as an independent form of explanation not reducible to “chance and necessity.” Such arguments also fail; indeed, intelligence itself appears to be a product of combinations of chance and necessity, where Darwinian processes are critically important in producing genuine novelty. Addressing the scientific mistakes of ID creationism requires attention to current science about intelligence, complexity, and information; it must be a collaborative effort between biologists, physicists, computer scientists and others.

Keywords: intelligent design, creationism, artificial intelligence, randomness

When the Intelligent Design (ID) movement attracts the attention of mainstream scientists, it does so as the latest incarnation of creationism. The ID literature reinforces this impression. ID proponents devote most of their efforts to denouncing “Darwinism,” by which they mean naturalistic theories of evolution. Some ID proponents accept common descent, some do not. But the ID movement is united in thinking that mindless mechanisms – Darwinian variation-and-selection in particular – cannot account for the diversity and complexity of life.

If ID was only a collection of neocreationist claims concerning biology, it would be relatively straightforward to address. For example, the most prominent biology-related argument for ID has been due to biochemist Michael Behe (1), who claimed that certain molecular machines were “irreducibly complex.” Structures such as the bacterial flagellum, he argued, could not be assembled gradually through a series of functional intermediate forms – all of their many components had to come together at once. Critics immediately pointed out that systems and their components need not have had the same functions throughout their history. Indeed, Behe has lately shifted his emphasis away from his original argument.

Instead, Behe and other ID proponents’ current arguments for design in biology describe the interlocking complexity of biochemical systems and

state that it is implausible that they could have been assembled gradually. They then say that “Darwinists” have to supply a fully-articulated sequence of successive changes; otherwise Darwinian evolution can be dismissed as mere speculation (2). Such attempts at shifting the burden of proof do not impress many scientists. Though incomplete, evidence that, for example, eubacterial flagella are related to and have evolved as secretory mechanisms (3) is compelling. Biologists need to update their responses to creationism, addressing old arguments that have now been cast in a biochemical idiom, but otherwise ID presents no challenge to biology.

Then there is ID and physical science. Unlike the biblically literalist champions of Young Earth Creationism, ID proponents tend to accept an old universe or take no position on the matter of age. Nevertheless, ID includes physical claims as well. Their main concern is identifying supposed mysteries such as fine-tuning in astronomy and physical cosmology and proclaiming these as evidence of design (4). Though fine-tuning arguments have found favor among some theological liberals as well as in ID, they appear to be useless in terms of advancing science (5). So again, if all ID did was to retool old-fashioned intuitions about divine design, the scientific response to ID would not need to extend beyond adapting standard responses to creationism. There would be little of intellectual interest in criticizing ID.

However, though the bulk of ID literature is devoted to recycling old errors, there are some aspects of ID that are more interesting mistakes – where figuring out exactly how ID goes wrong can help us advance our knowledge and understand evolution better. One area where ID gets interesting is in its claims about intelligence.

ID proponents have vigorously engaged in philosophical debates about whether naturalistic explanations are required in science. They find methodological naturalism to be an unjustified constraint on our ways of investigating the world. They would like, ultimately, to introduce intelligent agents as a fundamental cause in scientific explanations. This seems reasonable enough; after all, sciences such as archaeology explain many of their findings by human agency. However, ID claims much more than an ability to identify the work of agents about which plenty is known independently (6). Human and animal intelligence can plausibly be seen to be part of the natural world. ID is fundamentally revolutionary point of view only if intelligent agency is somehow beyond natural mechanisms.

To flesh out such ideas, ID thinkers observe that today’s natural scientific explanations only make use of randomness and of lawful, patterned events – in biologist Jacques Monod’s terms, “chance and necessity” (7). A physicist may predict a planetary orbit by writing down the appropriate equations from a theory of gravity, or describe radioactive decays as being completely random. In general, the physical world behaves according to combinations of chance and necessity. Biology follows the pattern of modern physics when explaining evolutionary adaptation. The raw novelty in the genome comes from blind variation and mutation - largely due to chance. This variation is

then subjected to nonrandom selection. In other words, biology also combines chance and necessity in its central theories. Furthermore, this approach has been so successful in modern science that it motivates a more comprehensive physicalism, according to which everything in our world is physically realized (8). ID claims that this is incorrect – that intelligent design is a third, independent mode of explanation that is not reducible to chance and necessity. Intelligence, in the ID view, is beyond physics.

A number of the leading lights of ID have presented the claim that meaningful information can only be created by intelligence, and that intelligence is beyond chance and necessity, as a central aspect of ID (9). In particular, William A. Dembski, the leading theoretician of ID, has explicitly argued that ID is a third option (10). Moreover, he has proposed what he claims is a mathematically rigorous way to tell if a certain data set contains “complex specified information” (CSI) which is supposed to be the signature of an intelligent cause. In fact, CSI, in Dembski’s view, is just a pre-specified pattern which is extremely improbable to be produced by any combination of chance and necessity. At the heart of Dembski’s version of ID (11, 12) are two propositions:

1. There is a rigorous mathematical procedure to detect CSI, which is a reliable signature of intelligent design.
2. Intelligent agency is not reducible to any combination of chance and necessity.

If these two claims could be sustained, ID proponents would be justified in their hopes to usher in a scientific revolution. In fact, they could claim some success even if their efforts to cast doubt on biological evolution should continue to fizzle out. This is because ID, especially in Dembski’s version, is primarily a claim about complexity and about intelligence – not just biology. Even if biologists are (as they almost certainly are) correct about common descent, and if they are right about some of the mechanisms behind evolution, all would not be lost for ID. If propositions 1 and 2 are correct ID proponents could still infer a guiding intelligence behind biological complexity – the designer would then have injected all the necessary CSI into the world in the beginning. Regardless of any philosophical wrangling about methodological naturalism, ID proponents can also state that this designing intelligence is something beyond mere physical mechanisms.

None of this is likely to happen. Just in the past few decades, natural scientists have continued to learn a lot not just about the details of biological evolution, but also the physics of complexity and the nature of human and possibly even machine intelligence. None of this new knowledge is any comfort to ID. It is still possible to find a few thinkers with ID sympathies who think that concepts of self-organization in nonequilibrium thermodynamics pose a challenge to mainstream biology (13). However, these are intellectually marginal currents. In the study of complexity, the overwhelming trend is toward an invigorating synthesis of perspectives from biology, physics, computer science and other relevant disciplines. So it is very implausible that

ID should be correct. Most scientists who pay any attention to ID therefore ignore the substantive claims involved in ID and concentrate on countering its political influence.

Nevertheless, a number of scientists and science-oriented philosophers have examined the claims of ID in detail. In particular, Dembski's work summarized in proposition 1 above has come in for heavy criticism. Dembski hopes to detect design through examining a data set and eliminating chance and necessity as possible explanations. We infer design regularly in everyday life, and it is certainly interesting to try and formalize the reasoning we use to do so. Dembski proposes a rigorous way of making design inferences, and his initial effort was intriguing enough to be published by a reputable academic press (14). However, though it may have some intuitive appeal, it has become clear that Dembski's procedure suffers from numerous fatal problems (15). For example, he often assumes a uniform probability distribution to calculate a very small probability for a structure, and then takes this as reason to eliminate all element of "chance" as part of its explanation. Even his notion of CSI appears to be ill-conceived and badly defined, and it certainly has little to do with "information" as understood in mainstream work in information theory (16). Indeed, some critics have judged that Dembski's work is of very low quality and has little substance to be taken seriously (17). Dembski later tried to bolster his position by making use of the "no free lunch" theorems, arguing that blind mechanisms cannot create CSI but smuggle the information in from carefully chosen fitness landscapes (18). Again, numerous basic errors plague this argument as well (19). In short, Dembski and the ID movement as a whole have achieved nothing close to a rigorous way to detect design; they only have some intuitions that at the most have some vague commonsense appeal.

If modern science shows us anything, it is that our intuitions can fail spectacularly outside the domain of everyday life. Still, intuitions do not get discarded lightly. Even with its numerous technical errors, ID proponents might remain confident that there is something to Dembski's approach. After all, they often say, ID is a new paradigm. We cannot expect it to appear on the scene fully worked out, entirely free of problems. Dembski or others may have to go back to the drawing board, but the basic intuition that intelligence is something beyond natural processes will remain ever-ready to be resurrected.

So some critics of ID also ask if there is some deeper flaw in the intuitions driving ID, something not even a retooled, patched up design-detection procedure akin to Dembski's can overcome. For example, philosopher of biology Elliott Sober points out that design arguments (including ID) are problematic because they can succeed only given independent knowledge about the goals and abilities of the designer (20). If so, Dembski-style attempts to infer that some data is a result of design without making assumptions about the nature of the designer are inherently flawed.

Sober's critique assumes that the likelihood form of design arguments are most defensible. But Dembski takes a different approach. If Dembski's CSI (or whatever new and improved variation ID can come up with) cannot indeed be assembled by chance and necessity, such criticisms would be moot. Moreover, Dembski's attempts to formalize a design inference implicitly includes knowledge about the kind of things human intelligence produces. ID proponents overwhelmingly come from conservative theistic backgrounds, and it is no secret that their designer is a personal, at least somewhat anthropomorphic God. So whatever the difficulties of generic design arguments in philosophy, it is not true that ID includes no expectations about designers – though the ID movement does not care to emphasize this, possibly for legal reasons.

To undercut the intuitions behind ID, we need something more: to explicitly argue that intelligence itself is a product of chance and necessity. Imagine that we were presented with a complex mathematical procedure useful in detecting design – that something related to proposition 1 were correct. This procedure could be a useful scientific tool; to borrow an example from Dembski, its uses might include tasks such as SETI astronomers figuring out if a signal they detected was produced by an alien intelligence (though SETI researchers today approach their problem quite differently than Dembski). But if we had good reasons to think proposition 2 were mistaken, then ID would still have no purchase on reality.

We have such reasons. The details of the argument, which rely on some of the technical apparatus of theoretical computer science, have been presented elsewhere (21, 22). In outline, however, it can be summarized.

Let us first characterize Dembski's approach to detecting design. Dembski might observe that if we encounter a slip of paper with "Bu sabah hava çok güzel, ama belki sonra bozabilir, belli degil..." printed on it, we have a very good notion that it is a meaningful message, even if we do not know Turkish and so have no clue what it means. We know enough about natural languages to see that it fits the appropriate pattern. Moreover, we can distinguish it from simple rule-generated strings such as "qaqaqaqaqaqaqa..." (the rule being "repeat 'qa' over and over") and random gibberish such as "uwl wdfjw2f af2h7kcfje/jvbppwvjo...". The Turkish sentence looks like the sort of thing an intelligence would produce. There is some nonrandom content in it, even if we do not know what it signifies. It might have been printed out by a computer, but in that case, we know that the actual content must have been pre-programmed into the machine. Machines are devices that work according to chance and necessity. And so Dembski argues that machines cannot create new CSI – they can only preserve or degrade the meaningful content.

Now, Dembski wants to infer design only from the message itself, without any knowledge of how it was produced. In that case, there is the question of distinguishing between a message printed by a computer and one scribbled out by a human. How can we say that the human is a genuinely intelligent source of new information, while a machine cannot do any such thing?

This is a long-standing question confronting researchers in artificial intelligence (AI), and it is no surprise that many ID proponents, including Dembski, have endorsed the position that humans can do things no mere machine is able to. In arguing against evolution, ID proponents continually assert that chance and necessity cannot assemble meaningful genetic information. Against AI, ID takes the same line: assert that chance and necessity cannot produce genuine novelty – that it cannot produce complex information. We know that humans are the source of new information, because we are flexible, creative, not bound by pre-set rules. Computers, by contrast, only follow pre-programmed rules.

The flaw in such an argument is that it does not adequately consider combinations of chance and necessity – in the computer context, procedures combining algorithms and randomness. As it happens, we know a good deal about just what a machine with access to a truly random function can accomplish and what it cannot. It turns out that the only tasks not performable by combinations of chance and necessity are certain “oracles,” and we know of nothing (humans included) that realizes such oracle-functions. In particular, information-containing output and creative tasks that introduce genuine novelty are not beyond machines that combine rules and randomness (22). “Artificial life” research provides some particularly telling examples (23). Dembski’s CSI is not and cannot be a signature for a kind of result no machine can ever produce. In a way reminiscent of Darwinian evolution (not coincidentally) randomness serves as a source of raw novelty, not conditioned by any rules. Rules, including interactions with a machine’s environment and with other machines, shape the raw novelty into something that is meaningful in its local context.

AI research faces a problem similar to what biologists once did: how to create meaningful information. And the Darwinian mechanism of variation-and-selection is a beautiful solution to precisely this problem. Hence much recent work in AI has taken a Darwinian turn. Moreover, recent thinking in the cognitive and brain sciences also highlights the role of Darwinian mechanisms in our own brains. So we can say, with considerable confidence, that intelligence is nothing supernatural. Intelligence is achieved by mechanisms combining chance and necessity, within the realm of ordinary physics.

ID falls hopelessly afoul of today’s understanding of complexity and information. This understanding, still partial and ever-expanding, combines insights from many separate disciplines. Physics sets the stage by describing a world operating according to chance and necessity. Physicists also help us understand how complex systems work by exploring self-organization and nonequilibrium thermodynamics, giving us clues about how complex self-replicating systems form. The mathematics underlying computer science gives us rigorous definitions of complexity and information, and a common language in a day when much of theoretical science has come to depend heavily on computer simulations. Cognitive and brain sciences, even though they remain far from maturity, still tell us much about human intelligence

that illuminates how chance and necessity combine to achieve complexity. But the centerpiece of our modern understanding of complexity comes from biology: Darwinian variation and selection. Darwin's mechanism is the answer to the question of how chance and necessity can bring genuinely new information into the world.

ID proponents are right to highlight the question of the origin of information. This is an interesting question. However, they treat information as a mysterious quantity and fail to make connections to established research concerning information. On top of this, they do not realize or do not acknowledge that mainstream science already possesses the critical elements of a satisfying answer to their question. In their political opposition to evolutionary science, ID proponents promise to be a significant irritant for scientific and educational institutions (24). But in responding to ID, its critics also have an opportunity to highlight today's developing multifaceted, interdisciplinary understanding of evolution and complexity. If more scientists thereby become more aware of how their specialties fit together with natural science as a whole, then ID might indirectly be of service to science after all.

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