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FEATURE

Science Denialism: Evolution and Climate Change

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Introduction

In spite of the United States' primacy in science and technology, there are two broad areas of science that many of our citizens refuse to accept: biological evolution and global warming. Most advanced countries find this paradox baffling. American rejection of evolutionary science has been frequently studied over more than a century. Our denial of climate science is a much more recent phenomenon, since climate science itself is only a few decades old. There are some interesting common elements in these two cases of science denialism, including the similar tactics used to attack both evolutionary and climate science.

First consider some of the superficial similarities. Opinion polls suggest that the scientific consensus in both evolution and global warming is rejected by many Americans. Denialism in both fields is supported by well-financed campaigns. Both scientific fields also have popular villains, namely Charles Darwin and Al Gore, whose very mention in many circles is sure to generate boos and smirks. Both issues have become increasingly politicized, with the more conservative elements of the Republican Party tending to ally themselves with the denialists (see, for example, Gelbspan 2004 or Mooney 2005).

There is also a tendency in both camps to ignore well-accepted science in favor of idiosyncratic interpretations to "explain away" observations supporting the mainstream (evolution and global warming) positions. Readers of *RNCSE* are familiar with creationist examples of this, but the global warming denialist contentions have not been discussed here. When global warming denialists are not stubbornly claiming that no warming is taking place, they contend that any warming seen is the result of cyclical or historical causes such as the ice ages. This is to cast doubt that human-generated greenhouse gases are important factors in climate change. And yet historical, non-anthropogenic climate cycles have no connection to the changes we are seeing today.

First, of course, today's warming is taking place far faster than any historical cycles. Further, the evidence clearly shows that we are not experiencing changes in the earth's orbit and rotation axis (which are the primary cause of the ice ages) or any changes in solar energy (which are implicated in the "medieval warm period" and the "little ice age"). Both the solar output and the orbit of the earth are monitored with exquisite precision by astronomers, and neither is changing. Most fundamentally, current climate changes carry the unambiguous signature of greenhouse warming: rapid increase in the atmospheric concentration of carbon dioxide and methane, cooling of the stratosphere while the troposphere warms, concentration of warming in polar regions, excess deposition of heat into

the oceans, and imbalance in the energy budget of the planet. Efforts to invoke historical "naturalistic" mechanisms to explain today's climate changes have no more validity than appeals to Lamarckian explanations for evolution.

Evolutionary theory and global warming theory both have strong and weak forms. In evolution the weak form is theistic evolution. This accepts the age of the earth and biological change, including common descent, while still maintaining belief in the Creator who has guided the evolutionary process toward the ultimate goal of humans formed in the image of God. The strong version relies only on natural processes and rejects the idea of a direction or preordained goal for evolution. In global warming the weak version accepts the reality of increasing temperatures, but attributes the current warming to various natural processes, a position which, as mentioned above, lacks scientific support. The strong version recognizes that the current rapid rise in temperature is unique and is caused by human consumption of fossil fuels. In both cases, many more people accept the weak version than the strong one. Scientists, however, prefer the strong versions, because the process of science relies on natural cause-and-effect relationships that can be used to understand the world around us. Efforts of supporters of the weak form of global warming to invoke inapplicable historical mechanisms to explain today's climate changes are as inscrutable and lacking in empirical evidence as efforts by supporters of the weak form of evolution to explain evolution through supernatural interference.

Readers may feel that biological evolution is much more firmly established than global warming, since it has been the foundation for our understanding of the living world for over a century. Global warming, in contrast, is a recent idea in the much smaller field of atmospheric and climate science. Perhaps in this respect the two fields cannot be compared, but I am struck by similarities in the campaigns used against both, which share many common elements of anti-science, populist propaganda.

Using Pseudoscience to Undercut Real Science

Although traditionally the primary opposition to evolution has come from fundamentalist Christians (and recently fundamentalist Muslims as well), it has become fashionable to reframe the issue in secular terms. This strategy has been forced on the evolution denialists by court decisions prohibiting the intrusion of sectarian religious beliefs into the science curriculum. Attempts to require the teaching of creationism or "intelligent design" (ID) in public schools have been rejected by the courts and by most school administrations.

In response to the adverse legal environment, the anti-evolution strategy consists of two parts: (1) insisting that evolution is only one of several possible descriptions of the origins of biological diversity and that fairness requires that we teach alternatives; and (2) asserting that the scientific evidence for evolution is actually weak, with increasing dissent among scientists. To support these positions, the anti-evolution forces try to frame their arguments in scientific terms, to support the claim that creationism (or ID) is a respectable alternative, and that there are many legitimate secular scientific criticisms of biological evolution. Their target, of course, is not to convert the scientific community, but to influence public opinion.

The warming denialists are focused on political policy, not grassroots public support. They must convince decision-makers that the evidence linking climate change to fossil fuel consumption is too weak to justify government regulations or incentives that might change

our energy policies. The only way they can make their case is to deny the international scientific consensus on the causes of climate change. With the support of energy-industry companies and such influential newspapers as the *Wall Street Journal* and the *Washington Times* (see Gelbspan 2004 and Mooney 2005), they insist that the science of global warming is weak and that many of the climate scientists are not only in error, but also actively conspiring to distort the data and suppress dissenting views.

To be successful, both denialist groups must mount what appear to be credible challenges to mainstream science. One strategy is to find a few pliable scientists to do research that undercuts evolution or climate science and publish this research in peer-reviewed scientific journals. The first of the projects or phases in the creationist "wedge strategy" was "scientific research, writing, and publicity," in order to establish the scientific credibility of ID. Performing research that affirmed creationist or ID ideas and getting this research published has proved impossible, but since the target audience does not read the scientific literature, there is an alternative. Because books, lectures, newspaper articles, and websites are not peer-reviewed, denialists can address these objectives through popular-level writing and publicity, and still convince much of the general public that their arguments are scientifically valid.

Tactics to Promote Pseudoscience

A populist strategy used by both groups of denialists is to reject any scientific evidence that is not obvious. In the ID world, this leads to the idea of irreducible complexity. If they (or the general public) cannot understand how natural selection could lead to the flagellum or the eye or the chemical sequence involved in photosynthesis, then they claim that science cannot do so either, and we must accept divine intervention. The warming denialists similarly reject the output of computer models. One often-repeated refrain is that the evidence for warming is based on models and therefore cannot be trusted. Climate models are indeed complex, and they do not always agree on details such as the timing of future warming. However, the evidence for warming is empirical, and its future trends are anchored in basic physics, such as the greenhouse effect and the heat capacity of the oceans.

The most sophisticated climate models generally agree in their predictions for the next twenty years, but predicting the future is not their primary purpose. A numerical model is a scientific research tool for exploring the effects of different assumptions and inputs. (For a general description, see http://en.wikipedia.org/wiki/Global_climate_model.) For example, climate models can help us understand how a major volcanic eruption will affect climate, or what is likely to happen under different CO_2 emission scenarios. Unfortunately, their scientific *strength*—the ability to show how different inputs can produce different results—is touted as a *weakness* by denialists.

Many proponents of creationism and ID have become expert debaters who know how to control both the venue and rules of engagement in their confrontations with scientists. A simple message skillfully crafted and presented to a sympathetic audience will generally defeat a scientist trying to discuss nuanced and complex issues in front of a hostile crowd. Such tactics keep the creationist base activated, even if they do not convert the scientific community.

The warming denialists likewise avoid big scientific meetings and prestigious journals. Instead they founded a faux scientific journal called the *World Climate Review* (http://www.gcrio.org/DifHolding/GCRIO381.html). They also played their political cards with extensive Washington lobbying. Senator James Inhofe (of the Senate Environment Committee) has called the threat of catastrophic global warming "the greatest hoax ever perpetuated on the American people" (http://inhofe.senate.gov/pressreleases/climateupdate.htm). In 1997, the US Senate passed a resolution blocking adoption of the Kyoto Protocol by a vote of 95–0 (http://www.lycos.com/info/kyoto-protocol--united-states.html). The situation in Washington deteriorated further under President George W Bush, with the spectacle of Hollywood science fiction writer Michael Crichton appearing as an expert witness on climate before Congress and lecturing at the White House on global warming.

The denialists can also simply lie—with impunity, since their statements are not subject to editorial or scientific review. Creationists can deny the existence of transitional forms, dispute the reality of vestigial structures, and accuse scientists of faking the fossils of human ancestors (citing the Piltdown Man hoax as their "proof"). Warming denialists can plot points incorrectly in their temperature graphs or entirely omit the data from the past twenty-five years, when the major increases have taken place. They assert the existence of solar variations when sensitive orbital measurements show there are none, and some of them even make the remarkable claim that increased CO_2 is good for the environment (Gelbspan 2004:24)

There are also larger conceptual distortions that appear in most denialist literature. On the biological side, the distinction is blurred between the origin of life and its evolution. The origin of life is a difficult and largely unsolved problem, but once the mechanisms of inheritance are in place, the process by which all life is descended from common ancestors is relatively straightforward. Ever since Darwin, evolution has been about the origin of *species*, not the origin of *life*. Textbook changes or disclaimers promoted by creationists, however, often focus on the origin of life, as in the 1996 Alabama disclaimer "No one was present when life first appeared on Earth, therefore any statement about life's origin should be considered a theory, not a fact" (http://ncse.com/news/2001/11/state-board-education-adopts-another-evolution-disclaimer-00208).

On the climate side, one of the most common accusations is that climate models are complex and do not adequately include some factors, such as cloud formation. The truth, of course, is that we don't need numerical models to tell us that the world is rapidly warming, or to recognize the fact that the CO_2 content of the atmosphere is increasing by more than 3% per decade (see, for example, http://www.esrl.noaa.gov/gmd/webdata/ccgg/trends/co2_data_mlo_anngr.pdf). No model is required to show that, at the current rate of increase, atmospheric CO_2 will increase by 50% in this century relative to pre-industrial values—a harbinger of much worse climate disruptions to come (some estimates of changes by the end of the 21st century are in a recent IPCC report for policy makers: http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr_spm.pdf).

Other myths and fallacies promoted by warming denialists include the misconception that carbon dioxide makes only minor contributions to greenhouse warming, relative to water vapor. In fact, it is the CO_2 (and increasingly methane) that determines the temperature structure of the troposphere. Water vapor amplifies the CO_2 greenhouse through positive

feedback. Another widespread denial concerns polar heating. It is in the high-latitude oceans that most of the extra heat is being deposited; hence the rapid melting of ice in both the Arctic and the Antarctic. The counterclaim that the Greenland and Antarctic ice caps cannot melt in less than several thousand years is based on the simplistic assumption that all the melting takes place from the surface. Much more important, however, is the accelerating movement of ice, lubricated by meltwater, generating huge icebergs that are eventually melted by warm seawater. Another common error is to confuse climate (long-term changes) with weather. Extreme weather in one location (such as heavy snow in the Atlantic seaboard) is not a valid argument against the reality of global warming.

The Role of Non-Profit Think Tanks

Non-profit institutes or think tanks have played critical roles in organizing the opposition to both evolution and climate change. The George C Marshall Institute was founded in Washington in 1984 primarily to support the Strategic Defense (Star Wars) Initiative, countering SDI opposition from scientists at the Union of Concerned Scientists (http://www.marshall.org/subcategory.php?id=9). The founders were prominent physicists associated with the Reagan administration: Frederick Seitz, William Nierenberg, and Robert Jastrow. In the late 1980s, they campaigned against environmental regulation by either denying that problems existed or opposing any government action to mitigate them. In 1989, the Institute issued its first report on climate issues, a book called *Global Warming: What Does the Science Tell Us?* coauthored by Jastrow, Seitz, and Nierenberg (see a summary of the main arguments in Jastrow and others 1991). This book blamed whatever global warming might be happening on the sun (see Oreskes and Conway 2010).

In the mid-1990s, the Marshall Institute became the prime critic of the UN Intergovernmental Panel on Climate Change (IPCC), a working group established by the United Nations and the World Meteorological Association (http://www.wmo.int/pages/index_en.html) in 1988. Contributors from over 130 countries included more than 1200 authors and 2500 expert reviewers. The assessment panels have operated under UN rules, in which unanimity is required; any member nation can in effect veto any statement of fact or recommendation. As a consequence, the reports have tended to be conservative and to lag behind the advances in climate science, just the reverse of accusations that "climate activists" hijacked the panels. For an insider's view of the IPCC system, see Stephen Schneider's (2009) *Science as a Contact Sport: Inside the Battle to Save Earth's Climate*.

The position of the Marshall Institute on climate change as presented on its website is deceptively simple (http://www.marshall.org/category.php?id=12). It concedes that "human activity, such as the burning of fossil fuels to power our homes and businesses, undoubtedly affect the global environment," but adds, "It is the extent of that effect and how it relates to changes in the modern climate which is the subject of current scientific debate". They say that their climate change program involves

> a critical examination of the scientific basis for global climate change policy. The intent is to promote a clear understanding of the state of climate science and assess the implications for public policy ... actions should flow from the state of knowledge, should be related to a long-term strategy and objectives and should be capable of being adjusted—one way or the other—as the understanding of human influences improves. (http://www.marshall.org/category.php?id=12)

From this good start they go on to deny the factual basis for climate change, asserting that we are unable to distinguish human-caused heating from "natural temperature variations." They concede that "naturally occurring greenhouse gases warm the earth by about 30°C" (http://www.marshall.org/subcategory.php?id=49), but they dispute that doubling the CO2 content of the atmosphere will increase this greenhouse effect. They conclude: "Because of the complexities of the climate system, there is no accepted estimate of the amount of warming due to the human emissions of greenhouse gases" (http://www.marshall.org/subcategory.php?id=49). Therefore they oppose any government action—for only the best scientific reasons, of course!

The Marshall Institute has exerted great influence in Washington based partly on the scientific stature of its founders, especially Frederick Seitz, who was once president of the National Academy of Sciences (1962–1969). Much of its funding has been from private industry and foundations, and it supports the anti-regulation positions of oil, gas, and coal industries (see Gelbspan 2004, Mooney 2005, Oreskes and Conway 2010). The Marshall Institute has interpreted its educational charter to apply primarily to the power brokers in Washington, providing seminars on environmental and defense issues for Congressional staffs and often organizing testimony at hearings (Oreskes and Conway 2010:56–57). Its positions generally parallel those of other conservative Washington think tanks, such as the American Enterprise Institute, the Heritage Foundation, and the Cato Institute.

The counterpart of the Marshall Institute among critics of evolution is the Discovery Institute in Seattle, and particularly its Center for Science and Culture (http://www.discovery.org/csc/). Bruce Chapman, who worked in the Reagan White House, founded the Discovery Institute in 1990 as a branch of the Hudson Institute (then in Indianapolis, now headquartered in Washington DC). The Center for Science and Culture (CSC), which has led the opposition to evolution, was founded in 1996. The CSC is the primary proponent of the wedge strategy, first articulated by Phillip Johnson, to undermine scientific materialism by attacking "Darwinism". Its objectives include sponsoring research on intelligent design (ID) to provide a scientifically respectable alternative to evolution—a rather spectacular failure, judging by the meager bibliography of published science on its website. Its members have written a number of books, however, primarily aimed at a non-scientific audience.

Like the Marshall Institute, the Discovery Institute's stated purpose is primarily public education. They promote ID to teachers, students, school boards, and lawmakers, producing educational materials, books and films. Americans United for Separation of Church and State writes, "[t]hough the Discovery Institute describes itself as a think tank specializing in national and international affairs, the group's real purpose is to undercut church–state separation" (http://www.au.org/media/church-and-state/archives/2002/05/the-discovery-in.html). One difference between the two Institutes is that the Discovery Institute sometimes tries to conceal its conservative Christian agenda, while the Marshall Institute is unapologetic about its environmental skepticism.

These think tanks pose as institutes for research and education, but in reality are little more than advocacy groups; however, to the public and politicians, they provide the cover of apparent scientific legitimacy. For example, both claim to showcase "scientific dissent" from the consensus scientific view relying heavily on the credentials of the signers rather than research findings.

Polls and Petitions

The opponents of evolution and global warming face a formidable challenge: to convince the public and decision-makers that there is significant dissent among scientists in two fields where in reality a strong consensus exists. They face nearly unanimous statements by scientific societies and academies of science all over the world affirming support for evolution by naturalistic processes and for anthropogenic global warming. To fight back, both denialist groups have used deceptive polling to support their claims of increasing scientific dissent and "theory in crisis."

The primary vehicle used to document dissent among scientists about global warming is called the Oregon Petition. It was organized by the non-profit Oregon Institute of Science and Medicine (http://www.oism.org/) and circulated twice, first between 1999 and 2001 and again from 2007 to 2008. The text of this petition reads:

> Proposed limits on greenhouse gases would harm the environment, hinder the advance in science and technology, and damage the health and welfare of mankind. There is no convincing evidence that human release of carbon dioxide, methane, or other greenhouse gasses is causing or will, in the foreseeable future, cause catastrophic heating of the earth's atmosphere and disruption of the earth's climate. Moreover, there is substantial scientific evidence that increases in atmospheric carbon dioxide produce many beneficial effects upon the natural plant and animal environments of the earth. (http://www.petitionproject.org)

Note that the wording refers only to "catastrophic heating of the earth's atmosphere," yet signers of this petition are often represented as questioning the reality of any greenhouse warming.

The marketing of this petition was clever and deceptive. It was mailed to an unknown number of scientists (probably several hundred thousand) with a supporting covering letter from Frederick Seitz, identifying him only as past president of the US National Academy of Sciences. Enclosed was a twelve-page article on "Environmental effects of increased atmospheric carbon dioxide" by Arthur Robinson, Noah Robinson, Sallie Baliunas, and Willie Soon (http://www.oism.org/pproject/s33p36.htm). This article followed the style and format of the *Proceedings of the National Academy of Sciences*, when in reality it was unpublished.

The original petition drive yielded 19 700 mail-in signatures. Only positive responses were solicited. Signers were asked to list an academic degree (about one third claimed to be PhDs) and to specify a discipline. Most were in engineering; only about one sixth identified themselves as trained in the atmospheric, environmental, or Earth sciences. There was no effort to determine which of them were active research scientists and no way for outsiders to check the authenticity of the names. An analysis of the list by *Scientific American* (http://www.scientificamerican.com/podcast/episode.cfm?id=john-rennies-seven-answers-to-clima-09-12-03) suggested that roughly 200 atmospheric or climate scientists might have signed.

In contrast, an often-cited study of published scientific literature by science historian Naomi Oreskes (2004) indicated solid support for the consensus view about global warming. She analyzed 928 abstracts of papers on climate change published between 1993 and 2003

in refereed scientific journals, finding that not one of these publications disputed the basics of climate change. A paper by Anderegg and others (2010) presented an analysis of publication and citation data for 1372 climate researchers and concluded that 97–98% of climate researchers support the science of anthropogenic climate change.

In 2001 the Discovery Institute began a similar effort to demonstrate that many scientists were disenchanted with biological evolution, which they like to call a field in crisis. A statement expressing skepticism about evolution was published in several magazines with requests for signatures from scientists who share this opinion. As of January 2011, 826 individuals from all over the world had signed the petition, which the Discovery Institute uses to support its claim that evolution lacks broad scientific support (http://dissentfromdarwin.org). Of course, what this list lacks is a denominator: 826 out of how many? In 2001, the year that the Discovery Institute first published this list with 100 signatures, the National Science Foundation listed 2.16 million scientists working in the US alone (http://www.nsf.gov/statistics/nsf05313/). Even the 2011 count is less that 0.04% of scientists working in the US ten years ago.

The "Scientific Dissent from Darwinism" statement is very simple.

> We are skeptical of claims for the validity of random mutation and natural selection to account for the complexity of life. Careful examination of the evidence for Darwinian theory should be encouraged. (http://www.dissentfromdarwin.org/index.php).

On their face, these are plausible statements: all scientists should be skeptical, and the basis of any theory should be re-examined as new evidence becomes available. However, for the past decade this list of "Scientific Dissenters from Darwinism" has been used by the Discovery Institute and others to support campaigns to "teach the controversy" and provide more "critical analyses of evolution." The Institute claims that this list supports the existence of significant scientific dissent from Darwinism, and that these dissenting opinions should be included whenever evolution is taught in the classroom.

Identifying the signers of this statement is difficult. Rather than providing their employers, people are frequently identified by the school they attended or temporary visiting appointments they may have held. Clearly if a person holds a science degree from a prestigious university, that carries more weight than if he is a financial analyst or runs a religious publishing house. Furthermore, there was no effort to screen the signatures by relevance of their discipline. Critics have pointed out that of the original 100 signatures, fewer than 20% were biologists, and even fewer were active researchers. Far from demonstrating dissent, these numbers are consistent with the claim often made that more than 99.9% of biologists in the United States accept evolution (see, for example, http://ncse.com/taking-action/project-steve).

Merchants of Doubt

Many of the strategies used by the opponents of both evolution and global warming are based on sowing misinformation and doubt. This approach is often called the "tobacco strategy", because tobacco companies used it effectively to delay health warnings and regulation of smoking. Historians Naomi Oreskes and Erik Conway (2010) have analyzed several examples of this strategy in their recent book *Merchants of Doubt: How a Hand-*

ful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming, and further supporting discussion is given by Chris Mooney in *The Republican War on Science* (2005) and Ross Gelbspan in *Boiling Point* (2004).

The tobacco industry in the 1950s could not disprove the link between smoking and cancer or heart disease, but they could undercut the science. Internal tobacco memos state "doubt is our product" (Oreskes and Conway 2010:15–16,34,288n129t). Big tobacco used science to fight science, funding a few pliable academic researchers, setting up non-profit foundations and organizations that released "scientific reports' and engaged in other forms of "education". Their efforts delayed effective government action by more than two decades. Other examples of the tobacco strategy include the denial of a relationship between production of CFCs (chlorofluorocarbons) and depletion of stratospheric ozone (fought by the chemical industry) and denial of a connection between smokestack emissions and acid rain (fought by electric utilities and coal companies).

Oreskes and Conway describe how a handful of famous and well-connected physicists such as Fred Seitz played a role in each of these disinformation campaigns. As one example, Fred Singer (2010) recently asserted that the science of ozone depletion is uncertain, replacing CFCs will be difficult and expensive, and the scientific community is corrupt and motivated by self-interest and political ideology—the same arguments used by global warming denialists (and not very different from some anti-evolution diatribes). Singer described his motivation in 1989 as follows: "There are probably those with hidden agendas of their own—not just to save the environment but to change our economic system. Some are socialists, some are technology hating Luddites; most have a great desire to regulate on as large a scale as possible" (Singer 1989:36–37). In 1991 he wrote that the real agenda of environmentalists was to destroy capitalism and replace it with some sort of worldwide utopian socialism—or perhaps communism (Oreskes and Conway 2010:134).

Conclusion

As the consequences of global warming become more apparent and more pressing, it is likely that educational policy in the United States will increasingly emphasize climate science in the curriculum. Indeed, climate change is present in the recently drafted framework that will serve as the basis for a new set of common state science education standards (NRC 2011). Along with this emphasis on climate science, however, will come a backlash, as the denialists turn their attention to combat the exposition of climate science, just as they have combated the exposition of evolutionary science. There have already been scattered incidents, as in Los Alamitos, California, where the local school board decided that climate change was a "controversial" issue in need of "balance" (Reardon 2011). As readers of *RNCSE* know, NCSE has been tremendously effective in challenging attempts to undermine the teaching of evolution. The strategies and tactics that NCSE has employed for years are now ripe to be deployed in the service of challenging attempts to undermine the teaching of global warming.

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