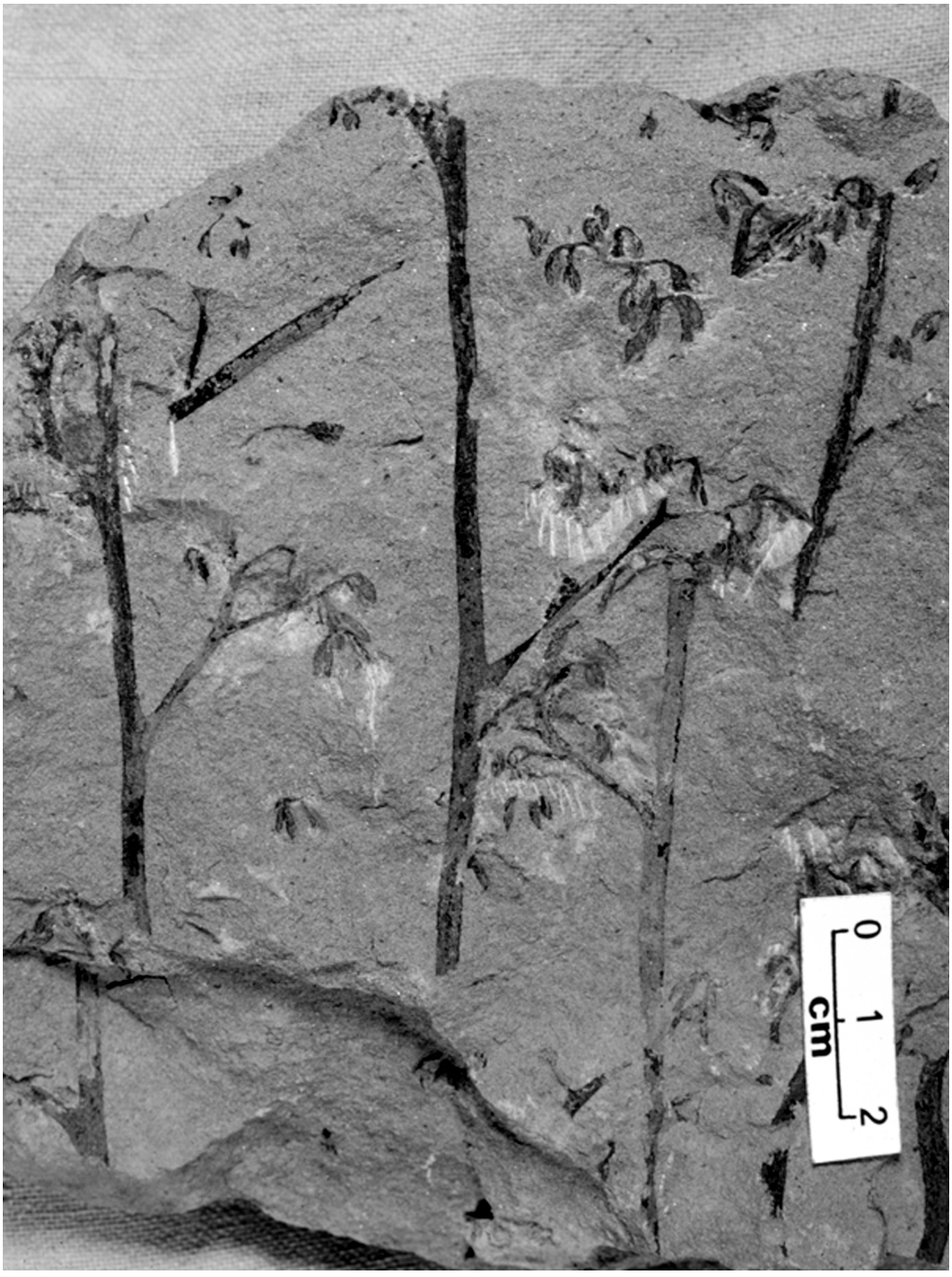
REPORTS OF THE NATIONAL CENTER FOR SCIENCE EDUCATION

DEFENDING THE TEACHING OF EVOLUTION IN THE PUBLIC SCHOOLS

Volume 23, Number 2 **MAR–APR, 2003**

CONTINUES *NCSE REPORTS* & *CREATION/EVOLUTION*



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Cover Illustration: *Psilophyton forbesii*: a very common Early Devonian plant, typical of plants during their major wave of diversification and evolution. Photograph courtesy of Patricia Gensel.

Early in 2002, NCSE received an invitation from the Botanical Society of America to participate in a special symposium on evolution education at Botany2002, the annual meeting of BSA and several sister organizations. That invitation expanded into a symposium presentation and a half-day workshop on teaching evolution. The front page of the centerfold in this issue — Ten Contributions of Plant Science to Evolutionary Biology — is the result of our conversations and interactions with plant biologists during and after those sessions. (Thanks to the organizer of those sessions on teaching evolution, Patricia Gensel, for the cover image.)

In those meetings, NCSE invited the BSA right back: we asked for plant biologists to send us manuscripts about the evolutionary biology of plants and how plant evolution could be used to improve teaching and learning evolution. The scientific articles in this issue represent two of the submissions to *RNCSE* that resulted from that invitation.

The first article, by Marshall Sundberg, explores how using plants can help students to understand evolutionary concepts and their real-life implications better. Since we know that about half the US population is unsure about evolution as the source of biological diversity over the history of life on earth, it is important to know whether the *way* we communicate this idea to students is effective.

Stanley Rice provided the second article — a field research experience that shows students the effects of natural selection on the distribution of tree species in Oklahoma and the timing of their reproductive activity. Because Rice's students explore these issues each spring, each class has the advantage of the data that students before them have accumulated, so that they can see a persistent pattern emerging and not be misled by outliers and anomalous data from one tree or one year.

IN THE NEWS

Hanover, New Hampshire, appears to be a hot spot for ID activity. Niles Donegan again reports on an ID "event" at Dartmouth College. From Lincoln, Nebraska, Clay Naff and Jim Bechtel report on a forum featuring Massimo Pigliucci and Paul Nelson in a very different sort of creation/evolution exchange — not really a "debate", according to the authors.

We also have two reports on issues of academic freedom — a recent clarion call of anti-evolutionists. Chris Mooney brings us up to date on the case of Michael Dini, the Texas Tech professor who would write recommendations only for students who used evolution to explain human origins. Piper Fogg reviews the case of Nancy Bryson, a chemistry professor at Mississippi University for Women who was asked to resign an administrative position after presenting a talk on "alternatives" to evolution to a group of honors students in February.

Lawrence Lerner has provided us with an in-depth review of the proposed new science education standards in West Virginia. Readers may recall that Lerner gave the original standards a grade of "F" for their lack of treatment of evolution. The new standards would earn a "C"; fortunately, the ID proponents did not succeed in making the changes they proposed.

In other news, anti-evolutionists are striking out at the PBS series *Evolution* once again, Glenn Branch reports. We also bring news of a few Darwin Day events that did not reach us in time for the last issue. Our updates column shows us that anti-evolutionism is popping up all over — from state legislatures to school boards.

ALL ABOUT — YOU

Our NCSE news again features the accomplishments of you — our members. First, Glenn Branch summarizes just some of what our members do to support evolution education around the country (and the world!). Then we acknowledge the generosity of those members whose financial support is "above and beyond". We appreciate our members who contribute to our cause in both these ways.

Finally, we carry the obituary of another long-time activist in support of evolution. Will Meikle died earlier this year. His most recent foray into the creationism/evolution contest was as a founding member of New Mexicans for Science and Reason, which mounted the grassroots campaign to keep evolution in New Mexico's science education standards. But there is so much more, as John Geohegan's remembrance reminds us.

BOOKS

Our centerfold features books on plant science, of course. Your purchases of these books supports NCSE. And don't forget to read our book reviews — as always, an interesting sampler of books on all aspects of evolution, the history of science, and anti-evolutionism.

NEXT ISSUE: THE ORIGIN OF LIFE

Our very next issue will be a special double issue on current research into the origin of life on earth. Although the biological processes on which evolution depends begin *after* life first appeared on earth, there are important implications for evolutionary theory embedded in the different theoretical models of life's origins. This will be a provocative and informative issue.

— Anj Petto

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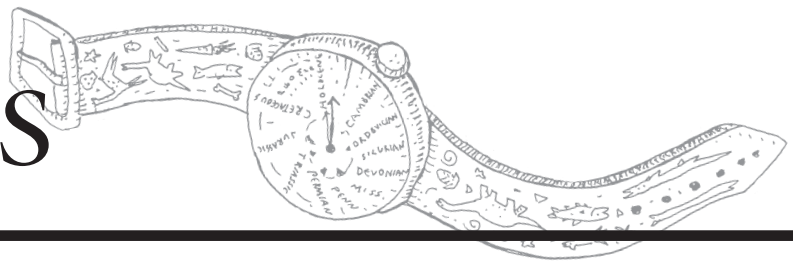
NEWS

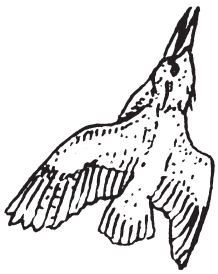


The West Virginia Science Standards and Their Critics

Lawrence S Lerner

In *Good Science, Bad Science: Teaching Evolution in the States*, published in 2000 by the Thomas B Fordham Foundation (available in PDF format at <http://www.edexcellence.net/library/lerner/lerner.pdf>), I evaluated the treatment of evolution in the science standards of every state (except for Iowa, which lacks any), assigning a grade ranging from A ("excellent or very good") to F- ("disgraceful"). West Virginia's science standards received a score of 3% and a grade of F ("useless or absent"), ranking above only the science standards then in place in Tennessee and Kansas.

NCSE asked me to review the draft of the proposed new science standards for West Virginia, using the same grading criteria as in *Good Science, Bad Science*, and also to comment on the evaluation of the proposed standards by the Intelligent Design Network (IDnet). I concluded that the standards as proposed would receive the grade of C ("satisfactory") for their treatment of evolution. If they were to be revised as IDnet suggested, they would receive the grade of F ("useless or absent").



Evaluation of the proposed standards

- Is the term "evolution" used whenever called for? Yes. 20 points/20 possible.
- Is biological evolution treated? Yes, but not intensively and not as the organizing principle of the biological sciences. 30 points/40 possible.
- Is human evolution treated? No. 0 points/10 possible.
- Is geological evolution treated? Yes. 20 points/20 possible.
- Is cosmology treated? A little. 2.5 points/10 possible.
- Are the connections among the historical sciences treated? The standard "demonstrate an understanding of the interrelationships among physics, chemistry, biology and the earth and space sciences" appears at every grade level but there is little concrete use thereof. 5 points/10 possible.
- Is creationist jargon used? No, although the use of "evolvement" (in the phrase "demonstrate an understanding of the history of science and the evolvement of scientific knowledge") is odd. 0 points/–20 possible.
- Is there a disclaimer of evolution? No. 0 points/–25 possible.

The proposed standards thus receive 77.5 points/110 possible, which equals 70% and corresponds to a grade of C ("satisfactory").

Comments on IDnet's objections and suggested changes

Recommendation 1: Objects or things?

The Intelligent Design Network's comments on the proposed standards (available at <http://www.intelligentdesignnetwork.org/sci_standards.htm>) display a certain paranoia, or at least an unreasonable suspicion. The very first recommendation is to "[r]evise the policy to remove any implication that humans are "living objects." IDnet explains:

> The standards introduce students, beginning at a very early age, to the concept that all "living" things are "objects". According to SC.1.4.1 first graders are to learn that natural objects are either "living or non-living".

But in fact SC.1.4.1 is the *only* place where "object" is used in this context. In common with almost all the state science standards I have seen, the proposed West Virginia science standards attach importance to the ability of young students to distinguish between living and non-living objects, things, or whatever they may be called. Everywhere else in the proposed standards, the word "living" is associated with either "thing" or "organism". To the latter there can be no objection; as to the former, there is ample precedent in Genesis; for example, Genesis 1:28, "… have dominion over … every living thing that moveth upon the earth."

IDnet's paranoia is expressed in the fear that students will infer that they and other humans are nothing but "things" and not ensouled individuals totally unlike all the (other) "beast[s] of the earth" (Genesis 1:30). No unbiased person can give credence to the notion that this is part of the agenda of the proposed standards. In any case, the spiritual nature of humans is a subject to be dealt with in venues other than the science classroom. Moreover, the essentially religious — not scientific — motives of IDnet are clearly demonstrated by their objection to SC.1.4.1.

Any insinuation of such distinctions into a science curriculum certainly falls under the heading of "creationist jargon", and would merit a deduction of 10 or 20 points from the total score, depending on its extent.

Recommendation 2: Is naturalism enough?

The second recommendation is:

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> Revise the Standards to eliminate the naturalistic doctrine that "natural objects" (natural phenomena, including life and its diversity), are not designed. Replace the doctrine with objectives that would encourage students to investigate and critically analyze the theories and evidence that supports both the design and naturalistic hypotheses.

This is standard "intelligent design" creationist jargon. There is a deliberate conflation of ontological naturalism with methodological naturalism. The former is the view that nothing supernatural exists — a point that may engender heated debate among theologians and philosophers but is irrelevant to the pursuit of science.

The latter, methodological naturalism, is not a "doctrine" but an essential aspect of the methodology of science, the study of the natural universe. If one believes that natural laws and theories based on them will not suffice to solve the problems attacked by scientists — that supernatural and thus nonscientific principles must be invoked from time to time — then one cannot have the confidence in scientific methodology that is a prerequisite to doing science. The spectacular successes over four centuries of science based on methodological naturalism cannot be gainsaid. On the other hand, a scientist who, when stumped while investigating a phenomenon, invokes a supernatural cause is sure not to gain any scientific understanding of the problem.

As for the phraseology "not designed", there is here an equivocation on the term "design". Living things certainly have organs and systems that are best described with reference to Aristotle's "final cause" — that is, the function that their form enables them to accomplish. But "design" can mean either of two things. First, it can mean the form itself, without reference to the way that the form came to be. No one doubts that the wings of birds are admirably designed to the function of flight, in this sense of design. What the "intelligent design" creationists are after, however, is the other meaning of design — the end-product of the work of a designer. "Intelligent design" creationists often hide the essentially theological nature of this meaning by insisting that the designer might have been some space aliens and not the God of their scriptures. But they do not maintain this position when addressing sympathetic church groups of their own or a similar persuasion.

Here again, such an approach would result in a deduction of at least 10 points for use of creationist jargon. But in addition, it would do damage to the treatment of biological evolution, resulting in a deduction of at least 10 and possibly 20 points.

Recommendation 3: The age of reason

Here is IDnet's third recommendation:

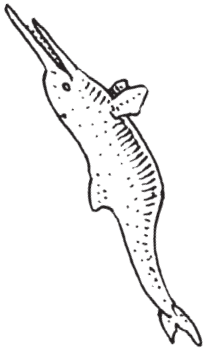
> Revise the Policy so that children are not introduced to "origins science" until they attain an age and maturity sufficient to fully comprehend the scientific bases for explanations and the philosophical implications of those explanations.

Specific reference is made to the third-grade standard SC.3.4.3, which requires students to "compare physical characteristics and behaviors of living organisms and explain how they are adapted to a specific environment (e.g., beaks and feet in birds, seed dispersal, camouflage, different types of flowers)".

Here again is evidence of misplaced concern. Adaptation *per se* does *not* imply evolution, though practicing biologists would certainly attribute the adaptations observed in living things to the process of evolution. If I say that squirrels are well adapted to life in trees, I am saying nothing about the process by which that came to be. Indeed, a creationist who admires the design work of God is likely to praise the beauty of the adaptation of the squirrel to the tree.

The fundamental objection, I suspect, is not to the term "adaptation" but to the idea that evolution is a far broader concept than creationists are willing to admit. A satisfactory treatment of evolution necessarily includes such elementary ideas as adaptation — ideas that are entirely appropriate to the primary grades. The scoring criterion "Is biological evolution treated?" takes this explicitly into account. For science standards to receive a full score of 20 points, they must ensure that at least some of the basic underlying concepts essential to understanding evolution are introduced at early grades. Many state science standards do so. The proposed West Virginia science standards are already rather weak in this aspect of the treatment of evolution, but introduction of these creationist ideas would result in a further degradation of the standards.

Recommendation 4: Value-neutral "origins science"



Here is the fourth recommendation:

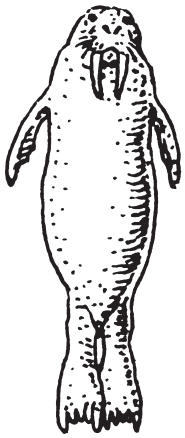
> Add explicit provisions that will encourage teachers to (a) discuss "origins science" objectively and without philosophical, naturalistic or religious bias or assumption and (b) help students think critically about evolutionary theory and understand the full range of scientific views that exist regarding origins of life and why "origins science" may generate controversy.

This is a peculiar recommendation. Except for the very last part, it describes what good teachers already do, not only in the biological sciences but also in all sciences. As for the phrase, "… why 'origins science' may generate controversy", there can be no doubt that scientists engage in controversy all the time as part of their work. But that controversy — in the life sciences as in all sciences — involves new research at the frontiers of the science, not the thoroughly substantiated and accepted basic concepts such as Newton's laws of motion, the conservation of energy, continental drift, or evolution.

Of course, such controversies are not the sort of controversy the creationists ("intelligent design" or otherwise) are referring to. They refer to the entirely extrascientific

— usually religious — objections that they themselves have to the fact as well as the theory of evolution. But if creationists really have *scientific* objections, they should bring them to the scientific community through the standard mechanism of peer-reviewed contributions to the relevant scientific journals — which creationists have never done. The function of K–12 science education is not to have students decide which basic laws of science are acceptable and which are not, but to have them learn what scientists do, how they do it, and what results they obtain. No amount of word-bending and inventing of "controversy" will aid the schools in fulfilling this goal.

Modifying the proposed standards to accommodate IDnet's recommendation would amount to introducing creationist jargon. In addition, it would damage the overall program of instruction in the nature of science, wreaking damage not only on the treatment of the life sciences but also on the treatment of the rest of the sciences.



Recommendation 5: Historical versus experimental sciences

Here is the fifth, and final, recommendation:

> Add objectives that will require students to learn about the naturalistic assumption that is used in current "origins science" and the effect that assumption has on textbook explanations, particularly in light of the historical character of "origins science".

Here IDnet is quite vague, and it is difficult to know how much damage such additions would cause. But much of this is a repeat of the issues raised in the discussion of IDnet's second objection. However, one of the suggested additions to implement the recommendation would positively mislead students about the nature and methodology of science, as well as the unity of the sciences:

> Differentiate between historical sciences such as evolutionary biology and experimental sciences [such as] physics and chemistry, understand methods used by scientists to test the credibility of historical hypotheses, understand the limitations of those methods to confirm historical explanations provided and understand how *bias* and the *"choice of what data to consider in the first place,"* may affect historical explanations [emphasis in original].

There is a serious distortion of all the historical sciences implied here, and scoring would be affected in the areas of geological evolution, cosmology, and the connections among the sciences.

Evaluation of IDnet's revisions of the standards

In the light of the above discussion, I can estimate the approximate score that I would assign to the standards if all these IDnet changes were implemented.

- Is the term "evolution" used whenever called for? Yes. 20 points/20 possible.
- Is biological evolution treated? Yes, but not in a way which encourages clarification of its role in the life sciences. 10 points/40 possible.
- Is human evolution treated? No. 0 points/10 possible.
- Is geological evolution treated? Yes, but less than ideally thoroughly. 10 points/20 possible.
- Is cosmology treated? No. 0 points/10 possible.
- Are the connections among the historical sciences treated? No. 0 points/10 possible.
- Is creationist jargon used? Yes. –20 points/-20 possible.
- Is there a disclaimer of evolution? No. 0 points/-25 possible.

IDnet's version of the standards thus receive 20 points/110 possible, which equals 18% and corresponds to a grade of F ("useless or absent").

The aftermath

On February 17, 2003, IDnet sent the West Virginia Board of Education an 11-page response to a version of my evaluation of the proposed science standards and of IDnet's comments on them (available in PDF format at <http://www.intelligentdesignnetwork.org/ReplytoLerner.pdf>). Laden with red herrings, quote-mining, and innuendo, it apparently failed to impress the board, which, on February 20, unanimously voted to accept the proposed science standards without any changes. Although the standards are not ideal — they receive only a C, remember — they are still a vast improvement. I would be pleased to think that my efforts helped to encourage the board to adopt them without succumbing to creationist pressure.

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More Darwin Day Events

In *RNCSE* 2003 Jan/Feb; 23(1): 4–6, we listed some of the Darwin Day 2003 events held around the nation and the world. Here are two more.

Oregon

On February 15, 2003, Oregonians for Rationality held a first annual Darwin Day lecture at Portland State University with a presentation by long-time NCSE member and evolution activist William Thwaites. His talk was entitled: "Paleontology before Darwin: Suitable for young audiences?" Thwaites's lecture discussed the geologic observations that led Darwin to his historic contribution to science and Thwaites's unsuccessful attempt to have this historical background for evolution included in a well-known high-school biology text.

Idaho

There were two events inspired by Darwin Day in Idaho. On February 9, Idaho Atheists held a social to commemorate the day. The second event was an informal gathering of supporters of evolution who have been active in preserving evolu-

tion in the Idaho science education standards and curriculum. Our correspondent in Idaho, Gary Bennett, also informed us that there is now an internet list-serve for Idahoans interested in evolution. It is managed by Rosemary Smith, a biology professor at Idaho State University. Interested readers can learn more about the list by e-mailing Smith at smitrose@isu.edu.

Paradigm Glossed: How to Make an ID Debate Worthwhile

Clay Farris Naff and
Jim Bechtel
Center for the Advancement of Rational Solutions

The firefly (*Photuris pyralis*) is a wonder of nature. Its tiny body contains luciferin and luciferase, two rare chemicals that scientists have been unable to synthesize. Yet, as any child who has grabbed one of the slow-flying insects on a summer evening knows, those substances produce a remarkable and beautiful phenomenon: cold light.

Curiously, *Photuris pyralis* never came up in the Great "Intelligent Design" Debate held at winter's end at Saint Paul United Methodist Church of Lincoln, Nebraska. Yet, somehow, the debaters — philosopher Paul Nelson of the Discovery Institute and evolutionary biologist Massimo Pigliucci of the University of Tennessee — managed to mimic the firefly's trick: they cast much light with little heat.

Over the span of nearly two hours, they offered arcane details of biology and earthy, sometimes humorous presentations of their arguments. In the end, they inspired the Center for the Advancement of Rational Solutions (CARS) to consider new ways of resolving the public policy impasse over the science curriculum.

Considering the unsavory history of creationism/evolution debates, this amounts in our view to a minor triumph. And yet nothing miraculous took place. On the contrary, we believe what transpired in Lincoln could be replicated — with variations — around the country. To that end, we would like to share the story of our event and insights about what made it work. The debate centered on the question: "Is 'intelligent design' a valid scientific alternative to evolution?" At the start the audience of some 150 people who braved a blizzard to attend were told that although this was to be a debate, "the only winner will be those of you who are willing to consider a point of view or information you haven't thought about before."

That position was in keeping with our group's outlook. Although the leadership of CARS is solidly in the evolutionary camp, the organization exists to promote rational reconciliation of religions with science and with each other. Its membership includes a variety of creationists, from biblical literalists to nonspecific ID advocates, whose views are welcomed within the group's discussions.

Talking Points

The debate opened with PowerPoint® presentations from each side. Nelson, who holds a doctorate in philosophy from the University of Chicago, surprised many by conceding from the start that, strictly speaking, "intelligent design" is not a valid scientific alternative to evolution — at least not yet. "Intelligent design", he admitted, has yet to demonstrate its validity or to be accepted by the majority of the world's scientists. However, he argued, the really fruitful questions concern the nature of science. Its commitment to methodological naturalism, Nelson said, "leaves you with only that one tool in your kit." Science would be "more honest" without this unnecessarily restrictive rule, he said.

Nelson introduced one of ID's two main arguments with a humorous anecdote about "Mint Jelly Ridge", a con man who faked injuries by pretending to slip on mint jelly in restaurants throughout the Midwest. Insurance companies who paid claims on behalf of restaurant owners detected a pattern that indicated design rather than accident, leading to Ridge's arrest and conviction. This, Nelson said, was an example of the design inference, something routinely used in forensics and a method that Nelson's Discovery Institute colleague William Dembski claims should be applied to features of nature.

Paul Nelson, at left, responds to a question from the audience. Clay Farris Naff, who moderated the debate, is seated center, with Massimo Pigliucci at the right.

In his presentation, Pigliucci offered a definition of biological evolution as both change in the frequency of genes and, historically, as the descent of species from common ancestors along the "tree of life". He took pains to exclude the origin of life from evolutionary theory. Pigliucci defended evolution on the grounds that it offers a coherent explanation for our observations of biological diversity, and it makes predictions that can be empirically tested.

In contrast, he said, "intelligent design" offers only flawed arguments with no predictive value. Taking on one of these — Michael Behe's argument for the "irreducible complexity" of certain microbiological features — Pigliucci said that it amounts to an "argument from ignorance". If something cannot be explained by evolution at present, he said, some would have us believe that it must have been intelligently designed. Such a strategy, however, consistently fails as science progresses, he argued.

By the same token, "intelligent design" advocates should be

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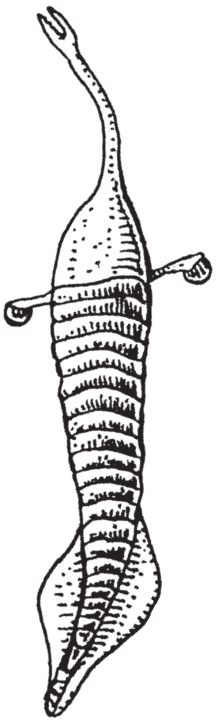
prepared to explain numerous instances of poor design in nature, Pigliucci asserted. He offered the example of rabbits that depend on certain bacteria in their guts to supply necessary digestive enzymes. Unfortunately, Pigliucci said, the rabbits have no means to pass on the bacteria except by having baby rabbits eat their mother's feces. He added that biological relatives of rabbits do have genes that produce the enzyme directly, so evolutionary theory would predict that remnants of the genes still exist in the rabbit, and, sure enough, Pigliucci said, the pseudogenes have been found.

Give and take

Up to this point, the arguments would have been familiar to anyone acquainted with ID–evolution disputes. Things got more interesting, however, when the debate moved into its free-flowing discussion phase. Nelson raised "Clarke's Law", the acclaimed science-fiction writer's dictum that any sufficiently advanced technology would appear to be magic to a less advanced civilization. He asked Pigliucci how Aristotle would have explained a television remote control. His opponent responded that Aristotle would have assumed a naturalistic explanation: a supernatural explanation cannot be tested, he said. Nelson responded by musing on whether "supernatural" remains a useful category. Perhaps it is time to move beyond that concept and make testable predictions outside the bounds of naturalism, he suggested.



Later, Nelson raised a possibility for a specific ID prediction. Referring to "orphan genes" occurring uniquely in some microorganisms without analogs in related species, he said that ID advocates should be prepared to predict that similar anomalous genes will be found scattered throughout the zoological realm. He also pointed to the origin of life as a focus for ID. Reasoning that RNA could not have held together long enough to give rise to life, Nelson speculated that the fragility of RNA could be a "signature" of the intelligent designer. Pigliucci replied that the frequency of "orphan genes" is well within the limits of random phenomena, and that RNA's fragility might have been solved by the "pizza model" of biogenesis, in which organic chemicals are thought to have self-assembled within stable films on rocks.

Self-critique

Most interestingly, each debater offered an unsolicited criticism of his own side. Pigliucci denounced "scientism" — the claim that science can eventually answer all questions — as indefensible arrogance. Nelson declared that teaching "intelligent design" in science classes would be wrong at this stage. Philosophy courses are the proper venue for the study of ID, he added, until it proves itself scientifically valid. This willingness to be self-critical and to trust in the civility of the other side contributed greatly to the thoughtful atmosphere. To be sure, there were skeptical and even emotional reactions from audience members during the question-and-answer segment that closed out the debate. But on the whole, it was a refreshingly high-minded occasion.

The lion's share of credit goes to the debaters themselves, who eschewed rhetorical tricks, distractions, and combativeness in favor of a serious, accessible consideration of the issues. Still, the structure and sponsorship of the debate undoubtedly helped. Putting the focus on "intelligent design" helped to prevent the debate from becoming a mere rehearsal of attacks on evolution (not that Nelson would necessarily have conducted himself that way).

Response to the debate was uniformly positive across the ideological spectrum. At the request of members, the next meeting of our organization was devoted to follow-up discussion. Three members requested time to offer brief prepared presentations. Two were defenses of evolution, while the other was a defense of "intelligent design" and a call for opening up the public school science curriculum to alternatives on the grounds of democracy.

Interestingly, in the ensuing discussion, considerable support emerged for the idea of teaching "intelligent design" — but not in science classes. Rather, there appeared to be support in the group for the idea of introducing philosophy of science and religion classes into the public school curricula alongside regular science classes. With appropriate safeguards on neutrality concerning religion, this might represent an avenue to reconciliation, with the added benefit of exposing students to philosophical discourse and critical thinking at the high school level.

Call it the firefly option.

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Creationist U

Chris Mooney

When it comes to America's unique crop of home-grown creationists, it is safe to say there are two places that they desperately aspire to get into: Heaven and the nation's public schools and universities. And while it is impossible to say how creationists have been faring in their quest for salvation, it is quite clear that these have been heady days for their standing on college campuses.

First, in the apparent conclusion to an episode I wrote about almost 3 months ago (Mooney 2003), the Department of Justice has closed its religious discrimination inquiry concerning Texas Tech biology professor Michael Dini over his letter of recommendations policy (DOJ 2003). You may recall that Dini had required, among other criteria, that students receiving medical school letters of recommendations from him be able to "truthfully and forthrightly affirm a scientific answer" to the following question: "How do you think the human

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species originated?" Faced with DOJ's investigation, Dini essentially backed down, changing his letters of recommendation policy so that it now states, "How do you account for the scientific origin of the human species? If you will not give a scientific answer to this question, then you should not seek my recommendation" (Blaney 2003).

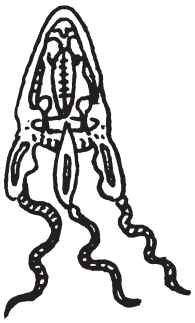
The difference is a subtle but important one: Dini's policy now challenges students to explain evolution, not believe in it. Justice Department Assistant Attorney General for Civil Rights Ralph F Boyd Jr had this to say of Dini's policy change: "A biology student may need to understand the theory of evolution and be able to explain it. But a state-run university has no business telling students what they should or should not believe in" (DOJ 2003). Texas Tech did nothing of the sort, of course: It merely allowed its professor, Michael Dini, to decide for himself on what basis he wishes to write recommendation letters for students, which is a voluntary activity in the first place. Only under a radically exaggerated notion of the rights of Christian students can this possibly be seen as religious discrimination — but it seems that just such a notion has taken hold at the Department of Justice. And this change, in turn, suggests that a legal environment highly favorable to creationists is in the offing.

Also troubling, though in a different way, is the following. In early May at the University of Arizona in Tucson, the massive McKale Memorial Center, home to the Wildcats basketball team and capable of seating some 15 000, hosted a debate over evolution between creationist guru Duane Gish and a University of Arizona ecology professor, Peter Sherman (Hall 2003). Creation–evolution debates are not unknown on college campuses, but this one was rather distinctive due to its high profile. As astronomer James McGaha, who was initially accepted to debate Gish but was subsequently turned down by event sponsors, explained in an interview, McKale Center is "probably the most recognizable place in Tucson to have something like this."

It is often debated in skeptic circles whether it is worthwhile or counterproductive to debate creationists. But the Arizona instance gives a pretty clear example of a case where such a debate would do more harm than good. Rather than a truly balanced "debate", there is ample reason to think that this choicest venue on the University of Arizona campus essentially served as a massive podium for the Institute for Creation Research's Gish — who, according to those familiar with his debating techniques, excels at convincing unsuspecting audiences that the theory of evolution is riddled with holes. For a fascinating account of how this event came into being, see the report in the *Arizona Daily Wildcat* by columnist Caitlin Hall, who charges that the University of Arizona evolution debate was deliberately designed "to make a mockery of evolution" (Hall 2003).

What do these two incidents have in common? Well, most obviously, they prove that the battle against creationism, and its cousin, "intelligent design" (Mooney 2002), is far from over and requires continuing vigilance. I think they suggest more than that, however. Especially in the case of the Arizona debate, it is clear that that the defenders of evolution were asleep at the switch. On a similar note, the unfortunate conclusion of the Dini affair shows that the US Department of Justice under John Ashcroft is committed to enforcing a concept of religious freedom that could have dramatic consequences for the standing of creationism at state universities.

Let us start with the Dini case. According to a Justice Department spokesperson, the Texas Tech inquiry was a project of the Civil Rights Division's Special Counsel for Religious Discrimination, Eric W Treene. Treene's position was recently created in John Ashcroft's Department of Justice; it did not exist before. Treene himself formerly worked as litigation director for the Becket Fund for Religious Liberty, described by Americans United for the Separation of Church and State as "a conservative Catholic-oriented legal group" (Boston 2002). Last summer, Treene's appointment to his post was hailed as a "New Day For Christians in Washington" by the Rev Rob Schenck, who heads a group called Faith and Action, which aims to remind lawmakers of "the prominent role that the Word of God played in the creation of our nation and its laws." Of Treene's work, Schenck had this to say: "He is an advocate for people of all religious beliefs, and even of none, but he is especially big-hearted for Christians like us" (Schenck 2002).



The Justice Department's Dini inquiry was spurred on by a complaint by Texas's Liberty Legal Institute, which like Schenck's group has supported the posting of the Ten Commandments on government grounds. On a similar note, the DOJ's Special Council for Religious Discrimination has also gotten itself involved in a Massachusetts federal district court case called *Westfield High School LIFE Club, et al v Westfield Public Schools*, where Treene helped to file a brief arguing that Westfield High School had been engaged in "viewpoint discrimination" by refusing to allow Christian students to pass out candy canes with religious messages. The Justice Department's involvement in this case followed on the heels of work by the Alliance Defense Fund, a Scotsdale, Arizona-based outfit that describes itself as a "unique Christian legal organization that works to protect and defend traditional family values, religious freedom, and the sanctity of human life."

Why point all this out? Well, because it shows that the Dini case did not simply come out of nowhere. Instead, the case reflects the Bush administration's new responsiveness to Christian conservatives who would, given the chance, love to unseat the teaching of evolution in public institutions. Failing that, these groups can try to subtly shift the legal climate in their direction through measures such as targeting a professor like Michael Dini, who was gutsy enough to try to write an anti-creationist stance into his letter of recommendations policy.

While there has been significant attention to the Dini case, no one yet seems to have realized that it represents a shift in approach by the Bush–Ashcroft Justice Department, and one that could

have profound implications for the standing of evolution in universities. Similarly, I am not aware of any major civil rights or legal organization that took the opportunity to stand up for Dini. (Dini himself did not respond to a request for an interview for this column.)

A similar lack of awareness — and activism — seems evident in the Arizona case. According to columnist Caitlin Hall, the machinations of the Calvary Chapel of Tucson and other debate organizers to ensure that Gish had an outstanding forum from which to launch broadsides against evolution are pretty extraordinary. As previously mentioned, they included first accepting, and then afterwards turning down, one pro-evolution debater, the astronomer James McGaha. Hall suggests the reason for turning down McGaha may have been that he would be too tough a competitor for Gish to handle.

Moreover, the notion that the event, as currently planned, was really a "debate" in the first place is dubious. According to McGaha, both Gish and his opponent had a staggering hour-long period to expound their views, followed by very limited rebuttal time and no cross examination or audience questioning. Rather than a debate, then, this event should be considered a pair of lectures. And that essentially means the University of Arizona has decided to give over its biggest venue for a creationist speech.

This is, of course, just what creationists want. As National Center for Science Education Executive Director Eugenie C Scott has written about creation–evolution debates: "The evolutionist debater is never going to be able to counter all of the misinformation that a creationist can put out in a lengthy debate format. And the way these things work is that suspicion is sowed in the minds of the audience no matter what" (Scott 1995). Another Scott warning has particular relevance to the Arizona situation:

> What usually happens in these debates? Usually they take place at the invitation of the other side, and usually they take place in a religious setting or minimally under religious sponsorship. That is the first problem. The audience that is most anxious to come, and that will be recruited the most heavily, is the one that supports the creationist. In the comparatively rare situation where the debate is held on a college campus, the supporters of good science and evolution are invariably in the minority in the audience, whereas the creationist supporters seem to exercise every effort to turn out their crowd. Do not be surprised to see church busses from many local communities lined up outside the debate hall. In some cases, the sponsors advertised only among the faithful, posting up only a handful of flyers on campus. Guess who came?

It is important not to be alarmist: Neither of these developments, either at Texas Tech or at the University of Arizona, heralds the unseating of evolution from its privileged place at the nation's universities. Far from it. However, both are important examples of creationists winning significant victories through clever strategizing, as their opponents stood idly by. Moreover, in both cases the creationist camp has cleverly exploited a liberal notion of open-mindedness and receptivity to differing viewpoints — especially open intellectual debate — in order to get a foot in the door. Unless the defenders of the teaching of evolution prove themselves willing to think strategically and counter creationists at every turn, they will most assuredly continue to lose small battles like this. And if they lose enough small battles...

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[*Reprinted with permission from* Doubt and About, *Chris Mooney's web column for the Committee for the Scientific Investigation of Claims of the Paranormal: <http://www.csicop.org/doubtandabout/>.*]

The *Evolution* Backlash: More of the Same

Glenn Branch
NCSE Deputy Director

The mission of Probe Ministries, founded in 1973 by James F Williams Jr, is "to present the Gospel to communities, nationally and internationally, by providing life-long opportunities to integrate faith and learning through balanced, biblically based scholarship, training people to love God by renewing their minds and equipping the Church to engage the world for Christ." Apparently its mission also required it to attack the PBS series *Evolution*. In a 3000-word posting on the Probe Ministry web site dated December 1, 2002, Raymond G Bohlin, the executive director of Probe Ministries, castigated the series for "speculation, exaggerated evidence and claims, glossing over of legitimate controversy, and a persistent hostility towards any religious perspective deemed incompatible with evolution." His complaint was essentially a précis

of the Discovery Institute's critique, *Getting the Facts Straight* (Seattle: Discovery Institute Press, 2001), which is not surprising in light of Bohlin's association with the Discovery Institute: he is a Fellow of its Center for (the Renewal of) Science and Culture. One novelty in Bohlin's critique is his attack on the web site for the *Evolution* series (<http://www.pbs.org/wgbh/evolution>), which focuses on Kenneth R Miller's essay "Life's grand design", reproduced there.

For Bohlin's critique, see <http://www.probe.org/docs/pbs-evol.html>. For a survey of the reactions of creationists and other ideological opponents of evolution to the *Evolution* series, see *RNCSE* 2001 Sep–Dec; 21 (5–6): 5–14 and 2002 Sep/Oct 22 (5): 13.

Paul Nelson at Dartmouth

Niles Donegan

Paul Nelson, a Senior Fellow of the Discovery Institute's Center for Science and Culture, spoke at Dartmouth College on February 19, 2003, to a crowd of approximately 150 people. The Campus Crusade for Christ and the Christian Medical Association were the local groups extending the invitation for him to speak on "Intelligent Design and Evolution — Unraveling the Controversy". He opened the presentation with a story about how a case of insurance fraud was discovered by investigating a detail repeated in each claim. The ability of detectives to uncover a pattern and convict the offender was then used to illustrate how intelligent action can be discerned from random noise.

Nelson's talk was far-ranging, but his examples were carefully chosen and cleverly worded. For example, he presented a single quotation by Stuart Kaufmann arguing against the RNA origin of life hypothesis — adding that RNA-based information would not last in geologic time — without mentioning other currently proposed alternatives to RNA in the emergence of early life. He also misrepresented the Mycoplasma as free-living organisms poorly adapted to environmental fluctuations without once mentioning that these are intracellular pathogens (*see* RNCSE *2002 Sep/Oct; 22 [5]: 30–5.*)

Next, he tried his hand at genomics. Starting with a 1999 paper on the minimal genome (identified as that of Mycoplasma), he spoke wondrously of how 30-odd open reading frames (ORFs) in the minimal set have no known function. He then made a spectacular leap by stating that because each new genome that we sequence presents a new large set of ORFs that have never appeared in any prior sequence or database, these ORFs should be considered unique, and that this uniqueness makes these organisms very distinct from one another in ways that evolution cannot explain. Of course, as I pointed out during the discussion session, we have complete genomic sequences of only 60 bacterial organisms and moderately detailed sequences for some 200 more. So this apparent uniqueness could just as easily be chalked up to sampling error. This situation is analogous to our trying to make generalizations about the "body plans" of living things if we were to draw a limited sample of organisms from as broad a set as these genomes represent — yeast, bacteria, algae, vascular plants, avascular plants, marine invertebrates, mammals, arthropods, and so on. The diversity would appear to be overwhelming compared to the size of the sample.

But the real discussion was not scientific. Beginning with the claim that Darwin's agenda was to "change the rules of science itself" as well as to document nature, he went on to attack the position of the National Academy of Sciences (NAS) that scientific inquiry is limited to considering "only" natural processes, suggesting that to serve science better, the definition of scientific inquiry be "broadened" to include the investigation of supernatural processes.

Six or seven highly critical questions followed his talk. Most focused on his philosophical arguments, criticizing ID as reactive and focusing only on the current gaps in science instead of finding its own supporting data. When asked about how old he believes the earth to be, he explained that for scientific purposes he assumes the standard 4.5 billion year age while still thinking that the Bible supports a much younger age. Nelson did say that he was opposed to teaching "intelligent design" in public schools, because he believes that "there's not enough theory to teach" ID at this point at that level. ID, he argued, must be developed more fully at higher educational levels.

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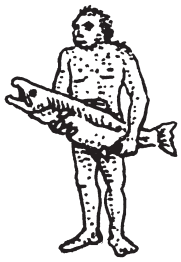


Science Administrator Who Questioned Evolution Reinstated

Piper Fogg

Mississippi University for Women has reinstated a science and math administrator it had demoted days after she gave a lecture questioning evolution.

After Nancy Bryson, an associate professor of chemistry, charged that the university had violated her academic freedom with the demotion, the institution's president announced last week that the professor would remain as division head of science and mathematics. The president, Claudia A Limbert, cited concern about "the incorrect perception" that Bryson had been demoted because of the lecture.

Bryson gave a presentation on February 20 to a group of honors students titled "Critical thinking on evolution". The talk covered alternative views to evolution, including "intelligent design" — a theory that an intelligent agent is responsible for the origins of earth and its history (*The Chronicle of Higher Education* 2001 Dec 21). "It pointed out some inconsistencies in Darwin's theory", said Bryson. Following the talk, a senior profes-

sor of biology stood up and read a rebuttal to her remarks. "He said it was religion masquerading as science", said Bryson.

The next day, according to Bryson, Vagn Hansen, the vice president for academic affairs, asked her to resign her administrative post but would not say why. She refused, and 3 days later received a letter stating that her contract as division head would not be renewed, she said. Hansen was not available for comment.

Bryson sent e-mail messages to faculty and alumni e-mail lists accusing the administration of dismissing her because of her lecture. Perry Sansing, the university counsel, denied her claims in an e-mail response to the lists. "Her personal opinions, and her presentations in particular, played no part in Dr Hansen's request for her resignation", Sansing wrote.

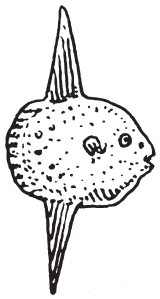
In a March 13 release, Limbert said she reinstated Bryson because events "created the incorrect perception that ... Bryson's nonrenewal ... was a consequence of her recent lecture." She reasserted the institution's "absolute commitment to academic freedom and freedom of speech".

In an interview, Sansing would not discuss the details of Bryson's reinstatement except to say that she and Hansen had previously had several conversations and written exchanges about her job performance, some of which occurred months before the lecture.

Bryson maintains that her original dismissal was linked to her February presentation and that administrators felt pressured to reinstate her after supporters had sent a number of e-mail messages and made calls on her behalf. "I think that turned the tide", she said.

Still, Bryson is not confident about her future at the university. The administration, she said, is disappointed because of the negative publicity. "I'm going to be watching my back."

UPDATES



Japan: A group of teachers produced its own science textbooks for middle school that cover topics — including evolution — omitted from the standard middle school textbooks approved by the Education, Science, and Technology Ministry. "The curriculum content of the current science textbooks was reduced by about 30% compared with [the] last academic year. The ministry plans to postpone teaching students about evolution and ions until high school", reports the *Daily Yomiuri* (2003 Jan 26). NCSE member Hiroshi Unoura, Professor in the Department of English Communication of Bunkyo Gakuin University in Tokyo and who specializes in educational issues, regards evolution as tangential to the controversy: evolution was selected for removal from the middle school curriculum, he thinks, because its removal would not have been — and was not — strenuously protested. (*Nature* [2002 Apr 25; 416: 778] reported that Japanese scientists "fear that the ministry is underestimating evolution's significance", however.) Unoura writes, "Although ... Japanese creationists, whose number is very, very small, have been happier since then, they don't have enough power to change the present situation in Japan by such a strong anti-evolution campaign as the one in [the United States]."

Kansas: On February 6, 2003, Senate Bill 168 was introduced into the Kansas Senate by the Senate Education Committee at the behest of Senator Larry Salmans (R–Hanston). SB 168 would have required schools to "encourage the presentation of scientific evidence supporting the origins of life and its diversity, objectively and without religious, naturalistic or philosophical bias or assumption." Seasoned observers recognized this language as similar to that used by anti-evolutionists nationwide either to discourage the teaching of evolution or introduce so-called alternatives such as "scientific creationism" or "intelligent design." But the Senate Education Committee was unaware of the anti-evolution implications of the bill. Chairman Dwayne Umbarger (R–Thayer) commented, "It mentioned nothing about the origin of life ... Not until later in the evening did I realize I'd been handed a hot potato" (quoted in the Lawrence, Kansas, *Journal-World*, 2003 Feb 8). But the bill was not voted on by the Senate: "We're not going to have time to have hearings", Umbarger explained. The *Journal-World* reported him as saying that "the bill already was dead in the water." And indeed SB 168 died in committee on March 1.

Louisiana: On April 1, 2003, Louisiana Representative Ben Nevers (D–District 75) introduced House Concurrent Resolution 50, which was referred to the Education Committee on April 2. HCR 50 seeks to "encourage city, parish, and other local public school systems to refrain from purchasing textbooks that do not provide students with opportunities to learn that there are differing scientific views on certain controversial issues in science." In particular, HCR 50 urges that "city, parish, and other local public school systems should refrain from purchasing textbooks that do not present a balanced view of the various theories relative to the origin of life but rather refer to one theory as proven fact", quoting the so-called Santorum Amendment (see *RNCSE* 2002 May/Jun; 22 [3]: 4–5). For the full text, see <http://www.legis.state.la.us/leg_docs/03RS/CVT1/OUT/0000K4Q7.PDF>.

Oklahoma: House Bill 1504, which would have required the inclusion of a version of the Alabama disclaimer in every textbook that discusses evolution (see *RNCSE* 2003 Jan/Feb; 23 [1]: 6–7), died in committee when the legislative deadline for action passed. The full text of the bill is available

on-line at <http://www.lsb.state.ok.us/2003-04HB/HB1504_int.rtf>.

Pennsylvania, Bangor: The Bangor Area School Board narrowly defeated a challenge to the proposed adoption of a high-school biology text because, according to opponents, it treated evolution as a "fact, not a theory". The textbook, *Biology*, 6th edition, by Campbell and Reece, raised hackles in this northeastern Pennsylvania town because it explicitly debunks "theory, not fact" arguments against evolution. According to a report in the *Express-Times* (Easton PA), it was school board vice-president Charles Cole who argued most eloquently *for* evolution and the textbook and whose efforts secured the vote in favor of adoption. In addition, Cole argued that the Pennsylvania state science education standards require that students learn about evolution and that the proposed text was in line with those standards: "We have to teach standard science." What was perhaps most alarming in the news article was reporter Jeff Schogol's discovery that "Officials from most neighboring school districts in New Jersey and Pennsylvania said they don't teach Darwin's theory as a fact." The news report of the proceedings can be found at <http://www.nj.com/news/expresstimes/pa/index.ssf?/base/news-6/105419907998670.xml>. Local NCSE members are working with the school board and offering support to board members, teachers, and parents.

South Carolina: Senate Bill 153 originally dealt with instructional materials and textbooks. During consideration of the bill on the Senate floor on April 9, 2003, Senator Michael L Fair (R–Greenville County) offered an amendment to SB 153 containing this provision: "The following must be placed in all science books published for kindergarten through twelfth grade: 'The cause or causes of life are not scientifically verifiable. Therefore, empirical science cannot provide data about the beginning of life.'" When another senator objected, no action was taken at that point on Fair's proposed amendment or on the bill itself. According to a report in the *Greenville News*, Senator Fair was irritated by the A grade given to South Carolina's science standards for their treatment of evolution by Lawrence S Lerner in his *Good Science, Bad Science* report for the Fordham Foundation. "Fair said his intention is not to inject other theories of origins into the public school curriculum, or to teach religion in the schools — even though he believes Darwin's theory is 'foolish' and is a religious belief in itself. His goal, he said, is to stimulate discussion in classrooms where 'dogmatic' teachers present evolution as fact rather than theory" (*Greenville News* 2003 Apr 15; available on-line at <http://greenvilleonline.com/news/2003/04/15/200304154775.htm>). The *Greenville News* also noted that Fair's view is at odds with that of the American Association for the Advancement of Science, the National Science Teachers Association, and the National Association of Biology Teachers. On April 29, Fair withdrew his original amendment, but proposed another, which would establish a "South Carolina Science Standards Committee", the 19 members of which would be appointed by various state officials and organizations. The committee would "(1) study science standards regarding the teaching of the origin of species; (2) determine whether there is a consensus on the definition of science; (3) determine whether alternatives to evolution as the origin of species should be offered in schools." According to an article in the *Greenville News*, Fair "said his intention is to show that Intelligent Design is a viable scientific alternative that should be taught in the public schools" (2003 May 1; available on-line at <http://greenvilleonline.com/news/2003/05/01/200305015608.htm>). Fair's new amendment was adopted by the Senate, which subsequently passed the bill; it is now before the Committee on Education and Public Works of the House of Representatives, but may not reach the floor for a vote before the end of the legislative session.

South Carolina, Aiken: After four years of unsuccessfully campaigning to have creationism taught alongside evolution in the Aiken County schools, Glenn Wilson announced at a meeting of the Aiken County Board of Education that he is giving up, according to a report in the Aiken *Standard* (2003 Feb 12). Wilson's campaign was a focus of a September 2002 ABC News report, "God's Country: Faith in the 21st-Century Bible Belt" (a transcript is available on-line at <http://abcnews.go.com/onair/DailyNews/ISOA_godscountry020906. html>), in which he was quoted as saying, "We really should not be teaching either view in science class. But if we are gonna teach one, then we have to teach both, just to be fair."

Tennessee, Blount County: The Blount County Board of Education rejected the adoption of three new biology textbooks because they present evolution but do not present creationism, the Maryville, Tennessee, *Daily Times* reported (2003 Apr 5; available on-line at <http://www.thedailytimes.com/sited/story/html/127192>). The textbooks in question were chosen by the biology teachers at the district's high schools. The vote to reject the textbook was originally reported as 2–1, with 4 abstentions; a later story in the *Daily Times* corrected the tally to 6–1 (2003 Apr 22; available on-line at <http://www.thedailytimes.com/sited/story/html/128793>). According to technology supervisor Brian Bell, who is charged with assisting teachers in choosing the textbooks, the next course of action would be for the science instructors at the high school to write a curriculum that includes creationism alongside evolution. With such a curriculum in place, the board would be content to adopt the three textbooks.

Texas: On March 25, 2003, the Public Education Committee of the Texas House of Representatives approved House Bill 1447 by a vote of 6–1 (with 1 abstention); HB 1447 will now be considered by the House as a whole. HB 1447 would return control of textbook content to the State Board of Education. Additionally, it would require that textbooks "… be free from factual errors, including errors of commission or omission related to viewpoint discrimination or special interest advocacy on major issues, as determined by the State Board of Education" and empower the board

to "reject any textbook that contains factual or other errors"; the language about "viewpoint discrimination" and "factual or other errors" is reminiscent of anti-evolutionary rhetoric. Among the witnesses speaking in favor of the bill were representatives of the Texas Eagle Forum and the Texas Justice Foundation; speaking against it were representatives of the Texas State Teachers Association, the Texas Federation of Teachers, and the Texas Freedom Network. For the text, history, and status of HB 1447, go to <http://www.capitol.state.tx.us/tlo/legislation/bill-status.htm>, select 78th Regular Session, and search for "HB1447". In the past, opponents of evolution education frequently used the Texas State Board of Education's textbook adoption process to pressure publishers to eliminate or downplay the treatment of evolution in textbooks.

Texas: On May 30, 2003, House Bill 1172, which was passed by the House of Representatives on May 10, died in committee. HB 1172 would have required that "each controversial issue addressed in the public school curriculum is presented in a balanced manner that reflects multiple viewpoints regarding the issue", a requirement that could have been used by creationists to introduce "alternatives to evolution." The bill would also have returned greater control over textbook content to the state Board of Education; until 1995, when the legislature limited its authority, the Board of Education was frequently a base for attacks on evolution education during the textbook adoption process. For the text, history, and status of HB 1172, go to <http://www.capitol.state.tx.us/tlo/legislation/bill_status.htm>, select 78th Regular Session, and search for "HB1172". Texas is currently in the process of adopting new biology textbooks; because of the size of its educational system, Texas exerts considerable influence over publishers and the national textbook marketplace. NCSE is working with members and allies in the state to monitor the process.

[*NCSE thanks Richard Baxter, Hiroshi Unoura, and the Texas Freedom Network for information used in this article.*]

In Memory of Will Meikle

John Geohegan

After a long period of declining health, Will Meikle died on February 21, 2003, due to heart problems. My friendship with Will started in 1984 when he called me on the phone after seeing my letter to the editor about misuse of the Second Law of Thermodynamics by "scientific" creationists. At the time, I believe, Will was a member of a Committee of Correspondence that kept watch on creationist activities.

As a chemist, Will found a deep satisfaction in understanding many phenomena such as tastes, odors, pheromones, DNA, heredity, and evolution in terms of their basic chemistry. It is difficult to overemphasize the importance of such a scientific footing as a basis for a happy life. At times it seemed to me that Will thought it was necessary to explain to me that matter was made of atoms, but I now believe he was trying to emphasize the importance of the basics I already accepted. Our conversations caused me to grow.

As our friendship grew and Will's health worsened, I visited him on a fairly regular basis at his home, where we would discuss a variety of topics from a scientific perspective. Will was a chemist, whereas my approach emphasized physics, and we often found disagreements that made for lively discussions. Occasionally we went out together for lunch or a lecture. I think that the high point of these outings was when we heard Linus Pauling speak at the University of New Mexico. Pauling was one of Will's idols.

Will was a member of New Mexicans for Science and Reason (NMSR) from its beginnings and served as its advisor on science and creationism. His extensive collection of writings on evolution and creationism was of great value to NMSR. Will called often on the phone, leaving cryptic and amusing comments on the answering machine. He was active in NMSR to his end. On the day before his death, he proposed that at our next get-together, we discuss a *Scientific American* article on dark matter. The next day, he was discussing with Dave Thomas the possibility of a science advisor for our new governor.

Will was born in Harrisburg, Pennsylvania, and did post-graduate work at Iowa State University. During World War II, he worked at various powder plants in Sunflower, Kansas, and Baraboo, Wisconsin. He moved to Albuquerque in 1960 to work at Sandia Corporation and later taught for the Albuquerque Public School System at Community School. He was past president of the St Andrew Society of Albuquerque, and the Science and Creationism advisor to New Mexicans for Science and Reason.

Should friends desire, memorial contributions may be made to the National Center for Science Education, PO Box 9477, Berkeley CA 94709-9477.

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[*This remembrance originally appeared in the NMSR Newsletter. It is reprinted with permission.*]

John Geohegan is a retired engineer, and founding president and current vice-president of New Mexicans for Science and Reason.

News from the Membership

Glenn Branch
NCSE Deputy Director

From time to time we like to report on what our members are doing. As the following list shows, they — and we — have a lot to be proud about!

Brian J Alters and **Craig E Nelson**'s perspective article "Teaching evolution in higher education" appeared in *Evolution* (2002 Oct; 56 [10]: 1891–1901). Here is the abstract:

> In the past decade, the academic community has increased considerably its activity concerning the teaching and learning of evolution. Despite such beneficial activity, the state of public understanding of evolution is considered woefully lacking by most researchers and educators. This lack of understanding affects evolution/science literacy, research, and academia in general. Not only does the general public lack an understanding of evolution but so does a considerable proportion of college graduates. However, it is not just evolutionary concepts that students do not retain. In general, college students retain little of what they supposedly have learned. Worse yet, it is not just students who have avoided science and math who fail to retain fundamental science concepts. Students who have had extensive secondary-level and college courses in science have similar deficits. We examine these issues and explore what distinguishes effective pedagogy from ineffective pedagogy in higher education in general and evolution education in particular. The fundamental problem of students' prior conceptions is considered and why prior conceptions often underpin students' misunderstanding of the evolutionary concepts being taught. These conceptions can often be discovered and addressed. We also attend to concerns about coverage of course content and the influence of religious beliefs, and provide helpful strategies to improve college-level teaching of evolution.

Alters heads the Evolution Education Research Centre at McGill University and is *RNCSE*'s associate editor for education; Nelson is Professor of Biology at Indiana University.

David Bloomberg and the Rational Examination Association of Lincoln Land (REALL), a group that he helped to found, were profiled in the Springfield, Illinois, *State Journal-Register* (2003 Feb 9; available on-line at <http://www.sj-r.com/sections/news/stories/N02092003,f.asp>). REALL, which maintains a web site at <http://www.reall.org/>, is "dedicated to the development of rational thinking and the application of the scientific method toward claims of the paranormal and fringe-science phenomena", including creationism; as the article reports, Bloomberg and other REALL members have testified before the Illinois State Board of Education on the need to include evolution in the biology curriculum.

NCSE Deputy Director **Glenn Branch** reviewed Janet Radcliffe Richards's *Human Nature after Darwin: A Philosophical Introduction* (London: Routledge, 2001) for *Philosophy Now* (2003 Mar/Apr; 40: 44–6). Praising Radcliffe Richards for her clear style, philosophical acumen, and sense of humor, he nevertheless criticized her for her mistaken view of "intelligent design" as a form of theistic evolutionism as well as her underestimation of theistic evolutionism in general. He also suggested that the philosophical aims of the book were somewhat compromised by her pedagogical agenda. "I would immediately recommend Ruse's book [*Can a Darwinian be a Christian?*] ... over Radcliffe Richards's to a reader who only wanted to read one", Branch concluded. "But I would then recommend that he or she find the time to read *Human Nature after Darwin* as well."

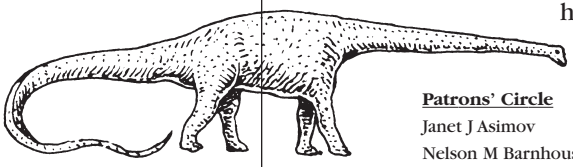
Michael Brass's *The Antiquity of Man: Artifactual, Fossil and Gene Records Explored* (Frederick [MD]: PublishAmerica, 2002), which critically examines Michael Cremo and Richard Thompson's Hindu-inspired creationism, was favorably reviewed by Enzo Ferrara in *Human Nature Review* (2003; 3: 160–2; available on-line at <http://human-nature.com/nibbs/03/brass.html>. Ferrara writes, "*The Antiquity of Man* successfully accomplishes its key intentions: to provide evidence for the evolutionary sequence of human phylogenesis and to contrast the scientific account of events with that favoured by some of its opponents. ... Brass exhibits knowledge of contemporary advances in palaeo-anthropology, and writes with a forceful style and a wide perspective." For further information on Brass's work, visit his web site at <http://www.antiquityofman.com>.

Daniel C Dennett's article "The mythical threat of genetic determinism" appeared in *The Chronicle of Higher Education* (2003 Jan 31; available on-line at <http://chronicle.com/free/v49/i21/21b00701.htm>). Dennett argues that, if genetic determinism is supposed to entail that genetically determined traits cannot be changed through "will, education, or culture", then "[t]here are no genetic determinists." "The issue", he writes, "is not about determinism, either genetic or environmental or both together; the issue is about *what we can change* whether or not our world is deterministic. ... Knowledge of the roles of our genes, and the genes of the other species around us, is not the

NCSE Thanks You for Your Generous Support

The NCSE Board of Directors and staff would like to acknowledge and extend their warm gratitude to all individuals, organizations, and firms that donated to NCSE. We also extend a s special thanks for their much-appreciated support to the following people who donated $100 or more between January and June 2002 (* indicates an NCSE board member or supporter). Those in the Patrons' Circle donated $1000 or more — a level of support that we consider heroic and that allows us a firm foundation for our efforts.

Thank you to all donors.



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enemy of human freedom, but one of its best friends." His article was adapted from his new book *Freedom Evolves* (New York: Viking, 2003), which was recently reviewed by Galen Strawson in *The New York Times* (2003 Mar 2), Mary Midgely in the *Guardian* (2003 Mar 1), Jerry Fodor in the *London Review of Books* (2003 Mar 6), **Michael Ruse** in the *Washington Post* (2003 Apr 1), Michael Shermer in *Science* (2003 Apr 4), and Melvin Konner in *Nature* (2003 May 1). Dennett is director of the Center for Cognitive Studies at Tufts University.

Taner Edis was awarded the Morris D Forkorsch award (together with $1000) from the Council for Secular Humanism for the best humanist book of 2002 for *The Ghost in the Universe* (Amherst [NY]: Prometheus Books, 2002) at the Center for Inquiry Conference, held in Washington DC, April 11–13, 2003. *The Ghost in the Universe* was reviewed by David Eller in *RNCSE* 2003 Jan/Feb; 23 (1): 29–30. Previous recipients of the Forkorsch award include Richard Dawkins, **Stephen Jay Gould**, and EO Wilson. The award was announced in *Free Inquiry* (2003 Spring: 23 [2]: 27); of interest in the same issue are Edis's article "Flipping a quantum coin" (60–1), Massimo Pigliucci's essay

"No free lunch for intelligent design" (14–5), Shawn Dawson's review of Pigliucci's *Denying Evolution* (65), and several letters about fine-tuning arguments (8, 61), including one from **Dave Matson**.

Time Traveling with Science and the Saints, a book by **George A Erickson**, was just published (Amherst [NY]: Prometheus, 2003). Erickson, in the words of the publisher, "surveys the historical record of the defenders of faith and the proponents of reason ... While condemning the Christianity that produced such abominations as the Inquisition and witch hunts, Erickson concludes on an optimistic note, emphasizing that science and secular society have broken free from centuries of religious opposition, and continue to benefit the world through mass education, modern medicine, and technological progress." A former director of the American Humanist Association, Erickson is also the author of *True North: Exploring the Great Wilderness by Bush Plane* (Guilford [CT]:The Lyons Press, 2002).

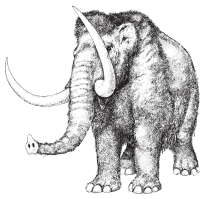
Karl Fezer spoke on "Evolution: What is known and what is not?" at the Unitarian Universalist Fellowship of Cumberland, West Virginia, on February 23, 2003. His talk drew on his recently published book *Scholarly World, Private Worlds: Thinking Critically About Science, Religion, and Your Private Beliefs* (Philadelphia: Xlibris, 2001). Fezer, who teaches biology at Concord College, was among the first members of NCSE's board of directors; he also served as the editor of *Creation/Evolution Newsletter* from 1984 to 1988.

The Hall of Ma'at, a web site (<http://www.thehallofmaat.com>) dedicated to debunking pseudoarchaeology, was described in Kristin M Romey's article "Seductions of pseudoarchaeology: Pseudoscience in cyberspace" (*Archaeology* 2003 May/Jun; 56 [3]; available on-line at <http://www.archaeology.org/magazine.php?page=0305/etc/web>). (Ma'at, by the way, is the ancient Egyptian principle of justice and balance.) One of Ma'at's directors is **Paul Heinrich**, who told *Archaeology* that it was the 1996 television program *The Mysterious Origins of Man* that prompted him to become active in debunking pseudoarchaeological claims: "As a geologist, I found the inability of the producers to distinguish between natural concretions and man-made objects, their naive acceptance of theories such as earth Crustal Displacement, which was refuted by geologists long ago, and numerous other flaws in the program to be so obvious that, given the show's popularity, I felt someone needed to take the time to point them out."Also mentioned in the article was Ma'at director **Michael Brass**, whose book *The Antiquity of Man* was reviewed by Tom Morrow in *RNCSE* 2003 Jan/Feb; 23 (1): 22.

"It's respect for knowledge", an op-ed piece by **Leonard Krishtalka**, appeared in the Lawrence, Kansas, *Journal-World* (2003 Mar 13). Discussing the complaint filed with the Department of Justice over Michael Dini's policy of not writing recommendations for students who do not accept evolution, Krishtalka explained, "the issue is larger than professorial responsibilities and student rights, or whether evolution should be a litmus test for medical school recommendations", citing recent controversies over creationism in Kansas, Ohio, and West Virginia. But "medicine is about more than mending broken bones, worn hearts, slowed nerves, or failing minds", he noted, arguing that understanding evolution is important to understanding the bases of medical diagnosis and treatment. Krishtalka is Director of the Natural History Museum and Biodiversity Research Center at the University of Kansas.

Jeffrey McKee's new book, *Sparing Nature: The Conflict Between Human Population Growth and Earth's Biodiversity*, just appeared (New Brunswick [NJ]: Rutgers University Press, 2003). The publisher writes, "Has our explosive population growth led to the mass extinction of countless species in the earth's plant and animal communities? Jeffrey K McKee contends it has. The more people there are, the more we push aside wild plants and animals. In *Sparing Nature*, he explores the cause-and-effect relationship between these two trends, demonstrating that nature is too sparing to accommodate both a richly diverse living world and a rapidly expanding number of people." The reviewer for *New Scientist* writes,"*Sparing Nature* is both highly informative and a delight to read." McKee is a board member of Ohio Citizens for Science, Professor of Anthropology at the Ohio State University, and the author of *The Riddled Chain* (New Brunswick [NJ]: Rutgers University Press, 2000).

NCSE Executive Director **Eugenie C Scott** and Deputy Director **Glenn Branch** collaborated on "Anti-evolutionism: Changes and continuities", which appeared as a special book article in *BioScience* (2003 Mar; 53 [3]: 282–6). They began by explaining the 3 pillars of anti-evolutionism — the claims that evolution is a theory in crisis, that evolution is incompatible with Christianity, and that it is only fair to teach "both sides" — and discussing their presence in the two book-length critiques of the PBS *Evolution* series from Answers in Genesis and the Discovery Institute. Scott and Branch then compared and contrasted young-earth creationism and "intelligent design", which they described as the two major forms of anti-evolutionism today. In the final section, "Making sense of it all", they briefly described a number of the noteworthy contributions to the creationism/evolution literature of the last few years, including **Robert T Pennock**'s anthology *Intelligent Design Creationism and its Critics*, **Barbara Forrest** and Paul Gross's forthcoming *Evolution and the Wedge of Intelligent Design*, Larry Witham's *Where Darwin Meets the Bible*, Karl Giberson and Donald Yerxa's *Species of Origins*, **Michael Ruse**'s *Darwin and Design*, John F Haught's *Responses to 101 Questions on God and Evolution*, **Keith B Miller**'s forthcoming anthology *Perspectives on an Evolving Creation*, the late **John A Moore**'s *From Genesis to Genetics*, Massimo Pigliucci's *Denying Evolution*, **Brian Alters** and **Sandra Alters**'s *Defending Evolution*, and *Darwin Day Collection One: The Single Best Idea, Ever*.



Two articles by **David E Thomas** — "Bait and switch on 'Roswell: The smoking gun" and a book review of Michael Drosnin's *Bible Code II: The Countdown* — appeared in *Skeptical Inquirer* (2003 Mar/Apr; 27 [2]). In addition, letters from **Vic Stenger** and **Taner Edis** in the same issue of *Skeptical Inquirer* reacted to a previous article by Massimo Pigliucci. Also of interest was William J Hoyt Jr's "Cobb County clowns stage another pi fight" (63–4), which discussed the furor over the anti-evolution textbook disclaimers and the controversial issues policy in Cobb County, Georgia (see *RNCSE* 2002 Sep/Oct; 22 [5]: 9–11, 12).

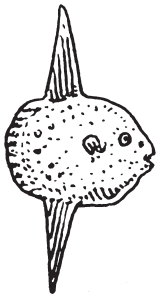
Michael Wavering, Associate Professor of Curriculum and Instruction at the University of Arkansas, was profiled in *The Morning News*, published in Springdale, Arkansas (2003 Mar 19; available on-line at <http://www.nwaonline.net/298687907634974.bsp>). The article, entitled "Evolution creates controversy in the classroom", discusses Wavering's strategies for preparing aspiring science teachers to handle the challenges of teaching evolution. "I want them to look upon science not as a body of immutable facts, but ... as a growing and improving explanation of nature", he told *The Morning News*. Wavering recently collaborated with **Don Duggan-Haas** on "Legislative challenges to the teaching of evolution: The science educators' response" (*RNCSE* 2002 Nov/Dec; 22 [6]: 30–4).

[*Publications, achievements, honors? Tell* RNCSE *so we can pass on the good news to all of our members. Call, write, or e-mail.*]

NCSE Highlighted in *American Scientist*

NCSE figured prominently in two places in the May–June issue of *American Scientist*, the magazine of Sigma Xi, the Scientific Research Society of North America. The first is an article on Project Steve, including quotes from one of the Steves, Steve Nowicki of Duke University. The second is in Keith Thomson's column on Hooke and fossils, in which he took a swipe at the Discovery Institute's misuse of the work of legitimate scientists — including his own — and cited NCSE Deputy Director Glenn Branch's "Analysis of the Discovery Institute's 'Bibliography of supplementary resources for Ohio science instruction'" (*RNCSE* 2002 Jul/Aug; 22(4): 12–24). To read all about it, connect to <http://www.americanscientist.org/template/CurrentIssue;jsessionid=baa8J7ceATcu27>.

[*Thanks to NCSE President Kevin Padian for alerting us to this story.*]



Toe to Toe with Bill Thwaites

Long-time NCSE member and activist Bill Thwaites often represented the evolution "side" in debates with young-earth creationists. Along with the late Frank Awbrey, Bill engaged YECs in many venues, including in special courses at San Diego State University. Now, Bill has compiled a set of recollections of those "days of yore", and NCSE has made them available on our website. Interested readers can view the memoir at <http://www.ncseweb.org/resources/articles/9024_toe_to_toe_with_youngearth_cr_1_20_2003.asp>.

Orchids Have Deep Evolutionary Roots

Scientists at the New York Botanical Garden recently made two startling announcements about orchids. First, Ken Cameron, NYBG Assistant Curator and Acting Director of the Lewis B and Dorothy Cullman Program for Molecular Systematics Studies, reported that orchids evolved much earlier than previously expected. The pattern of DNA variation among orchids on three continents shows that orchids arose before the break-up of the supercontinent Gondwanaland — which contained South America, Africa, and Australia — and that their ancestors were "rafted" apart as the continents assumed their modern positions. The DNA evidence shows that the epiphytic orchids — the ones that live in trees and have no roots in the soil — emerged relatively recently, but that the *other* type of orchids — the small number of extant species that do take root in the soil — are quite an ancient lineage.

The second announcement may come as more of a shock to the casual observer of flowering plants: orchids are dressed-up relatives of asparagus! In the past, botanists have used the structure and organization of a plant's flowers as a key source of information about its phlyogenetic affinity. The DNA analysis suggests that the orchids form two tribes within the Asparagales — one epiphytic and one ground-dwelling — and should be grouped on the basis of shared molecular affinities regardless of the morphology of their flowers.

This new finding is a good example, said Cameron, of how molecular botany can be used to evaluate "big picture" questions in evolution. To which we might add that the molecule–morphology connection is still a lively debate within evolutionary biology — as much alive in the plant sciences as elsewhere.

[*This report was prepared from a press release by the New York Botanical Garden found at <http://www.nybg.org/pr/orchid_age.html>.*]

Ten Contributions of Plant Science to Evolutionary Biology

Many advances in our understanding of the way that evolution produces the patterns in the history and diversity of life that we observe were first demonstrated by studying the evolutionary biology of plants. Here are 10 major advances in evolutionary theory that were discovered, demonstrated, or reproduced using plants.

1. Particulate Inheritance

Of course the ground-breaking work of Gregor Mendel must be among the greatest scientific discoveries relevant to evolution — and it was done in a small garden in Austria studying pea plants! Without a reliable model for the inheritance of features from one generation to the next, it was impossible to produce a convincing model of evolutionary change. It took decades for this work to come to light and to find its place within evolutionary theory, but today we recognize Mendel's work on the rules of inheritance — genetics — as fundamental to our models of organismal change.

2. Transposons

Genes were supposed to be fixed in place on chromosomes — subject to mutations and the occasional crossing over, but not capable of moving from their assigned positions. Working with corn, Barbara McClintock was the first to recognize that at least some DNA sequences were mobile. It took decades to understand why and how these movable genes (transposons) behaved as they did, but today we recognize that the relocation of genes can play an important part in evolutionary change.

3. Polyploidy

Most animals contain only 2 sets of chromosomes (1 set from each parent), although there are numerous exceptions. However, by the 1920s, botanists recognized that it is common for plants to have multiple sets of chromosomes — 8 sets is not unusual, and some species have as many as 80 sets. The ability to maintain a complex genome with multiple sets of genes raises important questions about genetic interactions, mutations, speciation, and even reproductive strategies. Increasing the number of chromosome sets appears to improve plant growth, cell size, photosynthetic capacity, and variability among individuals; indeed, gigantism, as a result of induced polyploidy, is a common goal of ornamental plant breeders.

4. Epigenetics

In 1928, SG Navashin recognized that genes inherited from one parent plant can be silent while only the genes from the other are active. More recently, plant scientists have observed that some changes in gene function appear to be inherited without any obvious change in the DNA sequence. Scientists working with plants are discovering that certain proteins have the ability to "silence" the expression of some DNA sequences and therefore affect the appearance of successive generations. The mechanisms of this phenomenon are still being explored, but work with plant hybrids and transgenic plants are at the forefront of this research.

5. Endosymbiosis

The existence of organelles within eukaryotic cells which have their own DNA sequences suggested to microbiologist Lynn Margulis that these cells were the product of ancient mergers among distinct unicellular organisms. In plants, these studies focus on chloroplasts as a defining feature acquired by the common ancestor of these organisms. Studies in other symbiotic systems, such as lichen, also show how genes and gene products can be affected by the symbiotic "partner" and lead to new features in one or more of the partner organisms.

6. Developmental and Regulatory Genes

Plants possess conserved genetic sequences that influence important developmental processes. Variations in these sequences among plant taxa help to map the evolutionary history of plants and the molecular pathways that produce characteristic features in modern plants from the features that existed in distance ancestors. For instance, the so-called MADS-box genes that control flower development in angiosperms are related to similar regulatory genes in ferns and gymnosperms.

7. Genomics

Complete sequencing of *Arabidopsis thaliana* has answered several vexing questions in evolutionary biology. For one, it left no doubt of the endosymbiotic origin of chloroplasts (see # 5). It also showed the value of complete sequencing for the study of evolutionary relationships among taxa. Finally, these studies aim to understand how these genes act to produce the features that are responsible for the adaptation, function, and form of modern plants. Furthermore, many of the regulatory genes in plants are homologous to regulatory genes in animals and other organisms. These studies help us to refine our understanding of the relationship of molecular changes to the emergence of new branches in the evolutionary tree.

8. Self-Incompatibility

Scientists have long recognized that sexual reproduction among close relatives results in less vigorous and less healthy offspring in plants as well as animals. Research with plants has demonstrated a sort of relative-recognition mechanism in the stigma — the structure responsible for capturing pollen to fertilize the ova. In many self-incompatible plants, the stigma reacts to pollen grains with a close genetic match by producing a protein that inhibits the growth of pollen tubes and prevents the pollen from reaching the ovary. This research has helped scientists to understand cellular actions that have significant large-scale evolutionary effects.

9. Environmental Stress Responses

Because plants cannot migrate in response to environmental stressors — heat, cold, salinity, and so on — all plants have "stress-response" genes that are activated to help them to survive changing environmental conditions. Some of these genes are conserved — found in very similar forms — throughout all plant taxa (and some non-plant taxa). These are involved in communication by means of ion transport across cell membranes. Other genes are shared only by certain plant clades. The distribution of these genes helps to understand the evolutionary history of plants and also to construct paleo-environments — approximations of the ecological conditions in which organisms lived in the distant past.

10. Macroevolutionary "Body-Plan" Changes

One of the most interesting questions in evolutionary biology has to do with the emergence of new or re-organized body plans as the basis for macroevolutionary change — the appearance of new taxa. In the 1880s, W Hofmeister focused on the different body plans that emerge within species that have alternating generations depending on whether the plant is reproducing by proliferation or by the production of gametes. Even though both generations share the same genes, the "body plan" and many observable anatomical features differ greatly between the generations. For instance, the tiny stalked capsule of a moss is 2N, while the leafy plant it grows out of is 1N. However, if a section of that 2N stalk is grown in tissue culture, it produces a leafy 2N plant that produces a 4N stalked capsule! Understanding how plants change body plans from one generation to the next can help scientists to understand how organisms can change body plans to start the emergence of a new taxon.

[*Adapted from "Plant Evolution at the Head of the Class", presented by AJ Petto in the symposium* Evolution: Highlighting Plants *at the Botany 2002 Conference. Thanks to our botanical colleagues for help with this text, especially Marshall Sundberg, who provided some specific examples and suggestions to improve the text.*]

Root and Branch

In his autobiography, referring to his work on *Primula*, Darwin wrote, "I do not think anything in my scientific life has given me so much satisfaction as making out the structure of these plants." And the evolutionary biology of plants remains a vital and vibrant field. Why, then, are there so few books about it available for the general reader? Assembling these lists, we try to provide a mix of popular and technical books, with the popular books predominating. But in our list of books on plant evolution, there are only two truly popular books, and these date from 1939 and 1964. Is there a knowledgeable botanist out there who is able and willing to try to enthrall the general public with a clear yet accurate glimpse of the panorama of plant evolution? In any case, featured here are a variety of introductory textbooks on and specialist treatments of the evolutionary biology of plants, as well as several works on paleobotany in particular and a few classic works. The following books are available through the NCSE web site: <http://www.ncseweb.org/bookstore.asp> — look in the new "In the latest *RNCSE*" section. And remember, every purchase benefits NCSE!

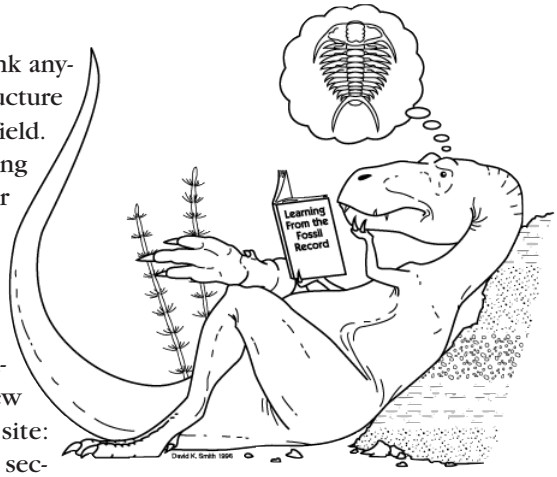


Illustration by Dave Smith, used with permission of the University of California Museum of Paleontology.

Introductory

Plant Life
by Roland Ennos and Elizabeth Sheffield
From the publisher: "There are almost one third of a million species of plants, which range in form from unicellular algae a few microns in diameter to gigantic trees that can grow to a height of 100 meters. *Plant Life* makes sense of the bewildering diversity of plants by treating them not just as photosynthetic factories, but as living organisms that are the survivors of millions of years of evolutionary struggle. The book examines plants from an evolutionary perspective to show how such a wide range of life forms has evolved and continues to thrive." Lavishly illustrated with color plates, electron micrographs, and line drawings.

The Evolutionary Biology of Plants
by Karl J Niklas
The reviewer for *American Scientist* describes *The Evolutionary Biology of Plants* as "a well-thought-out and elegantly written guide to the origins and causes of diversity among plant groups [that] allows us to grapple with the logic behind evolutionary change. Niklas weaves a discourse on evolutionary principles, illustrated with liberal examples from the plant kingdom of how evolutionary forces shape the structural innovations that characterize these organisms." Topics include adaptive evolution, species and speciation, origins and early events, the invasion of land and air, the aquatic landscape, the terrestrial landscape, divergence and convergence, and tempos and patterns. Niklas is the Liberty Hyde Bailey Professor of Plant Biology at Cornell University.

The Evolution of Plants
by KJ Willis and JC McElwain
The reviewer for *Current Books on Gardening & Botany* describes *The Evolution of Plants* as "a magnificent review of recent research in paleobotany, paleogeography, paleoecology and paleoclimatology — all focused on plants. It is an exciting synthesis, with plenty of illustrations, of the history of plants on earth for the past 430 or so million years." Topics include the evolutionary record and methods of reconstruction, earliest forms of plant life, the colonization of land, the first forests, major emergence of the seed plants, flowering plant origins, the past 65 million years, mass extinctions and persistent populations, ancient DNA and the biomolecular record, and evolutionary theories and the plant fossil record.

For the Specialist

Plant Variation and Evolution
David Briggs and Stuart Max Walters
First published in 1969 and now in its third edition, Briggs and Walters's classic text is fully up-to-date with coverage of the implications of molecular biology for plant variation and evolution. The reviewer for the *Journal of Plant Physiology* describes *Plant Variation and Evolution* as "suitable for university students in Environmental Sciences, Agricultural Sciences, Botany and Plant Biology. It is particularly a useful book for updates. The book is highly recommended for the professional practitioner in the field as a background, for plant physiologists and people in related fields it provides a thorough review of the field as it now stands."

Plants Invade the Land
edited by Patricia G Gensel and Dianne Edwards
Gensel and Edwards's anthology collects 13 papers originally presented at the Fifth International Organization of Paleobotany

Conference in 1996, dealing with the invasion of the land by plant life. "The essays in this collection", writes the publisher, "present a synthesis of our present state of knowledge, integrating current information in paleobotany with physical, chemical, and geological data." According to the reviewer for *Choice*, "[Gensel and Edwards have] accomplished what often eludes editors ... they have developed a cohesive, comprehensive, and scientifically satisfying story. ... Appropriate for the serious student ... and a valuable resource and think-piece for instructors and researchers in the field."

The Origin and Early Diversification of Land Plants
by Paul Kenrick and Peter R Crane
From the publisher, Smithsonian Institution Press: "Illustrated with line drawings and complete with appendices detailing the morphology of early fossil plants and their living relatives, *The Origin and Early Diversification of Land Plants* discusses the implications of its phylogenetic conclusions for understanding the evolution of land plant structure, life cycles, the appearance of groups in the fossil record, biogeographic patterns, and related geological events." Kenrick and Crane won the Henry Allan Gleason Award, conferred annually by the New York Botanical Garden for a recent outstanding publication in plant taxonomy, plant ecology, or plant geography, in 1997.

The fossil record

Petrified Wood: The World of Fossilized Wood, Cones, Ferns, and Cycads
by Frank J Daniels
A lavishly illustrated guide to petrified wood, suitable both for the collector's reference shelf and for the coffee table. The author writes, "While a beautiful, well-silicified, gem quality, colorful branch of petrified wood is now a rock, it once was part of a tree — a tree that may have been growing in a distant forest over 200 million years ago. Some of these trees grew when the continents of the earth were joined into one. It is difficult to imagine the events that allowed these petrifications to occur and the forces that later allowed them to be unearthed. Each specimen has a story of its own."

Paleobotany and the Evolution of Plants
by Wilson N Stewart and Gar W Rothwell
Stewart and Rothwell's popular paleobotany textbook, now in its second edition, describes and explains the origin and evolution of plants as revealed by the fossil record and reviews the paleobotanical data that informs our present understanding of the relationships between the major plant groups. Supplemented with line illustrations, half-tones, and summary charts. The reviewer for *American Scientist* writes, "I recommend it as an excellent text and as a valuable reference work for those in related fields", and the reviewer for *The Scientist* concurs: "I have seldom read a textbook with such enthusiasm and I shall recommend it to students and staff alike."

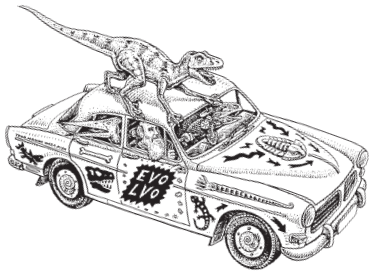
Common Fossil Plants of Western North America
by William D Tidwell
First published in 1975, the revised second edition of *Common Fossil Plants of Western North America* added 79 new genera and over 350 illustrations (bringing the total to over 800). For anyone interested in hunting and identifying fossil plants, especially west of the Mississippi, Tidwell's reference is simply a necessity. The reviewer for *Plant Science Bulletin* describes it as "an absolute must for all paleobotanists and botanical libraries (even if you already have the first edition), for all amateur collectors of fossil plants, as well as for any botanists with a fancy for ancient plants." The author is Professor of Botany at Brigham Young University.

Classics

The Life of Plants
by EJH Corner
From the publisher: "EJH Corner's perennial favorite *The Life of Plants*, copiously stocked with now-classic botanical illustrations, is one of the most fascinating and original introductions to the world of plants ever produced — from the botanist to the amateur, no reader will finish this book without gaining a much richer understanding of plants, their history, and their relationship with the environments around them." Originally published in 1964, the new edition of *The Life of Plants* from the University of Chicago Press features a new foreword by Karl J Niklas, author of *The Evolutionary Biology of Plants*.

The Various Contrivances by Which Orchids Are Fertilized by Insects
by Charles Darwin
In *The Various Contrivances* (1862), Darwin provided specific reasons for his belief "that it is apparently a universal law of nature that organic beings require an occasional cross with another individual; or, which is almost the same thing, that no hermaphrodite fertilises itself for a perpetuity of generations. ... This treatise affords me also an opportunity of attempting to show that the study of organic beings may be as interesting to an observer who is fully convinced that the structure of each is due to secondary laws, as to one who views every trifling detail of structure as the result of the direct interposition of the Creator."

Flowering Earth
by Donald Culross Peattie
Originally published in 1939 and still in print, *Flowering Earth* traces the evolution of plant life from the appearance of the earliest microorganisms to the rise of the modern floras, adroitly interweaving natural history, biography, and philosophical reflection en route. Mark Van Doren placed Donald Culross Peattie (1898–1964) as a nature writer in the ranks of Gilbert White, Henry David Thoreau, John Burroughs, WH Hudson, Richard Jeffries, and John Muir. The Indiana University Press edition features a new foreword by Charles B Heiser and a new afterword by Noel Peattie, as well as wood engravings by Paul Landacre.



NCSE on the Road

A Calendar of Special Events, Presentations, and Lectures

Date October 15, 2003
City St Paul MN
Presenter Eugenie C Scott
Title Evolution Awareness
Event A panel at the annual meeting of the Society for Vertebrate Paleontology
Time TBA
Location Science Museum of Minnesota
Contact Judy Scotchmoor, jscotch@uclink4.berkeley.edu

Date October 24, 2003
City Albuquerque NM
Presenter Eugenie C Scott
Title Legends and Hoaxes of Evolution
Event A talk at the Committee for the Scientific Investigation of Claims of the Paranormal
Time 12:00 noon
Location Radisson Hotel
Contact Barry Karr, skeptInq@aol.com

Date November 2, 2003
City Seattle WA
Presenter Eugenie C Scott
Title Evolution and Creationism: What is the Role of the Scientist?
Event Geological Society of America annual meeting
Time 12:00 noon
Location Washington State Convention and Trade Center
Contact Eugenie C Scott, scott@ncseweb.org

NCSE Speakers Available

Name Eugenie C Scott
Title NCSE Executive Director
Contact scott@ncseweb.org

Name Glenn Branch
Title NCSE Deputy Director
Contact branch@ncseweb.org

Name Eric Meikle
Title NCSE Outreach Coordinator
Contact meikle@ncseweb.org

Name Alan Gishlick
Title NCSE Postdoctoral Scholar
Contact gish@ncseweb.org

Name Philip T Spieth
Title NCSE Director of Operations
Contact spieth@ncseweb.org

Name Phina Borgeson
Title NCSE Faith Network Project Director
Contact borgeson@ncseweb.org

Name Skip Evans
Title NCSE Network Project Director
Contact evans@ncseweb.org

For more information or to arrange a presentation, connect to <http://www.nsceweb.org/ourstaff.asp> or call NCSE.

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Strategies to Help Students Change Naive Alternative Conceptions about Evolution and Natural Selection

Marshall D Sundberg
Emporia State University

> [S]tudents' initial qualitative, common sense beliefs ... have a large effect on performance ... but conventional instruction induces only a small change in those beliefs ... the basic knowledge gain under conventional instruction is essentially independent of the instructor (Halloun and Hestenes 1998).

This statement summarizes the outcomes of numerous studies on student learning that suggest a change in teaching methodology is critical to achieving a greater degree of scientific literacy among our students (Hake 2000; Mintzes and others 1998; Udovic and others 2002). Although this statement is a recognition of the constructivist philosophy of learning, it also acknowledges a more specific problem relating to many basic scientific concepts. For biologists, the most notable among these are evolution and particularly natural selection. Students bring many naive beliefs about evolution to the classroom, which are particularly resistant to change through traditional instruction (Sundberg 1997).

The purpose of my ongoing research in biological education is to identify and describe teaching strategies that are effective against such entrenched beliefs and that will promote a more sophisticated understanding of basic concepts. In this paper, I summarize the results of my most successful interventions to address (1) major concepts related to evolutionary theory and (2) concepts related to the nature of science.

The Course

Most of the investigative exercises described below have been used in an independent college introductory biology laboratory course, paired with a traditional lecture, but the greatest student gains were observed when "lecture" and laboratory were integrated into a single course. Students were a mix of biology majors and non-majors. The course was scheduled for two 3-hour blocks per week. This intensive block format allowed for great flexibility in varying the time commitment to a variety of pedagogical techniques and particular concepts. Five readings were used in lieu of a textbook: *Lives of a Cell* (Thomas 1974), *The Cartoon Guide to Genetics* (Gonick and Wheelis 1991), *Darwin for Beginners* (Miller and van Loon 1982), *Ever Since Darwin* (Gould 1977), and *Ecological Vignettes* (Odom 1998). A variety of "majors'" textbooks was also available for use in class or for checkout for use as an encyclopedic reference as needed.

The primary instructional technique was a Socratic dialog based on daily readings. These discussions were also used to introduce specific problems for laboratory investigation. For instance, Darwin's response to tropical diversity in the Amazon is used as a lead-in to the investigation on variation. The technique of concept mapping (Novak and Gowin 1984) is introduced early, primarily as a tool to identify questions for investigation. In a completed concept map, virtually every connector between concepts identifies a testable hypothesis. The class is divided into research teams the first day; these teams collaborate on investigations throughout the semester. Considerable peer instruction takes place during the performance of investigations and as results are reported to the class.

Controls for this study included traditional majors' lecture and laboratory, traditional non-majors' lecture and laboratory, traditional majors' lecture and investigative laboratory, and traditional non-majors' lecture and investigative laboratory.

The investigations dealing with evolution began with a passage from an 18th-century evolutionist's theory of evolution (Lamarck 1809, in Ames and Siegelman 1966: 28–9). I purposely chose Lamarck as an entry into the theory of evolution because most beginning students who express any belief in evolution actually have a Lamarckian understanding of the process. This is a starting point to which students can relate but which ultimately leads to results that students must reject. In this passage, Lamarck contrasts his theory with the dogma of special creation. Students read the passage, underlining key words and phrases. As a class we then construct a concept map of Lamarck's theory and identify possible points of

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testing. Figure 1 is a simple concept map of our current understanding, with the three concepts identified by Lamarck in boldface. These three concepts are the focus of investigation.

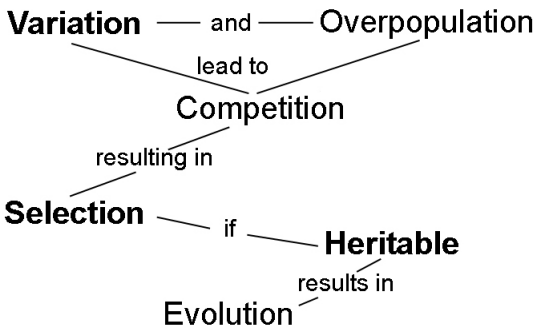

FIGURE 1. Concept map of evolutionary theory with concepts identified from Lamarck reading in boldface.

VARIATION

The null hypothesis, based on Lamarck's text, is that species tend to be perfectly adapted to their particular circumstances, so there should be no significant variation among them in observable features. I present the research teams with a tin of either pecan fruits or sunflower seeds and challenge them to design an experiment to test the null hypothesis. Each team must formulate a research plan and have it approved before beginning the experiment. A variety of measuring instruments is available in the laboratory, including metric rulers, vernier calipers, graduated cylinders, and balances. (Students are familiar with each of these tools from their earlier investigation of accuracy and precision in measurement and basic descriptive statistics.) Typical parameters chosen for investigation include length, width (there are several sampling questions here such as where to measure, whether to choose maximum or minimum, and so on), mass, volume, and color pattern. Research teams must graph and interpret their data.

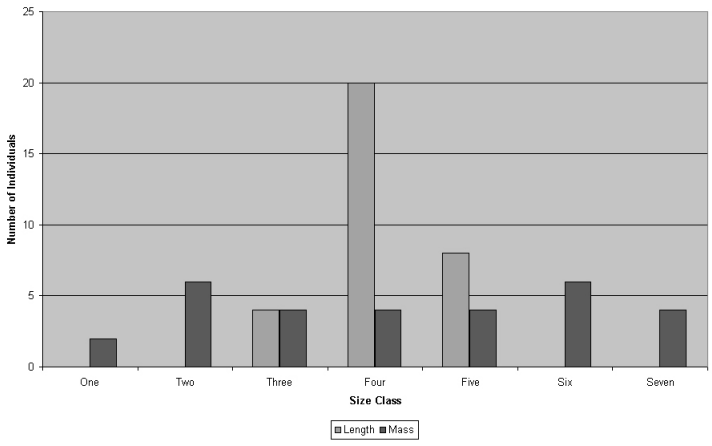

FIGURE 2. Summary student data of variation in seed length and seed mass.

Figure 2 summarizes data from two student groups, one measuring seed length and the other seed mass. For comparison, the data are standardized into size classes. These data are representative of typical student results and were chosen to show two very different, yet common, patterns that students will discover. In both instances, evidence of variation in the chosen character is measurable and distinct. In the case of length, variation approximates a normal distribution, with the majority of individuals found in size class four. Similar distributions generally occur for width and volume. Seed mass exhibits more variability and in this case is almost evenly distributed among the size classes. Color pattern in sunflower seeds would be similar.

Several questions typically arise as individual research teams present and discuss their data. For instance, given the data discussed above, teams may question whether the observed variation is significant. Some may argue that the observed variation in length is so small as to be unimportant, and thus the data do not falsify Lamarck's theory. This provides an opportunity for introducing the idea of a statistical test of an evolutionary hypothesis. Another common question concerns the presence or absence of what might seem a plausible correlation. In the above example, most students expect that longer seeds (or seeds of greater volume) would necessarily have greater mass. Here is evidence that what seems plausible is not always substantiated by data. Other unknown factors, in this case degree of hydration, may influence the data. These data can also be used to introduce the idea that the variation on which natural selection will work is random and does not arise to meet a specific need or purpose. Importantly, the variation investigation is simple and can be completed in one class period. A general characteristic of effective strategies for modifying ingrained misconceptions is that the tasks have simple manipulations and are of short duration (Sundberg and Moncada 1994).

SELECTION

Selection of existing characters is a key component of evolutionary theory; the testable null hypothesis is that the frequency of a specific trait in a population cannot be altered in subsequent generations by selection. For this investigation, we use two populations of fruit flies (*Drosophila melanogaster*) — wild-type "fliers" and vestigial-winged "crawlers". After the class has had an opportunity to examine individuals of both populations, the research teams are divided into two groups. The teams in one group are challenged to test if the wild-type phenotype can be selected for; the other teams will attempt to select for the vestigial-winged phenotype. Although two or more teams are faced with the same challenge, each team must design its own experiment and have it approved before it can proceed. In the laboratory, I provide fly populations, flynap (used to anesthetize the flies), fly medium, and 2-liter plastic bottles. Each research team must provide any other additional materials it will need for its experiment. Typical materials include threads to suspend small containers of medium, straws, double-sided tape, flypaper, water moats, petroleum jelly, and external light sources.

Teams typically begin by introducing equal numbers of male and female flies of both phenotypes into their experimental and control chambers. (Most of the bottles can be hung in the room for decoration once they are set up.) During subsequent class peri-

ods, teams examine and take notes on the flies in their bottles. Although differential mortality can often be observed quite quickly, the experiments are allowed to run until the flies have produced at least their first generation of offspring.

TABLE 1
SAMPLE STUDENT DATA FOR FRUIT FLY SELECTION

	None (Control)		For Fliers		For Crawlers	
	Flier	Crawler	Flier	Crawler	Flier	Crawler
Start	10	10	10	10	10	10
End	158	38	245	78	81	23
Caught in Flypaper					62	4

Table 1. Summary student data of selection for wild-type (flier) and vestigial-winged (crawler) fruit flies.

Table 1 illustrates typical results, from which we draw several important conclusions. The wild-type group is usually pleased by its success in selecting for fliers; selection can alter the frequency of a trait in later generations. But when challenged, these students realize that a significant number of vestigial-winged flies also reproduced. Under these conditions, the fliers were more likely to survive and reproduce, but the selection pressure was not so intense as to prevent vestigial-winged flies from reproducing, too.

Selection for vestigial-winged flies is usually less successful. Invariably there will be more flier offspring (which were selected against) than crawler offspring (which were selected for). The obvious explanation for students is that these teams were not successful in designing traps or obstacles that could effectively keep fliers from reaching a food source while permitting crawlers to feed. But these results, along with the control, also can be used to make the point that things are not always as simple as they seem. In fact, this provides the lead-in to a section on genetics. After studying Mendelian genetics, students are asked to re-analyze their fly data to see whether there might be some alternative explanations for their results. For instance, could a crawler mate with a flier? If so, what would be the phenotype of their offspring?

ADAPTATION AND HERITABILITY

These concepts also appear on the students' concept maps of Lamarck's theory. The null hypotheses are that organisms will not exhibit adaptation to environmental perturbation and that even if adaptions are evident, they will not be heritable. Perhaps the most common misconception about the mechanism of evolution is that individually acquired adaptations can be passed on to offspring. Therefore, this investigation is critical in helping students to develop a more sophisticated understanding of natural selection.

Research teams are provided with seeds of Wisconsin Fast Plants™ and asked to design an experiment to test the hypothesis concerning adaptation to the environment. Fast Plants™ are a particularly useful organism for this study because of the variety of characters that can easily be quantified: for example, number and size of leaves, number and size of internodes, overall length, and a variety of anatomical surface features such as hairs and stomata that can be sampled non-destructively. In addition, a variety of environmental treatments can be employed without concern for pain to the organism. Plants show much greater developmental plasticity in response to environmental factors than do animals. Finally, the life cycle is rapid enough that the treated generation can produce seeds that can be grown out in a second generation to test for heritability.

We usually begin by listing on the board as many environmental parameters as possible that might affect plant growth. Research teams are then asked to choose one parameter and design an appropriate experiment to test for an adaptive response. Variables involving light and water are the most commonly chosen, including light intensity, light quality (color), light duration, quantity of water applied, and substances added to water. Each team must investigate a different parameter and all research plans must be approved before the investigation can begin.

One of the more interesting student-designed experiments investigated the effect of gravity on stem growth. In this investigation, Fast Plants™ were grown in square styrofoam cubes that can easily be laid on their side; the experimental cubes were placed on their side as soon as plants germinated — a period of about 3 days. Every day thereafter, the cubes were rotated to the next side so that, at the end of a week, there was a full rotation. The plantlets developed with a "corkscrew" phenotype. The controls were grown in the upright position.

TABLE 2A
SAMPLE STUDENT DATA FOR SPIRAL PHENOTYPE
Original "Treated" Generation

Treatment	Day 2	Day 4	Day 6	Day 8
Upright Plants	0	0	0	0
Plants Rotated on Side	0	2	4	6

TABLE 2B
SAMPLE STUDENT DATA FOR SPIRAL PHENOTYPE
Offspring Generation — Grown Upright Only

Treatment	Day 2	Day 4	Day 6	Day 8
Offspring of Upright	0	0	0	0
Offspring of Rotated	0	0	0	0

Table 2. Summary student data of heritability of adaptation to an environmental factor.

The results of this experiment are shown in Table 2. The number of leaves produced in a spiral gyre were counted as "spiral revolutions". Under optimal conditions, approximately one leaf is produced per day and thus each new leaf produced when a plant is oriented horizontally will be in a spiral gyre. The null hypothesis — that there is no phenotypic effect from the changing orientation to the force of gravity — must be rejected because of the obvious response of the plant to its horizontal rotation.

This was a particularly interesting experiment because a complex phenotype was produced that mimics the growth pattern of certain horticultural varieties such as the corkscrew willow. However, this adaptation cannot be inherited. Seeds from the treated plants, when grown in "normal" position, retain the normal upright growth pattern. Individual adaptation to the environment is *not* natural selection! Individuals can alter their form or behavior, to a limited degree, in response to their environment, but they cannot change their inherited characteristics.

Assessment of Effectiveness

The assessment items used in this study are drawn from instruments used in previous work (Sundberg 1997; Sundberg and Dini 1993; Sundberg and others 1994; Sundberg and Moncada 1994). To standardize the results, only scores on identical items, specifically targeted to common and persistent misconceptions, are reported here. The Integrative/Investigative category represents 3 pooled sections; the Majors' Investigative Lab/Traditional Lecture category represents 4 pooled sections; and all other categories represent pools of more than 10 sections. In the previous work cited above, majors' pre-test scores tended to be slightly higher than those of non-majors, but these differences were not significant. This pattern continues to hold true.

There is a consistent tendency for investigative instruction, integrating lecture and laboratory, to be more successful in promoting student understanding of the nature of science and the theory of evolution than traditional lecture/laboratory or traditional lecture/investigative laboratory. Figure 3 illustrates scores on a content post-test given at the end of the semester. Pre-test scores were in the range of traditional lecture/laboratory post-test scores. Virtually no change was observed in these classes between pre-test and post-test scores. In all four categories examined, the highest scores were attained when student-active lecture and laboratory activities were integrated in their presentation. Similarly, scores for traditional lecture and laboratory were the lowest; there was not a consistent difference between majors and non-majors courses. Students in traditional lecture courses combined with investigative laboratories obtained intermediate scores, and again there was not a consistent difference between majors and non-majors. Although similar tendencies are clear with each concept, the only statistically significant gain over the traditional approach was found in the category of improving scientific literacy.

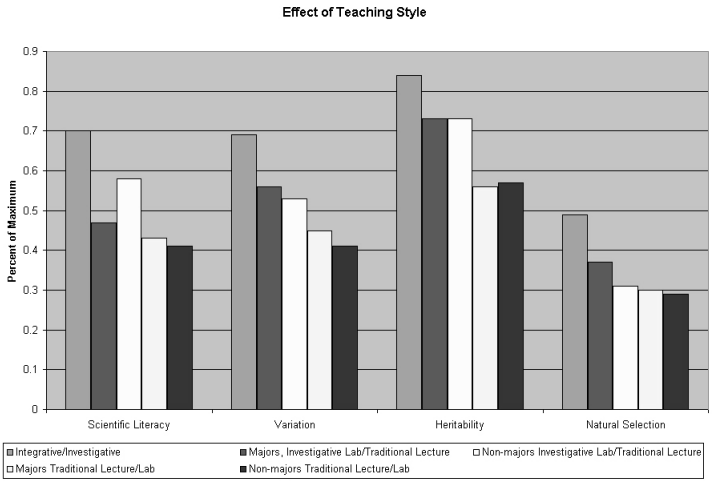

FIGURE 3. Impact of teaching style on student learning (percent correct on content post-test) in four concept areas: Scientific Literacy, Variation, Heritability, and Natural Selection.

It is also clear from the data that some misconceptions are more ingrained than others. In particular, misconceptions concerning natural selection are particularly resistant to instructional intervention. Scores in this category were the lowest and showed the least change between pre-test and post-test scores. Scores in heritability, directly related to Mendelian genetics, consistently showed the greatest gains.

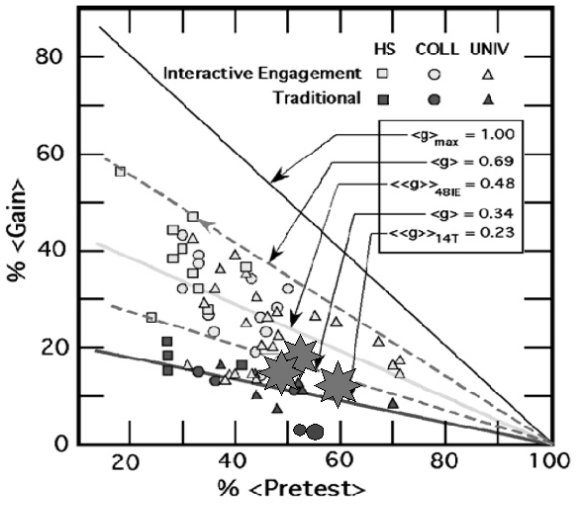

FIGURE 4. Data from current study superimposed on physics data reported by Hake (2002) demonstrating efficacy of "interactive engagement" over traditional lecture/laboratory. Three large "stars" represent experimental course from present study. Two large solid circles represent the TWO BEST sections of traditional control courses.

The results of this study are comparable to similar results in physics, which demonstrate that students taught by interactive engagement consistently outperform students taught by traditional lecture and laboratory (Hake 2002). Hake's report summarized results from 62 physics courses enrolling more than 6500 students and different grade levels and from around the country. I have plotted data from the present study on top of Hake's physics data (Figure 4). The three large stars represent the interactive/investigative sections from the present study and the two large circles represent the two highest performing sections of traditional lecture/investigative laboratory from this study.

Conclusion

It is well recognized that students bring to class many misconceptions concerning the nature of science and the nature of evolution. These beliefs, which often seem common sense and are reinforced by the media, are particularly resistant to modification — regardless of the pedagogy employed. This study provides some evidence to support the claim that student-active learning, where students are actively engaged in problem-solving, is more effective than traditional instruction in overcoming this barrier. Although with only one exception the data reported are not statistically significant, the consistency of the trends suggest that the observed differences are due to more than sampling error or chance.

South With the Spring: A Story of Evolution and Tree Buds

Stanley Rice
Southeastern Oklahoma State University

I write from Bryan County, Oklahoma, named after you-know-whom: William Jennings Bryan. After a lifetime of fighting for the causes of the common man, what is he remembered for? His final and fatal attempt to block the teaching of evolution in Tennessee at the Scopes Trial. He won and lost. Actually, it was not so much the science of evolution as the abuses of social Darwinism, with its celebration of strong people vanquishing the weak, that bothered this great statesman. And today, among the people of Bryan County, Oklahoma, it is not so much the science of evolution as the anti-religious sentiments that they imagine to accompany it that bothers this Christian, and conservative, population. And here I am, a biology professor who teaches evolution. What do I do? Do I try to be nice, or do I dangle evolution right in their faces?

Stanley Rice received his PhD in plant biology from the University of Illinois at Urbana-Champaign in 1987. He taught botany and other biology courses in New York, Indiana, and Minnesota, before joining the faculty of Southeastern Oklahoma State University in 1998.

I do both. I dress up like Charles Darwin (which, with my gray beard, requires only a Victorian hat and a ribbon tie) every February 12 (Darwin's birthday) and every October 12 (Discovery Day, also known as Columbus Day) for my spring and fall semester classes. I leave them with no doubt about the DNA and fossil evidence for human evolution — the part they find most threatening. But I also tell them about the differences between science and religion, and develop at some length a defense of their mutual compatibility. I tell them of my own Christian faith and how it is deepened by an understanding of evolutionary science — yes, even while I am standing there in my Darwin suit.

And I also tell them a story about tree buds and evolution. A fundamentalist who may get upset over ape-men is unlikely to become angry over tree buds. And while Lucy's bones and those of the Nariokotome boy hide in distant museums, my fellow Oklahomans cannot avoid an encounter, every spring, with the bursting of the buds of deciduous trees and shrubs. As a botanist, I want not only to teach evolution, but also to get my students just to *notice* the great spectacle of

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botanical springtime, at which they might never have looked closely.

As spring temperatures move north, life awakens: a beautiful spectacle recorded by Edwin Way Teale in his classic *North With The Spring* (Teale 1951). In any one location, the tree buds seem to burst all at once, very quickly. The rapid burst of buds occurs because the tissues of the leaves and flowers formed in the buds the previous autumn and were quietly waiting for springtime. When spring arrives, the tissues need only swell with water and burst away the scales.

But although the buds burst quickly, they do not burst all at once. Some trees and shrubs open their buds earlier than others. When I lived in Minnesota, I noticed that almost all the buds burst within a period of 2–3 weeks. But down here in Oklahoma, spring is much longer — a full two months elapses between the emergence of the American elm in February and that of the pecan in April.

In the spring of 2000, my plant taxonomy students and I did more than just notice this pattern; we also documented and analyzed it. The plant taxonomy class in 2002 repeated the project with very similar results. At the very least, having students keep records of which trees open their buds on which dates can get them to notice the tremendous diversity of tree and shrub species — we had 40 species in our study in spring 2000. But this activity can also contribute to worldwide research. Students all over the world record tree budburst dates and send them to the GLOBE program (<http://www.globe.gov>), where these data will be analyzed to detect the extent that global warming may be causing spring to come earlier in temperate climates (NOAA 2001). But we wanted to go further. We wanted to know *why* some tree species opened their buds earlier than others.

There are several possible reasons for the differences in budburst time. "Proximate" factors include patterns of temperature and changes in day length. Buds of deciduous trees may open earlier in a warm than a chilly springtime; however, a warm winter may have the surprising effect of *delaying* budburst because the winter warmth prevented breakdown of chemicals that inhibit budburst (Murray and others 1989). But we were interested primarily in "ultimate" factors — *evolutionary* ones.

The first flowering plants apparently evolved just before the early Cretaceous period, about 120 million years ago. At this time, the great world-continent of Pangaea had broken up; the Tethys seaway was separating the southern, equatorial continent (formerly Gondwanaland, later to become South America, Africa, Australia, India, and Antarctica) from the northern, temperate continents (remnants of Laurasia, later to become North America, Greenland, and Eurasia). Great forests emerged in the north temperate regions, with some deciduous trees, and some warm-evergreen trees. While the flowering plants as a group have a tropical origin, not all flowering plant families do. Some of the trees in the north temperate forests were in families that had evolved in the north temperate region, and others were in families that had migrated from the tropical south. During early Tertiary times, before about 30 million years ago, the climate was warm and even, and deciduous forests grew up to very high latitudes. By this time, all of the families of flowering plants had evolved (Jones and Luchsinger 1986: 118).

In the second half of the Tertiary, cycles of cooling began (see Wolfe 1987 for more information), culminating in the Ice Ages of the past 2 million years. The populations of trees either had to die, which many did, or adapt. They could adapt in either of two ways. They could *avoid* the cold — by restricting their range to regions in which frost damage was less likely — or they could *tolerate* the cold.

Cold temperatures damage plant tissues primarily by causing ice to form within them. While the ice crystals may puncture cell membranes, it turns out that the main problem is freeze-drying (Pearce 2001). The ice forms outside the cells, causing the insides of the cells to desiccate. In order to tolerate this, the plant's cells must have chemicals that help them to adjust to the dry conditions. Buds generally have these adaptations, but once a bud opens, the tissues may or may not have this protection. Plant families that have existed for a longer period of time in regions that have cold winters contain more cold-tolerant species than plant families that have existed in these regions for a shorter period of time.

For those trees that protect their young leaves and flowers from frost, there is a price to pay: they must use their materials and energy to manufacture these protective molecules and to *tolerate* the cold temperatures of a spring frost. The benefit that they receive is that they can open their buds earlier in the spring, even though there remains a risk of frost. In so doing, they can take advantage of wind pollination, or they can begin to spread their leaves sooner. They may thereby be able to reproduce sooner than, and to shade out, the other, slower species. The (evolutionary) reason that trees even exist at all is not to get their leaves closer to the sun — which is, after all, 93 million miles away — but to get their leaves higher *than those of other plants.* Or, to outdo their competitors in another way, they may open their leaves sooner than those of other plants.

For those trees that do not protect their young leaves and flowers from frost, there is a price to pay. By waiting until all (reasonable) danger of frost is past (that is, by *avoiding* it), they may have to grow their leaves in the shade of the earlier plants. But at least they do not need to expend energy on the protective molecules.

Some tree species produce flowers before leaves, and others produce leaves before flowers. For this investigation, we assumed that there would be a disadvantage if the trees sustained frost damage to either flower or leaf buds, and therefore they would protect either type of bud by tolerating or by avoiding the low temperatures.

Both groups of plants — the tolerators and the avoiders — are adapted to the climatic conditions we have today in North America; it is just that they are adapted in different ways. The hypothesis that my students and I tested was *plants whose ancestors evolved in temperate latitudes are more likely to tolerate frost better, and to open their buds earlier, than plants whose ancestors evolved in tropical latitudes.*

METHODS

Gathering the data to test this idea was simple but tedious. We had to record the budburst dates of as many trees as we could find. Each pair of students had to find 20 trees, of as many species as they could locate, and monitor them daily or as close to daily as they could. In addition, I also monitored numerous trees. We used the GLOBE protocol for assigning budburst dates (NOAA 2001). We gathered data from two locations — Tulsa, Oklahoma, latitude 36°N; and in the vicinity of Durant, Oklahoma, and in nearby areas of north Texas, latitude 34°N. These data sets will be hereinafter referred to as northern Oklahoma and southern Oklahoma.

We did not monitor budburst in every individual or every species that we encountered. We used these rules to decide which trees to measure: First, we chose only species native to eastern Oklahoma. For example, we omitted the Bradford pear *(Pyrus calleryana)* and white mulberry *(Morus alba).* Second, we omitted species that are commonly propagated by horticulturalists, even if native. For example, redbuds *(Cercis canadensis),* flowering dogwood *(Cornus florida),* and pin oak *(Quercus palustris)* are native to eastern Oklahoma, but many of the individuals may have been planted from genetic sources outside of Oklahoma. Non-native species and genotypes may burst their buds in response to environmental conditions different from those that would induce budburst in native stock. Third, we avoided juvenile individuals. Fourth, for species that spread clonally such as poison ivy *(Toxicodendron radicans)*, we chose ramets that were distant from one another and not likely to be in the same clade. Fifth, we avoided damaged individuals (for example, those with heavy mistletoe infestation). Aside from these restrictions, we monitored as many individuals of as many woody species as possible. This analysis used 513 trees from 40 species in 22 families. This sample obviously included a great deal of individual variation due both to local climate and to genetic diversity. We included this variation deliberately, in order to determine whether the hypothesis is correct despite local variations.

Then we analyzed the data. The level of statistical sophistication for analyzing the data can be adjusted to suit the class; in a high school class, for example, you may be content with a simple graph of the results (as in Figure 1). We used a computer-based analysis of variance. The independent variables in the main analysis were: (1) family origin (temperate versus tropical); and (2) species, nested within families. We conducted separate analyses to examine other hypotheses (see Discussion), in which we included, along with family origin, (3) pollination mode (wind versus animal), (4) wood type (diffuse- versus ring-porous). Our analyses also explored how variables may have interacted in complex ways. The response variable was budburst date (using February 1 as Day 1). We analyzed northern and southern Oklahoma trees separately. Each individual tree was an observation in this analysis. We used an analysis in which the statistical significance of the relationship of independent variable with the response variable was tested after the others had already been included. In this article, I focus primarily on the results of temperate versus tropical origin of the family, which tests the main hypothesis stated in the introduction.

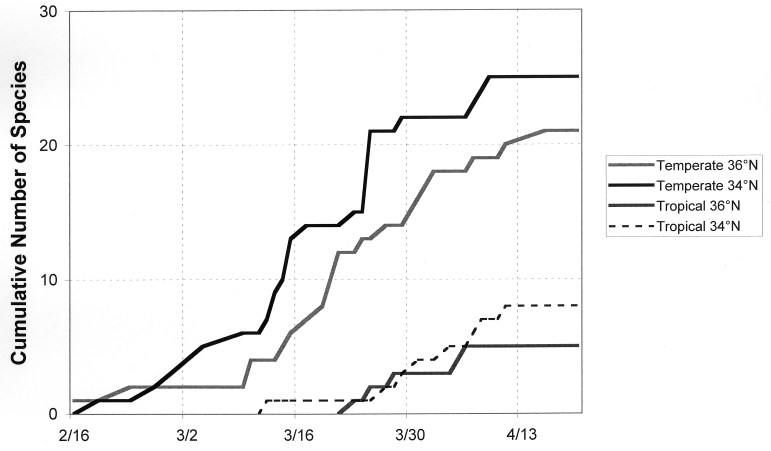

FIGURE 1. Cumulative budburst of species within families of temperate origin versus tropical origin, and from northern (36°N) versus southern (34°N) Oklahoma locations. At both northern and southern locations, the species within families of temperate origin burst their buds sooner.

There are two ways to determine whether a plant family is of temperate or tropical origin. First, the part of the world with the most species within the family is likely to be where the family evolved. We consulted the plant family distribution maps in Heywood (1978) to collect information on the worldwide distribution of living plant species within families. Second, fossil evidence indicates the part of the world and the time of origin. We used the information contained in Raven and Axelrod (1974) for this determination. The two sources of information coincided closely and gave the same results in the analysis below. Of course, this simplistic classification of plant families as temperate or tropical incorporates a great deal of variation; some tropical families, for example, may have originated in tropical highlands under climatic conditions more similar to those of north temperate regions. However, in order to use this exercise as an investigation for students or a demonstration for lay people, we cannot include the full complexity of factors that are involved in the study of historical plant geography. As just one example, the elm family, Ulmaceae, consists of two subfamilies, the primarily temperate Ulmeae and the primarily tropical Celtidae; however, for this analysis, we consistently used family, not subfamily, as the basis of classification, so elms were considered temperate.

RESULTS

In both northern and southern Oklahoma, woody plants in families of temperate origin opened their buds earlier than woody plants in families of tropical origin: an average of 12 days earlier in southern

Oklahoma, and 5 days earlier in northern Oklahoma. This pattern is clearly visible in Table 1, which lists average budburst dates of species in temperate families and species in tropical families in separate columns. Figure 1 also shows that species in families of temperate origin open their buds earlier than species in families of tropical origin. Table 1 and Figure 1 separate the northern and southern Oklahoma data sets, both of which show the pattern. The analysis of variance showed a significant difference between families of tropical and temperate origin, and significant differences among the species within the tropical and temperate categories, both at the $p < 0.0001$ level, for both northern and southern Oklahoma data sets. This indicates that there is less than 1 chance in 10 000 that the results are not explained by the hypothesized relationship.

This analysis was conducted on individual trees. This is a valid procedure, since each individual tree has its own budburst date. The variation of budburst dates within each tree species has been noticed at least since Darwin wrote *The Variation of Plants and Animals Under Domestication.* However, the same pattern emerges when we analyze the *average* budburst times of each *species.* In order to obtain a sufficiently large sample size for an analysis that used only the means, I had to merge the northern and southern Oklahoma data sets into a two-way interactive analysis of variance, which can determine the significance of two different factors in one data set. In this analysis, the only factor that was significant (at a probability level of $p = 0.029$) was temperate-versus-tropical evolutionary origin. Therefore, we reach the same conclusion whether we analyze the trees or analyze the species.

Discussion

It is important to reiterate that the species of woody plants we studied are all, *today,* temperate species; the temperate-versus-tropical origin represents a *vestigial* effect of evolution — trace characteristics that point to the organism's evolutionary past. For many "perfect" adaptations of the present, a creationist could say that the Creator made it that way; but for leftover processes from the past, such an argument is not credible (Gould 1980). To counter the anti-evolutionists' argument that we see evolution in all data sets because that is what we *want* to see, it is important to point out that we detected other patterns of variation in these data than the evolutionary one we were studying.

One of these patterns involves the *anatomy* of the trees. Each year, the trunk of a tree adds a new layer of wood. The wood consists largely of xylem, the cells that transport water from the roots through the trunks up to the leaves. Some of the cells of the xylem are large — some large enough to see with the unaided eye — while most are small. In some species, the *ring-porous* species, many large vessels are produced in the spring, and few or none during the summer; the large vessels therefore form a ring in just the spring wood. Other species are *diffuse-porous* because their large vessels, if any, are scattered through all of the wood layer. Large vessels are great at transporting water. In fact, a large vessel that is 3 times as wide as a small vessel can theoretically transport *81 times* as much water as the small vessel. The problem is that most of the large vessels are damaged, usually permanently, during the winter. A tree with diffuse-porous wood, in the spring, can rely on last year's wood — or even the wood from several previous years — to transport its water up so that it can burst the buds. But a tree with ring-porous wood has lost the use of most of its wood from last year, and of course from previous years — even though that wood is still there, helping to hold the tree up, it does not help much in the transport of water up to the buds. Trees with ring-porous wood, therefore, must start growing a new layer of wood before they can burst their buds. For this reason, it has been noted (for example, by Lechowicz 1984) that trees with diffuse-porous wood can get an earlier start in the spring. One of our analyses indicated that diffuse-porous species burst their buds sooner than ring-porous species (data not presented). However, even after the effects of wood type are included in the analysis, the temperate-versus-tropical distinction is still statistically significant. There are many exceptions — the earliest-budding species of tree in our study, the ring-porous American elm, being one (see Table 1 for the wood types in the species we studied).

Another pattern involves the *ecological interactions* of the trees. The earliest buds to burst are the flowers of the wind-pollinated trees such as elms and cottonwoods. Wind-pollinated flowers are small, and usually lack petals and nectar. Petals provide no advantage in attracting wind-borne pollen; in fact, they just get in the way of the wind's picking up pollen from some flowers and depositing it in others. These tiny, numerous flowers usually open before the leaves emerge, for the leaves, too, would interfere with the movement of pollen. Finally, the winds are, on the average, stronger in the early spring than in the late spring and summer. Insect-pollinated flowers (and those like trumpet creeper that are pollinated by hummingbirds) open later, when the insects and birds become active. This same pattern appears to occur in these data sets; however, upon analysis, these patterns turn out not to be significant, perhaps because there are many exceptions. While there are no insect-pollinated flowers that open in the very early spring, the insect-pollinated black cherries and wild plums open well before the midpoint of spring; and some wind-pollinated trees such as pecans open both flower and leaf buds as late as mid-April (see Table 1 for the types of pollination used by the species we studied).

Although these anatomical and ecological factors influenced budburst time, the statistically most significant factor was temperate-versus-tropical evolutionary origin. We also infer that the pattern based on evolutionary origin must have preceded the others. For example, it was only the trees whose ancestors evolved in temperate regions that were able to take advantage of the early spring winds for wind pollination. Only the trees that could tolerate spring frosts — and whose ancestors came from the temperate zone — could open their wind-pollinated flowers in February and early March.

Some of the species were more abundant than others. However, this is unlikely to have influenced the

Table 1.
Average budburst dates of woody species in Oklahoma

Family: species	Common name	Temperate families		Tropical families	
		Date northern Oklahoma	Date southern Oklahoma	Date northern Oklahoma	Date southern Oklahoma
Ulmaceae: Ulmus americana[b]	American elm	19 Feb (5)	16 Feb (11)		
Ulmaceae: Ulmus alata[b]	Winged elm		23 Feb (15)		
Aceraceae: Acer saccharinum	Silver maple	26 Feb (11)	28 Feb (6)		
Hamamelidaceae: Liquidambar styraciflua	Sweetgum		2 Mar (12)		
Rosaceae: Prunus angustifolia[a]	Wild plum		4 Mar (3)		
Aceraceae: Acer negundo	Boxelder	11 Mar (6)			
Vitaceae: Vitis rotundifolia[a]	Wild grape	11 Mar (4)			
Fagaceae: Quercus velutina[b]	Black oak	15 Mar (15)	10 Mar (4)		
Oleaceae: Fraxinus pennsylvanica[b]	Green ash	21 Mar (6)	9 Mar (3)		
Lauraceae: Sassafras albidum[a]	Sassafras				12 Mar (4)
Salicaceae: Populus deltoides	Cottonwood	19 Mar (18)	13 Mar (5)		
Aceraceae: Acer saccharum	Sugar maple		14 Mar (3)		
Rutaceae: Zanthoxylum clava herculis[a]	Hercules' club		14 Mar (2)		
Rosaceae: Prunus serotina[a]	Black cherry		15 Mar (2)		
Fagaceae: Quercus marilandica[b]	Blackjack oak		17 Mar (8)		
Platanaceae: Platanus occidentalis	Sycamore	23 Mar (4)	17 Mar (14)		
Fagaceae: Quercus stellata[b]	Post oak	17 Mar (4)	19 Mar (51)		
Fagaceae: Quercus muhlenbergii[b]	Chinquapin oak	4 Apr (2)	17 Mar (2)		
Betulaceae: Betula nigra	River birch	25 Mar (8)			
Cornaceae: Cornus drummondii[a]	Rough dogwood	23 Mar (3)			
Fagaceae: Quercus nigra[b]	River oak	23 Mar (5)	24 Mar (11)		
Juglandaceae: Carya texana[b]	Black hickory	23 Mar (10)	27 Mar (7)		
Ulmaceae: Ulmus crassifolia[b]	Cedar elm		27 Mar (5)		
Fagaceae: Quercus rubra[b]	Red oak		27 Mar (3)		
Fabaceae: Robinia pseudoacacia[a]	Black locust			23 Mar (5)	27 Mar (3)
Sapotaceae: Bumelia lanuginosa[a]	Chittamwood			25 Mar (5)	
Bignoniaceae: Catalpa speciosa[a]	Catalpa			28 Mar (4)	29 Mar (2)
Fagaceae: Quercus macrocarpa[b]	Bur oak	28 Mar (2)			
Salicaceae: Salix nigra	Black willow	4 Apr (8)	27 Mar (9)		
Oleaceae: Fraxinus americana[b]	White ash	2 Apr (3)	27 Mar (4)		
Ulmaceae: Celtis occidentalis[b]	Hackberry	2 Apr (2)	27 Mar (3)		
Anacardiaceae: Toxicodendron radicans[a]	Poison ivy			6 Apr (11)	31 Mar (10)
Juglandaceae: Juglans nigra[b]	Black walnut	8 Apr (4)	31 Mar (10)		
Bignoniaceae: Campsis radicans[a]	Trumpetvine			6 Apr (3)	4 Apr (3)
Fabaceae: Gleditsia triacanthos[a]	Honey locust				7 Apr (6)
Moraceae: Maclura pomifera[b]	Bois-d'arc				8 Apr (41)
Sapindaceae: Sapindus drummondii[a]	Soapberry		8 Apr (5)		
Ulmaceae: Celtis laevigata[b]	Sugarberry	16 Apr (8)	9 Apr (13)		
Juglandaceae: Carya illinoensis[b]	Pecan	20 Apr (10)	10 April (40)		
Ebenaceae: Diospyros virginiana[a,b]	Persimmon				11 Apr (27)

[a]Animal pollination; others wind or unknown

[b]Ring-porous wood; others diffuse-porous

Table 1. Average budburst dates of temperate and tropical species in northern Oklahoma (Tulsa, 36° N) and southern Oklahoma (Durant, 34° N). Number of trees sampled in parentheses.

results. The last species to burst its buds, the pecan, comes from a family of temperate, not tropical, origin, and is represented by numerous individuals in these data sets (Table 1); even though the pecan did not appear to fit the expected evolutionary pattern, the analysis of the entire data set still confirmed the expected pattern. The full story of spring budburst times is very complex, and this paper describes an attempt to look for a broad pattern. There are obviously many exceptions, but a successful evolutionary hypothesis would provide a reliable basis to explain variations in budburst dates in these species *and* provide general principles for patterns in species not yet studied — as well as potential explanations for those exceptional species, like the pecan, that depart from the general evolutionary expectations.

Each spring, warm temperatures travel north, and tree and shrub buds burst, but some of the trees and shrubs, vestiges of the ancient tropics, still look southward towards their origins, innocently retracing their evolutionary history. Lay people and schoolteachers can observe, measure, and analyze this evolutionary pattern — and, we hope, understand how and why scientists use evolutionary theory in modern biological sciences. Darwin observed these differences in budburst time, within and between tree species, but because he lived at a time of ignorance about continental drift and of the times and places of origin of the several plant families, he perhaps could not have imagined such a quiet vindication of this theory.

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Rushdie on Creationism

In his novel *The Satanic Verses* (New York: Viking, 1988), Salman Rushdie paints a memorable portrait of a creationist, Eugene Dumsday:

> "I am a man of science, sir, and it has been my mission, my mission and let me add my privilege, to visit your great nation to battle with the most pernicious devilment ever got folks' brains by the balls."
>
> "I don't follow."
>
> Dumsday lowered his voice. "I'm talking monkey-crap here, sir. Darwinism. The evolutionary heresy of Mr Charles Darwin." His tones made it plain that the name of anguished, God-ridden Darwin was as distasteful as that of any other forktail fiend, Beelzebub, Asmodeus, or Lucifer himself. "I have been warning your fellowmen," Dumsday confided, "against Mr Darwin and his works. With the assistance of my personal fifty-seven-slide presentation. I spoke most recently, sir, at the World Understanding Day banquet of the Rotary Club, Cochin, Kerala. I spoke of my own country, of its young people. I see them lost, sir. The young people of America: I see them in their despair, turning to narcotics, even, for I'm a plain-speaking man, to pre-marital sexual relations. And I said this then and I say it now to you. If I believed my great-granddaddy was a chimpanzee, why, I'd be pretty depressed myself" (p 75–6).

Elsewhere, in a review of Malise Ruthven's *The Divine Supermarket: Shopping for God in America* (New York: Arbor House, 1989), Rushdie writes, "Some years ago in South India I encountered the curious and unforgettable figure of Duane Gish, an American creationist scientist whose lectures were accompanied by a jolly slide show: when a slide of a chimpanzee came up, he'd say, 'Oops, that's my grandfather.' Gish gave me the model for the character of Eugene Dumsday in *The Satanic Verses*..." Rushdie's review was reprinted in his *Imaginary Homelands: Essays and Criticism 1981–1991* (London: Granta Books, 1991), p 368–70. That Rushdie found Gish unforgettable is clear from his 1999 essay "Darwin in Kansas" (reprinted in his *Step Across This Line: Collected Nonfiction 1992–2002* [New York: Random House, 2002], p 280–2), in which he again recounted his experience with Gish: "I was interested to note that a few minutes into the lecture the habitually courteous Indian audience simply stopped listening. The hum of conversation gradually rose until the speaker was all but drowned. Not that this stopped Duane. Like a dinosaur who hasn't noticed he's extinct, he just went bellowing on."

BOOKREVIEWS

Human Natures. Genes, Cultures, and the Human Prospect

by Paul R Ehrlich
New York: Penguin Books, 2000.
531 pages.

Reviewed by Peter Frost, Université Laval

Genetics or culture — which has done more to shape our human nature? This age-old debate is central to Paul Ehrlich's tome on the evolution of human behavior, society, and civilization. Although he treats both sides of the debate fairly, often confessing his own uncertainty, Ehrlich clearly comes down on the side of culture. Hence the title, *Human Natures*, which stresses the diverse ways we have developed from a common blueprint.

In our species, cultural evolution has certainly taken over from genetic evolution. Culture can pass on and create adaptations without being constrained by generation time and the long wait for useful mutations. Yet genes still have some advantages. If a situation arises often enough, we are better off with a genetically preprogrammed response. "Hardwiring" avoids the delays of learning how to respond to a situation that may have serious consequences the first time. The "ouch!" response does not have to be learned. Although Ehrlich does give hardwiring some role, he generally discounts it for two reasons.

His first reason is "gene shortage". Our genomes have fewer than 100 000 genes and our brains 100–1000 trillion synapses (p 124). That translates to at least 1 gene for every 1 billion synapses. Ehrlich concludes from this, on the assumption that one gene has one effect, that relatively few synapses are hardwired. Actually, a single gene can have many effects. It may produce different amounts of protein for different purposes, or even different proteins, depending on the way it is regulated by other genes and the way these other genes are regulated. So the number of hardwired synapses could be much higher than 100 000 — in theory, as many as there are ways of combining 100 000 genes with each other. Furthermore, if gene shortage had indeed prevented hardwiring, even when advantageous, would natural selection not have expanded the genome and reduced the proportion of junk DNA? Such selection has occurred in other species. The pufferfish packs the same genetic information into one-eighth the DNA (Lewis 2002). Given our genome's unused capacity, new genes should have been easy to create when needed.

Ehrlich's second reason is "imprecision of selection" (p 127). If a desirable effect is selected, the result is selection for a lot of other effects, most of them undesirable. So a behavior will not be hardwired unless it is really critical to survival. Ehrlich has certainly put his finger on a problem in evolution (and it is heartening to see him acknowledge that a single gene can have many effects). But the problem is not insuperable. Typically, natural selection will bring about duplication of the gene, with one copy specializing in one set of effects and the other in another. Or it will adjust regulator genes that are associated with any undesirable effects. Such fine-tuning has made possible the evolution of anatomy from one-celled ameba to many-celled humans. Why not the evolution of behavior?

In the genes-vs-culture debate, Ehrlich confesses no uncertainty on one point: Human races do not exist. He presents two undisputed facts. First, there is much more genetic variability within populations than between populations. "If all human beings except native Africans were wiped out, humanity would still retain somewhat more than 90 percent of its genetic variability" (p 52). Second, genetic variability is largely discordant. "Whether we plot skin color, height, indices of nose or face shape, frequencies of genes controlling blood groups, or any other characteristic, the resulting maps are in most cases utterly different from one trait to the next" (p 291). Human races are thus arbitrary: "Pick a different set of characteristics and you get a different set of 'races'." (p 292).

These two facts deserve closer scrutiny. First, it is true that genes vary more within human populations than between them. But the same pattern exists between many species. Genes vary more within single dog breeds than between dogs and wolves (Coppinger and Schneider 1995: 33; Vila and others 1997). Genes vary more within species of Lake Victoria cichlids than between them, despite clear interspecific differences in morphology and behavior (Klein and others 1998). Genes vary so much within *Lycaeides* butterfly species, and so little between them, that these species cannot be told apart when one examines their mitochondrial DNA or allozyme alleles — again despite clear differences in morphology (Nice and Shapiro 1999).

Second, it is true that genetic variability is discordant across human populations. But the same discordance exists across many species. All 6 species of Darwin's ground finches form a genetically homogeneous genus with very little concordance between mitochondrial DNA, nuclear DNA, and morphology (Freeland and Boag 1999). Considering those traits that concord so poorly within our species: How well do they concord across the species boundary between us and our primate cousins? ABO blood groups exist not only in humans but also in other primates (Klein and others 1998). According to this trait, I probably have more in common with certain apes than with Ehrlich. Height and skin color? Again, many of us are closer to some apes than to other humans. How about dental traits? Our species would still be indistinguishable: a large suite of dental traits exists in sub-Saharan Africans and non-human primates but not in humans outside Africa (Irish 1998).

If a single-trait approach is so poor at distinguishing species, it could hardly be better at distinguishing races. The only sensible approach is a multi-trait one. In other words, we should aggregate information from many different characteristics by superimposing maps of their variability on top of each other. If we do this for humans, the resulting composite map unmistakably reveals four regional groups: 1) sub-Saharan Africans; 2) Europeans and West Asians; 3) East Asians and Amerindians; and 4) Australian Aborigines (Cavalli-Sforza and others 1994; Mountain and Cavalli-Sforza 1997; Nei and Roychoudhury 1993).

But why must we aggregate so much to filter out the fuzziness in the data? The answer is that only a fraction of the genome changes when one population differentiates from another in response to differences in natural selection. The rest remains unchanged, either because the genes have little selective value or because they handle adaptive problems that are common to both populations. Over most of the genome, then, variability consists not of adaptive differences created by different selection pressures but rather of non-adaptive variations that similar selection pressures (or none at all) have left in place.

As the two populations become reproductively isolated, they no longer accumulate the same non-adaptive variations and so their genomes drift steadily apart. But this takes time. For instance, the two species of redpoll finches diverged some 50 000 years ago and clearly have distinct phenotypes, yet their mitochondrial DNA reveals a single undifferentiated gene pool (Seutin and others 1995). It is no surprise, then, that so much genetic overlap exists among human populations. The earliest split among them—the Out-of-Africa event — is on the order of 40 000 years ago (Pritchard and others 1999).

What about the fact that 90% of all human genetic variability lies in Africa? All that means is that the African gene pool is older and has accumulated more "junk" variability, a mere fraction of which was carried out of Africa by the small founder groups that peopled the rest of the world. The absurdity of drawing further conclusions is illustrated by another fact: a single chimpanzee subspecies has more genetic variability than all humans taken together (Gagneux and others 1999). So what? All that means is that chimps have stayed put with the same gene pool for a longer time.

Has Ehrlich failed, then, in his quest to merge culture and genetics into a common understanding of the human prospect? Yes, but in this he is no worse than others. Such a quest, by virtue of the many areas it must cover, will enter some that lie beyond the limits of normal debate. In another age, these areas were sex and religion. Are we more enlightened today?

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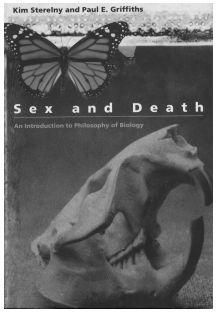

Sex and Death: An Introduction to Philosophy of Biology

by Kim Sterelny and Paul E Griffiths
Chicago: University of Chicago Press, 1999. 440 pages.

Reviewed by Niall Shanks, East Tennessee State University

This is a well-written book that should be of interest to a broad array of readers. Those readers wanting to get acquainted with the basic issues in the philosophy of biology (as well as those seeking an introduction to the biological ideas and concepts upon which such philosophizing feasts) will find this book to be a valuable resource. It would be possible to base a rich undergraduate course in the philosophy of biology on this book, and fragments of it could be used to supplement a range of other courses that find a need to touch on biological concepts and their significance. For example, the book contains discussions of sociobiology, the nature of life, and biological reductionism. Moreover, each chapter ends with suggestions for further reading. Helpful diagrams, pictures and explanatory "boxes" are sprinkled throughout the text, and there is both a valuable glossary and a useful index. My colleague George Gale at the University of Missouri at Kansas City has actually used this book, and tells me that, "reduction is covered particularly well: my students were able to really dig in their teeth ... and some excellent dialog across disciplines resulted" (quoted with permission).

However, this book has little to say about creationism or "intelligent design", and readers hungry for such material will have to look elsewhere. In contrast, the book does contain a very good and detailed introduction to the roles played by evolutionary ideas in the biological sciences, and the philosophical significance of those ideas. Certainly science teachers who have to confront creationism in the classroom will find this book to be a helpful resource when it comes to explaining the meaning and significance of central evolutionary concepts.

The book has been divided into 6 parts. Part 1 is introductory in nature and begins with a discussion of why we should care about the philosophy of biology. Although written before the Bush administration and its friends in Congress had begun hamstringing biomedical research with restrictions on stem cell studies and research involving cloning and human embryonic tissue, one comes away from the first part of the book with an understanding of how the biological sciences intersect with important social issues. This part of the book also gives the reader some insight into the basic ideas behind standard presentations of evolutionary biology, and the theoretical issues that these presentations generate.

Part 2 concerns genes, molecules and organisms. Biology in the 20th century has been driven by an ever deepening understanding of the molecular nature of life, and this culminated in the last two or so decades in the so-called "molecular revolution". This has led in turn to a thoroughly gene-centered view of evolution. (Purists may quibble that the authors should have spoken of *allele* frequencies where instead they speak of *gene* frequencies, but the authors' usage fits with the textbook tradition, objectionable as this may be to purists.)

The remainder of Part 2 raises issues about the validity of a genocentric view of evolutionary biology, and in chapter 5, the issue of the role of developmental biology and its implications for the interpretation of evolutionary claims makes a valuable debut. It is truly refreshing to see developmental considerations receive their due in a discussion of the meaning of evolution. Readers interested in finding out more about what biologists think of genes will enjoy chapter 6. Issues about genetic reductionism are treated in chapter 7.

Part 3 concerns organisms, groups, and superorganisms — in essence the issues are generated by puzzles concerning the nature of biological individuals and the various levels at which selection might operate. The biological hierarchy of organization runs from molecules at the bottom to intracellular structures, cells, tissues, organs, organisms, populations, species, ecologies, and on up to the biosphere itself. There are clearly entities with characteristic properties at lower levels of the hierarchy. Some theorists argue that the level at which explanations must be cast is the molecular level. Genes are the basic units of biological explanation, and selection acts on genes. Other theorists focus on the individual organism. But what of higher levels in the hierarchy? Are species individuals? Is there such a thing as group selection? The discussion of the nature of biological species, along with the thorny issue of group selection, is illuminating. It is accompanied by a good introduction to the basics of systematics.

Part 4 moves the discussion to consideration of topics generated by the nature of explanations in evolutionary biology. The first topic of discussion centers on the nature of adaptations and functional properties of organisms. The concept of *adaptation* is usefully contrasted with that of *exaptation*. This is a prelude for a discussion of the *adaptationist program* (or programs, since more than one view is at stake here) and its numerous critics. There is also a useful discussion of optimality modeling and game-theoretic modeling.

Against this background of basic theoretical issues, the authors then proceed to discuss the relations between evolutionary biology and ecology. Evolutionary biologists sometimes complain that ecology is a branch of biological science not sufficiently steeped in evolutionary reasoning. Evolutionary biology, moreover, is a historical science in which reconstruction of the past is of crucial importance. Yet some prominent ecologists have sought to downplay historical considerations in favor of the construction of general ecological models that might in some sense transcend the noise of history. The book provides a clear introduction to these thorny topics, and Part 4 ends with a discussion of controversies surrounding the so-called "big pictures" that have been offered of the nature of life on earth. Among the questions discussed are these: Does the history of life manifest a tendency toward increasing complexity? Is evolution in some sense "progressive"? In short, how are we to think of the major evolutionary transitions witnessed in the history of life? How are we to think of mass extinctions? And what is the role of contingency in historical processes? To use an image suggested by the late Stephen Jay Gould, would the history of life be more or less the same if we could somehow re-run the movie?

In Part 5, the authors open a veritable Pandora's box of issues by discussing the nature of sociobiology and evolutionary psychology. This part of the book could be used in a range of courses outside of the confines of philosophy of biology, for example, in courses touching on social theory, political science, and ethics. The application of evolutionary ideas to humans and the nature of human societies have always made people uncomfortable. In part this is because we seem to be uncomfortable when it is ourselves, and especially our biology, that is the subject of cold, scientific scrutiny. In part it is because notable examples of these sorts of biological investigations have historically been rather poor from a scientific standpoint and (not unrelated to this) have been tainted by unsavory, extrascientific motivations.

In this part of the book, I think, it would have been useful if the authors had devoted a little more time to the nature and history of ethological explanations. Nevertheless, the reader comes away with an appreciation of the central ideas behind the adaptive, modular theory of mind that evolutionary psychologists have come to champion. The important issue of cultural evolution (and analogies and disanalogies with biological evolution) receives a mere two pages of discussion. This takes brevity too far, especially since cultural presuppositions bedevil sociobiology and evolutionary psychology. The case study concerning emotions, was, however, a valuable component of this part of the book.

Part 6 contains the authors' concluding thoughts. Here they touch on

such issues as the origins of life and complexity theory. This discussion is too brief to be useful and arguably should have been left out (in favor, perhaps, of more detail in Part 5). Notwithstanding this criticism, this is a really good book. It was a genuine pleasure to read it for this review.

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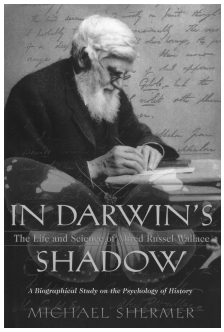

In Darwin's Shadow: The Life and Science of Alfred Russel Wallace

by Michael Shermer
New York: Oxford University Press, 2002.
422 pages.

Reviewed by Aubrey Manning, University of Edinburgh

Opening this book, I had a quibble about its title. Is Alfred Russel Wallace really such an unfamiliar figure today? Was he seen by his contemporaries as overshadowed by the great man? I am not sure. Indeed, Shermer's account of his later life reveals how much Wallace stood out then — he became recognized, at least in Britain, as "the last of the Great Victorians". In part this was a result of his remarkable longevity, for he lived on to the age of 90 (until the end of 1913). Remarkable is the right term because during his extended expeditions to the Amazon and the Malay archipelago (modern Indonesia), he was frequently brought to death's door by malaria, yellow fever, and many other tropical plagues. He must have had the constitution of the proverbial ox!

This is a distinguished and scholarly biography with excellent coverage of the science. Shermer is concerned with the history of evolutionary ideas and uses the interaction between Wallace, Darwin, and others to great effect. He goes beyond this to examine the extraordinary range of Wallace's interests and how they came to dominate different stages of his life. It is always clear and attractively written but is very detailed in places and probably not best suited for non-specialists wanting an introduction to Wallace's life. They might first go to Peter Raby's very good *Alfred Russel Wallace: A Life* (Princeton: Princeton University Press, 2001; reviewed by John Wilkins in *RNCSE* 2003 Jan/Feb; 23 [1]: 39–40), but it is to Shermer one must go to dig deeper.

Wallace had little of Darwin's science background in his family nor the privileges of money. He was eighth-born into a family that never had much to spare. He had little formal education but considerable opportunity for reading and inquiry. He had quickly to earn a living and did a little teaching, then spent a few years as a surveyor working for the burgeoning railway companies. In view of what came later, it is interesting to note that very early on he came to abandon conventional religions as poorly equipped to explain the phenomena of nature. Also, he and a brother attended evening classes in one of the "mechanics' institutes" where working people could learn science and some philosophy. Wallace was here introduced to the socialist ideals of Robert Owen, the founder of New Lanark. But from his earliest days he loved an outdoor life; he was captivated by the natural world and became a very acute observer. He met up with HW Bates, a young man of very similar tastes, and together they planned a major expedition to the Amazon basin, to be financed entirely from the collections they would make. This set the form of all Wallace's early career: his fascination with the variety of life provided his delight, his intellectual challenge, and his livelihood!

He was quite early in correspondence in Darwin, who recognized that the revelation of the huge variety of species Wallace was describing from the tropics and their geographical distribution were of great significance. Indeed, they began to throw some light on "that mystery of mysteries", as Darwin described the origin of species in the introduction to his crucial volume. It was clear that Wallace himself was musing on that mystery, and Darwin probably knew this. Then came the bombshell of a letter he received in June 1858 sent from the remote East Indies. Wallace there set out ideas on natural selection and its operation virtually identical to those which Darwin had been painstakingly developing over the 20 years since he returned from the voyage of the *Beagle*.

The story of how Darwin and Wallace came to publish a joint paper in that year and how Darwin subsequently accelerated into action over the *Origin* is now fairly familiar. It has aroused bitter accusations of plagiarism from those — and there are always iconoclasts among us — who accuse Darwin of deception at Wallace's expense. Shermer provides here a most detailed and sensitive analysis of those crucial months and all that has been written about them. He totally acquits Darwin, clearly believing that he was basically a nice person, and I totally agree with him! Darwin often acknowledges the extent of Wallace's contribution, particularly in relation to the geographical distribution of animals and plants, which lent powerful support to evolutionary ideas. There is certainly no sign that Wallace ever felt a trace of resentment. He obviously admired Darwin and throughout his long life continued to refer to him and promote the concept of natural selection. He remained extraordinarily modest and self-effacing about his achievements. It was quite a struggle for his colleagues to get him to accept election to the Royal Society of London, for example.

Wallace's one departure from Darwin and from the power of natural selection concerned the human brain, which he believed forced him to accept a designing force beyond nature. Why else would "savages" be already in possession of a brain identical to that of the more civilized when only the latter uses its amazing capacities to the full extent? Alas and alas, I feel! How could Wallace, who was such an acute observer, not recognize the scope of the civilizations around him as he moved through the Malay archipelago? But then even the greatest people have blind spots. Darwin remained convinced that natural selection was behind it all, but even he found it hard to cred-

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it that he was from the same species as the natives of Tierra del Fuego!

Certainly Wallace pursued various potty ideas such as spiritualism in the latter part of his life. He clearly lacked judgment in some cases; Shermer relates the comic story of Wallace's attempt to win 500 pounds (which he probably needed — he was never flush with funds!) from a wager offered by a lunatic who believed the earth was flat. Careful measurements were made along a 6-mile, dead-straight stretch of canal. The curvature was clear, but no money was forthcoming, nothing but a stream of insulting and threatening correspondence and bills from lawyers.

Nevertheless, Wallace was also seriously involved with the betterment of human societies and retained his youthful allegiance to socialist ideals. He was extraordinarily productive on a variety of issues. What other biologist would have contributed books on *Land Nationalisation* and *Social Environment and Moral Progress* among all the extensive biological work! Shermer provides a full bibliography of Wallace, which in itself is a remarkable record of a remarkable and admirable man. The book is well-illustrated and includes some delightful photographs of Wallace as an old man. There is one of him, near the end of his long life, resting on the ground in the sunlight of a woodland path, still delighting in the natural world. It is one of many images from this excellent biography I wish to retain.

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Redesigning Humans: Our Inevitable Genetic Future

by Gregory Stock
New York, Houghton Mifflin Company, 2002. 277 pages.

Reviewed by Jeffrey M Otto, Genaissance, Inc.

In this book, Gregory Stock, director of the Program on Medicine, Technology, and Society at the School of Medicine of the University of California at Los Angeles, tackles one of the most controversial and fascinating issues facing 21st-century medicine: genetic engineering of humans. On the front flap of the dust jacket, we are treated to the following tantalizing paragraph:

> Forget worries about cloning people. In the future, technological advances will bring far more meaningful and controversial changes to our offspring, says Gregory Stock. As scientists rapidly improve their ability to identify and manipulate genes, people will want to protect their future children from diseases, help them live longer, and even influence their looks and abilities. Stock, an expert on the implications of recent advances in reproductive biology, clearly shows that neither governments nor religious groups will be able to stop the coming trend of choosing an embryo's genes.

After reading this book, I can offer the following two statements: 1) Stock has convinced me that his thesis is mostly if not entirely correct and 2) everyone interested in 21st-century medicine and genetics should read this book. Despite the daunting challenge of the material, Stock's approach makes it accessible to both the professional and the layperson.

To make his point, and to take the reader along on this amazing journey, Stock combines references to popular culture, including cinema and literature, interviews with and comments from some of the top scientists in the field, statistics, history, and a solid understanding of both the scientific and ethical challenges regarding the genetic manipulation of humans. That he succeeds so completely is due in no small measure to his ability to take complicated and scientifically challenging concepts and explain them in a way that makes them both familiar and new to the reader.

In the early chapters, Stock outlines why he believes that some projects for human redesign are inevitable while others will not come to be. His thoughts on cyborgs seem particularly on mark. He presents the argument that cyborgization (the incorporation and fusing of machine components into our bodies) of humans has limited application due primarily to the more limited risks associated with fyborgization (the functional incorporation and use of machines with our bodies). On page 25, he compares the fyborgization use of a hearing aid with the cyborgization of a cochlear implant. Because the hearing aid is convenient, functions properly, and is easily upgradeable, it seems unlikely that anyone would risk the surgery associated with the cochlear implant unless it provided a function not met by the external hearing aid. He sums up the problems of cyborgization nicely on page 20:

> Hollywood images of human-like cyborgs lull our thinking, because they so completely ignore the messy realities of basic physiology. If a detail like wound healing comes up at all in a sci-fi fantasy about human chip-heads, some unspecified advanced technology usually mends the incision in seconds. This is mere theater. The inner terrain of our brain resembles neither the neat geometry of the computer chip nor the abstract corridors of cyberspace; it is flesh and blood. Wounds heal slowly. Pain lingers. Aging skin sags.

After systematically dismantling the idea of human advancement through the use of cyborgenic technology, he tackles the driving force for genetic engineering: genetic disease. Stock begins chapter 3 ("Setting the stage") with a recounting of the death of Jesse Gelsinger after his participation in a phase I gene therapy trial. Using this seminal event as a springboard, Stock outlines the key differences between somatic and germline manipulations. From the author's perspective, while somatic cell gene therapy has to overcome almost insurmountable obstacles, we are already on the way to successful treatment of genetic diseases through germline manipulation. At the end of this chapter, he presents his compelling thesis statement:

> Human germline manipulation will come into being not as a replacement for existing technologies like embryo screen-

> ing, but as an extension of them. Germline modifications will appeal to us to the extent that they can deliver compelling benefits that we cannot obtain using simpler procedures. Direct germline intervention is the logical conclusion of our ongoing progress in reproductive biology and the ultimate expression of it, and its realm will likely be human enhancement.

From this point on, the book really takes off, discussing the likely mechanisms to be employed in achieving the end described in the above thesis statement. What I found most interesting was the concept of artificial, upgradeable, and modifiable chromosomes. These auxiliary chromosomes would contain cassettes flanking upgraded versions of genes that would be transmitted to the designer human. Through methodologies already in place, these auxiliary chromosomes could be prevented from germline transmission to future offspring. Thus, with each passing generation, the parents of the yet-to-be-born child would need to screen their embryos and then select the correct chromosome for insertion. As science progresses, these auxiliary chromosomes would increase in efficiency, complexity, and power. These chromosomes might be used not only for preventing genetic disease, but also to create supercharged immune systems capable of warding off common viruses and childhood diseases — thus eliminating the need for vaccination.

After presenting a viable approach for germline manipulation and outlining the driving forces that make it inevitable, Stock uses the rest of his book to investigate what these technologies will be capable of (and what they will not be capable of), the bioethical questions that arise, and of course, the fissure that will separate the haves from the have-nots.

While to some, the title of this book may suggest a text that is ethically irresponsible, perhaps advocating the creation of "genetic Frankensteins", I have found it to be everything but that. Stock has an excellent understanding of the science, but also has a compassionate understanding of humanity. This book makes a strong argument that while germline manipulation will happen, specifically because both the scientific know-how and the public's desire are there, we can navigate the difficult ethical waters by addressing the tough questions now.

After finishing this book, I have found myself convinced that Stock's vision of the future is likely to be substantially accurate. As a consequence, to avoid the most dangerous of the pitfalls, we need to start thinking now about the tough questions that will be facing us and our children, 10, 20, and 30 years down the road. Without reservation, I recommend this book as a starting point for this journey.

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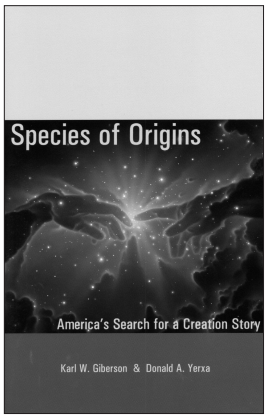

Species of Origins: America's Search for a Creation Story

by Karl W Giberson and
Donald A Yerxa
Lanham (MD): Rowman &
Littlefield Publishers, Inc, 2002.
277 pages.

Reviewed by George E Webb, Tennessee Tech University

The continuing controversy over the teaching of evolution in the public schools has undergone various transformations during the last century. From the post-World War I campaign of William Jennings Bryan through the creation science movement of Henry Morris to the "intelligent design" efforts associated with Phillip E Johnson, opposition to the inclusion of evolutionary concepts in the science curriculum has remained a constant in recent American history. Emphasizing the constancy of anti-evolution sentiment, however, can lead to the conclusion that a monolithic movement seeks to remove Darwin from the public schools. A closer analysis reveals a far more complex situation.

The authors of *Species of Origins* (one a physicist, the other a historian) provide an overview of the various ideas behind the evolution/creation debate in the United States in an effort to clarify our understanding of this long-standing controversy. Following an introduction in which they stress their goal of a fair and balanced treatment of the various creation explanations (thus, *species* of origins), they provide a brief overview of the evolutionary explanation accepted by the scientific community. Specialists in the various disciplines they survey will, to be sure, blanch at the authors' discussions of such complex topics as the physics associated with the immediate aftermath of the Big Bang and the origin of life on earth, but the nonspecialist will at least be exposed to important concepts.The authors end this chapter by emphasizing that despite the widespread acceptance of the evolutionary account by scientists, opinion polls consistently indicate that the public largely rejects this explanation.

Once the dichotomy between the scientific and public perspectives on origins is identified, they take the logical next step and rigorously analyze the different explanations offered by opponents to evolution. In an extensive and well-informed discussion of the creation science movement of Henry Morris and his colleagues, they emphasize that this version of anti-evolution sentiment must be examined within the scientific, religious, and social contexts of the movement. The literalistic reading of the Bible and the deeply-held concern about the decay of traditional morality are as important to the creation science perspective as is its focus on a 6-day creation and a global flood. The authors provide a carefully crafted discussion of all 3 contexts and are especially effective in describing the scientific arguments used by these creationists.

The authors make it clear, howev-

er, that religious aspects dominate creation science. The importance of religion to creation scientists is in stark contrast to the situation among natural scientists, at least among those most active in the popularization of the evolutionary world view. In an intriguing chapter, the authors discuss the work of several popularizers, including Richard Dawkins, Steven Weinberg, Stephen Jay Gould, and others. Although they emphasize that a wide range of attitudes toward the science/religion clash exists among such popularizers, the authors conclude that traditional religion has no role to play in the popularizers' perspectives. The overt atheism of Dawkins is countered by the sense of loss Weinberg expresses over the lack of purpose in modern views of the universe, but persons of faith often find no significant difference between the two views. Gould's suggestion that science and religion work best when each restricts its focus to its own separate sphere works no better. The scientific sphere is concerned with facts, in his view, while the religious sphere is concerned with ethics and morality. To suggest that religion has nothing to do with "truth" is hardly a concept likely to attract support from the religious community.

Is there a middle path? The authors devote the remainder of their book to an examination of possible alternate explanations that would maintain both scientific and religious integrity. Such concepts as the gap and day/age models of creationism (rejected by Morris and his followers), as well as various versions of theistic evolution, are all described in sufficient detail to show the reader how complex the middle way might be. In the same category is the most recent of anti-evolution efforts, the "intelligent design" movement. The authors devote the last two chapters to this concept and its reception, providing a sound overview of the ideas involved in this latest challenge to Darwin.

The great strength of this book rests in the authors' decision to take the continuing evolution/creation debate seriously. They thus accept that any study of this topic must take the various components of the debate seriously, as well. Readers who want a balanced account of the various modes of anti-evolution sentiment of the past half century will find in *Species of Origins* a valuable introduction to an intriguing cultural phenomenon.

But is it possible that the authors have taken these anti-evolution views *too* seriously?

In their introduction, the authors acknowledge that they have accepted the postmodern view of the supposed clash between science and religion and have embraced the "methodological agnosticism" (p 10) of historian Ronald L Numbers in an effort to provide a more accurate view of the debate. Such earlier concepts as a "warfare" between science and religion have largely been abandoned by historians of science, who now stress that the relation between the two throughout history has been much more complex than the earlier metaphors implied. Thus, creating a dichotomy between the "progressive" world of science and the "reactionary" world of religion is both inaccurate and counterproductive. Far better, the authors emphasize, to treat the creationists with the same intellectual respect as the scientists.

This is an admirable goal, to be sure, but it guides the authors into the postmodern muddle of the "science studies" perspective, in which the concept of an accurate portrayal of nature is an illusion. Consider the subtitle of this volume: "America's Search for a Creation *Story* [emphasis added]". The chapter in which they summarize the modern scientific explanation of origins carries the title, "The Modern Creation *Story* [emphasis added]". The authors emphasize frequently the need for a creation "story" for all cultures, ancient and modern, and stress that the current debate shows that such a need continues in the early 21st century. Thus, American society seeks a "story" that will satisfy a deeply rooted cultural need.

The difficulty, of course, comes when there are two competing stories, one of which is largely based on a religious world view and the other largely based on a naturalistic world view. To determine which is "right", one needs to be able to evaluate the evidence presented in support. Is such evaluation taking place in contemporary America? If so, the question posed early in the authors' discussion takes on added significance: Why is it that most Americans reject the scientific explanation of origins?

The answer is embedded in the postmodern perspective the authors embrace. It is another example of the contemporary rejection of expertise that has increasingly guided discourse and decision-making over the last few decades. If we are dealing with different "stories", then does that not suggest that all "stories" are more-or-less acceptable? Or do we appeal to an "authority" who might have special expertise? This latter solution seems to be absent from non-evolutionary explanations of origins. Phillip E Johnson, the acknowledged founder of the "intelligent design" movement, plays a major role in the authors' discussion of contemporary anti-evolution sentiment. His credentials for offering a challenge to evolutionary explanations include his status as "a brilliant Berkeley law professor" (p 198), his academic position as "a recognized authority in criminal law and a tenured professor at Boalt Hall, the prestigious law school of the University of California at Berkeley" (p 200), and his ability to read popularizations of evolutionary theory "carefully through the eyes of a lawyer" (p 200). The publication data of most of the authors' cited references concerning anti-evolutionary ideas include the names of very few major publishers; most of these works have been published by religious publishing houses or in journals outside the academic mainstream. In short, those who seem to be the leading figures in the anti-evolution campaign (whether in creation science or "intelligent design") rarely have the background one would expect from individuals who are challenging one of the best established scientific concepts of the contemporary world.

Despite the authors' careful and balanced discussion of the various modes of thought concerning creation, in the final analysis their "story" suffers from a willingness to accept that scientists have no privileged position in crafting explanations of the natural world. A lawyer and a biologist are on equal footing when they attempt to offer explanations of the origin and development of life on earth. Surely, such a perspective carries the concept of "fairness" well beyond its proper role.

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