REPORTS OF THE NATIONAL CENTER FOR SCIENCE EDUCATION

DEFENDING THE TEACHING OF EVOLUTION IN THE PUBLIC SCHOOLS

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CONTINUES *NCSE REPORTS & CREATION/EVOLUTION*

CONTENTS

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Cover:
The mudskipper, *Periophthalmodon barberus*, a fish with a number of anatomical and physiological macromodfications of their fish-like body plan that enable them to live and forage on land.
Courtesy of Ulrich Kutschera, ©2006

Other artwork ©Ray Troll, 1997
For more information on Ray's work explore his website at <www.trollart.com>.

FROM THE EDITOR

Those of us of a certain age remember the nonsensical riddle: "What's the difference between a duck?" It is a nonsense question, of course, but this trivial question resonates with an important question in biology — what *is* a species?

Modern biologists study "species" — the fundamental unit of taxonomy — even through there are several ways to define the term. John Wilkins explains in this issue that this diversity reflects the process of scientific inquiry: researchers craft definitions that match the data and organisms that they study without necessarily trying to provide a one-size-fits-all definition for all of life. This is a reflection of the processes of biological change that have produced the patterns of variation and similarity in living organisms that we recognize as evolution. Just as who is in one's family depends on whether we use genetic or social data, whether a group of similar organisms constitutes one species or more depends on the processes that produce and maintain variation among organisms. Wilkins argues that this is a healthy debate — and a *real,* scientific one. It shows the diversity of processes that can produce evolutionary change and all the ways that they can contribute to the speciation that we can observe in the history of life on earth.

Contributions by Alan Gishlick, Dan Bolnick, and Ulrich Kutschera show that anti-evolutionists have been working hard to make the biblical concept of created "kinds" scientifically respectable, but for this work the biblical criterion will always trump any biological data or analytical outcome: that is, research results must always conform to the literal interpretation of "kinds" as distinctly created and biologically unrelated.

Gishlick reviews the basic concepts of "baraminology" while Wilkins does the same for ideas about species. Both of them provide a glossary of current terminology to help readers keep all the terms and concepts straight — both in these articles and in other readings on species and "kinds". Bolnick examines the supposed methodological innovation behind so-called discontinuity systematics, and Kutschera shows how these ideas have surfaced in European scientific sources.

IN THE NEWS

A look at news on the evolution front shows lots of flare-ups around the globe. In Europe, where we reported recently evolution was more widely accepted than in the USA, there is significant anti-evolution activism, including among government officials responsible for educational policy. In Kenya, some church leaders are opposing an exhibit at the National Museums of that country's world-famous human fossils. And for those who have followed the dubious career of Dr Dino — the irrepressible Kent Hovind — Greg Martinez reports on the recent conviction of Hovind and his wife Jo on federal tax-evasion charges in a Florida court. This follows on the heelds of Hovind's finally pleading no contest to charges stemming from his failure to obtain a building permit for his Dinosaur Adventure Land. Hovind claimed that the permit requirement infringed on his right to free exercise of religion. Commission Chairman Mike Whitehead reportedly replied: "Scripture also says 'Render unto Caesar what Caesar demands,' and right now Caesar demands a building permit."

In the Members' Pages, Randy Olson, who made the film *Flock of Dodos,* has allowed us to reprint his ideas on more effective communication of science to the public. Somehow his "top ten" ideas grew to eleven. This is a "tear-out" page, meant to be copied, shared, and pinned to bulletin boards everywhere.

And for those too young to know, the answer to the riddle is: "One of its legs is both the same."

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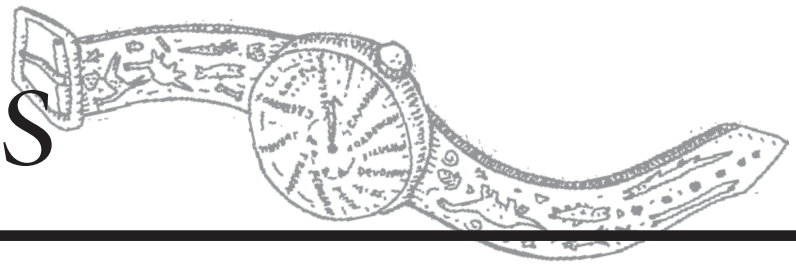
NEWS



California Schemin'

An El Tejon Soccer Coach Tried to Smuggle Creationism Into Her "Philosophy" Classroom, But Alert Local Parents Blew the Whistle

Rob Boston, Americans United for Separation of Church and State

California resident Kenneth Hurst was shocked when his children brought home a document describing some new course offerings at Frazier Mountain High School in Lebec.

Among the listings was a course called "Philosophy of Intelligent Design". Its description read: "The class will take a close look at evolution as a theory and will discuss the scientific, biological, and Biblical aspects that suggest why Darwin's philosophy is not rock solid. This class will discuss Intelligent Design as an alternative response to evolution."

"Topics that will be covered," the course description continued, "are the age of the earth, a worldwide flood, dinosaurs, pre-human fossils, dating methods, DNA, radioisotopes, and geological evidence. Physical and chemical evidence will be presented suggesting the earth is thousands of years old, not billions. The class will include lecture discussions, guest speaker, and videos. The class grade will be based on a position paper in which students will support or refute the theory of evolution."

Hurst, who holds a doctorate in geology and works at NASA's Jet Propulsion Laboratory near Pasadena, could see right away that this course had little to do with philosophy and a lot to do with promoting creationism. Backed by Americans United, he and other Kern County parents went to court to stop the school from teaching religion — and won when the school's board of trustees voted to end the class and agree never to offer it again.

The new case, coming less than a month after Americans United's victory over "intelligent design" in Dover, Pennsylvania (*see* RNCSE *2006 Jan–Apr; 26 [1–2]*), proves that the fight over creationism in public schools is far from dead. If anything, creationist advocates are still on the march and continue targeting local school boards.

In Lebec, the course was the brainchild of Sharon Lemburg, coach of the school's girls' soccer team and wife of an Assemblies of God pastor. Lemburg, who does not have a degree in any area of science, is clearly sympathetic to creationism. Her course syllabus listed questions about "intelligent design" that AU says reflect a creationist bias. Among them were, "Why is this a movement and why is it gaining momentum?" and "Why is it so threatening to society, the educational system, and evolutionists?"

Lemburg also proposed showing 24 videos to the students. According to AU's legal complaint, 23 were "produced or distributed by religious organizations and assume a pro-creationist, anti-evolution stance," including several by the Institute for Creation Research, a California-based religious ministry that attacks evolution, and Answers in Genesis, a similar group based in Kentucky.

As word began to spread about the class, the El Tejon school board hastily convened a special meeting on New Year's Day, with less than 24 hours notice to the public. At the meeting, the board voted 3–2 to approve the course with a "revised syllabus".

The revisions, AU asserted, did not improve the course. Several young-earth creationist videos were replaced with DVDs advocating "intelligent design". Even though course material propping up two longtime creationist canards — that evolution violates the second law of thermodynamics and that the fossil record backs creationism — were eliminated, the overall effect of the course, AU maintained, was still to promote religion.

Americans United sought to resolve the matter without litigation. On January 4, Americans United Legal Director Ayesha N Khan wrote to officials in the El Tejon Unified District, asking them to cancel the class.

Citing a line of federal court cases striking down creationism in public schools, Khan wrote, "Simply put, these decisions bar public schools from seeking to debunk evolution for religious ends or from teaching (or giving 'equal time' to) religious theories on the origins of life. Frazier Mountain's 'Philosophy of Design' course does both. It is clear, and we believe the evidence would show, that Ms Lemburg's purpose in teaching the course is to undermine evolution and to promote a religious perspective in its stead. It is equally clear that a reasonable observer would understand this to be the effect of the course."

The course was being offered during a special "intersession" period scheduled to last just four weeks. At Frazier Mountain High, courses offered during this time are geared toward students who need remedial help. Those who do not need remedial work take electives. Given the short time frame, Khan requested an immediate response from school officials.

Two days later, Superintendent John W Wight wrote back, saying he would not cancel the course. Wight asserted that Khan "may have been misinformed" about the nature of the course.

"We do not understand your demand that the course be can-

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celled," Wight wrote. "After reading your letter, our legal advisors have pointed out that they are unaware of any court or California statute which has forbidden public schools to explore cultural phenomenon, including history, religion or creation myths."

AU contends exploring "cultural phenomenon" is the last thing Lemburg wants to do. Her class was clearly tilted toward the creationist point of view, and she planned to bring several creationist speakers into the classroom. She apparently made no serious effort to line up evolutionists.

Lemburg originally indicated that she would ask James Selgrath, one of two science teachers at the high school, to address the class. But Selgrath told the Frazier Park *Mountain Enterprise*, "I have no plans to do that."

Selgrath added that he does not support teaching creationism at the school, remarking, "I have a PhD in reproductive biology with a specialty in genetic engineering. I was on the faculty at Tufts University for seven years. I am a scientist." Selgrath later joined Tim Garcia and Jim Atkinson, math and science teachers in the district, at a board meeting to lodge a protest.

Lemburg's syllabus also listed "Francis Krich" as a speaker. She later conceded this was a misspelling of Francis Crick, the Nobel-Prize–winning biologist who, along with James Watson, discovered the double helix structure of DNA. A native of England, Crick did live and teach in Southern California for a while, but he won't be traveling to Kern County to address the class. He died in July of 2004.

Unable to persuade the board to drop the course, Americans United filed a lawsuit on January 10 and asked a federal court in California to issue a temporary restraining order to block continuation of the class.

To help make the case, AU submitted a 24-page affidavit from Dr Eugenie Scott, executive director of the National Center for Science Education in Berkeley, California (*see "Problems with the intersession course", p 6)*. Scott, a physical anthropologist and author of the recent book *Evolution vs Creationism: An Introduction*, asserted, "It is my expert opinion that Mrs Lemburg's class purports to 'teach the controversy' in a balanced way, but that it actually reflects a decided pro-creationism, anti-evolution stance. It does so in two principal ways: First, it treats creationism and evolution as equal 'philosophies,' thereby undermining the credibility of evolutionary theory; second, as between the two, it plainly favors the creationist perspective."

AU acted on behalf of 11 parents, among them Hurst, who has children in the 10th and 12th grades in the El Tejon district. In court papers filed by AU, Hurst said the course "conflicts with my beliefs as a scientist. I believe this class undermines the sound scientific principles taught in Frazier Mountain High School's biology curriculum and is structured in a way that deprives my children of the opportunity to be presented with an objective education that would aid the development of their critical thinking skills."

Hurst, a Quaker, added that the class also offends his religious views, asserting it "reflects a preference for fundamentalist Christianity over all other religious and scientific viewpoints."

The El Tejon district, located in a rural area nestled in the mountains about 65 miles north of Los Angeles, serves fewer than 1500 students. When Hurst learned of the course, he talked with Lemburg directly to discuss his concerns. Hurst walked away from the conversation confident that she wanted to teach creationism.

"During their conversation, Mrs Lemburg repeatedly referred to 'intelligent design' as 'creationism,'" read AU's court documents. "She also informed Dr Hurst that the original title of the course had been 'Creationism vs Evolution.' Furthermore, although the proposed syllabus stated that the course would cover complicated scientific topics, such as the laws of thermodynamics and the fossil record and dating methods, Dr Hurst concluded from the conversation that Mrs Lemburg had no knowledge of these or other scientific subjects. By the end of the conversation, it was clear to Dr Hurst that Mrs Lemburg planned to use the class to advocate against evolution and in favor of the religious beliefs of 'intelligent design' and creationism."

Lemburg seems to acknowledge having religious motivations. "I believe this is the class that the Lord wanted me to teach," she wrote in a letter to the editor of the *Mountain Enterprise*.

The controversy divided the mountain community, a normally sleepy place that the *Times* described as "63 miles north of Los Angeles and a time warp away in ambience." Letters to the editor have poured into the *Mountain Enterprise*, and locals did not hesitate to opine on the matter to visiting reporters.

Pastor Scott Irwin of the Lebec Community Church sided with the board. "Attention is good," Irwin, who opposes evolution, told the *Times*. "I think Lebec is taking a big step for what is true."

But not far away, Abbe Gore, who provides internet services to the community, criticized the board for acting in haste. "What surprises me is that the local school board decided to go ahead with this class knowing full well it would be controversial," Gore said. "It's an unfortunate way to put Frazier Park on the map."

TV preacher Pat Robertson also felt compelled to weigh in. Addressing his "700 Club" audience January 17, Robertson insisted "There are inexplicable gaps in the so-called evolutionary theory" and remarked, "It just seems like to me for people to say a court — a judge — to say that you cannot enter into this area of inquiry because Barry Lynn and that bunch of atheists say you can't do it, I just think there's something terribly wrong about this."

Although often reported in the media as a battle over "intelligent design", the Lebec fight really centers more on traditional creationism. Lemburg's syllabus contains several references to "intelligent design", but most of the material she planned to use promoted young-earth creationism.

Lemburg's approach made the Discovery Institute, a Seattle-based pro-ID think tank, very nervous. On January 11, Casey Luskin, an attorney with the Institute, wrote to Wight and requested clarification: "Under the current formulation, the course title 'Philosophy of

design' misrepresents 'intelligent design' by promoting young earth-creationism under the guise of 'intelligent design'." Luskin continued: "We respectfully request that you either reformulate the course by removing the young-earth creationist materials or retitle the course as a course not focused on 'intelligent design'. Otherwise, this course could be damaging to scientists and other scholars investigating 'intelligent design' as a genuinely scientific alternative to Darwinism because the course conflates 'intelligent design' with Biblical creationist religious views about creation."

Americans United Executive Director Barry W Lynn said from a legal perspective, the Discovery Institute's claims are irrelevant and just another example of that group's attempts to portray ID as science, not religion. Although ID jettisons some of the more overtly religious claims of traditional creationism, the concept remains a faith-based one, Lynn said. ID proponents, he asserted, have no plausible candidate for the "designer" other than God.

Days before the hearing in federal court, AU attorneys made one more effort to resolve the matter by appealing directly to the school board. Harry Schwartzbart, president of the San Fernando Valley Chapter of Americans United, attended a January 13 meeting of the El Tejon Board, accompanied by two dozen local church-state separation advocates. Among them was the Reverend Skip Lindeman, pastor of the United Church of Christ Church of the Lighted Window in La Cañada. Both Schwartzbart and Lindeman read statements to the board, urging them to settle the lawsuit and drop the course. This time, the board was more open to compromise. Attorneys with Americans United, assisted by lawyers with the Los Angeles office of the national firm of Arnold & Porter, spent the weekend of January 14–15 negotiating with the board. An out-of-court settlement in the *Hurst v Newman* case was announced January 17.

Under the terms of the settlement, the course terminated one week early. The district's board of trustees has also agreed to language stating, "No school over which the School District has authority, including the High School, shall offer, presently [*sic*] or in the future, the course entitled 'Philosophy of Design' or 'Philosophy of Intelligent Design' or any other course that promotes or endorses creationism, creation science, or 'intelligent design'."

Khan said the board made the right move. "This course was far from intelligently designed," Khan said "It was an infomercial for creationism and its offshoot, 'intelligent design'. The class would never have survived a court challenge, and the board of trustees made the right call by pulling the plug on it."

AU executive director Lynn agreed. Lynn congratulated the El Tejon board for avoiding costly and time-consuming litigation, unlike the school board in Dover, Pennsylvania.

"We are delighted with the board's decision to discontinue the 'Philosophy of Design' course and never offer it again," said Lynn. "Public schools have no business promoting religion. I hope that other public schools learn from this incident and reject efforts to bring religious doctrines into classrooms."

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Problems with the Intersession Course

Eugenie C Scott
Executive Director, NCSE

NCSE's executive director Eugenie C Scott was asked to write a declaration in support of the plaintiffs' motion for a temporary restraining order, and if necessary a preliminary injunction, in Hurst et al v Newman et al. *The following discussion of specific problems with the "Philosophy of Intelligent Design" course that was at issue in the case is taken from her declaration.*

Eugenie C Scott

Introduction

In my expert opinion, the purpose and effect of the course at issue in this lawsuit are not to present a comparative treatment of the various philosophical issues surrounding evolution and creationism.

Rather, the purpose and effect of the class are to disparage the scientific status of evolution and to present as superior to evolution the religious ideas of creation science and "intelligent design". In other words, the course advocates on behalf of a particular religious view, and a sectarian one at that; special creationism is a minority view in American Christianity.

The evidence on which I base that conclusion pervades the course description, the original syllabus, and the revised syllabus — and turns on four general observations.

Lack of diversity

First, although the revised syllabus for the class asserts that the course will present the "world views on origins," the course does not even begin to provide students with the diversity of viewpoints on this matter. (It is worth noting that among the other intersession classes are a class specifically on "Comparative Religion" and another on "Mythology." The first is truly comparative, covering five major religions, and the second is on ancient myths and their influence on books [and] movies, such as *Star Wars*. This shows that there is at least an awareness at the school of how to treat religious views in a comparative fashion.) Instead, the course presents a single religious viewpoint, namely creationism (whether as creation science or "intelligent design").

Despite the original course title "Philosophy of Intelligent Design," the original version of the syllabus was dominated by creation science — the same view that the Supreme

Court in *Edwards* held could not be taught in public schools.

The course description, which I understand has remained unchanged, emphasizes creation science by, for example, advocating the belief that there is scientific evidence that "the earth is thousands of years old, not billions." It also states that the course will "take a close look at evolution as a theory and will discuss the scientific, biological, and *Biblical* aspects that suggest why Darwin's philosophy is not rock solid" (my emphasis).

The revised version of the syllabus emphasizes "intelligent design", but traces of creation science still appear, especially in such course materials as the video *Chemicals to Living Cells: Fantasy or Science*, which is sold by the creation-science ministry Answers in Genesis.

The syllabi, course description, and course materials make no mention of any non-Western religious viewpoints on the origins of life and its history. In any class purporting to provide a comparative treatment of cultural phenomena, that omission is remarkable. Anthropologists regard origin myths — stories about the ways in which the world and its inhabitants were formed (usually as the work of supernatural beings or forces) — as a cultural universal. There is certainly no shortage of origin myths available for discussion. Yet the course description and the original syllabus here reflect a narrow focus on a particular sectarian account of origins.

Similarly, there is no mention in the course materials of any religious viewpoints, Western or non-Western, that accept evolution. An example of these would be any of the many varieties of Christian theology known as theistic evolution: A number of mainline Christian denominations in the United States regard evolution as no threat to their theological views. For example, a number of prominent religious figures, including the late Pope John Paul II, have expressed the view that evolution is compatible with, or even enriches, their faith. A number of prominent scientists, including Francis Collins (the leader of the Human Genome Project), have made similar claims. But students in this course will not learn about any of these views. Instead, they will be told that evolution and religion are involved in (in the words of one of the videos on the original syllabus) a "War of the Worldviews".

The absence of the viewpoints of other religious traditions from the course materials belies any claim that the course's aim is to present a balanced, comparative, or objective treatment. Moreover, since the only religious viewpoint presented is in opposition to evolution, the effect is to present evolution as intrinsically antireligious. The course thus employs the "two-model" approach (beloved of proponents of creation science and "intelligent design") that Judge Overton aptly described in the *McLean* case as a "contrived dualism."

Bias in the course materials

Second, the course materials make clear that the class is being taught from an anti-evolution, pro-creationist and pro-"intelligent design" perspective.

The course description promises that the course will present evidence that "Darwin's philosophy is not rock solid" and present evidence "suggesting the earth is thousands of years old, not billions," thereby plainly reflecting a manifestly pro-creationist perspective. Furthermore, the course description's reference to treatment of "the age of the earth, a world wide flood, dinosaurs, pre-human fossils, dating methods, DNA, radioisotopes, and geological evidence" bespeaks a plainly religious agenda, as these are topics repeatedly singled out by proponents of creationism and "intelligent design" as reflecting areas on which evolutionary theory is flawed.

Twenty-three of the 24 videos listed on the original syllabus are one-sided presentations, produced by creation-science ministries and advocating a pro-creationism perspective, without any critical treatment of the arguments or other rebuttal. These videos are not ordinarily regarded as suitable material for the public schools because of their poor scientific quality as well as their religious advocacy. The twenty-fourth video, *The Fire Below Us*, pertains to volcanic activity rather than evolution and can scarcely bear the weight of holding up the "pro-evolution perspective".

The video selections — including *Unlocking the Mystery of Life* — also advocate the view that scientific practice should be changed and methodological naturalism should be abandoned in order to accommodate reference to the supernatural.

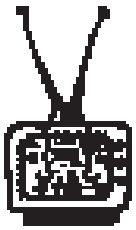
Similarly, the original syllabus devoted two days each to the "Laws of Thermodynamics" and "Fossil Records and Dating Methods". These are areas of scientific inquiry that proponents of creation science have traditionally attacked, with the scientific community regarding the attacks as lacking any scientific merit.

On the original syllabus, two of the five prospective speakers ([Ross] Anderson and [Joe] Francis) are identifiable proponents of creation science; a third, "David Kopich," is probably meant to refer to a local proponent of creation science named David Coppedge. Of the two prospective speakers on the original syllabus who were supposed to present the case for evolution, one is a local parent [Kenneth Hurst, the lead plaintiff] who opposed the class. The other is the Nobel laureate Francis Crick (misspelled "Krich"), *who died in 2004*.

The revised syllabus appears to have been revised to de-emphasize creation science in favor of "intelligent design", presumably in the hope that the course would better be able to survive constitutional scrutiny. The revision is thus a microcosm of the national debate, in which "intelligent design" emerged in the wake of *Edwards v Aguillard* as a form of creationism intended to avoid the Supreme Court's decision declaring the teaching of creation science in schools to be unconstitutional.

"Intelligent design" was recently recognized in *Kitzmiller v Dover* as unconstitutional for the same reasons as creation science was in *Edwards*. Although the erroneous scientific claims distinctive of creation science, such as those involving the age of the earth and thermodynamics, are no longer explic-

itly mentioned in the revised syllabus, "intelligent design", as the progeny of creation science, retains many of the same erroneous scientific flaws. All but one of the videos listed on the revised syllabus are the products of the "intelligent design" movement. Those videos, like the creation-science ones, are not ordinarily regarded as suitable material for the public schools.



Both the original and revised syllabi include numerous videos purporting to address the "evidence against evolution," but not a single video on either list addresses the gaps/problems with creationism or "intelligent design". Because creation science and "intelligent design" are religious rather than scientific viewpoints, *advocating* the tenets of these viewpoints — as opposed to addressing them in an appropriate context and in an objective manner — amounts to religious advocacy that cannot have a valid secular purpose.

Misrepresentation of the standing of evolution

Third, the course materials present a distorted view of the scientific standing of evolution. Throughout those materials, evolution is presented as a "worldview" or "philosophy". In the anti-evolution movement, these terms are often used synonymously with "religion", in order to suggest that evolution is accepted only on faith, thus converting evolution from a scientific theory (which has a particular meaning and special status in the scientific community) to a belief system (which does not).

In that regard, the very first sentence of the course description reads, "This class ... will discuss the scientific, biological, and Biblical aspects that suggest why Darwin's *philosophy* is not rock solid" (emphasis added).

Topics in the original syllabus include "Is Evolution a science or a philosophy?," "Is Evolution based on a religion?," and "Is evolution based on philosophy?" Although those questions are not explicitly answered in the syllabus, the fact that these questions are raised repeatedly in a course entitled "Philosophy of Intelligent Design" strongly implies that the instructor intends to teach or suggest that evolution is based on a "philosophy". The videos on the syllabi, such as "War of the Worldviews," further support that conclusion.

In the revised syllabus, although one topic is "How does the Philosophy of Intelligent Design differ from the Theory of Evolution?" (a formulation that might suggest evolution is no longer going to be presented as based on "philosophy"), the very next topic on that syllabus demonstrates otherwise by referring to "this debate concerning philosophies" — that is, evolution and "intelligent design".

Similarly, the revised syllabus states that "Equal and balanced instructions will be given on all philosophies". Because the only concepts taught are a religious view and evolution, this statement has the effect of labeling both concepts as "philosophies." Neither the original nor the revised syllabus calls for informing the students that the scientific community overwhelmingly accepts evolution.

Inaccurate and irresponsible treatment of evolution

Fourth, and related to the third consideration, is the fact that the course materials do not treat evolution in ways that are either scientifically accurate or pedagogically responsible. A genuine comparative treatment of cultural ideas concerning the origin and history of life would not necessarily have to discuss scientific ideas at all. It would be sufficient, for example, to describe the origin myths of a number of different cultures, to compare and contrast them, and to discuss the role that the origin myths play with respect to the rest of their cultures. But if scientific ideas like evolution are to be discussed in such a course, they should be discussed in a scientifically accurate and pedagogically responsible way. That is not the case with the course at issue here.

As noted, the original syllabus devoted two days to "Laws of Thermodynamics", which is a topic from physics. It is primarily proponents of creation science, and not physicists or other scientists, who regard that topic as relevant to the scientific study of evolution, for creationists incorrectly maintain that the Second Law of Thermodynamics renders evolution impossible.

The revised syllabus describes evolution as a view "on the origin of life". In the sense most common in modern biology, "evolution" denotes descent with modification — the scientific theory that living things have descended, with modification, from common ancestors. The origin of life is a separate question and a separate area of research.

Additionally, there is reason to doubt that the course presents evolution in a way appropriate to the students' ages and level of preparation. In the original syllabus, *no* scientifically credible and pedagogically appropriate instructional materials about evolution are listed. Apparently Mrs Lemburg was content to have the students learn about evolution almost entirely from creationist sources. Since evolution is typically presented in California only in high-school biology, it is likely that the students in this course would have had, at most, one course in which they were formally exposed to evolution; and some of the students may not have had even that. They therefore would not have the prerequisite knowledge to enable them to evaluate critically the scientific claims contained in the creationist sources.

In the revised syllabus, non-creationist instructional material about evolution was added: the PBS series *Evolution*, the "Understanding Evolution" website, and *Evolution vs Creationism*. As a consultant to the first two and the author of the third, I can certainly vouch for their scientific credibility. However, none of these materials was intended to provide a first exposure to evolution. The *Evolution* series was intended for a general adult audience, and (like any science documentary) was not intended to provide a complete education to its viewers. The parts of the Understanding Evolution website to which the revised syllabus refers are aimed at teachers who are striving to improve their ability to teach evolution effective-

ly. They are not directed, aimed at, or geared to students. While there is a section of the website that provides a basic introduction to evolution, it is not mentioned in the syllabus, and it would not in any case be appropriate as the students' primary source of information about evolution. *Evolution vs Creationism* is suitable for advanced high-school students and for college students, but certainly not for students who have not yet even taken a biology course at the high-school level. And like the Understanding Evolution website, the book provides only the most rudimentary introduction to the science of evolution; it is no substitute for a real biology class with a competent teacher using a mainstream textbook.

If there were genuine scientific evidence against evolution — that is, if scientists had scientific debates over whether evolution actually occurred — there might be a secular pedagogical reason for teaching students "the controversy." The scientific community, however, overwhelmingly views evolution (the inference of common descent of living things) as a solidly supported scientific view. (The National Association of Biology Teachers writes, "Modern biologists constantly study, ponder and deliberate the patterns, mechanisms and pace of evolution, but they do not debate evolution's occurrence." Similarly, the National Science Teachers Association has stated, "There is no longer a debate among scientists over whether evolution has taken place," and specifically recommends that "[p]olicy-makers and administrators should not mandate policies requiring the teaching of creation science or related concepts such as 'intelligent design', 'abrupt appearance', and 'arguments against evolution'."). Indeed, the consensus of the scientific community is that "[t]he contemporary theory of biological evolution is one of the most robust products of scientific inquiry" (American Association for the Advancement of Science, AAAS Board Resolution on Intelligent Design Theory, 2002; the AAAS is the largest general scientific society in the world).

Conclusion

Because there is no scientific "evidence against evolution" and there is no pedagogical value in teaching "evidence against evolution," yet there are conspicuous religious motivations for promoting this practice, it is difficult to avoid the conclusion that the underlying purpose and the intended effect of efforts to require the teaching of "the evidence against evolution," such as those in the course at issue here, are to protect or advance a particular set of religious beliefs.

Presenting evolution in a philosophy class as a philosophy or belief system on a par with the religious view of creationism misrepresents the nature of evolution. It confuses students about what evolutionary theory is, interfering with their education when they are presented with the concept of evolution in their science classes. There can be no valid secular purpose for misleading students about the nature of evolutionary theory in a public-school philosophy class any more than there can be in a public-school science class.

Any citizen, of course, has the right to advocate a religious position, including advocating theism over materialism. But that does not translate into the right to engage in such religious advocacy in the public-school classroom. Mrs Lemburg's "Philosophy of Design" class is just such advocacy. It therefore suffers from the same defect as the teaching of creation science in *Edwards* and *McLean*, and the inclusion of intelligent design in the curriculum in *Kitzmiller*.

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[*For the sake of readability, headings were added, paragraph numbers and internal references were removed, and footnotes were incorporated into the text; a few corrections and amplifications were inserted in square brackets. For the entire declaration as submitted, visit <http://www2.ncseweb.org/hurst/Scott_expert_witness_declaration-20060110.pdf>.*]

"Critical analysis" in Ohio: The return of the zombie

Glenn Branch
NCSE Deputy Director

Like a zombie in a horror film, the "Critical Analysis of Evolution" effort returned to haunt the Buckeye State, despite a series of stakes through its heart. In 2002, Ohio adopted a set of science standards including a requirement that students be able to "describe how scientists continue to investigate and critically analyze aspects of evolutionary theory" (see *RNCSE* 2002 Sep/Oct; 22 [5]: 4–6). When the indicator was introduced, it was widely feared that it would provide a pretext for the introduction of creationist misrepresentations of evolution. In 2004, those fears proved to be justified, when, over the protests of the state's scientific community, the board adopted a corresponding model lesson plan that clearly sought to instill scientifically unwarranted doubts about evolution (see *RNCSE* 2004 Jan/Feb; 24 [1]: 5–6, 8–9).

Following the decision in *Kitzmiller v Dover* and the revelation that the board ignored criticisms of the lesson plan from experts at the Ohio Department of Education, the board reversed its decision, voting in February 2006 to remove the "critical analysis" indicator from the standards and to rescind the lesson plan (see *RNCSE* 2006 May/Jun; 26 [3]: 7–11). At the same time, however, the board charged its Achievement Committee to "consider whether the deleted model lesson, Benchmark H and Indicator 23 should be replaced by a different lesson, benchmark, and indicator, and if so, to present any recommendation to the entire State Board for adoption." Since it was the Achievement Committee that approved the controversial indicator in the first place, the *Columbus Dispatch* (2006 Feb 20) remarked ruefully, "Meet the new committee, same as the old committee."

The Achievement Committee, like the board as a whole, was divided over issues concerning evolution education, and thus was

expected to take months to decide whether a replacement indicator was necessary. The first development occurred in July. According to the current science standards for the tenth grade, students are expected to be able to "[d]escribe that scientists may disagree about explanations of phenomena, about interpretation of data or about the value of rival theories, but they do agree that questioning response to criticism and open communications are integral to the process of science." At a meeting of the board's Achievement Committee on July 10, 2006, board member Colleen Grady proposed the addition of, "Discuss and be able to apply this in the following areas: global warning; evolutionary theory; emerging technologies and how they may impact society, e.g. cloning or stem-cell research."

The fact that evolution and global warming were the only areas of science cited as examples where scientists disagree was of immediate concern. (A similar pairing occurred in Michigan, where House Bill 5251 called for students to "use the scientific method to critically evaluate scientific theories including, but not limited to, the theories of global warming and evolution"; see *RNCSE* 2006 May/Jun; 26 [3]: 12–16.) Before the meeting, Steve Rissing, a biology professor at the Ohio State University, told the *Columbus Dispatch* (2006 Jul 9), "This is so transparent ... These are not controversial areas of science," and in reaction to Grady's proposal, Patricia Princehouse of Ohio Citizens for Science told the *Dayton Daily News* (2006 Jul 11), "We knew they wouldn't just give up and go home. We didn't think they'd come back so soon."

The *Dispatch* (2006 Jul 11) reported, "Education Department staff will put Grady's proposal into draft form for consideration at the board's September meeting. It is not clear whether there is enough support among committee members to recommend any proposal to the full board." Meanwhile, the *Dispatch* (2006 Jul 13), took a strong stand against the proposal on its editorial page, declaring, "This fight should have been dead and buried in February ... But a few dogged members still insist on 'teaching the controversy' about evolution, even though the controversy has been manufactured by disingenuous people who wish to introduce the supernatural into science classrooms. ... These few wily board members are the best possible evidence that evolution exists; their tactics mutate every time the public catches on to what's happening."

As the board's September meeting approached, the Campaign to Defend the Constitution — a new organization "fight[ing] for the separation of church and state, individual freedom, scientific progress, pluralism, and tolerance while respecting people of faith and their right to express their beliefs" — urged supporters of the integrity of science education to lobby school board members to reject Grady's proposal should it be introduced. The *Toledo Blade* (2006 Sep 7) reported that during a teleconference on September 6, 2006, members of the Campaign described the proposal as "a Trojan horse carrying religion into the science curriculum." The *Blade* added, "Patricia Princehouse, a lecturer in philosophy and evolutionary biology at Case Western Reserve University, who joined the Campaign to Defend the Constitution group, said treating evolution and other topics as though they are somehow different from the rest of science is a way to sneak creationism back into the science curriculum."

A spokesperson for the Ohio Department of Education told the *Blade* that no specific topics would be mentioned in a draft of the proposal, and the *Akron Beacon-Journal* reported (2006 Sep 7), "The nine-page document itself is evolutionary. Earlier this year, a proposal was to encourage debate of specific issues: Evolution, global warming and stem cell research. Now, it encourages students to conduct research and have open discussion in the classroom." Nevertheless, board member Martha Wise (a strong voice for the integrity of science education in Ohio; see *RNCSE* 2006 May/Jun; 26 [3]: 11) commented that the proposal "is a lot of gobbledygook — it's just another wedge into the teaching of ID in science classes." Lawrence Krauss of Case Western Reserve University worried, "When they teach history, are they going to say some people say the Holocaust never happened?"

The new version of the proposal, now dubbed the "Framework for Teaching Controversial Issues" template, became public before the Achievement Committee's September meeting, and was quickly the subject of — appropriately — a critical analysis of its own. Ohio Citizens for Science issued a statement (available on-line at <http://www.ohioscience.org/Controversial_Issues_Response.pdf>) regarding the framework, describing it as "*incoherent* if, as its major proponent has stated, it will have teachers and students 'challenge everything.' It is impossible to challenge everything in each school class; to even attempt such a thing would result in chaos and no learning" (emphasis in original). The statement added, "Clearly the template is in fact the latest step in ongoing efforts to orchestrate a religiously motivated attack on the theory of evolution ... While science relies constantly on genuine critical analysis, it does not use denigrating debate tools based on political propaganda and ill-informed by evidence."

Additionally, Alan Leshner — the chief executive officer of the American Association for the Advancement of Science and the publisher of its journal *Science* — forcefully criticized the framework in his op-ed for the *Akron Beacon-Journal* (2006 Sep 11), writing, "ID advocates who in the past were concerned only with critical analysis of evolution are adding scientific concepts they oppose on religious grounds, including embryonic stem cell research, as subjects where the scientific consensus would come under attack in Ohio's classrooms. Although the advocates have crafted their arguments carefully, a critical analysis of their version of critical analysis suggests it's an old product in a new wrapper — and that it poses clear and palpable threats to the education and future of Ohio's children."

At the September 11, 2006, meeting, the Achievement Committee declined to consider the "Controversial Issues" tem-

plate. James L Craig, co-chair of the committee, said, "We've run out of time," according to a report in the *Columbus Dispatch* (2006 Sep 12), and peremptorily adjourned the meeting. The decision not to consider the template was surprising, since, as the *Dispatch* reported, the board received "national attention and thousands of e-mails" concerning it in recent weeks, owing in part to the campaign organized by the Committee to Defend the Constitution. It was speculated that the committee was dragging its heels in the fear that the board would vote against any replacement.

Although the Achievement Committee decided not to consider the framework at its September meeting, the *Beacon-Journal* (2006 Sep 13) observed that "the issue could come up for a vote at next month's regularly scheduled board meeting" in October. The *Dispatch* reported (2006 Sep 12), "Privately, several board members say they support an immediate vote so debate can end. The proposals, they say, are unnecessary and divisive and draw attention from more important topics." Meanwhile, the *Beacon-Journal* (2006 Sep 17) editorially commented, "Continuing this very political debate promises to harm the quality of education for Ohio students."

At the committee's October 9, 2006, meeting, however, the template was not even on the agenda and so "critical analysis" was still alive, despite a reported promise from Craig to kill the "critical analysis" effort. Patricia Princehouse of Ohio Citizens for Science told the *Canton Repository* (2006 Oct 10), "He sandbagged all of us." Confiding "I really don't care for the template," Craig cited the committee's inability to arrive at a consensus as the reason for the failure to vote on the template. Steve Rissing offered a different explanation: Craig "probably feared he would lose the election if he openly moved the template forward, so he made reassuring noises to scientists while claiming ignorance of the progress the template was making."

On October 10, 2006, the second day of the board of education's monthly meeting, supporters of the integrity of evolution education turned out in force, armed with copies of the *Repository*'s article printed on bright yellow paper to catch the attention of members of the board and those attending the meeting, and prepared to use the public comment period to criticize the board for its inaction. As it happened, however, board member Martha Wise, who led February's effort to remove the "critical analysis" language, proposed to discharge the Achievement Committee from any further responsibilities concerning possible replacements from that language. Seconded by Rob Hovis, the motion passed 14–3.

After the vote, Wise told the *Columbus Dispatch* (2006 Oct 11), "It was time to move on." Princehouse thanked the board, saying, "I'm deeply impressed by the leadership and courage of the board with making a clean break from creationism." Similarly, the *Dispatch* seemed to assume that the controversy over evolution education in Ohio was finally over, headlining its story, "State education board drops evolution debate," and describing the board as having "pulled the plug on its seemingly incessant debate over Darwin's theory of evolution." But the zombie may not be out of action yet: angered by the board's vote, Achievement Committee co-chair Michael Cochran assured the *Dispatch*, "I will guarantee you that as long as I am chair [*sic*] of the committee, it's gonna be on the agenda next month."

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Evolution Safe, After a Delay, in Michigan

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At its October 10, 2006, meeting, the Michigan State Board of Education voted unanimously to approve a set of content expectations for the new high school graduation requirements in science in which evolution is appropriately treated. Previously, in September, the board voted to defer considering the content expectations for a month, at the behest of anti-evolution legislators who apparently sought to lobby for the weakening of evolution. But, as a press release issued on October 10, 2006, by the Michigan Department of Education emphasized, "In approving the Science content expectations, the State Board also solidified its strong support for Evolution."

At its September 12, 2006, meeting, the board voted to delay adoption of part of the state's science standards until October in order to give the legislature extra time to comment, according to a report from the Associated Press (2006 Sep 13). The delay was granted after the board received a request from Representative Brian Palmer (R–District 36), chair of the House Education Committee, and Senator Wayne Kuipers (R–District 30), chair of the Senate Education Committee. The motion passed by a 6–2 vote, despite protests from critics, including the ACLU of Michigan.

It was feared that the ulterior purpose of the delay was to enable anti-evolution legislators to lobby for the weakening of evolution in the standards. Palmer, for example, sponsored or cosponsored various anti-evolution bills in the past, including 2003's House Bill 4946, which would have amended the state science standards to refer to "the theory that life is the result of the purposeful, intelligent design of a Creator." During the current legislative session, he supported HB 5251, which targeted both evolution and global warming, and HB 5606, which repeated key language from HB 5251 (see *RNCSE* 2005 May–Aug; 25 [3–4]: 15–17 and 2006 May/Jun; 26 [3]: 12–16).

Moreover, the *Detroit Free Press* reported in its editorial (2006 Sep 14) that Palmer and Kuiper submitted their request in order to accommodate their colleagues Representatives Jack Hoogendyk (R–District 61) and John Moolenaar (R–District 98), both of whom have a lengthy history of anti-evolution activity in the legislature. According to the *Free Press*,

"As it stands, the policy directs that teachers demonstrate how fossil records, comparative anatomy and other evidence 'may' corroborate the theory of evolution. Hoogendyk and Moolenaar are pushing to have the words read 'may or may not.'"

Reviewing Hoogendyk and Moolenaar's suggested changes, Michigan Citizens for Science commented, "*The Free Press* only mentions one small aspect of the changes they're pushing for, all of which are designed solely to cast doubt on evolution. Anywhere in the standards where any certainty is expressed at all, even on the most mundane and obvious of concepts, they seek to insert weasel words to cast doubt where none really exists. ... Clearly, their goal is simply to put so many weasel words into the science standards that students will doubt what is in actuality one of the most compelling and well supported theories in all of science" (see <http://michigancitizensforscience.org/main/nfblog/2006/09/15/free-press-editorial-on-boe-decision>).

The *Free Press*'s editorial proceeded to criticize the board for its vote, writing: "This is just another attempt to keep a door open to teaching creationism or intelligent design. The board should have closed it, as science teachers requested. Board members get elected to make decisions, not to defer to political pressure." The delay was particularly unfortunate, the newspaper added, because the standards were supposed to be in place by October 3, in time to be discussed at a statewide conference of science teachers. But in the end, the *Free Press* (2006 Oct 11) reported, it was "clear which concept won the debate between evolution and intelligent design."

The treatment of evolution in the content expectations was in fact slightly improved, thanks to the testimony of concerned citizens, including the Michigan Science Teachers Association and Robert T Pennock and Gregory Forbes of Michigan Citizens for Science. The *Grand Rapids Press* (2006 Oct 11) reported, "Kids in biology will now have to 'Explain how a new species or variety originates (rather than "may originate") through the natural process of evolution.' They also will be asked to show how fossil records, comparative anatomy and other evidence [support] the theory of evolution rather than 'may' support it." These revisions are especially striking, since, as the *Free Press* reported, anti-evolutionist legislators were pushing to have "may" replaced with "may or may not".

Members of the board of education were outspoken about their support for the integrity of evolution education. The board's vice president, John C Austin, was quoted in the Michigan Department of Education's press release as explaining, "We do not want to create any uncertainty in the Board's support of Evolution ... We need to send a clear statement that there is no ambiguity on the part of the Board that Evolution is good science." Board member Reginald Turner agreed, "Science supports Evolution in the way it's set forth in the content expectations before us," adding, "The word 'may' clouds the science of evolution after decades of scientific evidence, and is inconsistent with what we know about evolution today."

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Legal Troubles Plague Kent Hovind

Greg Martinez

On November 2, 2006, a federal jury found flamboyant young-earth creationist Kent Hovind and his wife Jo guilty on all counts in their federal tax fraud trial. The pair faced 58 charges, including failure to pay employee-related payroll taxes and evading bank reporting requirements. The founder of Creation Science Ministries and the creator of Dinosaur Adventure Land in Pensacola, Florida, Hovind has been the subject of investigations from both the Escambia County government and the Internal Revenue Service. The year 2006 was one of steadily escalating legal problems for Hovind and his anti-evolution amusement park.

Greg Martinez lives in Florida and visited Dinosaur Adventure Land in 2004 for Skeptical Inquirer *magazine. He has continued to follow DAL creator and young-earth creationist Kent Hovind through his many legal trials.*

Dinosaur Adventure Land

Hovind refused to pay a $50 filing fee for a building permit to Escambia County when he built Dinosaur Adventure Land in 2001. He has argued that the fee constituted an infringement on his religious freedom. After more than four years of delays by Hovind (including requesting repeated changes in judges due to alleged bias, switching attorneys and then eventually requesting a public defender, and then failing to appear in court), the case finally had a hearing in March 2006 before Circuit Judge Michael Allen. Allen ruled that the owners of the park were in contempt of court, and within days Escambia County authorities padlocked all the buildings on park property, including the science center, fossil shop, museum and schoolhouse. A fine of $500 per day would be levied if any of the sealed buildings were used or occupied.

On April 6, 2006, Kent's son Eric appealed to the Escambia County Commission for an exemption to the permitting requirements. The Commission refused the request. The *Pensacola News Journal* (2006 Apr 7) quoted Commission Chairman Mike Whitehead as saying to Hovind, "Scripture also says 'Render unto Caesar what Caesar demands,' and right now Caesar demands a building permit."

On June 5, 2006, Hovind finally pleaded *nolo contendere* as charged to three counts of violating the county building code, constructing a building without a permit, and refusing to sign a citation. He was ordered to pay a fine of $225 per count and to pay back taxes on the property totaling $10 402.64. His plea and payments brought closure to a long battle that Hovind estimates on his website cost him $40 000 in legal fees, all as a result of his refusal to pay the initial $50 building permit fee and submit to inspections of the

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California: As expected, *Association of Christian Schools International et al v Roman Stearns et al* — the lawsuit in which the University of California system is charged with violating the constitutional rights of applicants from Christian schools whose high school coursework is deemed inadequate preparation for college — is going to proceed. In a hearing in late July 2006, Judge S James Otero stated that he was not inclined to rule in favor of a motion by the university system to dismiss the suit (see *RNCSE* 2006 May/Jun; 26 [3]: 12–16). Now, as the *Los Angeles Times* (2006 Aug 9) described, "In a 25-page ruling, Otero granted limited relief to the university, dismissing the lawsuit's allegations against several UC administrators in their individual capacities, among others. But he said he would allow Calvary Christian and the other plaintiffs to pursue their key claims against the public university system on the basis of constitutional protections to freedom of speech, association and religion." The case is expected to go to trial within a year; for background, see *RNCSE* 2005 May–Aug; 25 [3–4]: 12–13.

Creationism is not the only issue involved in the case, to be sure. But creationism is involved, since the plaintiffs — the Association of Christian Schools International, the Calvary Chapel Christian School in Murrieta, California, and six students at the school, none of whom have been refused admission to the University of California — object to the university system's policy of rejecting high school biology courses that use textbooks published by Bob Jones University Press and A Beka Books as "inconsistent with the viewpoints and knowledge generally accepted in the scientific community." One of the lawyers representing the plaintiffs is Wendell R Bird, a former staff attorney for the Institute for Creation Research. As a special assistant attorney general for Louisiana, he

work on the complex of buildings — a second degree misdemeanor.

The Internal Revenue Service Comes Knocking

The settling of this case did not mean Hovind was free from any more government interest in his park and ministry, however. An IRS raid in April 2004 of Dinosaur Adventure Land and his Creation Science Evangelism facility (which is also his home) finally came to fruition when Hovind and his wife Jo were arrested on July 13, 2006, and were indicted in federal court on 58 charges, including making threats against IRS investigators and failing to pay $473 818 in employee-related payroll taxes. Forty-four of the charges were for evading banking requirements. The indictment alleges that Hovind and his wife illegally withdrew $430 500 from an AmSouth bank branch between July 20, 2001, and August 9, 2002. Most withdrawals were made only days apart and were consistently for amounts just a few hundred dollars below the $10 000 starting point for federally required cash transaction reporting (a pattern known as "smurfing").

Kent and Jo Hovind initially refused to enter a plea when appearing before US Magistrate Judge Miles Davis, denying the legitimacy of the government in the case and invoking his freedom to practice his religion. Against the advice of their public defender, the Hovinds tried to enter pleas of "subornation of false muster" (a common tactic used by tax protesters when appearing in court), but finally entered pleas of not guilty when they were pressed by Judge Davis. Davis also stripped Kent Hovind of his passport and his guns, viewing him as both a flight risk and a risk for violence because of the charges of threats made against investigators.

Hovind appealed this part of the decision, arguing that the travels restrictions interfered with the free practice of religion. He stated that he was scheduled to travel to several South African cities in August 2006 to debate creationism with prominent South African scientists. US District Judge Casey Rodgers agreed with Assistant US Attorney Michelle Heldmeyer that Hovind did indeed pose a flight risk and denied the appeal.

Kent and Jo Hovind's trial was originally scheduled to begin September 5, 2006, but was postponed until October 17, 2006. The trial was expected to last for five days, but took over two weeks after a delay of almost a week due to Jo Hovind's defense attorney Jerry Berringer's illness, and a three-day–long cross examination of IRS Special Agent Scott Schneider (who led the four-year investigation) by Kent Hovind's defense attorney, Alan Richey. Judge Rodgers admonished Richey several times during the cross examination for asking irrelevant questions. The trial phase ended abruptly after the afternoon lunch recess on November 1 when both defense attorneys rested their cases without calling any witnesses or presenting any defense. Richey stated that he did not "believe that the government had met its burden" of proof.

After deliberating only two and a half hours, the jury delivered a guilty verdict for Kent Hovind on all 58 charges. He faces a maximum of 288 years in prison. Jo Hovind was convicted of 44 of the counts (the ones addressing evading bank reporting requirements). She faces up to 225 years.

Jo Hovind remained free pending the couple's January 9 sentencing date, but Kent Hovind was ordered into custody by Judge Rodgers, who deemed him a flight risk and "a danger to the community". (Trial testimony revealed that the IRS raid of Hovind's home in 2004 found cash totaling around $42 000 and six guns, including one SK-S semiautomatic rifle.) (*On January 19, 2007, Hovind was sentenced to ten years in prison; details to follow in a future issue of* RNCSE.)

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defended the state's "equal time" law, which was ruled to be unconstitutional in *Edwards v Aguillard*. He is the author of *The Origin of Species Revisited*, which compares evolution and a version of creationism he called "abrupt appearance."

Texas: The attorney general of Texas, Greg Abbott, recently reaffirmed the standing interpretation of the 1995 state law that restricts the power of the Texas state board of education to review and reject the content of textbooks used in the public schools. Abbott's opinion, issued on September 18, 2006, was in response to a request from board member Terri Leo (District 6), who was among the most vocal critics of the eleven biology textbooks under review by the board in 2003. Despite a barrage of objections from creationist organizations in Texas and across the country, all eleven books were eventually approved (see *RNCSE* 2003 Sep–Dec; 23 [5–6]: 4–7). In her request, dated January 6, 2006, Leo asked for the attorney general to reconsider 1996's Opinion Nr DM-424, which held that "[t]he State Board of Education has no authority under the Texas Education Code to adopt rules regarding the content of state-approved textbooks establishing criteria for approval beyond the criteria contained in section 31.023 of the Education Code. The board's authority to adopt or reject textbooks does not extend to consideration of ancillary items provided to school districts free of charge."

A brief (available on-line at <http://www.texscience.org/opinion/TSTA-Brief.pdf>) from a number of groups, led by the Texas State Teachers Association and also including the Texas Freedom Network and the Texas Association of Biology Teachers, urged the attorney general to reaffirm DM-424, contending that Leo's request "telegraphs a desire by some members of the SBOE to return to the day when textbook decisions were made on non-educational grounds," when "the SBOE's textbook adoption process was entangled with ideology, politics, and religion, and was a forum for divisive political battles that focused on ideological rather than educational or pedagogical concerns." A separate brief from Texas Citizens for Science (available on-line at <http://www.texscience.org/opinion/TCSBriefToTexasAG.htm>) argued that DM-424 served Texas students well, commenting, "For example, the biology textbooks adopted in 2003 are the best that this state has purchased since at least the 1950s, for the topics of evolution and origin of life in them remained uncensored, despite a tremendous and expensive effort to accomplish such censorship using the current rules (conformance to TEKS [Texas Essential Knowledge and Skills] and no factual errors), which national- and state-based creationists mistakenly thought would be sufficient."

In his opinion, Abbott overruled portions of DM-424 that denied the board's authority over "ancillary items" — supplementary materials that accompany textbooks — but, importantly, reaffirmed the conclusion that the board's statutory authority over textbooks is limited to identifying the TEKS standards, evaluating the books for factual errors and physical standards, and ensuring that they "foster the continuation of the tradition of teaching United States and Texas history and the free enterprise system." Attempts to broaden the board's statutory authority (such as 2004's House Bill 220, which died in committee in 2005; see *RNCSE* 2005 May–Aug; 25 [3–4]: 15–17) have failed in the legislature in the past. In a September 18, 2006, press release, Texas Citizens for Science commented, "Both the Attorney General and the Texas Legislature have acted for the good of Texas citizens and should both be commended," and similarly, Kathy Miller of the Texas Freedom Network told the Associated Press (September 19, 2006), "The Legislature and both Democratic and Republican attorneys general have now told the politicians on the State Board that they may not use public school textbooks to promote their own personal and political agendas."

Nevertheless, in the next round of biology textbook adoption proceedings, the anti-evolution faction on the board is likely to continue to attempt to compromise the presentation of evolution in the textbooks under review with the tools at its statutory disposal — by arguing, as it argued in 2003, that the textbooks are factually in error or not in conformity with the TEKS standards. Cutting to the heart of the matter, the *Austin American-Statesman* (2006 Sep 22) editorially commented, "State law mandates that the board approve textbooks that cover curriculum standards, are free of factual errors and meet manufacturing standards. Despite Abbott's ruling mostly affirming that law, we doubt that the 15-member board will get the message. That is why the Legislature should totally eliminate the board's authority over textbook selection." The next round of biology textbook adoption proceedings is not expected to begin until 2009 at the earliest, however, and the next battleground for evolution education in Texas will be during the next round of review, and possible revisions, of the TEKS standards for science in 2007.

National: "Like a gap in the fossil record, evolutionary biology is missing from a list of majors that the US Department of Education has deemed eligible for a new federal grant program designed to reward students majoring in engineering, mathematics, science, or certain foreign languages," the *Chronicle of Higher Education* (2006 Aug 22) reported. The grants — called SMART Grants, after the National Science and Mathematics Access to Retain Talent program — were authorized by Congress in 2005 with President Bush's support. The *Chronicle* suggested that the absence of evolutionary biology from the list "apparently indicates that students in the evolutionary sciences do not qualify for the grants," adding, "and some observers are wondering whether the omission was deliberate."

On August 17, 2006, Lawrence M Krauss of Case Western Reserve University expressed his concern to the Department of Education, which administers the SMART Grants, describing the omission of evolutionary biology as "a serious omission." He subsequently told the *Chronicle*, "I'm not making any accusations," but added, "I'm concerned it's not there." A spokesperson for the Department of Education speculated that the absence of evolution from the list was a "clerical consolidation of some kind." A blank line appears in the list in lieu of 26.1303, where evolutionary biology would normally have appeared; the only other such blank line in the section of the list for life sciences is 26.0908: Exercise Physiology. Evolution is, however, mentioned elsewhere in the list.

Two days after the *Chronicle* broke the story, both *New Scientist* and *The New York Times* provided further details. The *Times* (2006 Aug 24) reported that a spokesperson for the Department of Education described the omission of evolutionary biology as inadvertent: "There is no explanation for it[s] being left off the list ... It has always been an eligible major." And a press release (2006 Aug 24) from the Department of Education stated, "The misunderstanding occurred as the result of a draft document that omitted evolutionary biology from a list of majors put forth for use by colleges. As soon as the omission came to our attention, we took steps to correct it. However, regardless of its omission on that one document, evolutionary biology was and continues to be SMART grant eligible."

Not everyone was wholly convinced by the explanation. Barmak Nassirian of the American Association of Collegiate Registrars and Admissions Officers told the *Times*, "I am not at all certain that the omission of this particular major is unintentional," adding, "But I have to take them at their word." NCSE's Glenn Branch told *New Scientist* (2006 Aug 24), "On its own, it's not really a smoking gun ... But in the context of actions that other people in the federal government have taken, it is suspicious." Krauss told the *Times*, "Removing that one major is not going to make the nation stupid, but if this really was removed, specifically removed, then I see it as part of a pattern to put ideology over knowledge." And Steven W Rissing of the Ohio State University commented, "We are doing a terrible disservice to our students if this is yet another example of making sure science doesn't offend anyone."

Canada, Quebec: The Quebec Ministry of Education is launching a crackdown on unlicensed evangelical schools, following a complaint from Pierre Daoust, director-general of the Commission Scolaire au Coeur-des-Vallees in Thurso, Quebec, about the failure of such schools to follow the provincial curriculum. Daoust told the *National Post* (2006 Sep 24), "these evangelical schools teach their own courses on creationism and sexuality that don't follow the Quebec curriculum." There are at least thirty unlicensed religious schools in the province; according to the *National Post*, "[t]he Quebec government has known about unaccredited religion-based schools for years, but has tolerated them for fear of offending the denominations sponsoring them." Education minister Jean-Marc Fournier told the Toronto *Globe and Mail* (2006 Oct 26), "Schools that have a permit must of course follow the curriculum, which includes the teaching of Darwin's theory of evolution." In neighboring Ontario, the *National Post* reported, independent schools are not required to teach either evolution or sex education.

Germany: The vice president of the Association of German Biologists, Ulrich Kutschera of the University of Kassel, expressed concern about creationism in Germany after recent comments from the education minister of the state of Hesse, Karin Wolff. In October, *Deutsche Welle* (2006 Nov 2) reported, "Wolff said she believed biblical creation theory should be taught in biology class as a theory, like the theory of evolution." Kutschera, a leading German evolutionary biologist, retorted, "Ms Wolff should catch up on things and read a science book," adding, "On the one hand there are creationist myths, and on the other hand, there is evolutionary biology." A previous report in *Deutsche Welle* (2005 Dec 21) discussed the attempted inroads of the "intelligent design" movement in Germany; although a German educational spokesperson insisted, "Evolution is taught in biology class in all German schools ... There are no endeavors to change this, nor will there be in the foreseeable future," Kutschera warned, "More emphasis is necessary on biology in German schools in order to counteract the lack of knowledge about evolution." (For a brief review by Kutschera of the spread of "intelligent design" in Europe, see *RNCSE* 2005 May–Aug; 25 [3–4]: 17–18.)

Kenya: The National Museums of Kenya are under pressure by fundamentalist churches to de-emphasize their famous collection of hominid fossils, which include the most complete skeleton yet found of *Homo erectus* ("Turkana Boy"), unearthed by Richard Leakey's team in 1984. Bishop Bonifes Adoyo, chairman of the Evangelical Alliance of Kenya, which claims to represents churches of 35 denominations with 9 million members, told the *Telegraph* (2006 Aug 12), "Our doctrine is not that we evolved from apes, and we have grave concerns that the museum wants to enhance the prominence of something presented as fact which is just one theory." Leakey responded, "The National Museums of Kenya should be extremely strong in presenting a very forceful case for the evolutionary theory of the origins of mankind," adding, "it must be forthright in defending its right to be at the forefront of this branch of science." The Nairobi Museum Galleries are presently closed for renovation; Wired News (2006 Sep 18) reported that the museums plan "to prominently house the [hominid] collection as 'scientific evidence' of evolution when it re-opens in 2007, a representative said."

Poland: The journal *Nature* (2006 Oct 25) reported that Mirosaw Orzechowski, Poland's deputy education minister, told a Polish newspaper, "The theory of evolution is a lie ... It is an error we have legalized as a common truth." Orzechowski belongs to the League of Polish Families (LPR), which *Nature* described as "the ultra-right-wing coalition partner in the conservative Polish government." Although the minister for education, Roman Giertych, also a member of the LPR, is reportedly sympathetic to creationism, the Associated Press (2006 Oct 26) reported him as saying, "As long as most scientists in our country say that evolution is the right theory, it will be taught in Poland's schools," and as describing Orzechowski's outburst as his private opinion. In the meantime, the minister of science, Micha Seweryski, stated, "the opinion of a minority will not change teaching in schools." The Polish scientific community expressed its support of evolution education in open letters condemning Orzechowski; Maciej Zylicz, a signatory, told *Nature*, "However, the point that really requires further discussion is not evolution, but how a minister can say such stupid things."

International: Sixty-seven national academies of science, representing countries from Albania to Zimbabwe, have endorsed the Interacademy Panel's new statement (available on-line at <http://www.interacademies.net/?id=6179>) on the teaching of evolution. Among

NCSE Welcomes New Staff

Glenn Branch, NCSE Deputy Director

Many hands make light work, as the saying goes, and NCSE is pleased to announce the addition of three new members of its staff.

Charles Hargrove

Louise Mead

Peter MJ Hess

NCSE possesses a unique trove of material on the creationism/evolution controversy, and we regard it as part of our mission to preserve it for posterity — as well as for occasions such as *Kitzmiller v Dover*, where NCSE's archives helped to establish the creationist antecedents of the "intelligent design" movement. Replacing Jessica Moran as the Archives Project Director is **Charles Hargrove**, who comes to NCSE after stints at the Bancroft Library, the Japanese American National Library, the Carnegie Institution of Washington, and the Smithsonian Institution Archives. He earned his master's degree in library and information sciences at the University of Texas, Austin, where he also earned a master's degree in archaeology. He is hard at work cataloguing, organizing, and expanding NCSE's copious collection of books, periodicals, articles, correspondence, and ephemera relating to the creationism/evolution controversy. If you have any materials that you would like to donate to NCSE's archives, or if you would like to use the collections, feel free to contact him at hargrove@ncseweb.org.

Louise S Mead is NCSE's new Education Project Director. We have long wanted to have a staff member to concentrate on outreach to the educational community, and Mead fits the bill excellently. After teaching science at the high school level in Connecticut, Mead earned her PhD in Organismic and Evolutionary Biology from the University of Massachusetts, Amherst. Her research interests include understanding the evolutionary processes that create and maintain biological diversity, specifically, how sexual selection shapes patterns of evolutionary change and influences the evolution of sexual isolation and speciation. After post-doctoral fellowships at Oregon State University and the University of California, Davis, and papers in journals such as *Evolution*, *Ethology*, and *Trends in Ecology and Evolution*, she joined NCSE, where she will be developing materials pertaining to evolution education, representing NCSE to the education community, speaking to the press about issues involving evolution education and challenges to it, and counseling teachers and others facing challenges to evolution education. (Her e-mail address here is mead@ncseweb.org.)

Finally, **Peter MJ Hess** is NCSE's new Faith Project Director, replacing **Phina Borgeson**, who occupied the same post on a part-time basis. Hess comes to NCSE from the Center for Theology and the Natural Sciences, where he administered a number of science/religion programs as well as authoring a number of scholarly papers; his book *Catholicism and the Sciences in the Modern World, 1400–2000*, co-authored with Paul Allen, is to be published by Greenwood Press in 2007. He earned his PhD at the Graduate Union Theology Seminary in 1993, with a dissertation on *Nature and the Existence of God in English Natural Theology from Hooker to Paley, 1596–1802*, taught at a number of colleges and universities in the San Francisco Bay area, and belongs to the International Society for Science and Religion. At NCSE, he will be in charge of developing outreach programs to and educational resources for the faith community, with the goal of fostering a constructive engagement with evolution. (His e-mail address here is hess@ncseweb.org.)

Welcome to all three.

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the signatories are the United States National Academy of Sciences, the United Kingdom's Royal Society of London, the Royal Society of Canada, the Australian Academy of Science, and the Royal Swedish Academy of Sciences, which awards the Nobel Prizes in Physics and Chemistry and the Crafoord Prize. Concerned that "in various parts of the world, within science courses taught in certain public systems of education, scientific evidence, data, and testable theories about the origins and evolution of life on Earth are being concealed, denied, or confused with theories not testable by science," the signatories "urge decision makers, teachers, and parents to educate all children about the methods and discoveries of science and to foster an understanding of the science of nature."

IAP's co-chair Yves Quere told the BBC (2006 Jun 21) that the scientific community is increasingly concerned that children are not being taught the basic facts of evolution and the nature of scientific inquiry. The statement accordingly lists a number of key facts that "have been established by numerous observations and independently derived experimental results from a multitude of scientific disciplines," including the age of the universe and of the earth, the change of the earth over time, and the common ancestry of life on earth. The statement also acknowledges that "human understanding of value and purpose are outside of natural science's scope" and that "a number of components — scientific, social, philosophical, religious, cultural and political — contribute to it," adding, "These different fields owe each other mutual consideration, while being fully aware of their own areas of action and their limitations."

[*NCSE thanks Steven Schafersman of Texas Citizens for Science for information used in this article.*]

Baraminology: Systematic Discontinuity in Discontinuity Systematics

Alan Gishlick, Gustavus Adolphus College

CREATIONIST "SYSTEMATICS"

Creation science comes as a surprise to many scientists, and thus I suspect that the fact that there is creationist *systematics* will come as an even bigger surprise to systematists. Yet creationists do practice a form of systematics, called "baraminology", and for creationist science it is surprisingly rigorous and internally consistent. It employs terminology and methodology not wholly unfamiliar to mainstream systematists (see sidebar, p 21).

The term "baraminology" comes from *baramin,* which was constructed from the Hebrew root words *bara* (created) and *min* (kind) by creationist Frank L Marsh (1941). Baraminology has also been referred to as "discontinuity systematics" (ReMine 1990; Marsh 1941, 1976). Baraminologists consider the baramin to be a taxonomic rank corresponding to the "created kinds" of Genesis. "Intelligent design" creationists are interested in baraminology as a way of quantifying discontinuities in the tree of life (Scherer 1993, 1998; Hartwig-Scherer 1998) and as a boundary between "macroevolution" and "microevolution" (Scherer 1993, 1998), although they tend to shun the term *baramin* and prefer the term "basic type" (Scherer 1993; Hartwig-Scherer 1998), perhaps because it avoids religious implications. It is also used as a proof of the actions of a designer or special creator (ReMine 1993; Scherer 1998).

The basic idea behind discontinuity systematics is that there are boundaries in the history of life that cannot be crossed. The aim is to find the "discontinuities" in the history of life, or the limits of common ancestry (ReMine 1993). While Marsh may have originated discontinuity systematics in the 1940s, it has been updated and refined to a form that is rapidly becoming one of the most active areas of creationist "scientific" research, and some of its methodology has been applied in near-mainstream research (for example, Scherer 1993). This area of research is also one of the places where "intelligent design" creationist and young-earth creationist "research" overlap.

What is most amazing is the number of traditional systematic methods and terminology that are employed by baraminologists. While they use many of the same methods as most systematists, from cladistics to the Analysis of Pattern (ANOPA) method, they use these tools to identify the "gaps", rather than the *connections* in life as most systematists do. This is why baraminologists principally employ phenetic methods of Sokal and Sneath (1963) — which are based on overall similarities in appearance or general features — computing distance matrices for a group of taxa and producing character *mismatch* statistics based on the matching coefficient of Sokal and Michener (1958). They see phenetics as useful in determining the biological gaps.

In addition, baraminologists employ cladistics for determining intra-holobaraminic relationships, as well as homoplasy (similarity in form *not* attributed to common descent) for separate groups (Robinson and Cavanaugh 1998a). Baraminologists recognize synapomorphy (shared features that *are* attributed to common descent) as an example both of a feature that unites a holobaramin, and also of a "discontinuity" among groups. The synapomorphy that diagnoses a group suggests a creative event by God (Wood and others 2003). Baraminologists are very much concerned with having an accurate definition of "kind" because it is vague as commonly used (Awbrey 1981) and because a consistent definition will enable the discovery of the basic created kinds — and ultimately a calculation of the number of animals present on the ark, for young-earth creationists.

Baraminology has had deep roots, but more recently there has been an attempt to codify it into a working method of research for creationist biologists. This culminated in the formation of the Baraminology Study Group (BSG) based at Bryan College in Dayton, Tennessee (<http://www.bryancore.org/bsg/index.html>). This group has hosted several conferences on baraminology starting in 1997, and has published a book on baraminological methodology called *Understanding the Pattern of Life* (Wood and others 2003). This book offers a concise and relatively complete explanation of baraminology and its practice.

BARAMINOLOGICAL TAXONOMY

The role of discontinuity systematics is to establish the boundaries of common descent. To designate their groups and boundaries, baraminologists employ terminology and designations suspiciously similar to that of most systematists, and in particular to Mayr's evolutionary systematics. The baraminological terminology originally codified by ReMine (1993) and expanded upon by Frair (2000) is shown in the sidebar (see p 21).

For baraminologists, these taxonomic designations have different functions. The ultimate goal is to take polybaramins and break them down into their component monobaramins and their respective holobaramins. These holobaramins could then be placed in apobaramins of structurally similar animals.

Alan Gishlick was formerly a post-doctoral scholar at NCSE; he is now teaching at Gustavus Adolphus College.

Baraminologists suggest that it is useful to talk about apobaramins because the holobaramins have many similarities that cross holobaraminic boundaries. Apobaramins are considered useful for studying larger groups of morphologically similar animals. Frair (2000) suggests that humans should be compared with the group most structurally and functionally similar to them: the great apes. There is a sort of cognitive dissonance going on with apobaramins, in that baraminologists are still using the power of phylogenetic inference, even though they deny phylogeny. If the groups are not phylogenetically related, why should baraminologists expect them to be comparable?

Once holobaramins have been determined, the phylogenetic relationships of the in-group members of a baramin could be worked out (Frair 2000). However, baraminologists do not think that displaying these relationships in the forms of trees would be useful. After producing trees, baraminologists have suggested that something other than trees may be more informative for depicting relationships; they suggest that other schemes, such as networks, lattices, or pattern recognition projection plots may do a better job (Frair 2000). Apparently, showing trees is a bit to descent-oriented for comfort. This is probably because representing relationships as *descent,* even within a holobaramin might leave people with the "wrong" impression. If people were to think too much about descent within a holobaramin, they may start to think that it can be extrapolated to apobaramins. However, baraminologists propose a slightly different notion of descent within groups:

> [D]ifferent members of a holobaramin could have resulted from a sorting out to the offspring of different genes (DNA) from parental organisms. This is a common occurrence today. Or, since the time of creation there could have been some hereditary modifications of the DNA (mutations), and these were passed on to the diverging offspring. Selection in nature could have influenced the potential for survival of the diverse siblings. (Frair 2000)

Finally, it is interesting to note that baraminologists, like phylogenetic taxonomists, claim to eschew "essentialist" thinking, which seems odd given their notions of limited created "kinds"; however, this is because they recognize that diagnostic baraminological features can be lost through variation within a kind. The result is that combinations of other features in the "kind" are used to unite them in a monobaramin (Wood and others 2003).

Finding the "Discontinuities" of life

Practitioners of discontinuity systematics claim that it carries no model-based assumptions and therefore can be used independently of creation theories. Their claim is that they do not presuppose discontinuities, but rather follow the data to discover discontinuities where they exist (ReMine 1990). In practice, however, this is not the case. Frequently and explicitly, biblical criteria are used when discontinuities fail to be found among groups that "should be" discontinuous, as in the case of humans and chimps in Robinson and Cavanaugh (1998a). Wood and others (2003) explicitly state that the biblical criteria are paramount and that discontinuities are presupposed because of the separate creation events mentioned in the Bible. Thus, baramins may be defined on a number of criteria, but the "scriptural" criterion takes precedence and is the only one necessary. However, because there are no scriptural definitions for much of life, in *those* cases the other criteria are used.

In these cases, baraminologists use a number of membership criteria to determine the boundaries of the holobaramins. These criteria were first proposed as generalizations by ReMine (1990) and have been fleshed out by subsequent works; however, few have been extensively tested or employed as of yet (Wood and Cavanaugh 2003). Save for the biblical criteria, all measures are considered fallible, and thus proponents argue that multiple criteria should be employed when attempting to diagnose a holobaramin (Wood and Cavanaugh 2003; Wood and others 2003).

Morphological criteria

Baraminologists have spent perhaps the most research time on the morphological criteria. Within these criteria, baraminologists construct measures of baraminological distance corresponding to character mismatches among the features of the groups they are analyzing. To measure baraminological distance, baraminologists employ a wide range of methods for discovering morphological gaps, borrowing traditional methods such as cladistics and phenetics and developing their own methods. In the computation of such units, traditional cladistic consistency measures and phenetic distance measures are used, along with other multivariate statistical methods. Baraminologists are especially enamored of phenetics (as in Sokal and Sneath 1963) because this approach is particularly amenable to a typological view of life (ReMine 1990). Included in morphological criteria are the identification of morphologies, organs, metabolic pathways, cellular processes, or functions that are unique to a group (sometimes considered synapomorphies) and thus supposedly suggestive of separate origins.

In selecting organisms for morphological analysis to divide monobaramins from apobaramins, baraminologists use typical taxonomic procedures. Baraminologists start with a classification, or according to Robinson and Cavanaugh (1998a), a hypothesized phylogeny (which is ironic given their denial of large-scale phylogenetic relationships), because they assume this group would contain truly holobaraminic groups. Animals of closely allied taxonomic groups are selected as in-groups and nearest neighbor groups are selected as out-groups for biological comparability (Robinson and Cavanaugh 1997).

Baraminologists also use cladistic methods. They compute trees using traditional cladistic software. Groups with high correlations within a bootstrapped dataset are considered potentially holobaraminic and then must be tested for phylogenetic discontinuity of their subgroups. High levels of homoplasy are also considered indicative of separate baramins, which baraminologists propose are a result of separate creations.

Baraminologists consider homologies to exist *within* holobaramins; homoplasies are features shared *among* holobaramins (Wise 1990). Baraminologists assume that a certain level of homoplasy delineates a phylogenetic discontinuity (Wise 1990), but no discrete criterion has yet been provided. For scriptural reasons, baraminologists think that organisms are too well designed to have true independence of characters (Wood and others 2003), which they argue calls into question the utility of independent character data.

In order to determine the degree of homoplasy, baraminologists compute a "Homoplasy Index" (HI) — the equivalent of 1–CI of traditional cladistic analysis (Kluge and Farris 1969). If the HI is high, then separate baramins are preferred. If the HI is high within a holobaramin, it is proposed to be the result of "gene scattering" from a complex ancestor through hybridization (Robinson and Cavanaugh 1998a; Scherer 1993). As with other baraminological measures, there is no specific measure of what degree of HI represents separate baramins and no explanation of why finding high HIs *within* a diagnosed holobaramin is not evidence that it is really an apobaramin. Robinson and Cavanaugh (1998a) note that there is a 0 homoplasy index between humans and apes in their dataset, which they suggests speaks to an imperfect measure by that criteria in some circumstances — namely those in which the analysis does not produce the answer they want. Therefore they caution researchers about using the HI as a criterion.

Molecular criteria

Baraminologists have recently become interested in molecular criteria to define a baramin because they offer the chance to search for discontinuities at the "fundamental" level of life (Robinson 1997; but see also Marsh 1971). The reasoning is similar to that of traditional systematists, and baraminology uses some of the same data and analytical techniques. Baraminologists believe that all holobaramins went through a severe bottleneck at the time of the Noachian Flood, so mitochondrial DNA should be an ideal systematic tool (Robinson 1997). Like other systematists, baraminologists download sequences from on-line databases such as GenBank and use typical phylogenetic alignment methods. Baraminologists use taxa that they believe are "phylogenetically distinct" for out-groups in molecular analysis. They then compare sequences by percent sequence difference compared to taxonomic rank, use parsimony distance estimates to construct groupings, and finally evaluate these groupings by bootstrap methods. Molecular methods were pioneered by Robinson (1997) for turtle baraminology. Baraminologists also utilize DNA/DNA hybridization and blood serum reactivity measurements to determine baraminological divisions.

Ecological criteria

The ecological criteria were first proposed by Wise (1992), who argued that ecological and trophic differences reflected separate originations or groups. Wise based this on the idea that the taxonomic rank of family reflected created kinds and his observations that the families tend to contain animals with similar ecologies and trophic levels. Thus, different ecological or trophic features should delineate separate baramins. Wood and others (2003) suggest that this criterion would be most useful for single-celled organisms, citing the radically different ecologies and cellular metabolisms found in bacteria and archaea, which, they argue, suggest separate origins.

Fossil or stratigraphic criteria

This criterion is a bit hard to understand and employ. For young-earth creationist baraminologists, the stratigraphic record is not reflective of the ancestral history of living things, but rather of deposition during the Noachian Flood. Thus the stratigraphic position of organisms should be irrelevant under this model.

Hybridization criteria

Based on the early work of Marsh (1941, 1976), the idea is that the limits of a baramin or basic type can be established for a group of organisms by their ability to hybridize. This is proposed as a testable, definable rank above that of species. It does not matter whether the hybridization is natural, or the offspring is fertile, only that hybridization is possible through some means, including artificial insemination (Scherer 1993). In order to establish these criteria, baraminologists collect and catalog hybrid data, supplemented by some hybridization studies of their own (Scherer and Hilsberg 1982; Scherer 1993). Hybridization potential is correlated with other measures of baraminological distance to test whether groups believed to be monobaraminic are capable of hybridization; if they are, then it provides support for an actual phylogenetic relationship between the organisms (Robinson and Cavanaugh 1998b). One wonders if they are willing to investigate the hybridization criteria for humans and chimps, which was not discussed in Robinson and Cavanaugh (1998a). A hybridization database is available on-line through the website of the BSG (<http://www.bryancore.org/hdb/>). Hybridization work is one area where practitioners of "intelligent design" and young-earth creationists overlap.

Biblical criteria

The biblical criteria are paramount and trump all other criteria (Wood and others 2003). There are two grades of biblical criteria; the first whether the Bible specifically references the baramin as specially created, and the second whether the Bible implies that it was specially created (Wood and others 2003). There are a number of studies that show how the biblical criteria are employed in baraminological estimates. Robinson (1997) provides a good example for turtles.

First, baraminologists search for any identification of a baramin in biblical texts. In the case of Robinson (1997), it is suggested that turtles are identified in Leviticus. Second, baraminologists determine whether the animal is "clean" or "unclean", thus determining how many pairs were brought onto the Ark. In Robinson (1997), turtles are determined to be unclean;

thus only one pair of each turtle baramin would have been required. Robinson also suggests the marine turtles would not have been on the Ark. In the case of humans and primates, Robinson and Cavanaugh (1998a) conclude that even though other criteria cannot separate humans and primates, the biblical criteria specifically states that humans are a separate baramin, so the other data are in effect immaterial.

To aid their quest for discontinuity, baraminologists have developed two semi-original and supposedly objective methodologies, ANOPA and BDIST, which they use along with more traditional systematic methods.

ANOPA

One of the membership criteria proposed by ReMine (1990), the "true lineage" can be considered part of the morphological criterion and the stratigraphic criterion. The idea behind this is that organisms could be represented as discrete points in a three-dimensional morphospace. If organisms could be connected by a continuous lineage in morphospace, then they could be considered part of the same baramin. Analysis of Pattern (ANOPA) is a statistical tool developed by Cavanaugh to determine whether such lineages exist (Cavanaugh and Sternberg 2004). Cavanaugh claims that this method is useful for investigating three-dimensional morphological data quantitatively; however, it appears to differ little from principal components analysis with a fancy graphical display, and its measures are suspect (*see Dan Bolnick's analysis of ANOPA, p 22*).

BDIST

Baraminologists have developed their own analysis software, which performs a distance analysis similar to that of Sokal and Sneath (1963). This is called BDIST (Wood 2001) and is available for free download at <http://www.bryancore.org/bsg/bdist.html>. This program is designed to utilize cladistic datasets in NEXUS format as used by PAUP* (Phylogenetic Analysis Using Parsimony; available on-line at <http://paup. csit.fsu.edu/>).

BDIST computes the "coefficient of baraminic distance" as originally described by Robinson and Cavanaugh (1998a). This coefficient is a form of the simple matching coefficient of Sokal and Michener (1958). This baraminic distance represents the percentage of characters two taxa share in common. If there is a "chain of positive and significant baraminic distance correlations" connecting all the taxa, then they are monobaraminic (Robinson and Cavanaugh 1998a). Basically, BDIST computes a phenetic distance matrix.

Overall, however, the BDIST methodology has not been extensively applied, and there is no evidence that the algorithmic effects of large datasets, or the role of missing data, have ever been studied by baraminologists. Baraminologists appear to apply an old phenetic method, without really studying how it works. More interestingly the method might not really work at all. In the published applications of the method so far, in no case did it actually distinguish between two baramins. In cases where it returned results baraminologists could live with, they determined a holobaraminic status for the group. This was the case for felids (Robinson and Cavanaugh 1998b), flaveriinae (Wood and Cavanaugh 2001), and fossil and recent equids (Cavanaugh and others 2003). In conditions where it did not return results favorable to baraminologists, other criteria are applied to achieve the desired result. This was the case for humans and primates (Robinson and Cavanaugh 1998a) where BDIST did not show a separation. Instead, the authors employed ad hoc "ecological criteria" to achieve separate baramins, while not discussing the "biblical criteria".

Only the study on equids (Cavanaugh 2003) included both fossil and living taxa, and none of the other studies contained datasets with missing data. Therefore, this study served as a template to see how they would investigate fossil and recent morphological datasets. In their treatment of the Evander (1989) data for fossil horses, Cavanaugh and others (2003) removed the missing data by recoding it so that "unknown" data were coded as 0, absence as 1, partial derivation as 2, and presence as 3 and 4 (some characters have more than 2 states). The recoding of unknown data to a specific value that can be used in the analysis makes the dataset use all characters; however, it falsely increases the amount of morphological variation by assigning a numerical value to an unknown. In a sense, the authors artificially create a morphological character state where there is none. This only has minor effects on the overall analysis since it only applies to five characters in a single taxon, so recoding the dataset correctly to include the missing data did not significantly alter the results. However, the effects would be more profound in larger datasets with more widely scattered missing data.

The BDIST software, as configured by Wood, screens out any character with less than "95% relevancy". Why this threshold was chosen is not explained, nor how it is determined. Based on investigation of datasets, relevancy appears to be determined by percentage of missing data for a character relative to total number of taxa. This makes the application of this method to fossil datasets difficult. Surprisingly, characters with no variation (either all 0s or 1s) are not considered "irrelevant" (as they would be in cladistic analyses because they would be "uninformative"). The importance of including characters and taxa with missing data has been shown (Donoghue and others 1989). Recoding missing data as valued, as Cavanaugh and others (2003) have done, however, would have a measurable distorting effect on the results, particularly if the amount of missing data was a larger proportion of the dataset.

When the relative baraminic distances are compared with the phylogenies produced by the datasets, the overall result is a steady, gradual trend in decreasing baraminic distance relative to the phylogeny. These results are comparable to those generated from the Evander (1989) data for fossil horses. Thus, with no significant baraminic distance shifts within the datasets, it could be concluded that dinosaurs and birds belong to the same holobaramin. This makes sense in an evolutionary context: the more transitional features one finds in a set of related organisms, the lower the relative distance between any two taxa will

be. In general, including more fossil taxa with transitional morphologies will decrease phylogenic discontinuity, which may explain the datasets that baraminologists have analyzed so far.

Conclusion

Despite its use of computer software and flashy statistical graphics, the practice of baraminology amounts to little more than a parroting of scientific investigations into phylogenetics. A critical analysis of the results from the one "objective" software program employed by baraminologists suggests that the method does not actually work. The supremacy of the biblical criteria is explicitly admitted to by Wood and others (2003) in their guidebook to baraminology, so all their claims of "objectivity" notwithstanding, the results will never stray very far from a literal reading of biblical texts. I will give the baraminologists credit in one area: they are up-front about their motives and predispositions and true to their biblical criteria and methodology, which is more than can be said about "intelligent design" proponents.

Baraminology Glossary

The baraminological groups were originally codified by ReMine (1993) and expanded by Frair (2000).

Holobaramin: All known living and extinct forms understood to share genetic relationships. It is the entire group of organisms related by common ancestry. This would correspond to Mayr's (1963) holophyly or Hennig's (1950) monophyly.

Monobaramin: A group containing only organisms related by common descent, but not necessarily all of them. This could be a group containing one entire holobaramin or a portion of it. This would correspond roughly to Mayr's (1963) monophyly or Hennig's (1950) paraphyly.

Apobaramin: A group consisting of one or more holobaramins. The group of holobaramins may share similar morphology, ecology, and function, but, by definition, *not* common descent. This may be somewhat like polyphyletic groups.

Polybaramin: A grouping of two or more individuals who are part of at least two holobaramins. It may be a combination of holobaramins, monobaramins, apobaramins, and individuals that by definition do not share a common ancestor. This is consistent with traditional notions of polyphyly.

Baraminologists also recognize a number of taxonomic groupings — **archaebaramin** (the original created individuals of a holobaramin), **neobaramin** (the extant individuals in a holobaramin), and **paleobaramin** (the extinct members of a baramin, or a wholly extinct baramin) — that do not have counterparts in traditional systematics.

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ANOPA: "Statistical" Systematics for Young-Earth Creationists

Dan Bolnick, University of Texas, Austin

Creationists have been working hard to make their views appear as legitimate science. Part of this strategy has been to get papers published in peer-reviewed scientific journals. Creationists have used two strategies to achieve this goal. First, the recent review paper on "intelligent design" (Meyer 2004) in the *Proceedings of the Biological Society of Washington* was published by bypassing the normal peer-review process. According to a recent statement from the council that publishes the journal, the editor Richard Sternberg handled the paper in a manner "contrary to typical editorial practices" (<http://www.biolsocwash.org/>).

The second approach is to sanitize the content of the paper. Two other papers written by creationists have been published in peer-reviewed journals in 2004 (Behe and Snoke 2004; Cavanaugh and Sternberg 2004). Unlike Meyer's paper, which was handled by a friendly editor who retired soon after (and also co-authored the Cavanaugh and Sternberg paper), these have actually passed through the peer review process. This was accomplished by removing any overt reference to creationism or "intelligent design", a strategy clearly outlined in a recent paper by a group of young-earth creationists:

> To make a creationist theory "theory-neutral" (that is palatable to non-creationists), much of what makes it distinctly creationist must be removed. This may be useful, for example, in order to get a controversial scientific study reviewed by competent evolutionary scholars in a secular journal, but the elimination of creationist content as a general practice generates more work for creationists. To integrate "theory-neutral" research back into the creation model from which it came, all that was excised must be replaced. (Wood and others 2003)

Such excision is a clever, if disingenuous, ploy that underlies the recent publication of a paper by the young-earth creationist David Cavanaugh and the biologist Richard Sternberg in the peer-reviewed *Journal of Biological Systems*. Both authors have been active members in the Baraminology Study Group, whose website proclaims that its "ultimate goal is to develop origin models that accommodate empirical data in a biblical framework of earth history through scientifically sound analysis of biological data and scholarly analysis of biblical texts" (<http://www.bryancore.org/bsg/aboutmain.html>).

To this end, Cavanaugh has been developing a quantitative method for identifying whether a collection of species represent a single "created kind" or are sufficiently distinct as to qualify as members of different holobaramins. This method, called "Analysis of Pattern" (ANOPA), is touted as a method to "reduce the dimensionality of multi-dimensional data with minimal loss of information and no assumptions about the data's distribution" (Wood and Cavanaugh 2003: 2). By reducing complex multivariate data down to three dimensions, ANOPA allows the user to visualize patterns of similarity and difference among species to see if they fall into discrete clusters. This purely descriptive method could then be combined with statistical inference (confidence intervals around the clusters) to ascertain whether these clusters might overlap. The implication is that overlap would imply membership in a common holobaramin, and disjunction would imply separate baramins.

As of late 2004, three papers had been published using ANOPA. The first two were published in creationist journals (*Origins* and *Occasional Papers of the Baraminology Study Group*) and clearly apply ANOPA as a criterion for evaluating whether groups of species (subtribe Flaveriinae and tribe Heliantheae, respectively) represent one or more of the Bible's created kinds (Cavanaugh and Wood 2002; Wood and Cavanaugh 2001). Both papers provide only the sketchiest description of ANOPA as a method, citing an unpublished paper. Without full description of the method, it was impossible to evaluate their claims about its value, for example: "Because these calculations *require no assumptions* about the distribution of the data and *retain more information* regarding dataset variation, ANOPA can reveal patterns obscured by other variance-analysis methods such as Principal Component Analysis. Consequently, ANOPA is the *best available method* to display biological character space and reveal taxonomic patterns." (Wood and Cavanaugh 2003, emphasis added).

A complete description of ANOPA has finally become available, in a peer-reviewed journal. Taking the strategy outlined in Wood and others (2003) to get through peer review, Cavanaugh and Sternberg wrote a paper describing ANOPA — a method developed for

Continued on page 27

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Ten (Eleven) Things Evolutionists Can Do to Improve Communication

Randy Olson

1) **Quality Control:** So much of the mass communication of evolution is dull and uninspiring. For example, the AIBS-sponsored video *Evolution: Why Bother?* is tragically bad — nothing but talking heads and still images. Any introductory film student could have explained to them that in film and video the primary communication takes place through the *images* presented. When all we show are faces talking, we communicate virtually nothing. We need the simple, honest feedback gained by showing these productions to our neighbors and watching them fall asleep. Just send the sponsors a note that this is not good enough. Raise the bar. It's that simple. When evolution media looks bad, evolutionists look bad. Cost to you of this suggestion: $0.

2) **Attitude:** *Never* "rise above" one of the simple principles we learned in acting class. Whenever we condescend, we lose the sympathy of our audience. When evolutionists call ID proponents "idiots", it just makes the audience side with the people being ridiculed. It is a simple principle of mass communication. Even though Stephen Jay Gould was my hero in graduate school nearly 30 years ago, my students at USC find his style and voice to be arrogant, elitist, condescending, verbose … the list goes on. Cost to you of this suggestion: $0.

3) **Concision:** It is a by-product of the information era. Get used to it. In fact, practice it. The most effective means of communication is through storytelling. The shorter, more concise, and punchier the story, the more engaged and interested the audience. Scientists need to maintain accuracy and precision, but shorter, punchier stories will not hurt anything. Observe Hollywood and advertising pitchmen: they are able to tell entire stories in very few words. Cost to you of this suggestion: $0.

4) **Modernization:** A recent CNN poll showed that 44% of Americans get their information on science and technology through television — more than through any other medium. So why isn't the world of science communication geared towards this, even just a little bit? There are now dozens of science *writing* programs around the country; why no science *electronic media* programs? Cost to you of this suggestion: $0.

5) **Setting Priorities:** Effective communication costs money — real, cold, hard dollars. Scientists sit through technical talks with bad visuals and poor sound, and seem to accept it as standard practice. On a wider scale, this is mirrored in the tiny allocation for science communication in research grants (occasionally a few dollars are allocated for outreach). Compare this with businesses making products and spending perhaps half of their budgets on marketing and advertising. *Everyone* needs to accept that we live in an information-glutted world, and if we do not pay sufficient attention to communicating effectively what we have to say, then we will be unheard. It is a matter of priorities. Cost to you of allocating more funds to communication: as much as you can afford, but it is time to make it hurt a little, to make up for the lack of priority on communication in the past.

6) **Understanding:** Intellectuals are handicapped as mass communicators. I had this line in my film, and took it out because it sounded too insulting, but it's true. Mass audiences do not follow people who *think*, they follow people who *act*. Try taking an acting class and you'll get to know about this intimately. Cost to you of this suggestion: $0.

7) **Risk Taking/Innovation:** Every stock investor knows you allocate at least 10% of your stock portfolio to high-risk ventures. There are no signs that formal investment in high-risk innovation of science communication has been taking place. You need to ask your science agencies what percentage of their funding is going to high-risk, wild ideas for mass communication. They may sound irresponsible, but without these ideas, you end up with homogenization. Come on, folks, we're talking about basic out-breeding dynamics here. Cost to you of this suggestion: $0.

8) **Humor:** This is yet another by-product of the information era. It is no coincidence that news anchors, who were stoically serious 30 years ago, today tell jokes and tease each other, or that *The Daily Show* on Comedy Central is the most popular form of news for kids (as well as *a lot* of adults); or that Michael Moore, Al Franken, and Bill Maher have become such popular news critics. Humor has become a major channel of communication. So lighten up, evolutionists. Cost to you of this suggestion: $0.

9) **Unscripted Media and the Mass Audience:** This goes with modernization. The mass audience has changed drastically in just the past decade. About half of the acting jobs available a decade ago in Hollywood have been lost to reality television — which is unscripted entertainment. The mass audience is bored and desperate for anything unpredictable. This is why, at our Yale University screening of *Flock of Dodos*, when evolutionist Richard Prum, in a moment of brilliance, yanked the microphone away from me as I droned on about the need for spontaneity, the audience erupted more than at any other moment in the entire evening. Cost to you of this suggestion: $0.

10) **Sincerity:** Even though Prum was a bit ungainly after grabbing the microphone, the audience didn't care. The gesture was so sincere, came from such a visceral level, showed such passion, such risk-taking, so much desire to act (rather than just pontificate as I was doing), that he stole their hearts. There is a great deal to be learned from that. Cost to you of this suggestion: $0.

11) **Casting:** All advocates are *not* created equal when it comes to communicating with the public. Suffice it to say: even if you have a Nobel prize and even if you give really *great* lectures, you *still* might not be the best person on camera. One bad twitch will set back your cause despite all your knowledge and advanced degrees. But … pick the *right* person even if this is only the chair of a state curriculum writing committee— in my movie this was Steve Case, who is the most popular and instantly likable scientist I've ever seen on film — and the impact can be far greater than what you get using any Nobel laureate. And by the way, there's only one group of people who can decide for certain if your spokesperson is effective: your *audience*. Theirs is the only opinion that matters. Cost to you of this suggestion: potentially bruised egos and $0.

Value of better public understanding of science: priceless.

Mystery of mysteries

In the introduction to the *Origin of Species*, Darwin began by explaining that on his voyage on the *Beagle*, he was struck with certain facts that "seemed to me to throw some light on the origin of species — that mystery of mysteries, as it has been called by one of our greatest philosophers." While Darwin's contribution to unraveling the mystery of mysteries was substantial, as were those of the biologists who expanded the Modern Synthesis to incorporate the full range of natural history, there is still plenty of important scientific work to be done, both in investigating speciation in the laboratory and the wild and in articulating and assessing different models of speciation and different systems for classifying the forms of life. To pursue such mysteries further, check out the following books, ranging from the popular to the technical, all of which are now available through the NCSE website: <http://www.ncseweb.org/bookstore.asp> — look in the "In the latest *RNCSE*" section. And remember, every purchase through the website benefits NCSE!

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

The Classics

On the Origin of Species
by Charles Darwin
Neither praise for the *Origin* nor testimony to its influence is needed! But NCSE recommends the first edition, in which Darwin expressed himself with a clarity, force, and concision not to be rivaled by the second through sixth editions. A facsimile was published by Harvard University Press, with a preface by Ernst Mayr. As the reviewer for *Science* observed, "it was a very happy idea ... with this very reasonably priced and beautifully produced book, not only historians of science but also biologists will have the opportunity of following the fascinating thought-trails, still far from fully explored, of that remarkable man Darwin."

Genetics and the Origin of Species
by Theodosius Dobzhansky
In *Genetics and the Origins of Species* (originally published in 1937, with revised editions following in 1941 and 1951), the great geneticist Theodosius Dobzhansky presented the whole of contemporary genetics as a reaffirmation of Darwin's legacy. In his introduction to the 1999 reprint, Stephen Jay Gould described the book as "the pivot and founding document of the modern synthesis. ... Like most great books, Dobzhansky's volume is not merely a review and categorization of existing data. It is a long argument for a general attitude toward nature and a specific approach that might unite the disparate elements of evolutionary theory."

Systematics and the Origin of Species
by Ernst Mayr
Systematics and the Origin of Species, published in 1942 and reissued, with a new introduction, in 1999, is widely regarded as largely responsible for the crowning achievement of the Modern Synthesis: demonstrating the compatibility of the evolutionary patterns and processes to be found in natural populations with both Darwinian natural selection and Mendelian genetics. It also introduced the biological species concept, according to which species are "groups of actually or potentially interbreeding natural populations that are reproductively isolated from other such groups." Perhaps the most distinguished evolutionary biologist of the twentieth century, Ernst Mayr was a member of NCSE; he died in 2005, at the age of 100.

The Latest

Speciation
by Jerry A Coyne and H Allen Orr
Speciation is again at the forefront of evolutionary research, and Jerry A Coyne and H Allen Orr's *Speciation* is a unified, critical, and up-to-date account of the scientific research relevant to the origin of species. Reviewing the book in *RNCSE* (2005 May–Aug; 25 [3–4]: 40–41), Norman A Johnson wrote, "Jerry Coyne and Allen Orr, who have alone and together made several seminal discoveries in speciation, have written a magisterial, comprehensive volume … Had Coyne and Orr just published their annotated bibliography, that would be a great service for professional evolutionary biologists and their students. But they do so much more!"

Endless Forms: Species and Speciation
edited by Daniel J Howard and Stewart H Berlocher
The publisher writes, "This volume presents the newest research findings on speciation bringing readers up to date on species concepts, modes of speciation, and the nature of reproductive barriers. It also discusses the forces that drive divergence of populations, the

<http://www.ncseweb.org/bookstore.asp>

genetic control of reproductive isolation, and the role played by hybrid zones and hybridization in speciation." After a historical introduction, there are essays on five themes: species concepts; geography, ecology, and population structure; reproductive barriers; hybrid zones and speciation; and "perspectives" — including a personal memoir by Guy Bush, a champion of sympatric speciation, to whom the book is dedicated.

Frogs, Flies, and Dandelions
by Menno Schilthuizen
In *Frogs, Flies, and Dandelions*, Menno Schilthuizen provides a lively and accessible introduction to contemporary controversies over modes of speciation, arguing in the process for the validity of sympatric speciation (a position taken by Darwin himself, but widely rejected nowadays). Reviewing the book in *RNCSE* (2003 Jan/Feb; 23 [1]: 37–8), John Wilkins wrote, "The arguments are presented in this book with as much attention to detail — and to both the biology *and* the personalities — as any book I have even seen. Schilthuizen is that extreme rarity — a biologist who writes entertainingly and clearly for lay audiences."

In The Wild

Darwin's Dreampond: Drama on Lake Victoria
by Tijs Goldschmidt
Like the finches of the Galápagos, the cichlids of Lake Victoria have descended from a recent common ancestor, and radiated, spectacularly, across the range of available ecological niches. In *Darwin's Dreampond*, Tijs Goldschmidt not only explains the evolution and the ecology of the Lake Victoria cichlids, but also engagingly relates his adventures and misadventures as a researcher in the field. Mark Ridley comments, "The biological story itself is fascinating, and Mr Goldschmidt tells it well. But the genius of his book lies in the way he has combined the science with travel writing. He interleaves the two in a highly readable way, so that his Tanzanian experiences lighten the science."

Evolution in Hawaii
by Steve Olson
Intended as a supplement to *Teaching about Evolution and the Nature of Science*, *Evolution in Hawaii* focuses on the Hawaiian islands as laboratories of evolution in the wild. Included is a speciation exercise in which, as the preface describes it, "Using real genetic data from 18 species of *Drosophila* flies in Hawaii, students draw evolutionary trees depicting the relationships of the species and investigate the link between speciation and the ages of the Hawaiian islands. By letting students explore the mechanisms involved in the origin of species, the teaching exercise demonstrates how descent from a common ancestor can produce organisms with widely varying characteristics."

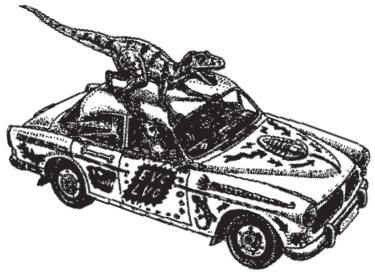
The Beak of the Finch
by Jonathan Weiner
From the publisher: "On a desert island in the heart of the Galápagos archipelago, where Darwin received his first inklings of the theory of evolution, two scientists, Peter and Rosemary Grant, have spent twenty years proving that Darwin did not know the strength of his own theory. For among the finches of Daphne Major, natural selection is neither rare nor slow; it is taking place by the hour, and we can watch." Praised by the *Washington Post Book World* for its "[e]vocative writing, exhaustive research, and Weiner's memorable portrait of the engaging Grants," *The Beak of the Finch* won the Pulitzer Prize for General Non-Fiction in 1995.

Philosophy

The Poverty of the Linnaean Hierarchy
by Marc Ereshefsky
In *The Poverty of the Linnaean Hierarchy*, Marc Ereshefsky, a professor of philosophy at the University of Calgary, offers a survey of competing philosophies of classification, articulates and defends a form of pluralism with regard to species concepts, and argues that the Linnaean system ought to be abandoned in favor of a post-Linnaean, rank-free, phylogenetic taxonomy (like PhyloCode, with a few differences). Elliott Sober writes, "This book is of practical importance to biologists, but its analysis of the relationship between theories and classification schemes will also be of compelling interest to philosophers of science."

The Units of Evolution: Essays on the Nature of Species
edited by Marc Ereshefsky
From the publisher: "*The Units of Evolution* [published in 1991] is the first anthology devoted solely to the nature of species, one of the most hotly debated issues in biology and the philosophy of biology. The anthology is evenly balanced between biological and philosophical issues, making it equally useful for workers in both fields. In his general introduction, Marc Ereshefsky sketches the framework for the debate, explaining how biologists disagree over the definition of the term *species,* and philosophers struggle to evaluate the scientific utility of a categorization device that might lack a single defining characteristic."

Species: New Interdisciplinary Essays
edited by Robert A Wilson
In a dozen specially commissioned essays, the contributors to *Species* offer a variety of perspectives — not only biological but also philosophical, historical, and anthropological — on the concept (or concepts) of species. Robert N Brandon hails *Species* as "a fresh, well-conceived collection on one of the most persistent problems in the philosophy of biology — the species problem." The contributors are John Dupré, David L Hull, Kevin de Queiroz, David L Nanney, Kim Sterelny, Richard Boyd, Robert A Wilson, Paul E Griffiths, Scott Atran, Frank C Keil and Daniel C Richardson, Marc Ereshefsky, and Brent D Mishler.



NCSE on the Road

A Calendar of Special Events, Presentations, and Lectures

Date May 2, 2007
City Oberlin OH
Presenter Eugenie C Scott
Title The Evolution of Creationism
Event Lecture for the science departments
Time 7:00 PM
Location Oberlin College
Contact Dennis Hubbard, dennis.hubbard@oberlin.edu

Date May 3, 2007
City Cincinnati OH
Presenter Eugenie C Scott
Title Why Universities and Museums Don't Present Creationism as Science
Event Presentation in the Charles and Ralph Dury Science Lecture Series
Time 7:00 PM
Location Cincinnati Science Center
Contact Jerry Warner, warner@nku.edu

Date May 17, 2007
City New York NY
Presenter Eugenie C Scott
Title What Do Creationists Believe About Human Evolution?
Event A talk sponsored by the LSB Leakey Foundation
Time 7:00 PM
Location American Museum of Natural History
Contact Danielle Dana, danielle@leakeyfoundation.org

NCSE Speakers Available

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

Name Andrew J Petto
Title NCSE Board Member
Contact editor@ncseweb.org

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

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Title NCSE Public Information Project Director
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Name Susan Spath
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Check the NCSE web site for updates and details — <http://www.ncseweb.org/meeting.asp>.

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young-earth creationist purposes and used as such in other venues — but presented here without any reference to creationism. Cavanaugh and Sternberg (2004) also apply ANOPA to a group of well-known North American freshwater fishes, the Centrarchidae (sunfish, bass, crappies, fliers), for which a large dataset of morphological traits was available.

This publication raises an interesting strategic question: how should the scientific community handle papers written by creationists, describing methods or ideas designed to support creationist research, that make no overt reference to creationism? One option is to treat such papers the way we treat any scientific work: assess the strength of its methods, and the rigor of its interpretation. Therefore, the remainder of this essay will be spent describing and critiquing ANOPA, and its particular application by Cavanaugh and Sternberg (C&S).

How is ANOPA supposed to work?

Multivariate data are a common feature of studies that try to classify species based on morphological similarities. Such data are difficult to visualize because we cannot simultaneously view relationships among more than three variables at a time. Statisticians have gotten around this problem with a variety of methods such as Principal Components Analysis (PCA) that try to reduce the variation in many different variables, down into a smaller number of important variables that capture most of the action. This is best illustrated in Figure 1a, where we have hypothetical data on the number of vertebrae and gill rakers for each of twenty species. There is clearly important variation in both traits, so we do not want to ignore one of them. We can get around this problem by "rotating" the axis of the graph so that one axis (the "first principal component") captures most of the action. We could then either ignore the remaining variation, or use a second principal component axis that is perpendicular to the first, to "explain" the remaining variation. If we have ten variables instead of the two illustrated in Figure 1, there will be ten possible Principal Components (PCs), but in general we find that the first couple of PCs capture most of the meaningful information.

ANOPA tries to do something very similar, reducing some large number of variables down to three axes of variation that are meant to capture any meaningful patterns in the data (Cavanaugh and Sternberg 2004). The algorithm for ANOPA is simple, and is summarized in Figure 2.

The method assumes we have a standard dataset for cladistic analysis. That is, each species is given some value for each of a number of different traits. These traits can be continuous (for example, body size), ordinal (for example, number of vertebrae), or categorical (for example, presence or absence of a trait, or a number of different character states). Each trait represents a different (but not necessarily independent) dimension of variation among species. In the visual illustration of ANOPA, we will assume just two such dimensions for clarity (Figure 2A). There are two conceptually distinct versions of ANOPA: 1-dimensional ANOPA draws a histogram of distances among points, while 2- or 3-dimensional ANOPA

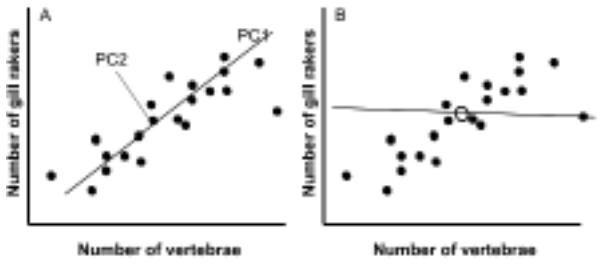


Figure 1
A) Rotation of axes by Principal Components Analysis.

B) Rotation via ANOPA, connecting the centroid to the most most distant data point to form the primary axis. Location/choice of outgroup will have a major effect on results.

reduces the data down to three variables and produces a scatter plot of the data points to look for disjunct groups.

For 1-D ANOPA, we first identify the central point ("centroid") in the cloud of data, the average of each trait across all species (Figure 1B, 2B). We then calculate the Euclidean length of the vector connecting each species' point to that centroid (Figure 2C). Looking at a histogram of these distances (Figure 2D), C&S suggest that different peaks in the histogram correspond to different subgroups. In fact, these results can arise from random chance: the data in Figure 2D appear to have 3 groups, but this is an artifact of small sample sizes drawn from a single normal distribution. One's choice of how wide the histogram bars are will affect resolution and may create statistically non-significant groups, or can obscure real groups. The 1-D test can also fail to identify distinct groups (Figure 3), indicating that it is likely to be very sensitive to both overall sample sizes and the evenness of sample sizes among groups.

Part of the problem with the 1-D ANOPA is, of course, that one dimension is insufficient to capture variation in two or more dimensions (Figure 3). The

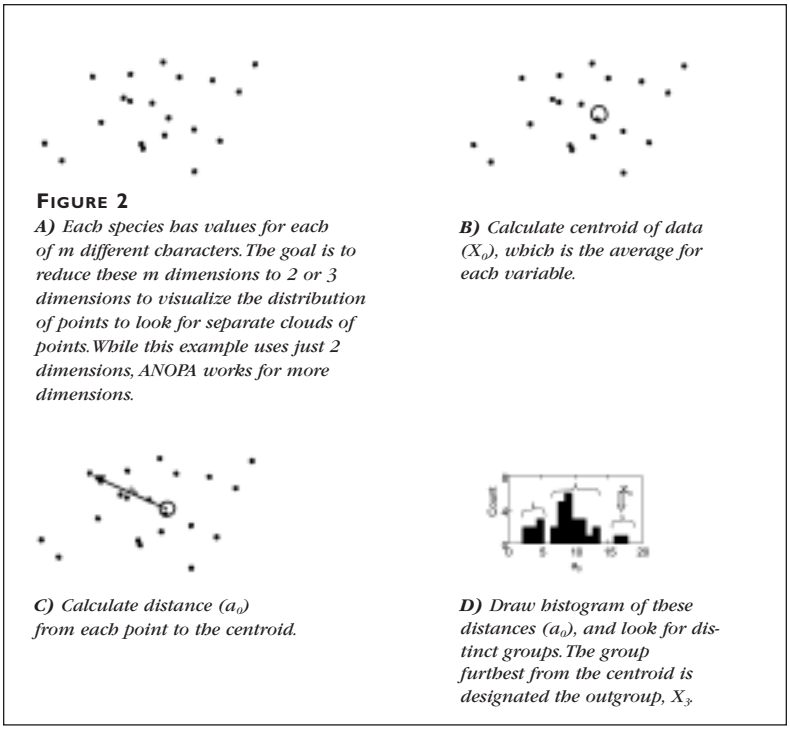


Figure 2

A) *Each species has values for each of m different characters. The goal is to reduce these m dimensions to 2 or 3 dimensions to visualize the distribution of points to look for separate clouds of points. While this example uses just 2 dimensions, ANOPA works for more dimensions.*

B) *Calculate centroid of data (X_0), which is the average for each variable.*

C) *Calculate distance (a_0) from each point to the centroid.*

D) *Draw histogram of these distances (a_0), and look for distinct groups. The group furthest from the centroid is designated the outgroup, X_3.*

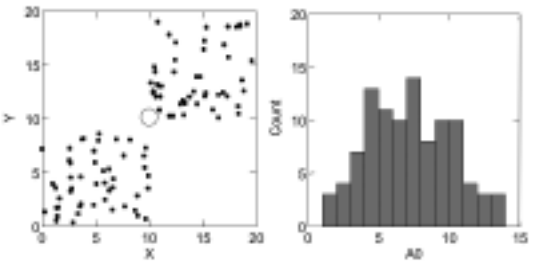


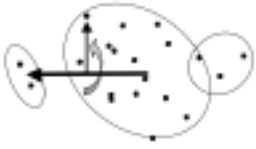
FIGURE 3
The 1-D ANOPA will fail to identify two distinct groups with equal sample sizes. Because the centroid falls equidistant between the groups, the distance measure a_0 will have a single mode.

other problem is that distance from a centroid may not be the best single dimension to use. Consequently, C&S propose an extension to the 1-D method: 3-D ANOPA. This is more akin to Principal Components Analysis, reducing numerous dimensions in the data down to three dimensions that can be plotted on a graph to search for visually distinct clusters. The first step is to define an "out-group". C&S advocate using the histogram of disparity (Figure 2D) to pick out the most divergent species or clump of species that can be designated as a morphological out-group. Note that this use of "out-group" is quite distinct from what is meant in phylogenetic analysis. Rather than representing an ancestral character state to root character state transitions along a phylogeny, C&S use the outgroup to define the first major axis of variation in the multivariate cloud of data.

Next, C&S draw a "relation vector" from the centroid to the point representing the outgroup (Figure 4A). This is analogous to the first principal component axis in PCA, with a critical distinction. Whereas the first principal component axis seeks to explain the most variation in the data, the "relation vector" merely connects the centroid to the most distant point, or "out-group". This distinction is also illustrated in Figure 1B. Next, each data point is characterized in relation to this vector. Dropping a perpendicular line from each species down to the vector (Figure 4B), the point can be defined by 3 dimensions: 1) the distance along the relation vector from the centroid to the perpendicular, t_0, 2) the distance along the perpendicular line from the vector to the point, d_2, and 3) the angle at which this line is rotated around the vector, ar, (Figure 4C). One can then create a scatterplot of any two of these axes, or a 3-D plot, and look for apparently distinct groups. If multiple groups are identified by the 1-D ANOPA or 2-D scatterplots, C&S outline a way to build confidence intervals around these plots (Figure 4D). This involves calculating the standard deviation for each morphological variable, building an ellipse with length equal to two standard deviations along each variable, then rotating this ellipse to fit the three ANOPA dimensions. C&S provide no quantitative criteria with which to evaluate the statistical significance of non-overlapping or overlapping confidence intervals.

FIGURE 4
A) *Draw a vector X_2 from the centroid to the outgroup mean.*

B) *Each data point can be represented in two dimensions by determining: the distance along the vector t_0 and the perpendicular distance to the vector d_2.*



C) *A third dimension can be added by determining the rotational angle (ar) of vector d_2 around the vector t_0. This angle is calculated in reference to the vector from t_0 to an arbitrarily chosen point.*

D) *Now multi-dimensional data can be summarized as a 2- or 3-dimensional scatterplot (t_0, d_2 and ar). Standard deviations of each variable are used to draw confidence intervals around each group identified by this scatterplot.*

IS ANOPA A USEFUL METHOD?

Is ANOPA really a valid and useful method for analyzing patterns in morphological data? Wood and Cavanaugh (2003) claim that "ANOPA is the best available method to display biological character space and reveal taxonomic patterns," in part because the method "requires no assumptions about the distribution of the data and retain[s] more information regarding dataset variation" than Principal Component Analysis (Wood and Cavanaugh 2003). In fact, ANOPA requires a number of unstated assumptions and retains *less* information than PCA. There are five major flaws with ANOPA:

1) **Lack of objective criterion for identifying discrete groups within the data.** Judging by its development by baraminologists, the implicit goal of ANOPA is to identify groups or species that are morphologically distinct from other groups (Cavanaugh and Wood 2002; Wood and Cavanaugh 2001, 2003; Wood and others 2003). Yet what ANOPA actually does is to reduce multi-dimensional data down to three dimensions. It does not provide an objective, quantitative method for identifying discrete groups. Instead, Cavanaugh and Sternberg state that "the practiced eye of an experience [*sic*] analyst could discern the patterns of relationships within a given dataset" (p 158). Contrary to what their title implies, there is no part of the algorithm that statistically recognizes patterns in the data. It merely rotates the data, and patterns are evaluated by eye.
2) **Use of unordered data.** Given continuous data (for example, body mass) the mathematical rotations C&S use to calculate t_0, d_2, and ar are mathematically sound. However, such data are rare in morphological cladistic datasets, which are often comprised of categorical data that are arbitrarily coded with numbers, but could just as easily have been represented by letters or any

other symbols. For instance, the centrarchid dataset used by C&S includes a variable describing the basihyal teeth in each species, coded as 0 (medial patch of teeth), 1 (no dentition), or 2 (two bilateral patches). Because the three character states have no meaningful order, it is meaningless to calculate an average value, or distances from that average. Since ANOPA depends on such distances, the method is inappropriate for unordered or categorical traits. C&S nevertheless apply the method to the centrarchid dataset, which contains many such arbitrarily ordered categorical traits.

To get around this problem, C&S point out that many unordered characters can be assigned an order. For instance, a particular codon in a gene can call for any of 20 common amino acids. C&S suggest assigning an order to amino acids based on traits such as how hydrophobic they are. However, there are, in fact, a number of traits that might be used to order amino acids, which may give very different orders. Arbitrarily selecting one of these will potentially bias results, so there must be a clear criterion for choosing orders for categorical traits. C&S offer no such criterion, instead making an implicit assumption that the chosen criterion is biologically the most meaningful one.

3) **Choice of out-group.** One's choice of out-group has a major effect on ANOPA results because it determines the primary axis of variation in the resulting data rotation. C&S suggest using the species(s) furthest from the centroid as the outgroup. This has the advantage of providing a semi-objective way of choosing the out-group, though the choice of whether to use one or more species is left to the user's discretion. Unfortunately, there is no guarantee that a vector from the centroid to the most distant point will: 1) maximize the amount of variation explained by the axis (as PCA does); or 2) maximize the discriminating power between groups (as discriminant function analysis does). C&S provide no justification for why the "relation vector" is the best rotation for identifying morphologically distinct groups, nor do they discuss how sensitive their results are to one's choice of out-group. This is made all the more problematic by their decision to ignore their own objective criterion for choosing an out-group. The out-group for their analysis of centrarchids fishes was a hypothetical morphology based on questionable assumptions about ontogenetic trajectories.

4) **Lack of statistical rigor.** Cavanaugh and Sternberg claim to find "statistically significant groupings" within the centrarchids (Cavanaugh and Sternberg 2004: 154). It is unclear how they reached this conclusion, since at no point in their description of ANOPA is there any method for assessing statistical significance.

In 1-D ANOPA, groups are identified by visual inspection of a histogram (Figure 2D), which has two problems. First, the number of peaks and distinct groups in histograms depends on one's choice of how wide to make the bars. C&S advocate looking through a range of bar widths to search for distinct groups, an approach that will often yield false positives. Second, low sample sizes (as in the 22 species of centrarchids used in their paper) will almost inevitably produce distinct peaks in any histogram merely as a result of random sampling effects. They provide no statistical method for testing the null hypothesis that different peaks in the histogram could be generated by random sampling from a single distribution.

There is a more serious attempt at statistical rigor in 2-D ANOPA, in which one can draw confidence intervals around different sub-groups, and see whether these intervals overlap. Two problems emerge here. First, C&S calculate the intervals by forming an ellipse based on the standard deviations of the two major ANOPA axes. They claim, "Due to the way that t_0 and d_2 are calculated they are orthogonal, independent distances, thus have independent variances" (Cavanaugh and Sternberg 2004: 164). This is not necessarily true, as independent axes can still have dependent variances, so their confidence intervals may be incorrect. Second, ANOPA is supposed to "make no assumptions about the distribution of the data" (Wood and Cavanaugh 2003). The very concept of confidence intervals is predicated on either an assumption of some parametric distribution, or is derived from a resampling routine such as bootstrapping. Without these, ANOPA's confidence intervals are meaningless and formal significance tests impossible. C&S therefore fail to outline any quantitative way to assess statistical significance. Note that they also ignore any effects of error or variance within species' datasets. ANOPA's statistical properties (that is, consistency) have not been documented; its performance has not been tested. Yet even if the confidence intervals could be trusted, one must be wary of any method that proposes to identify groups by visual examination of the data then carry out post hoc statistical tests on those groups.

5) **Loss of information.** According to Wood and Cavanaugh (2003), one of the selling points of ANOPA is that it "retain[s] more information regarding dataset variation"(p 3) than Principal Components Analysis. They have provided no formal mathematical proof that this is true, nor simulations or examples showing that ANOPA can succeed where PCA fails. In fact, it is unlikely that such a proof is possible for two reasons. First, there is no way to reduce highly multidimensional data down to three variables without losing substantial amounts of information. Second, Principal Components Analysis *does not need to lose any information at all*, because it is not limited to three dimensions as is the case for ANOPA. In the example of PCA provided in Figure 1, there were two variables to

begin with, yielding two principal component (PC) axes. Every data point can be precisely described in terms of those two PC axes; there is no loss of data unless one *discards* the PC axes that explain less variation (PC2 in the case of Figure 1). Generalizing to multi-dimensional data, if there are *m* different variables describing each point, PCA can provide up to *m* different PCA axes. These *m* axes can still precisely locate each data point, but are guaranteed to be independent of each other ("orthogonal"), unlike the original *m* variables. Data are only lost if one discards low-variance PCA axes. Admittedly, discarding low-variance axes is common practice, but it is neither necessary, nor likely to eliminate one's ability to distinguish distinctive clusters in morphospace. C&S could achieve their same baraminological aims by examining each PC axis for bi- or multi-modal distributions, if they deployed a suitable statistical test.

Interpretation of ANOPA results

When applied to the right kind of data, ANOPA is a mathematically sound way of rotating the data to reduce it to three dimensions. However, data rotation alone does not identify discrete groups or patterns in morphospace. Instead, Cavanaugh and Sternberg rely on "the practiced eye of an experience[d] analyst" (2004: 158), making clear that ANOPA does not provide an objective statistical tool for identifying morphologically distinct groups. Nonetheless, the authors have applied it to several datasets to search for evidence of such discrete groups (Cavanaugh and Sternberg 2004; Cavanaugh and Wood 2002; Wood and Cavanaugh 2001).

The first published application of ANOPA was on morphological data for the flowering plant subtribe Flaveriinae (Wood and Cavanaugh 2001) and later the larger tribe Heliantheae as a whole (Cavanaugh and Wood 2002). While both cases are clearly written from a biblical and young-earth creationist perspective, in neither case did the authors find strong evidence of distinct groups that might be identified as different holobaramins. This led to the curious conclusion that all 20 000 species of the family Asteraceae may be a single created kind that diversified after the Flood (Cavanaugh and Wood 2002). There is no clear discussion of the speciation or population genetic process that could lead to this diversity in the short time following the Flood.

In contrast, the *Journal of Biological Systems* paper (Cavanaugh and Sternberg 2004) was obviously sanitized for a scientific review process, and appears with no discussion of any evolutionary or creative processes. Instead, the authors focus purely on the existing pattern of morphological differences among species of centrarchids. Without any discussion of the mechanisms that produce this pattern or its implications, one wonders what the point of the exercise is. Yet there are hints at a creationist interpretation in the text, as in the statements that "the shape of the taxic groupings simply transcends a branching pattern" (p 155), and "that centrarchids anatomical data [may] have an overall poor fit to tree structures" (p 141). Given the authors' creationist sympathies, it is likely that they interpret this lack of fit to reflect a non-evolutionary history of centrarchids.

It is true that centrarchids' morphological variation is complex, with many homoplasies that complicate efforts to construct a robust phylogenetic tree. In a recent paper, Near and others (2004) count 27 distinct phylogenetic hypotheses that have been proposed at various times. This systematic inconsistency indeed suggests that anatomical data do not fit a tree structure very well. However, there are two possible explanations of this pattern. First, centrarchids may not have arisen by a branching pattern of sequential speciation events. While Cavanaugh and Sternberg do not explicitly endorse this point of view, their discussion points in that direction. However, it is important to note that a lack of *sequential* branching does not disprove evolution, as rapid bursts of speciation and diversification are well-known and can produce unresolvable phylogenies ("hard polytomies"). The alternative explanation is that centrarchids really did follow a regular pattern of branching evolution, but that morphological traits have evolved so quickly that distantly related species gain similar trait values and so appear similar for some traits, and dissimilar for others. Cavanaugh and Sternberg ignore this possibility.

Recent analyses of DNA sequence data from seven different genes for all 32 species of Centrarchidae provide a very well-resolved phylogeny (Near and others 2004, 2005). Not only do individual genes provide strong support for a regular evolutionary branching, but also all seven genes analyzed by Near and others provide similar topologies. This molecular data make it clear that branching evolution can nevertheless produce species that are morphologically poorly resolved, consistent with the second explanation listed above. It is also worth noting that one of the early morphological phylogenies, based on osteological characters that are ecologically less functional and so likely to show less homoplasy, provided a branching pattern identical to that found in Near and others (Branson and Moore 1962).

Conclusions

If ANOPA were a sound method, it could be quite useful for biologists interested in identifying disjoint sets of data points. For example, the technique might be useful in distinguishing the ecological niches of different species. However, Cavanaugh and Sternberg have given no convincing evidence that the technique is preferable to existing statistical methods (PCA, discriminant analysis, cluster analysis). Still more troubling, ANOPA provides no objective method for identifying discrete groups, uses no statistical framework for hypothesis testing, and is inappropriate for the categorical data to which Cavanaugh and Sternberg apply it. Finally, Cavanaugh and Sternberg interpret their results without careful consideration of alternative hypotheses for their results. Integrating in recent molecular results, it is clear that the patterns identified by Cavanaugh and Sternberg are consistent with traditional evolutionary explanations, and centrarchids do not really "transcend a branching pattern of evolution".

The Basic Types of Life: Critical Evaluation of a Hybrid Model

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Two years ago the publication of a pro-"intelligent design" (ID) paper in a low-impact peer-reviewed journal, *Proceedings of the Biological Society of Washington,* sparked a series of responses within the scientific community. When the controversial article entitled "The origin of biological information and the higher taxonomic categories" by the Discovery Institute's Stephen C Meyer was made available online on August 28, 2004, public reaction followed immediately. On September 6, a News & Features reporter from *Nature* contacted me with the following request: "I would like to hear your thoughts on the significance of the Meyer publication. Is it very rare for ID papers to appear in any peer-reviewed journal, and I wonder what the ID movement will make of this?" Since I was at a scientific meeting when this e-mail arrived in my office, my comments came too late and were not included in the news story published on September 9 (Giles 2004).

Our colleagues of the NCSE did an excellent job in dissecting and rejecting the pseudoscientific claims in the Meyer paper. Their critique is available on-line on The Panda's Thumb (<http://www.pandasthumb.org/archives/2004/08/meyers_hopeless_1.html>, a website devoted to evolutionary biology and its critics.

In this report I will show that other pro-ID statements and articles have crept unnoticed into the recent scientific literature. I will concentrate on the European ID movement that was recently described in this journal (Kutschera 2003a, 2004a; see also Kutschera 2003b, 2006a, 2006b; Graebsch and Schiermeier 2006) and will also critically evaluate the hybrid creation/evolution hypothesis of Reinhard Junker and Siegfried Scherer (1998, 2006).

Creation of *The Basic Types of Life* in 1992

In 1993, a multi-author monograph edited by microbiologist Siegfried

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Scherer was published in German (with a summary in English) wherein the "Grundtypen des Lebens" (basic types of life) were introduced. In a report on the Third International Conference on Creationism, the creationist dogmas of Scherer and others (1993) were summarized as follows:

> What are the concepts of creationism of which we are certain and sure: foundations that we can reliably rest upon in our defence and promote in strategic advance? One of the cardinal and most powerful tenets is undoubtedly the *Genesis Kind*. In *the Bible* (*Genesis*, Chapter 1), God created animals and plants after their own kind[s]. The opinion among creationists today is that these kinds overall represent higher taxonomic groups such as the family, and that God created an inbuilt capacity for variation within a kind but not between kinds. What is new is the particularly exciting developments in this field of research by Siegfried Scherer and his colleagues. They employ the term *Basic Type*, coined by Frank Marsh some decades ago, to denote a Genesis Kind, and outlined their findings at the 3rd International Conference on Creationism at Pittsburgh.
> ...
> An abundant literature of hybridi[z]ation data is in existence, particularly for the birds and mammals. At least 1 in 10 bird species is known to hybridi[z]e. So for a world total of 9672 bird species, 895 species have bred in the wild with at least 1 other species. As well as interspecific, intergeneric and even intertribal crosses have been found. To these can be added a great number of hybrids obtained in captivity. Scherer and colleagues have seized the opportunity to harness this data by constructing cross-breeding matrices, and in some cases have added supplementary criteria. In this way, 14 Basic Types of animals and plants have been demarcated which display hybridi[z]ation within the Types, but not between the Types and their nearest taxa. The Basic Types include, for example, the Anatidae (ducks, geese and swans), Equidae (horses and zebras), Cercopithecidae (old-world monkeys), Canidae (dogs, wolves and foxes), Maloideae (apples and relatives), Aspleniaceae (spleenwort ferns) and Triticeae (wheat, barley, oats and rye).
> ...
> During the European Creationist Congress in 1992, a number of us had a brainstorming session to evaluate the known criteria for demarcating the Genesis kinds and to search for the best way forward.
> ...
> Scherer and colleagues have recently brought these ideas together into a publication, *Typen des Lebens*, which contains an overview, then a chapter focusing on each Basic Type. This is an important book. It may provide the most significant contribution yet offered in this decade to a creationist research programme. (<http://www.biblicalcreation.org.uk/scientific_issues/bcs052.html>)

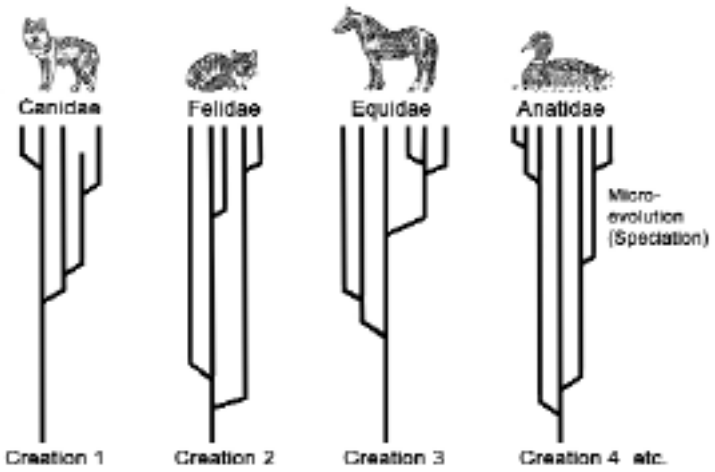

FIGURE 1
The basic types of life: God created animals (and plants) after their own kinds. These basic types were equipped with a built-in capacity for variation: via microevolutionary processes new species are produced (adapted from Korthof 2004).

In their popular schoolbook *Evolution — Ein kritisches Lehrbuch* (*Evolution: A Critical Textbook*), Junker and Scherer (1998, 2006) introduce these "basic types" as an "scientific" alternative to the occurrence of novel phenotypic variants, species, and ultimately new body plans via natural processes (macroevolution). The "Creator" (God in the Bible) is also called the "Designer", so that the term "ID creationism" appears appropriate (Kutschera 2004a, 2004b, 2006a, 2006b). They use the term "genetisch polyvalente Stammformen" (genetically polyvalent ground types) when they refer to the "Schöpfungseinheiten" (created units of life) in their textbook. This terminology is misleading, because such a combination of words from the biological literature sounds "scientific", but is only a euphemism of Bible-based dogmas.

To the chagrin of the authors, evolutionary biologists have ignored this version of ID creationism in academic books and articles (Kutschera 2006a). However, Junker and Scherer succeeded in getting their creationist dogmas into the scientific literature — one major goal of virtually all anti-evolutionists (Scott 2005).

It should be added that the first author of the *Critical Textbook*, the theologian and former biology teacher Junker, explicitly pointed out that the "basic types" of life were created "via the word of the God in the Bible about 10 000 years ago" (see Kutschera 2004b for further discussion). This time interval is not mentioned in the collection edited by Scherer (1993) nor in the textbook of Junker and Scherer (1998, 2006). However, it forms the time frame of their creationist model of "creation plus microevolution (speciation)", which is usually depicted in mini-trees without common descent (Korthof 2004): The Creator (or Designer) acted via independent biblical miracles. A few thousand years later, microevolution occurred, so that the created "basic types" diversified.

Basic types in the scientific literature: *Flora*, *TREE*, and *NR*

In order for a monograph to become accepted in the world of science it is imperative to receive positive reviews in established journals. In the journal *Flora*, which published a positive book review of the fifth edition of the *Critical Textbook* (see Kutschera 2003a), the same reviewer had expressed his enthusiasm for Scherer's "basic types" in a long article (Weberling 1996). His book review is composed of an introduction, in which he refers to the "established fact that bastards between animal and plant species occur frequently," a description of all the chapters, and a positive final comment. His basic message can be translated as follows: "The referee concludes that the 'Basic Types' concept should be tested and recommends that the ideas described in this book be followed up" (Weberling 1996).

The young-earth position — 10 000 years since the creation of the "basic types" — resonates in the literature authored by the European ID creationists. For instance, in a News & Comment article published in *Trends in Ecology and Evolution* by Loewe and Scherer (1997), the authors argue as follows: "The hypothetical descent of mankind from 'mitochondrial Eve' has been much debated … Nobody was actually there … If molecular evolution is really neutral at these sites, such a high mutation rate would indicate that Eve lived about 6500 years ago." It should be noted that Loewe and Scherer (1997) did not refer to the "basic types", but other phrases commonly used by creationists are apparent in this article; for example: "Nobody was actually there." Perhaps more important is that this note was published in a high-impact journal — one widely read and respected by practicing scientists.

The rapid speciation in East African cichlid fishes described by Salzburger and Meyer (2004) is another focus of creationist "research activities" to prove the concept of the "basic types". In their textbook, Junker and Scherer (1998, 2006) refer to the first appearance of cichlids less than 12 000 years ago in certain African freshwater ecosystems. On the basis of this apparent young age of certain species, Menting (2001) described Junker and Scherer's (1998) supranaturalistic "speciation model" in the respected German scientific journal *Naturwissenschaftliche Rundschau* (*NR*). The author concluded that "the biologists Junker and Scherer regard the explosive speciation events as a process that is caused by polyvalent basic types with an built-in capacity for variation" (Menting 2001). This reference to the dogmatic views of the German creationists in *NR* led to an exchange of letters between biologists and Menting (see Kutschera 2004b). The editor of *NR* explained that he was unaware of the covered promotion of the "basic types" in his journal and pledged not to accept such a manuscript again.

Today we know that the age of "less than 12 000 years" cited by Junker and Scherer (1998) is a gross underestimate: Salzburger and Meyer (2004) provide phylogenetic data documenting that Lake Victoria's cichlid fauna is about 100 000 years old — about ten times older than required by the biblical "basic types" model described above.

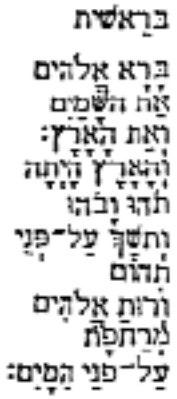
בְּרֵאשִׁית
בָּרָא אֱלֹהִים
אֵת הַשָּׁמַיִם
וְאֵת הָאָרֶץ׃
וְהָאָרֶץ הָיְתָה
תֹהוּ וָבֹהוּ
וְחֹשֶׁךְ עַל־פְּנֵי
תְהוֹם
וְרוּחַ אֱלֹהִים
מְרַחֶפֶת
עַל־פְּנֵי הַמָּיִם׃

Figure 2
Original sentence from the Bible (Genesis 1:1), where the first description of the creation myth appears (from Peschek and others 2004).

Abrupt appearance of species in the *Annual Review of Genetics*

A major achievement of the European ID movement was the publication of a review article, "Chromosome re-arrangement and transposable elements" (Lönnig and Saedler 2002) in a high-impact book series. Lönnig and Saedler (2002) discuss the possibility of a "partly predetermined generation of biodiversity and new species". This proposal is further described as a "non–selection-driven, autonomous origin of part of biodiversity," as an "abrupt appearance of biodiversity and new life forms," and as the "possibility of abrupt boosting of biodiversity and species formation". To convince the reader, the authors use a three-step strategy in support of their claims.

First, they cite statements of the German anti-Darwinist Otto Schindewolf (1896–1971) and the geneticist Richard Goldschmidt (1878–1958), who both were strong opponents of neo-Darwinism and the synthetic theory (Kutschera and Niklas 2004). Schindewolf believed in a "sudden, discontinuous direct refashioning of the type complex from family to family," a religious dogma related to the "basic types" model. Goldschmidt stated that the "neo-Darwinians never built up as much

as the semblance of an new species by recombination and micromutations." In the fruitfly *Drosophila*, "in which numerous mutations have been recombined, never has even the first step in the direction of a new species been accomplished, not to mention higher categories" (Lönnig and Saedler 2002).

Second, the authors state that the origin of higher systematic categories depends on the "genesis of irreducibly complex structures" and refer to the publications of the US ID creationists Behe and Dembski, and their German counterpart Lönnig. Finally, Lönnig and Saedler (2002) describe the Cambrian explosion and cite Darwin's statement that this phenomenon must remain "inexplicable and may be urged as a valid argument against the theory of descent with modification" (Darwin 1872). According to Lönnig and Saedler (2002), this verdict "still seems to have some force for the uncommitted observer". In their conclusion, the authors point out that there are currently "many opinions" on the origin of species and refer to publications of prominent evolutionists such as Maynard Smith, Stanley, and Benton and to those of ID-creationists, such as Dembski, Behe, and Lönnig, which are treated as equivalent, valid contributions to modern science. In their final statement, Lönnig and Saedler (2002) argue that we should "continue to welcome the plethora of different and diverging ideas and hypotheses on the origin of life … wherever they may lead".

As expected, Meyer and other members of the ID movement refer to the review of Lönnig and Saedler (2002) in their publications and regard this article as a major achievement in their agenda against naturalistic thinking and "atheistic" science. The "basic types of life" are not mentioned by Lönnig and Saedler (2002), but the authors refer to Menting (2001) and other sources where this supranaturalistic concept is discussed (that is, popular books and pamphlets that are at the fringe of the scientific literature). Examining their bibliography, it is obvious that Lönnig and Saedler (2002) did not meet the usual standard of citations of credible sources. Several evolutionary biologists protested the publication of this pro-ID article in the *Annual Review of Genetics*. One of the editors responded to a colleague, apologized for the editorial board's erroneous decision, and promised that such an error will not occur again.

The creation myth in *Physiologia Plantarum*

The concept of "basic types" (Scherer 1993) is based on a dogma in the Bible (Genesis) that states that God created animals and plants; its proponents estimate that this event occurred at about 10 000 years ago. It is obvious that creationists are eager to get this perspective on the Bible into the biological literature, because these modern anti-evolutionists like to call themselves "scientists" or "ID theorists": they don't like the old-fashioned word "creationist" and avoid it wherever possible (Pennock 2003; Kutschera 2003a, 2003b, 2004a, 2006a, 2006b; Numbers 2006).

I was very surprised to see that this goal of the ID movement has now been reached. In a recent issue of the journal *Physiologia Plantarum*, a periodical that is devoted to the physiology, biochemistry and molecular biology of plants (including algae and cyanobacteria), Peschek and others (2004) published a minireview on the role of cyanobacteria during earth's history. Although Peschek and others admit that "cyanobacteria entered the stage as the first … oxygenic phototropic prokaryotes about 3.2 billion years ago," they incorporated the creation story as written down in the Bible. Moreover, they reprint a biblical document that is reproduced here. The legend to their Table 1 contains the Hebrew text shown in Figure 2, with the caption "The crucial steps in the evolution of the universe, of our earth, and of life on this earth. Left-hand side: Original sentence (Moses 1, 1) introducing the creation myth described in the Holy Bible ('At the beginning God made …') — and who knows how it really happened …?" (ellipses in original).

How could this theological dogma slip into an international journal devoted to plant sciences? I do not know whether or not the authors are adherents of Bible-based anti-evolutionism. However, in this minireview, Scherer — the ID creationist and "father" of the "basic types" of life — is quoted repeatedly. Seven of Scherer's papers on cyanobacteria are listed in the references. I suspect that under the influence of Scherer, this reproduction of a biblical mythos has crept into the journal *Physiologia Plantarum*.

Basic Types as sterile pseudoscience

Scott (2005), Pennock (2003), and others have pointed out that methodological naturalism as an approach to teaching and research about evolution is a religiously neutral undertaking. Modern science is based on an international consensus that a priori excludes supernaturalistic forces (acts of a Creator or a Designer, biblical miracles, and so on). The ID movement seeks "nothing less than the overthrow of materialism …, aiming to replace this with a theistic understanding of nature" (Pennock 2003). The "basic types" model of the German ID creationists, depicted in minitrees without common descent, is a perversion of science for following reasons:

1. Supernatural forces of a Designer (identified as God in the Bible) are mixed up with natural processes (microevolution or speciation), leading to a sterile "hybrid model" without explanatory power.
2. According to Junker and Scherer (1998, 2001), the independent acts of the Designer/Creator cannot be described and analyzed with the methods of modern science. Therefore, this biblical miracle can not be accepted within the framework of modern biology.
3. Darwin's principle of common descent of all forms of life has been verified by an extensive body of molecular data, depicted in the universal phylogenetic tree (Kutschera and Niklas 2004;

Kutschera 2006a). Junker and Scherer's "basic types" model ignores one of the most important insights of molecular biology, which has been corroborated by hundreds of independent research projects and published in the scientific literature.

4. According to the biblical dogma, intermediate forms between "basic types" have never been "created". However, many such "connecting links" in the fossil record of life (notably among vertebrates) are described in the literature (Futuyma 1995; Kutschera and Niklas 2004).

5. Junker and Scherer (1998, 2006) do not mention the biblical time interval (10 000 years), but describe the documented age of the earth of about 4600 million years as only a "common assumption". Even if we ignore the dogmatic 10 000 years since the creation of the "basic types", this hybrid model is incompatible with facts from paleontology. For instance, fossil horses (Equidae) are known since the early Eocene (about 55 million years ago), but the cat family (Felidae) is much younger (early Oligocene, about 34 million years ago; see Benton 1997). Independent acts of creation at the same biblical time point are incompatible with these documented facts.

6. According to the "basic types" model, microevolution (speciation) took place via natural processes, but macroevolution (the occurrence of novel body plans) is the result of miracles. However, the exact mechanisms of speciation in nature are not better known than the major transitions in the fossil record of life (Kutschera and Niklas 2004, 2005). Both evolutionary processes are under investigation by biologists around the world, and progress occurs at about the same pace. Why should we not accept macroevolution and attribute speciation — processes that are not fully elucidated (Salzburger and Meyer 2004) — to miraculous (supernaturalistic) acts of a Designer? Junker and Scherer (1998, 2006) would respond: "The Bible tells us so!"

These arguments and others (Futuyma 1995; Korthof 2004; Kutschera 2004a, 2006a, 2006b; Neukamm 2006) show that the creationist "basic types" model is no alternative to naturalistic evolution, which is supported by thousands of mutually supporting research papers that have been published in the peer-reviewed scientific literature over the past century. However, the molecular mechanisms that bring about phenotypic evolution in the various lineages of organisms are still under investigation (Kutschera and Niklas 2004, 2005).

Conclusions

The ID movement gathered momentum around 1990 under the leadership of a law professor at the University of California, Berkeley, and reached Europe a few years later (Kutschera 2003a, 2003b, 2004a, 2004b, 2006a; Graebsch and Schiermeier 2006; Numbers 2006). The German microbiologist Siegfried Scherer — a former associate of the US-based Discovery Institute — introduced the hybrid model "Creation plus microevolution leads to biodiversity" under the label of the so-called "basic types of life" in 1993. This theistic view of the evolutionary forces forms the core of a popular German text book that has been translated into several European languages (Junker and Scherer 1998, 2006). When this essay appears in print, the sixth edition of this German "Bio-Bible" will be in the shelves of evangelical Christian bookshops around Europe. Unfortunately, ID creationism "made in Germany" is a success story.

Phillip Johnson, the father of the US ID movement, expressed his views in his bestseller *Darwin on Trial* (since 2003 also available in a German translation) as follows. "[creationist] doctrine has always been that God created basic kinds, or types, which subsequently diversified. The most famous example of creationist microevolution involves the descendants of Adam and Eve, who have diversified from a common ancestral pair to create all the diverse races of the human species" (Johnson 1991: 68). It is obvious that the "basic types" model introduced by Junker and Scherer (1998, 2006) is similar to (or even identical with) the miraculous story told by Johnson. This pseudoscientific view goes back at least to Frank L Marsh (1944) and was revitalized in a 1992 conference on creationism. Since then, the concept has crept into the scientific literature, mostly unnoticed by the corresponding journal editors. Therefore, scientists around the world should stay alert so that a further infiltration and undermining of the international literature on evolutionary studies can be prevented. Since science is by definition nontheistic, it follows that theistic views and dogmas can never become part of naturalistic theories in evolutionary biology.

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Species, Kinds, and Evolution

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Introduction

Creationists oppose the idea that species can evolve indefinitely and charge evolutionary biologists with failing to define their terms properly. In this article I want to trace briefly the history of the idea of species and show that it is in fact a virtue of biology that it tries to make its terms follow the evidence rather than to define them all up front. The idea that species were universally thought to be fixed prior to Darwin is simply wrong — many creationist thinkers of the classical period through to the 19th century thought that species could change. The issue of evolution was, in fact, impossible to suggest until the claim was made that species were fixed, and as soon as it was suggested, so too was evolution. There has been a longstanding vagueness about living "kinds" that goes back to the classical era and that follows from good observation. What is more, nothing in the biblical or theological traditions requires that species are fixed, only that kinds exist, which neither evolutionists nor traditional creationists ever denied.

Because the number of species "concepts" in the literature is high, I have also tried to put them into context and list them for easy reference (*see sidebar p 42–3*). That way, when a "concept" is referred to in a text, it can be compared to other candidate conceptions. It is clear to me, at any rate, that there are many conceptions of species, and that biologists use the one that best suits the organisms they study. I think of this as a "conceptual delicatessen" — when scientists need a species concept to suit the organisms being studied, they will typically assemble a custom "club sandwich" from previous ideas. This is not bad practice — if science is about learning and using words to express that learning, then we should expect that they would do this, and in fact they *should*.

To understand the concept of species, we must understand how the notion developed in the history of biological research. One point that must always be borne in mind: people did not suddenly become smart upon the publication of *On the Origin of Species*, nor were they bad observers before that date. And keep in mind a related point: religious commitment had little to do with the sorts of conclusions natural historians and biologists reached before

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Darwin, and it seems that *in science*, it still does not now.

The evolution of the species concept

> Then God said, Let the land produce vegetation: seed-bearing plants and trees on the land that bear fruit with seed in it, according to their various kinds. And it was so. The land produced vegetation: plants bearing seed according to their kinds and trees bearing fruit with seed in it according to their kinds. And God saw that it was good. …
>
> And God said, Let the water teem with living creatures, and let birds fly above the earth across the expanse of the sky. So God created the great creatures of the sea and every living and moving thing with which the water teems, according to their kinds, and every winged bird according to its kind. And God saw that it was good. …
>
> And God said, Let the land produce living creatures according to their kinds: livestock, creatures that move along the ground, and wild animals, each according to its kind. And it was so. God made the wild animals according to their kinds, the livestock according to their kinds, and all the creatures that move along the ground according to their kinds. And God saw that it was good.
>
> Genesis 1,
> verses 11–2, 20–1, 24–5,
> New International Version

So long as people have been farming plants and raising livestock, they have been aware that one organism gives birth to another very like it. That is, they have known that living things come in kinds. This is not confined to the Bible, of course. Aristotle knew it. So did Theophrastus, his student, sometimes called the father of botany. It is not, as they say, rocket surgery.

So given the relatively short time scale of human observation, it followed that people would tend to think that species, living kinds, were stable; and they did. But they did not think species were *unable* to change for a very long time, not until John Ray, a brilliant English 17th-century botanist who compiled the first complete flora (of Cambridgeshire, and then of England), wrote in an influential work:

> After long and considerable investigation, no surer criterion for determining species has occurred to me than the distinguishing features that perpetuate themselves in propagation from seed. Thus, no matter what variations occur in the individuals or the species, if they spring from the seed of one and the same plant, they are accidental variations and not such as to distinguish a species … Animals likewise that differ specifically preserve their distinct species permanently; one species never springs from the seed of another nor vice versa.

This was the first recorded *biological* definition of "species", although the logical term had been used in biological contexts for a long time prior to that. But his was not the traditional view. Following a suggestion of Aristotle that new species were formed by hybridization at water holes in Africa, St Augustine, among others (including one of the translators of the King James Bible), happily accepted that new species could be formed out of old ones. Linnaeus himself, who is sometimes regarded as the originator of species fixism, observed hybridization between two plant species in his own garden, and late in life revised his view that species were as the "Infinite Being" had first created them. Certainly there was no tradition in Christian theological circles that species *had* to be unchanging before then.

During the Middle Ages, little natural history — or biology as we would now call it — was being done. But there was an exception: the Holy Roman Emperor Frederick II of Hohenstaufen (1194–1250) was a keen falconer, and wrote, literally, the book on it, finding that Aristotle was sometimes a bit too credulous, and worse that he failed to discuss hawks, falcons, and hunting birds. Frederick had the resources and the time to do a proper study, and he found that bird species were not simple things at all. He settled on interbreeding as a standard. Albert the Great, who had access both to Frederick's falconers and writings, followed this idea. But both still took seriously enough the old idea of spontaneous generation of species from other species to investigate it. Frederick sent envoys to Sweden looking for evidence for or against the idea that the barnacle goose arose out of worms (which is how it got its name). He found no evidence and concluded that the idea was based on ignorance. Albert did breeding experiments and managed to show that the geese laid eggs in the usual manner.

So we should first of all abandon the idea that people before Darwin thought that species were fixed, necessarily. Some did; many did not. Moreover, almost as soon as the idea of species-fixism caught on, it was challenged. Linnaeus made the idea popular in his *Systema Naturae*, the first edition of which was in 1735. In 1745, physicist Pierre Maupertuis argued in his *Physical Venus* that species did evolve, that they did so through a crude version of natural selection, and that inherited characteristics were passed on in a 3:1 ratio through both mother and father. While this did not influence many people at the time, it indicates that fixism was not universal among scientists even when it was still a new idea.

Why is it that we tend to think pre-Darwinians were all fixists? In part this is because Darwin has been used as a turning point in modern biology, which of course he was, and so some, the leading evolutionist Ernst Mayr among them, have tried to make him the ultimate source of all that is correct in modern biology. Furthermore, we think that religious belief before Darwin must have forced people to be fixists. But many quite orthodox Christians held to transmutation of

species, and in some cases where this was denied, such as by the great anatomist Baron Cuvier, it was not for religious reasons but from a lack of evidence (although Cuvier managed to present the evidence that florae and fauna were not constant through time, even in Europe).

It is also not true that belief in creation as such forced a species-fixist position. Apart from deism, which perceived God as a creator who effectively left the world to run by the laws he created, many Christians held that the work of creation was still under way. And Christians who were natural historians, whether botanists or zoologists, often described species fairly well.

There is another myth — that before Darwin naturalists thought that species were defined by their morphology or their "essence". But morphology was used by taxonomists simply as a way to identify species, not as the cause of them, and even Linnaeus knew that his "Natural System", as it came to be called, was a useful convention, not a natural system at all. Taxonomists argued about *how* to define species, but in nearly all cases this was about how many and what kinds of characters were reliable. In the early 19th century, there was no "species problem", but only a "species question", which a minor geologist by the name of Charles Lyell called "that mystery of mysteries" — why were there species? It was not a question he, an orthodox Christian, thought could be answered from Scripture. Neither did his eventual disciple Darwin think that.

Darwin's view of species has likewise been misunderstood, in part because he did not really consider the definition of a species to be the primary question. Like many professional taxonomists (Darwin wrote the first and still one of the best descriptions of barnacles), he found the constant squabbling about whether this variety or that was a separate species or the same to be a nuisance to doing the work. He cited with wry amusement one taxonomist, Phillips, who declared "at last I have found out the only true definition — 'any form which has ever had a specific name'!" And there was, in 1842, a set of standards from which all modern taxonomic rules derive — Darwin was a committee member — which formally instituted the rule of Linnaeus that species had to have a binomial (a genus and species name), and that only professionals could name species (to stop bird-watching enthusiasts naming every different plumage as a species). In the *Origin*, he wrote:

> … it will be seen that I look at the term species as one arbitrarily given, for the sake of convenience, to a set of individuals closely resembling each other, and that it does not essentially differ from the term variety, which is given to less distinct and more fluctuating forms. The term variety, again, in comparison with mere individual differences, is also applied arbitrarily, for convenience's sake.

On the basis of this and other comments, he seemed to be saying that a species was not a real thing, but that it was just what we *called* something for convenience. But in his works overall, he treats species as real things, mostly (but not always) isolated by infertility, with different ecological adaptations. His point was, and it remains a sticking point today, that the difference between a species and a *variety* within a species was vague. This, of course, is due to the fact that species, like sand dunes, rivers and clouds, have no hard and sharp boundaries between them because of evolution.

About the time evolution had been universally accepted by naturalists (now called biologists), but before the new Darwinism of the synthesis of genetics and evolution had been settled, one EB Poulton wrote a paper in 1903 entitled "What is a species?" in which he addressed what now became the species "problem". This set the agenda for the next century. From being the useful identification of kinds that might vary, in the late Middle Ages and after, through to being a problem of who got to name species and how they were to be differentiated, now species were the "units" of evolution, and of biology in general. And a veritable explosion of attempts to define species followed. By the end of the 20th century, there had been some 22 distinct concepts identified by RL Mayden, and depending on how one divides them, some few others have been added. By my count, there are around 26 concepts (*see sidebar, p 42–3*).

Well, not exactly concepts. There is only one *concept*, which we label by the word "species". There are 26 or so *conceptions*, or definitions, which we define in other ways. This slightly picky philosophical point matters. We are arguing over the best way to define a concept. This depends on scientific data, theory, and other factors (some of them political, within the scientific community). We might deny that the concept even *has* a useful definition, or we might think that we have been misled by the use of a single word and seek a number of different concepts that serve the purposes of science and knowledge. I mention this because one of the oft-repeated claims made by anti-evolutionists is that if we cannot define our terms, we cannot show that species evolve. This canard goes back to Louis Agassiz, the famous geologist and paleontologist, who single-handedly introduced America to biology. Agassiz wrote:

> [I]f species do not exist at all, as the supporters of the transmutation theory maintain, how can they vary? And if individuals alone exist, how can differences which may be observed among them prove the variability of species?

Darwin rightly snorted to Agassiz's one-time student Asa Gray:

> I am surprised that Agassiz did not succeed in writing something better. How absurd that logical quibble — "if species do not exist how can they vary?" As if anyone doubted their temporary existence.

Creationists will often claim that they are not interested in the species level, though. Initially, cre-

ationism did require fixity of species. In the 1920s, when George McCready Price equated "species" to the biblical "kinds", he was forced, to allow for the Ark to carry "every kind", to raise the bar higher. Even this was not original. In the late 18th century, Buffon, Cuvier's predecessor, had suggested that there was a "first stock" from which all members of a kind had evolved, so that all cats evolved from an original animal, modified by geography and climate, for instance. So creationists themselves have a "vagueness problem" no less than evolutionary biology does. Life is vague. Certainly the creationist "kind", or "baramin", as they mangle the Hebrew for "created kind", is extremely elastic. Given that elasticity, the motivation for the inference that was made naturally during the 17th and 18th centuries that *species* do not evolve is undercut. If kinds are not exact in reproduction, why think that the Genesis account is enough to prohibit evolution? The answer is, of course, that biblical literalism is not the primary motivation here for opposition to evolution.

The species problem

Reproductive isolation conceptions

It begins in 1935, when a young fruit fly geneticist named Theodosius Dobzhansky published a paper "A critique of the species concept in biology" in a philosophy journal. Not that there had not been developments after Darwin. Various people had suggested that species were "pure gene lines" or "wild-types" that did not vary much. Mendelian genetics caused a lot of debate about species. Dobzhansky claimed that a species was:

> … a group of individuals fully fertile *inter se*, but barred from interbreeding with other similar groups by its physiological properties (producing either incompatibility of parents, or sterility of the hybrid, or both).

This was the original genetic version of reproductive isolation concepts (Buffon had proposed interbreeding as a test a century and a half earlier, which Darwin rejected). Unfortunately, a version framed by Ernst Mayr got called the "biological" species concept, in contrast to what were seen as "nonbiological" concepts that relied largely on form and based in museum taxonomy, which were called "morphological" concepts by Mayr. But I think it is better to call these Reproductive Isolation Species Concepts (RISC) than "biological" ones, for any decent species conception is biological. Mayr's version changed over the years, but the one taught to most undergraduate biology students is the original:

> A species consists of a group of populations which replace each other geographically or ecologically and of which the neighboring ones intergrade or interbreed wherever they are in contact or which are potentially capable of doing so (with one or more of the populations) in those cases where contact is prevented by geographical or ecological barriers.

Or shorter:

> Species are groups of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups.

Much of the focus on species after this centered on Reproductive Isolating Mechanisms, or RIMs for short. Mayr's view was that species are formed when part of the species is geographically isolated from the main range and evolves in its own way such that when it gets back in contact, RIMs have evolved, as it were, by accident, and the two no longer interbreed successfully. Selection against hybrids, which are, so to speak, neither fish nor fowl in ecological adaptations, then strengthens the isolation (a process called "reinforcing selection"). Mayr's version of the origin of species, published in 1942 and reiterated for the next 60 years (Mayr survived to 100, outliving many of his adversaries, and thus getting the last word), is called the *allopatric* theory of speciation. Allopatry means that two populations, or species, or groups, of organisms live in different areas (*allo-* = other, *patria* = homeland). The alternative kind of speciation, which is in effect Darwin's view, is called *sympatric* (*sym-* = together) speciation, and it is highly contentious among specialists, with some thinking that it occurs, particularly among fruitflies and lake-bound fishes, where it has been studied, and others thinking that it does not, and the debate goes on. It requires that RIMs evolve in place, so to speak, and the naysayers think this is unlikely to occur. If sympatric speciation does occur, then there can only be one reason — natural selection. Recent theoretical work shows that it is possible if the conditions are right. What we do not yet know for sure is how often the conditions *are* right.

There is another uncontested class of speciation processes — usually involving hybridization, that old idea of Aristotle. In plants particularly, but also in animals, fungi, bacteria, and so on, sometimes entire genetic complements can double, triple or more, resulting in a condition known as polyploidy. When this happens, sometimes the chromosomes and genes do not line up due to differing genetic structures of the parents, but an extra doubling of the genome, followed by a cell division, can give the cell a paired set of chromosomes, allowing it effectively to found a new species in one or a few generations. When two species interbreed, this allows the resulting organism to have a matched set of chromosomes. It has been estimated that nearly all ferns, for example, have a case of polyploidy in their ancestry, and as many as 7% of actual fern species are formed this way. It has also been seen in flowering plants, corals, grasshoppers, other insects, and reptiles. It is even hypothesized that the entire mammalian branch of the evolutionary tree was started with this kind of event. So in a sense, Linnaeus and Aristotle were right … sort of. Even Mendel thought this might be the reason why new species

evolve, which informed his research into hybrid forms, although he studied hybridization within, not between, species.

Evolutionary conceptions

So the RISC conceptions have a lot of leeway for interpretation. But they are not the only conceptions on the board. One kind of conception goes by the name *evolutionary species concepts*, which is also a misnomer (because all species have evolved). On this view, it does not much matter if two possible species under consideration are reproductively isolated. Even if there is gene flow between them on a regular basis, what counts is whether or not they remain evolutionarily distinct. Dobzhansky's definition has a hint of this, but the original formulation is due to a paleontologist, George Gaylord Simpson. Simpson defined it this way in 1961, although there is an earlier and more technical definition from ten years before:

> An evolutionary species is a lineage (an ancestral–descendant sequence of populations) evolving separately from others and with its own unitary evolutionary role and tendencies.

What counts here is that no matter what happens in terms of gene exchange, the populations remain distinct, and have their own forms, adaptations, and fate. The term "lineage" used here is particularly important, as it focused biologists' thinking more in evolutionary terms, and gave rise to yet another class of conceptions — phylogenetic species concepts.

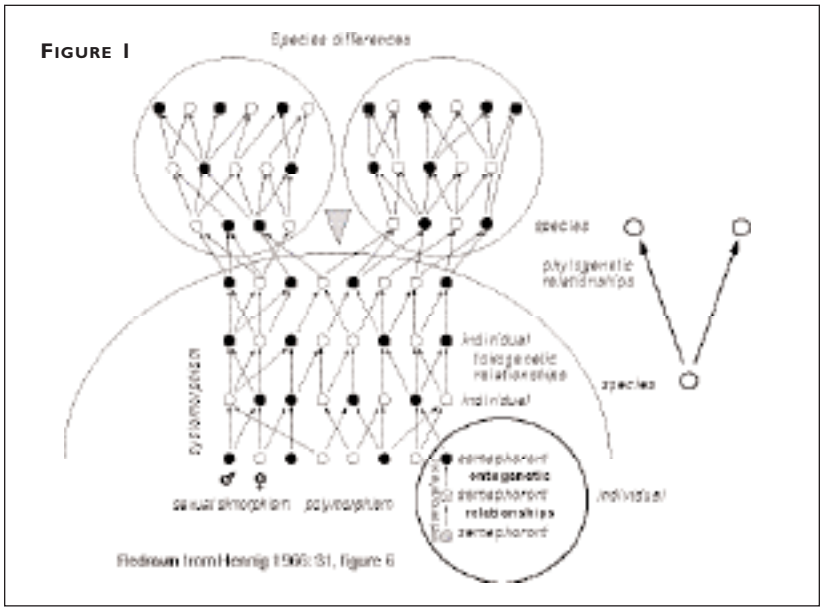
Evolutionary conceptions have been expanded since Simpson to include asexual organisms (which do not, strictly speaking, form populations, since that term involves *inter*breeding). The important point is that there is a single lineage over time. In contrast, the RISC conceptions involve a single time "horizon", which means that a species is something that *at a particular time and place* is not interbreeding with other populations, and they also, necessarily, exclude asexual organisms.

Phylogenetic conceptions

There is a group of species conceptions that go under the shared name of *phylogenetic species concepts*. A phylogeny is, of course, an evolutionary history, and the initial proposal for a phylogenetic conception came from Willi Hennig, an East German entomologist who nevertheless managed to influence a great many biologists during the height of the Cold War. Hennig's methodology and philosophy of classification is known today as "cladistics".

Hennig did not set out to come up with a new species concept. He pretty much assumed something like an amalgam of Mayr's and Simpson's definitions. The difference was that he focused on the lineage element, and combined it with a clear and formal account of making groups logically. In his book *Phylogenetic Systematics*, translated into English in 1966, he included a diagram about speciation (redrawn above as Figure 1), and when to name a new species.

FIGURE 1



Redrawn from Hennig 1966: 31, figure 6

There are several lineages in this diagram. Ignoring the technical terminology (Hennig was a great one for coining classical names), you can see that each individual organism is part of a *genealogical* lineage. These, when grouped together, form a *species* lineage. Clearly what makes a species lineage is the fact that the overall tangled net of genealogical lineages has not yet divided (as in the right-hand diagram marked "phylogenetic relationships"). When it has, says Hennig, the old species is extinguished and two new ones come into being (as in the separate circles at the top).

This provision caused a lot of anxiety. It seemed to be saying that a species *has* to go extinct when new ones come into being, but of course a new species can evolve without modifying the old one much, if at all. Hennig's convention, as it is known, was more a point about *naming* species than a definition of their biological nature. When a new species arises, the old name refers to only a part of its descendants and for Hennig that meant it was no longer a "natural" group being named. It is rather like calling rock music "blues" because it is a descendant of blues. What Hennig said would mean that what is still "blues" has to get a new name so that musicologists can talk without ambiguity (so it might get called "traditional blues").

Phylogenetic species conceptions come in three broad flavors. One is the "pure" Hennigian conception described above. But Hennig's methodology also relied on dividing organisms by shared features, which is a diagnostic question. So another phylogenetic conception, which I call the autapomorphic conception (after one of Hennig's technical terms that means "derived forms"), defines a species as the final node

on a phylogenetic tree, which is based on comparison of many features. If the analysis does not produce any smaller group, then the organisms in this group constitute a species. This has a side effect of increasing the number of species over the older RISC conception — by as many as five times — and for this reason it is not accepted by many taxonomists. On the other hand, if a species really *is* just the as-yet-undivided tangled net of genealogical relations, this is what we have to deal with. The autapomorphic conception tends to leave historical issues about whether or not the phylogenetic tree is a good historical representation to one side. The "species" here is diagnostic.

The other conception I call the phylogenetic taxon conception. On this view, a species is just another kind of taxon in a phylogenetic tree — one that happens to be *monophyletic* and undivided. *Monophyly* in this case simply means that no descendent of the original species is excluded, so that if a single species *did* divide into two, it would have been a species before, but is now two species, which is pretty obvious. However, this view allows the old name to be "kept" by one of the descendants.

Phylogenetic conceptions are in a way parasitic on biological conceptions like RISC. In order to know that two organisms are in the same species, one has to eliminate subspecific features such as, for example, different plumages or immune system molecules or genes. Otherwise one can divide the organisms up right down to individuals with novel mutations or slight variations. There are those who do this, too, who intend to eliminate "species" from the working vocabulary of biologists and replace it with "evolutionary group" or "least inclusive taxon"; we may refer to them collectively as "species eliminativists".

Ecological conceptions

In the 1920s, a Swedish botanist named Göte Turesson proposed that there were different kinds of "species", one of which was a response to the local ecology. Though not Mendelian, as Turesson appeared to think the environment changed genes directly, his *ecospecies* concept has been revived from time to time. Various authors, including Mayr, have suggested that what makes a species is occupation of an ecological "niche", and in 1976 American botanist Leigh Van Valen suggested that a species was a lineage "which occupied an adaptive zone" differently to other species. Van Valen's "proposal" (he did not call it a definition) combined both Mayr's RICS account and Simpson's evolutionary account, for the "adaptive zone" idea is Simpson's as well.

Van Valen's example case was the American white oak complex, *Quercus*, which will interbreed fairly freely, and yet remains stable phenotypically. This is due, he said, to adaptation for particular ecological needs. Similar cases have been found elsewhere; for example, Australian eucalypts interbreed with more distant relatives, but are often infertile with closer ones.

The idea that underpins this conception is the famous "adaptive landscape". A species, no matter what the gene flow between populations of other species, occupies a "peak" in that landscape (*see, for example, the view espoused by Richard Dawkins in his* Climbing Mount Improbable *[New York: WW Norton, 1996]*) where the metaphor of an adaptive landscape implicitly assumes this. Ecospecies are formed when the adaptive landscape "fractures", to use a term from philosopher Kim Sterelny. Recent work on speciation suggests that this is a factor in most cases, although it has a different role in allopatric speciation than in sympatric or polyploid speciation.

A grab bag of conceptions

As with any taxonomy, there are a few things that do not fit neatly into this scheme. Many of the current conceptions mix and match aspects of these conceptions, so a particular description might be characterized as, say, an isolationist, evolutionary, genetic account. But there are also species conceptions that make positive proposals, for example, for asexual species. At one time it was open to doubt that such things existed, or were rare, but apart from bacterial species (which sometimes do not have "sexes" but can exchange genes in various conditions), there are an increasingly known number of "parthenogenetic" species (in animals — in plants they are called "apomictics") that do not need to fertilize their ova or seed. Organisms that are descended from sexual organisms are sometimes asexual, such as the famous whiptail lizards of the southern USA and northern Mexico (genus *Cnemidophora*). In many cases these are formed by hybridization between closely related species, in animals and plants. Viruses also form "species" called "quasispecies", usually without crossing over their genetic material.

Another species conception is sometimes called "conventionalism", or less accurately but more commonly "species nominalism". This view is very popular among those whose ideas about evolution derive from the work of geneticist JBS Haldane early in the 20th century. It is basically the claim that species are just names, chosen for convenience, so that specialists can talk to each other. However, if species are just convenient fictions, how do specialists know that their terms refer to the same things?

And finally let us consider the problems of identifying species in fossils. Not all information about an organism is recorded in a fossil. We have data about hard parts, and, more rarely, skin or feather impressions, but we are not given their genetics, behaviors, colors, ranges, or mating preferences. And these are often the markers of being a RISC species, or are used to diagnose phylogenetic species. "Paleospecies", as they are sometimes called, may be less arbitrary than conventionalist species, but they do not necessarily map onto "biological" species.

Consider the debate in human evolution over whether *Homo sapiens* left Africa entire, as it were, or whether a prior paleospecies, *Homo erectus,* interbred with *H sapiens* afterwards. Recent work by Alan Templeton suggests there have been three major migrations out of Africa, each of which has left a genetic mark on the modern population. So, are *H erectus* and *H sapiens* one species, or two?

SPECIES CONCEPTS IN MODERN LITERATURE

SUMMARY OF 26 SPECIES CONCEPTS

There are numerous species "concepts" at the research and practical level in the scientific literature. Mayden's (1997) list of 22 distinct species concepts along with synonyms is a useful starting point for a review. I have added authors where I can locate them in addition to Mayden's references, and I have tried to give the concepts names, such as *biospecies* for "biological species", and so on (following George 1956), except where nothing natural suggests itself. There have also been several additional concepts since Mayden's review, so I have added the views of Pleijel (1999) and Wu (2001a, 2001b), and several newer revisions presented in Wheeler and Meier (2000). I also add some "partial" species concepts — the *compilospecies* concept and the *nothospecies* concept. In addition to Hennig's conception (1950, 1966), I distinguish between two *phylospecies* concepts that go by various names, mostly the names of the authors presenting at the time (as in Wheeler and Meier 2000). To remedy this terminological inflation, I have christened them the *autapomorphic species conception* and the *phylogenetic taxon species concept*. Asterisks identify the "basic" conceptions, from which the others are formed.

1. AGAMOSPECIES*

Asexual lineages, uniparental organisms (parthenogens and apomicts), that cluster together in terms of their genome. May be secondarily uniparental from biparental ancestors. Quasispecies are asexual viruses or organisms that cluster about a "wild-type" due to selection. See Cain (1954), Eigen (1993, for quasispecies). *Synonyms*: Microspecies, paraspecies, pseudospecies, semispecies, quasispecies, genomospecies (Euzéby 2006, for prokaryotes).

2. AUTAPOMORPHIC SPECIES

A phylospecies conception. A geographically constrained group of individuals with some unique apomorphous characters, the unit of evolutionary significance (Rosen 1979); simply the smallest detected samples of self-perpetuating organisms that have unique sets of characters (Nelson and Platnick 1981); the smallest aggregation of (sexual) populations or (asexual) lineages diagnosable by a unique combination of character traits (Wheeler and Platnick 2000). Nelson and Platnick (1981); Rosen (1979).

3. BIOSPECIES*

Defined by John Ray, Buffon, Dobzhansky (1935); Mayr (1942). Inclusive Mendelian population of sexually reproducing organisms (Dobzhansky 1935, 1937, 1970); interbreeding natural population isolated from other such groups (Mayr 1942, 1963, 1970; Mayr and Ashlock 1991). Depends upon endogenous reproductive isolating mechanisms (RIMs). *Synonyms*: Syngen, speciationist species concept.

4. CLADOSPECIES

Set of organisms between speciation events or between speciation event and extinction (Ridley 1989), a segment of a phylogenetic lineage between nodes. Upon speciation the ancestral species is extinguished and two new species are named. See Hennig (1950; 1966); Kornet (1993). *Synonyms*: Internodal species concept, Hennigian species concept, Hennigian convention.

5. COHESION SPECIES

Evolutionary lineages bounded by cohesion mechanisms that cause reproductive communities. See Templeton (1989).

6. COMPILOSPECIES

A species pair where one species "plunders" the genetic resources of another via introgressive interbreeding. See Harlan (1963); Aguilar and others (1999).

7. COMPOSITE SPECIES

All organisms belonging to an internodon and its descendents until any subsequent internodon. An internodon is defined as a set of organisms whose parent–child relations are not split (have the INT relation). See Kornet and McAllister (1993).

8. ECOSPECIES*

A lineage (or closely related set of lineages) which occupies an adaptive zone minimally different from that of any other lineage in its range and which evolves separately from all lineages outside its range. See Simpson (1961); Sterelny (1999); Turesson (1922); Van Valen (1976). *Synonyms*: Ecotypes.

9. EVOLUTIONARY SPECIES*

A lineage (an ancestral–descendent sequence of populations) evolving separately from others and with its own unitary evolutionary role and tendencies. See Simpson (1961); Wiley (1978, 1981). *Synonyms*: Unit of evolution, evolutionary group. *Related concepts*: Evolutionary significant unit.

10. EVOLUTIONARY SIGNIFICANT UNIT

A population (or group of populations) that (1) is substantially reproductively isolated from other conspecific population units, and (2) represents an important component in the evolutionary legacy of the species. See Waples (1991).

11. GENEALOGICAL CONCORDANCE SPECIES

Population subdivisions concordantly identified by multiple independent genetic traits constitute the population units worthy of recognition as phylogenetic taxa. See Avise and Ball (1990).

12. GENIC SPECIES

A species formed by the fixation of all isolating genetic traits in the common genome of the entire population. See Wu (2001a; 2001b).

13. GENETIC SPECIES*

A group of organisms that may inherit characters from each other, a common

We may be able to work that out through the sort of work Templeton is doing, but we equally may not.

Knowing species

Now the "biological", the evolutionary and the phylogenetic conceptions have an operational problem for biologists — except in very rare circumstances, it is almost impossible to give the criteria of the definitions for identifying and demarking species. There have been cases where two forms have been identified as the same species because they were observed mating, but there just are not the resources or the time to do experiments of assortative mating to tell in every case. In fact, many "biological" and evolutionary species, such as tigers and lions, which have been isolated for millions of years, *can* interbreed in artificial conditions, and their progeny are fertile, so mating tests might not help anyway. Back in the 18th century, Buffon established that some species could occasionally interbreed (which is why he thought that there was a first stock for groups of animals). So the definitions, or conceptions as I prefer, are not much help. And so far as evolutionary conceptions go, we simply have no direct access to the evidence we need in the case of extinct and even extant species. It might be true that species have distinct fates, but often we do not know.

It is important to separate the issues of what species *are* from the

gene pool, a reproductive community that forms a genetic unit. See Dobzhansky (1950); Mayr (1969); Simpson (1943). *Synonyms*: Gentes (singular: gens).

14. Genotypic cluster
Clusters of monotypic or polytypic biological entities, identified using morphology or genetics, forming groups that have few or no intermediates when in contact. See Mallet (1995). *Synonyms*: Polythetic species.

15. Hennigian species
A phylospecies conception. A tokogenetic community that arises when a stem species is dissolved into two new species and ends when it goes extinct or speciates. See Hennig (1950, 1966); Meier and Willman (1997). *Synonyms*: Biospecies (in part), cladospecies (in part), phylospecies (in part), internodal species.

16. Internodal species
Organisms are conspecific in virtue of their common membership of a part of a genealogical network between two permanent splitting events or a splitting event and extinction. See Kornet (1993). *Synonyms*: Cladospecies and Hennigian species (in part), phylospecies.

17. Least Inclusive Taxonomic Unit (LITUs)
A taxonomic group that is diagnosable in terms of its autapomorphies, but has no fixed rank or binomial. See Pleijel (1999); Pleijel and Rouse (2000).

18. Morphospecies*
Defined by Aristotle and Linnaeus, and too many others to name, but including Owen, Agassiz, and recently, Cronquist. Species are the smallest groups that are consistently and persistently distinct, and distinguishable by ordinary means. Contrary to the received view, this was never anything more than a diagnostic account of species. See Cronquist (1978). *Synonyms*: Classical species, Linnaean species.

19. Non-dimensional species
Species delimitation in a non-dimensional system (a system without the dimensions of space and time). See Mayr (1942, 1963). *Synonyms*: Folk taxonomic kinds (Atran 1990).

20. Nothospecies
Species formed from the hybridization of two distinct parental species, often by polyploidy. See Wagner (1983). *Synonyms*: hybrid species, reticulate species.

21. Phenospecies
A cluster of characters that statistically covary; a family resemblance concept in which possession of most characters is required for inclusion in a species, but not all. A class of organisms that share most of a set of characters. See Beckner (1959); Sokal and Sneath (1963). *Synonyms*: Phena (singular: phenon) (Smith 1994), operational taxonomic unit.

Phylospecies
The smallest unit appropriate for phylogenetic analysis, the smallest biological entities that are diagnosable and monophyletic, unit product of natural selection and descent. A geographically constrained group with one or more unique apomorphies (autapomorphies). There are two versions of this and they are not identical. One derives from Rosen and is what I call the *autapomorphic species conception*. It is primarily a concept of diagnosis and tends to be favored by the tradition known as pattern cladism. The other is what I call the *phylogenetic taxon species conception*, and tends to be favored by process cladists. See Cracraft (1983); Eldredge and Cracraft (1980); Nelson and Platnick (1981); Rosen (1979). *Synonyms*: Autapomorphic phylospecies, monophyletic phylospecies, minimal monophyletic units, monophyletic species, lineages.

22. Phylogenetic Taxon species
A phylospecies conception. A species is the smallest diagnosable cluster of individual organisms within which there is a parental pattern of ancestry and descent Cracraft (1983); Eldredge and Cracraft (1980); the least inclusive taxon recognized in a classification, into which organism are grouped because of evidence of monophyly (usually, but not restricted to, the presence of synapomorphies), that is ranked as a species because it is the smallest important lineage deemed worthy of formal recognition, where "important" refers to the action of those processes that are dominant in producing and maintaining lineages in a particular case Nixon and Wheeler (1990); Mishler and Brandon (1987).

23. Recognition species
A species is that most inclusive population of individual, biparental organisms which share a common fertilization system. See Paterson (1985). *Synonyms*: Specific mate recognition system (SMRS).

24. Reproductive competition species
The most extensive units in the natural economy such that reproductive competition occurs among their parts. See Ghiselin (1974). *Synonyms*: Hypermodern species concept.

25. Successional species
Arbitrary anagenetic stages in morphological forms, mainly in the paleontological record. See George (1956); Simpson (1961). *Synonyms*: Paleospecies, evolutionary species (in part), chronospecies.

26. Taxonomic species*
Specimens considered by a taxonomist to be members of a kind on the evidence or on the assumption they are as alike as their offspring of hereditary relatives within a few generations. Whatever a competent taxonomist chooses to call a species. See Blackwelder (1967), but see also Regan (1926); Strickland and others (1843). *Synonyms*: Cynical species concept (Kitcher 1984).

issues of how species are *known* or *identified*, because while evolutionary biology and genetics indicate some of the processes by which species evolve, the tests we use to find out whether two organisms are the same species or not may in fact be quite incidental to the causes of their *being* species. Many tests are used, mostly genetic and molecular tests these days. A recent proposal called *DNA barcoding* uses a particular gene on the cellular organelles known as mitochondria quickly to identify species for conservation and other purposes, but nobody thinks that the gene, COX1, *causes* speciation. In fact in cases where the "speciation genes" have been studied, they are nuclear genes, not mitochondrial genes (and anyway it is unlikely that the same genes cause speciation in all groups). When creationists attack evolutionary biology for not being able to define the term "species", they are confusing the identification and diagnosis of species and the meaning of the *term* "species". Occasionally, some scientists do the same thing.

Suppose we take a nonbiological example — "mountain". If we cannot give a universal definition of that term, it does not mean there are no mountains, or even that we cannot tell whether we are looking at one. And the geological theory of plate tectonics explains why there are mountains even when the term is not definable. Definitions are for philosophy, but

science can do without them if it needs to. Species are the phenomena of biology that the theory explains, not a priori concepts that have to be clarified exactly. It may be that, as some propose, we ought to replace the term with a range of other terms, such as "evolutionary group", "least inclusive taxonomic unit", and so on. Some "species" will be both evolutionary groups and least inclusive taxa. Some may not. The jury is still out as to the worth of these ideas.

Evolutionary biologist Massimo Pigliucci and philosopher Jonathan Kaplan have proposed that the term "species" is in fact what philosophers call a "family resemblance predicate". This is when being an instance of a general kind referred to by a word (the classic philosophical example is "game") has many criteria, and as long as most of them are met by a particular instance, it is a part of the kind. If evolution proceeds as we should expect from modern theory, then this plethora and confusion of species concepts is easily explained — evolution is a gradual process at genetic and behavioral scales (but it can be abrupt at geological and ecological scales), and so we will see species in all kinds of stages of speciation, extinction, interbreeding compatibility, and so on. On a creationist account, of course, no such explanation is forthcoming. If "kinds" are fixed, we should see only the expression of created variety (and of course that variety could not have possibly passed through the Ark, but let us assume that creationism is separate from Flood literalism), and that should be definite and limited. Instead we see species in groups of varying and ill-defined variety. It is a lot of weight for a simple word — "kind" — to bear. Science does not need it — so long as the ways words are used by each speciality will serve to describe what is observed.

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MEDIAREVIEW

Cladistics: A Practical Primer on CD-ROM

by Peter Skelton and
Andrew Smith
accompanying booklet by
Neale Monks, 80 pages
Cambridge: Cambridge University
Press, 2002.

**Reviewed by Alan Gishlick,
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Teaching cladistic methodology has always been a challenge, especially if you want to present an in-depth introduction to the topic as opposed to a brief overview. One of the standard sources for teaching cladistics in upper-level systematics classes was *The Compleat Cladist* (Wiley and others 1991). That book, however, has long been out of print, and unless you wanted to send your students to a used book dealer to find a textbook, there were few decent choices other than photocopies and primary literature.

With the publication of the *Cladistics* CD-ROM and booklet, there is now a good introductory resource on cladistics available for teachers. The CD-ROM is meant to be the main teaching source and can be used on its own; the booklet, by itself, can also serve as a good stand-alone text. The descriptions are clear and easily understandable in both media, with the booklet helping to elaborate the concepts presented in the CD-ROM. Used together, they constitute perhaps the best widely available resource for teaching introductory cladistics.

The booklet is meant as a companion for students using the CD-ROM to learn the basics of cladistics as well as the way phylogenies are computed. Its five chapters are well-organized, progressing logically from the very basic concepts behind cladistics to defining characters and character homology, generating cladograms, and testing the robustness of those cladograms, and finally to a practical hands-on exercise that allows the student to generate both molecular and morphological trees of several species of echinoids and to compare the results of the analyses.

The booklet has an excellent introduction to parsimony, and it goes through a series of complex topics with clarity and simplicity. It has a very clear introduction and explanation of molecular-based cladistics absent from previous texts. I do wish that there were more of a focus on morphological characters at the beginning. It contains an excellent discussion of homology and homoplasy in respect to pleisiomorphy and synapomorphy. It also offers perhaps the clearest discussion I have read for determination of homology in molecular data.

The CD-ROM is both informative and interactive. It is especially useful for teaching about molecular characters. The final section gives the student the opportunity to code characters from raw morphological and molecular data and then perform the analysis with the aid of the CD-ROM.

The chapters in the CD-ROM are interspersed with interactive exercises that test the student's understanding of the various concepts as they are presented. I found them to be, on the whole, rather good. There were a few places where the exercises were not quite clear. Although the CD-ROM gives the student a chance to create matrices from raw morphological and molecular data, I think that there still is a lot of value in working out the transformation series the old-fashioned way, by hand. That is how to acquire a real understanding of what modern computer programs for cladistics are doing inside the "black box". So there is room for improvement in the exercises, but otherwise I have no problem with them. Indeed, I think that more exercises, especially in the booklet, would be useful.

Perhaps the biggest problem with the CD-ROM is the narration. The text of the CD-ROM is spoken in a rather stuffy and pedantic British accent, which cannot be turned off. This conjures visions of American students sitting in their computer labs imitating the voice in horrible American British accents, saying things like "These parsimony criteria are jolly good." I mean no offense to speakers of the Queen's English, whose accents I generally find to be quite pleasant; however, in this case, I could have done without. I have no idea how British students may perceive the narration, but for Americans, the ability to replace the narration with a more familiar accent or at least on-screen text would be a welcome addition to the CD-ROM. Of course, such a minor point should by no means deter both students and teachers alike from acquiring this excellent introduction to a very important topic in the modern life sciences.

Overall, *Cladistics* is an excellent resource for learning the methods that are universal in systematics today. The booklet is an excellent learning resource useful for students in systematics classes or for people who wish to learn the methods of cladistics for themselves. The interactive CD-ROM exercises provide good hands-on activities, and the focus on molecular methods is invaluable, given their significance to current phylogenetics. Now if only there was a way to turn off the stuffy British narration ...

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