SPECIAL DOUBLE ISSUE

REPORTS OF THE NATIONAL CENTER FOR SCIENCE EDUCATION

Volume 20, Numbers 1–2

JAN–APR, 2000

CONTINUES
NCSE REPORTS &
CREATION/EVOLUTION

US Supreme Court Rejects Disclaimer Appeal

Of Pandas and People – Still No There There

NCSE Announces 1999 "Friend of Darwin" Awardees

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CONTINUES *NCSE REPORTS* & *CREATION/EVOLUTION*

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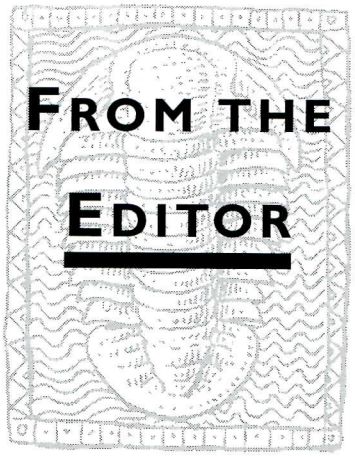


This issue contains a little surprise for our readers. If you pay attention to the cover, you will see that this issue combines numbers 1 and 2 of volume 20 of *RNCSE*. Although we have succeeded in delivering the promised 6 issues each calendar year, we are aware that the difference between the cover date and the date of production can be a cause for confusion. Therefore, we decided to combine the first 2 numbers of this volume in order to bring the publication date more in line with the date of printing and mailing.

Pandas and...

Most of our readers know that the supplemental high school textbook *Of Pandas and People* carried the first appeal to "intelligent design" when the first edition was published in 1989. Over the past year, "intelligent design" advocates have received a lot of press and promoted the use of *Pandas* as a textbook, a supplement, or a library resource for schools in several states. In this issue Gary Bennett shares with us an abridged version of his commentary on *Pandas* prepared for the textbook approval committee appointed by the Idaho Department of Education. The committee eventually declined to approve *Pandas* for classroom use.

In addition, Frank Sonleitner has provided us with another extensive bibliography that explores the scientific research that, according to *Pandas*, supposedly indicates shortcomings in current scientific explanations concerning earth and planetary science, evolution, adaptation, the origin of life, genetics, and so on. The resources in this feature are organized according to the chapters and the topics in the second edition of *Pandas*.

What Color is Your Mousetrap?

Irreducible complexity, according to Michael J Behe's *Darwin's Black Box*, is evidence of design. Niall Shanks and Karl Joplin take on the concept of irreducible complexity by exploring Behe's mousetrap metaphor — can a mousetrap still trap mice if a change in one component causes a significant change in its functionality? Shanks and Joplin argue that duplication or redundancy of parts (as we see in the genomes of many living things) is a clue about how new functions can arise without fatal errors in vital processes. Redundancy provides a naturalistic pathway for complex structure-function relationships to emerge at the biochemical level.

We also reprint an essay by Barry Palevitz published originally in *The Scientist*. Palevitz suggests that the answer to the apparent puzzle of irreducible complexity in biochemical systems is much the same as that for complex anatomic structures — exaptation. Palevitz presents numerous examples at the biochemical level of structures that can perform a number of functions in addition to their "specific" function, and he also suggests ways in which these structures can change their "specific" functions through exaptation.

Milestones

We are happy to announce the 1999 Friend of Darwin Awards in this issue. These are given annually to a few people who work hard to promote good science education in our schools and to defend evolution in the media. Each year there are literally thousands of people who get involved in supporting evolution throughout the country, and we are grateful for their unsung support. This award gives us a chance to thank a few of those who have worked especially hard on this issue over the past years.

We are sad to report the death of Bob Schadewald — a long-time advocate of evolution and friend of NCSE. Bob served our cause and our organization gallantly and with a good humor and dedication undiminished by years of engagement with anti-evolutionists of every sort. We will miss Bob and his contributions dearly.

NCSE welcomes a new staff member — Eric Meikle. Eric comes to us from the Institute of Human Origins and is a welcome addition to our staff. Look for his introduction in this issue.

In the News

Glenn Morton reports on the "intelligent design" conference in Waco, Texas, which was held at the controversial Polanyi Center at Baylor University. Richard Duhrkopf describes the ongoing controversy between Baylor's faculty and the promoters of the Polanyi Center. Advocates of "intelligent design theory" held a congressional briefing in May; David Applegate summarizes the events.

There was a fair amount of activity in state and local boards of education. We carry in-depth reports from West Virginia, South Carolina, and California. Disclaimers are again in the news; the US Supreme Court declined to hear a challenge to the court decision barring the disclaimer in Tangipahoa Parish, Louisiana. But other localities — including some states — are considering similar disclaimers.

On the other hand, grassroots organizations in Kansas joined together to hold a "Scopes Week" in support of evolution. And, just as we were going to press, we learned that the results of the primary elections in Kansas are likely to change the balance of power on the elected state school board. We will have a complete report on recent developments in Kansas in the next issue.

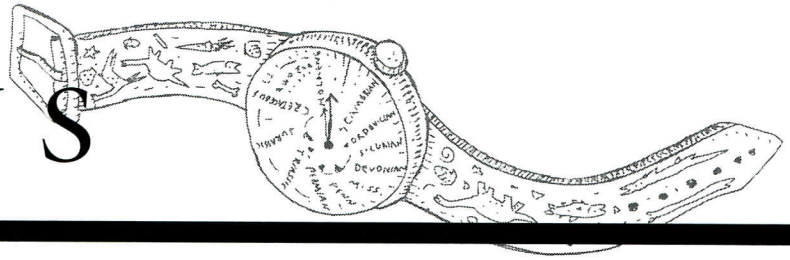
Give the Gift of RNCSE

We are pleased to provide our members with the opportunity to give subscriptions to *RNCSE* to their friends at the special rate of $25.00. Simply fill out the form on the back of this issue and return it with your payment to NCSE, PO Box 9477, Berkeley CA 94709-0477.

Anj Petto

RNCSE 20 (1-2) was printed in September 2000.

NEWS



Supreme Court Rejects Evolution Disclaimer

Barbara Forrest and Molleen Matsumura

On June 19, 2000, the Supreme Court voted 6-3 — with Justices Scalia, Rehnquist, and Thomas dissenting — not to hear an appeal of *Tangipahoa Parish Board of Education v Freiler*. It was the first time in 6 years that a legal case concerning creationism reached the Court. In 1994, the Court had refused to review *Peloza v Capistrano*, instead letting stand a lower court's decision that teachers' First Amendment rights are not violated by a school district's requirement that they teach evolution (Scott 1994). The Court's latest action let stand the decision of the Fifth Circuit Court of Appeals that the Tangipahoa Parish Board of Education had violated the First Amendment by requiring teachers to read a "disclaimer" whenever they introduced the topic of evolution.

BACKGROUND

In 1994, having reluctantly decided not to adopt creationist curriculum materials for fear of litigation, the Tangipahoa Board of Education adopted the following policy:

> Whenever, in classes of elementary or high school, the scientific theory of evolution is to be presented, whether from textbook, workbook, pamphlet, other written material, or oral presentation, the following statement shall be quoted immediately before the unit of study begins as a disclaimer from endorsement of such theory.
>
> It is hereby recognized by the Tangipahoa Board of Education, that the lesson to be presented, regarding the origin of life and matter, is known as the Scientific Theory of Evolution and should be presented to inform students of the scientific concept and not intended to influence or dissuade the Biblical version of Creation or any other concept.

Sponsored by the ACLU and represented by First Amendment attorney Marjorie Esman, parents in the district filed suit. US District Judge Marcel Livaudais Jr ruled the disclaimer to be unconstitutional, ordering the board to pay all attorney fees (*Freiler v Tangipahoa Parish School Board*). In his decision, Livaudais wrote:

> As hard as it tries to, this Court cannot glean any secular purpose to this disclaimer... A review of all of the evidence presented leaves little doubt that the reasons for the adoption of the resolution were religious....
>
> In mandating this disclaimer, the School Board is endorsing religion by disclaiming the teaching of evolution in such a manner as to convey the message that evolution is a religious viewpoint that runs counter to the religious belief of the Biblical theory of Creation, or other religious views. An endorsement of religion is a violation of the Establishment Clause and thus must be invalidated.

The board appealed the ruling, and in August 1999 a 3-member panel of the Fifth Circuit Court of Appeals upheld Judge Livaudais's ruling, calling the board's "articulated purpose" of promoting critical thinking "a sham".

In September 1999, the board proposed an alternative disclaimer stating that the school system

> recognizes that some of its students believe that evolutionary theory is inconsistent with their own beliefs about the origins of life. Others disagree and believe that these other explanations of life's origin and the scientific theory of evolution are not in conflict. The school system takes no position on these beliefs, but this class will teach the scientific theory of evolution.

The plaintiffs rejected this new disclaimer, and the board appealed for a rehearing by all 15 members of the Fifth Circuit Court, which denied the appeal by an 8-7 vote on January 24, 2000.

Despite the defeat, Board President Jake Bailey, who had drafted the original disclaimer, said that he was encouraged by the dissenting opinion. Barry Ashe, the attorney representing the board in the case, commented, "The dissenting statement is vindicative for the School Board for its position from the very beginning. I don't see why we should turn back now" (Hammond *Daily Star*, January 26, 2000). However, other board members wanted to avoid further

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Barbara Forrest is an Associate Professor of Philosophy at Southeastern Louisiana University and recipient of NCSE's Friend of Darwin Award; she actively opposed adoption of creationist curriculum materials by the Tangipahoa Board of Education, and later arranged for several organizations to sign amicus briefs opposing the Tangipahoa disclaimer. Molleen Matsumura is the Network Project Director of NCSE.

litigation, and in early February the board decided against further appeals by a 5-4 vote.

Two of the board members later changed their positions on the appeal. Maxine Dixon placed the issue on the board's agenda for February 22, 2000, saying she had "received new information" since the earlier meeting. When asked by member Donnie Williams to reveal her "new information", Dixon said, "I just saw things clearer." Al Link had explained his initial opposition to appeal by saying that he was "not really sure how the disclaimer will help the education process." Justifying his decision to change his vote, he said, "I made a mistake. I looked at it in a different manner. It is a matter of education that we present to our students that there is more than one theory of how we got here." When Dixon, Link, and Carl Bardwell changed sides, the board voted 7-2 vote to appeal the Circuit Court's decision (Baton Rouge *Advocate*, February 23, 2000).

A CAUTIONARY TALE

The board's appeal was filed on April 7, 2000. Soon afterward the board encountered an obstacle: when attorneys who had donated their services to the district wanted to file a reply to the opposition brief by the plaintiffs, the board's insurance company refused to pay printing costs. Since other court costs were looming, board members worried that the insurance company might also refuse to cover future costs, such as the expense of flying attorneys to Washington DC to argue the case (Hammond *Daily Star*, June 9, 2000).

The incident provides a cautionary tale. Even when law firms donate their services to school boards adopting anti-evolution policies, boards may still have to pay some costs of litigation. Concerned citizens should urge their school boards to find out what costs are involved and which are covered by their insurance companies. They should also consider the possibility that they will lose and have to pay attorney fees (as the Tangipahoa School Board did). Such costs can reach tens of thousands of dollars, and a district's finances can be significantly affected.

AFTERMATH – A NEVER-ENDING STORY

The Supreme Court's 6-3 refusal to hear the case was significant. Plaintiffs' attorney Esman commented to NCSE, "Courts remain unanimous that science must be taught as science, and the Supreme Court has now affirmed that basic and fundamental principle."

However, Esman's assessment that "after 6 years of litigation, this matter is now resolved" was soon contradicted by Board President Bailey. On June 20, Bailey told the Baton Rouge *Advocate*: "[e]ven though the battle is over, the war isn't. ... I'd prefer evolution was not taught. It's a theory and it hasn't been proven."

Bailey later said that he would "make contact with other systems" to get ideas for rewriting the disclaimer and that he was considering eliminating evolution from the district's curriculum (according to Esman, Louisiana schools are required by state law to teach evolution).

Other anti-evolutionists are similarly undaunted. Scalia's dissent in the Court's 1987 decision striking down Louisiana's "equal time" law has generated several new legal strategies among opponents of evolution. Now they will probably take heart from his dissent in this decision.

With the concurrence of Justices Rehnquist and Thomas, Scalia insisted that the disclaimer's reference to "the biblical version of Creation" is only "an illustrative example" and complained that "[t]oday we permit a Court of Appeals to push the much beloved secular legend of the Monkey Trial one step further."

On July 27, University of California Law Professor Phillip Johnson, a leader in the "intelligent design" movement, told Nightline interviewer Ted Koppel:

> [A] public movement is beginning to question the dominant religious philosophy of our time — effectively, the established religion of our culture — which is scientific naturalism, materialism.... We want to challenge that....And you know the group I really want to talk to is the American Civil Liberties Union, which is being used by people who are not in favor of civil liberties.

Esman, who is on the boards of both the Louisiana and the national ACLU, commented, "I'm ready for him."

CORRECTION

The obituary of Thomas H Jukes in *RNCSE* 19 (6): 10-11 failed to make it clear that it was Jukes's own view that the scientific support for the harmful effects of DDT eventually evaporated.

REFERENCES

Baton Rouge *Advocate,* February 23, 2000, <http://theadvocate.com/news/story.asp?storyid=11122>.

Baton Rouge *Advocate,* June 20, 2000, <http://theadvocate.com/news/story.asp?storyid=14061>.

Baton Rouge *Advocate,* June 21, 2000, <http://theadvocate.com/news/story.asp?storyid=14121>.

Freiler v Tangipahoa Parish Board of Education, 975 F. Supp. 819 (E.D. LA Aug. 8, 1997).

Hammond *Daily Star,* January 26, 2000, <http://www.zwire.com/news/newsstory.cfm?newsid=673546&BRD=1423&PAG=4612>. Last accessed July 21,2000.

Hammond *Daily Star,* June 9, 2000, <http://www.zwire.com/news/newsstory.cfm?newsid=519517&BRD=1423&PAG=4612>. Last accessed July 21,2000.

Nightline, July 27, 2000. <http://www.abcnews.go.com/onair/nightline/transcripts/nl000727_trans.html>. Last accessed July 31,2000.

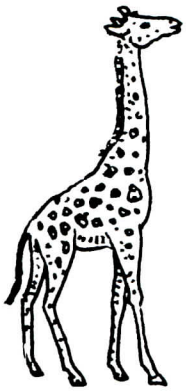
John E Peloza v Capistrano Unified School District, 37 F. 3rd 517 (9th Cir. 1994).

Scalia A. Dissenting opinion, 120 S.Ct. 2706 (2000).

Scott EC. Peloza appeal reversed! *NCSE Reports* 1994 Winter; 14 (4): 4, 5.

Anti-Evolutionists Open a New Front

David Applegate



May 10, 2000, was just another day on Capitol Hill. With the Congress in session, a dozen or so briefings took place as interest groups were eager to bring their issues before congressional staff. As such, there was nothing particularly remarkable about the briefing and reception by the Seattle-based Discovery Institute on this day. Nor was it surprising that the briefing was part of a broader strategy by the Institute to "cultivate and convince" opinion leaders and policymakers, including congressional staff. What readers might find remarkable about this briefing was its topic: Scientific Evidence for Intelligent Design and Its Implications for Public Policy and Education. It may be that this otherwise normal day was an early move by "Intelligent Design" creationists (IDCs) on their newest front in the struggle against evolution: the US Congress.

Last summer's events in Kansas rekindled the creation/evolution debate around the nation. The Associated Press rated it the top story of 1999. Since then, efforts to discredit evolution have intensified, with conflicts raging in county school boards and state capitals. For much of the last 2 decades, the issue has been quintessentially local. But the May 10 briefing could represent a return to a national stage.

Leading Lights and Heavy Hitters

How well did the briefing succeed in reaching its target audience? Although only about 50 people attended, about a dozen members of Congress were involved — including 2 from the House Science Committee. These members served as honorary "hosts" for the briefing or introduced the speakers. Rep Charles Canady (R–Florida), chairman of the Subcommittee on the Constitution, arranged for the use of a House Judiciary Committee hearing room. Sen Sam Brownback (R–Kansas) and Rep Tom Petri (R–Wisconsin) warmly introduced several of the speakers. Petri is first in line to become chairman of the House Committee on Education and the Workforce at the end of this year. Thus, the committee responsible for federal education programs may be run next year by a man who expressed his hope for a "swelling chorus" of support for "intelligent design" theory.

Those who attended the briefing were treated to a 3-hour primer on ID creationism from some of the movement's best-known advocates, including Whitworth College philosophy professor Stephen Meyer, Lehigh University biology professor Michael Behe, and University of California law professor Phillip Johnson. All are fellows of the Discovery Institute's Center for the Renewal of Science and Culture (CRSC). Joining them was another CRSC fellow, Nancy Pearcey — the former executive editor of *Breakpoint*, a conservative talk radio show hosted by born-again Watergate figure Charles Colson, with whom Pearcey writes a regular column.

A "Purely Scientific" Debate

Most of the ID advocates were excellent communicators. They stayed away from highly technical jargon except to amaze their audience with the incredible complexity of life. They transformed the listeners' amazement into laughter at scientists' trying to explain this complexity as the result of random, evolutionary processes. They led the audience to the "obvious" conclusion that life could only be the handiwork of an intelligent designer. Consider it Occam's razor run amok: confronted with 2 explanations, one that appears dizzyingly complicated and improbable, and another, disarmingly simple, choose simple. Choose design.

They did not thump Bibles. They did not try to convince the audience that dinosaurs are the "behemoth" of the Book of Job nor did they seek to explain that the Grand Canyon was formed during the Noachian flood. The IDCs voiced their acceptance of the depth of geologic time, modern genetics, even certain aspects of evolution itself. In fact, IDCs not only accept the advances of science, they argue that those advances have revealed a universe of physical and biological systems so complex that they could not possibly have come from evolutionary processes.

Indeed, one theme was how "shocked" scientists have been by their discoveries of the awesome complexity of living systems. Shocked and disheartened, because their outmoded theories such as Darwinian evolution — adequate perhaps for the limited knowledge of the 19th century — cannot handle that complexity. This approach cleverly places ID theory at the cutting edge of scientific discovery while relegating Darwin to the dustbin of history.

Intelligent design, they said, is one side of a debate between 2 competing, empirically derived scientific theories — a debate, they claimed, that does not include religion. In their view, they are engaged in an open-minded investigation to follow the empirical evidence about life on earth wherever it leads. They contrast such openness with a rigid scientific orthodoxy that forcibly constrains explanations to purely natural phenomena, disallowing explanations that involve a higher intelligence.

However, the tone of the congressional briefing is not consistent with articles published by ID's "leading lights" in the nonscientific literature. For example,

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Pearcey wrote in the May 22 issue of *Christianity Today*: "Clearly, while [intelligent design theory] does not require any theological presuppositions, it has theological implications: It is resolutely opposed to the atheistic, purposeless, chance view of evolution taught in the power centers of science."

The speakers also tarred evolutionary theory with the controversial findings of social scientists who apply Darwinism to human interactions. Pearcey shocked the audience with a recent book that asserted rape was a natural male impulse driven by the need to confer evolutionary advantage. She also blamed Darwinism for the excesses of popular culture, quoting lyrics from a current hit song: "You and me, baby, ain't nothin' but mammals, so let's do it like they do on the Discovery Channel."

Ironically, the IDCs accept the achievements of science and indeed place their theory at the pinnacle of modern knowledge, but also demonize both the scientists who made those advances and the naturalistic method by which the advances were achieved. At the briefing Johnson replayed the portrayal of scientists from his popular books as an elite priesthood jealously guarding the power and prestige garnered from the ascendancy of their Darwin-inspired creation myth, having deposed the church's priests. There is a disconnect between the pains they take to portray the debate between ID and evolution as purely scientific and this separate line of argument portraying Darwinism as a religion.

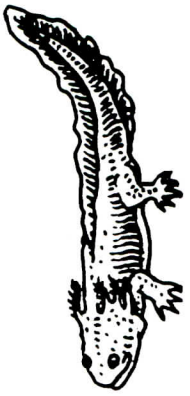
The Political Landscape

I have previously asserted (*Geotimes*, October 1999) that the events in Kansas must serve as a wake-up call for scientists to get involved in their local school boards and in local and state governments. But I also suggested that they do so with their eyes open to the political landscape. IDCs are an important part of that landscape, and they have a sympathetic audience for their populist portrayal of scientists as an elite responsible for societal perversion. "Intelligent design" will be even more a part of the landscape if its partisans succeed in convincing the often warring factions among anti-evolutionist camps to unite under their big tent.

Why is this briefing so important to those interested in quality science education? The Discovery Institute chose to hold its briefing at the same time that both the House and Senate were actively considering legislation to overhaul federal K–12 education programs. Scientific societies and other interested groups faced serious challenges as they tried to retain provisions in new federal legislation to support and strengthen science and math education. If anti-evolutionists move into the congressional arena and gain support from leading members of Congress, good science will face an even tougher challenge. Their efforts threaten to erode science education at the very moment when our technology-based society needs it more than ever.

For a summary of the May 10, 2000, congressional briefing, visit <http://www.agiweb.org/gap/legis106/id_update.html>.

[Adapted with permission from David Applegate's column in Geotimes *2000 Jul; 45 (7): 12, 58.]*



The Search for Noah's Ark in the Science Curriculum?

Jerry L Day

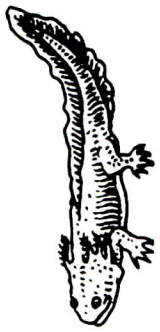
On December 16, 1999, the San Bernardino County *Sun* carried a front page article entitled "Mythic Science", in which a science teacher at a local high school related details about his personal quest to locate Noah's Ark upon Mount Ararat. A television interview of the teacher was aired on February 7, 2000, on the "Evening Edition" program produced by the local PBS affiliate, KVCR, San Bernardino.

Comments made by the teacher in the interviews indicated that he was incorporating material related to his search for Noah's Ark into his public high school science class. In the interviews, the teacher said that he used the Ark search as "an example of the scientific method" and that he presented alternative theories of geology to his students, including the notion "that there could have been a global event that formed much of the sedimentary rock layers".

The immediate concern raised by these interviews was that the Genesis narrative of the Noachian Flood and related creationist concepts of flood geology were being presented, as science, in the context of a public high school science class. This is not only bad science; it is bad theology in the view of many religious communities, including the Roman Catholic Church. This also appeared to be a violation of the Establishment Clause of the First Amendment of the US Constitution, since the teacher is employed at a public school, is therefore an agent of the government, and, as such, is prohibited from advocating religious claims to his students.

Having scrutinized these interviews, a number of concerned individuals contacted the NCSE and other organizations, formed a coalition to address the issue, and contacted the appropriate school district administration with our concerns. Our efforts have been successful. About 3 months after the issue was first raised, the school district has taken steps to ensure that this teacher will stop using material that could be interpreted as creationist in nature and present only the approved science curriculum to his class.

Dealing with this issue has been a valuable learning experi-



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ence for my associates and me. I would like to share with you some of the lessons we have learned.

- *Do not overreact.* Our concern on learning of the teacher's activities was that school authorities might somehow be condoning or turning a blind eye to what the teacher was doing. It soon became apparent that members of the school board and administration were simply not well informed about the issues and that it would take time for them to come up to speed. In hindsight, some portions of our initial letters, though carefully reasoned, were more aggressive in tone than was appropriate. The result was that it probably took more time than was necessary for the school administration to trust us; unfortunately, we were viewed initially as extremists.

- *Keep your manner friendly, dignified, and nonconfrontational.* Throughout our interactions with school district administrators, we were careful to treat them with respect and as professionals. At one point, maintaining a nonconfrontational demeanor entailed distancing ourselves from potential allies who apparently relished the controversy as much as or more than the opportunity to obtain a satisfactory resolution. At another point, we declined the offer of media attention about the issue because we had achieved a cooperative relationship with the school district administration. We decided that sparing the district the publicity would expedite a speedy resolution of the issue. Acting in a nonconfrontational manner enabled our group to communicate effectively with the school district administrators who had the power to resolve the issue.
- *Attend school board meetings and introduce yourself to those officials with whom you have corresponded.* A friendly handshake helps to establish a personal rapport, and it always helps for names to be connected to faces. When we deliberately passed up the opportunity to comment in the open forum session of a school board meeting, the district administration came to understand that we were not extremists seeking controversy, but concerned, individuals seeking a reasonable solution.
- *Do your homework and use available local resources.* In our case, local colleges and universities provided our group with 2 very effective representatives of the scientific and educational communities. Local high schools provided several other concerned science educators. The San Bernardino County Democratic Central Committee also provided valuable assistance in locating concerned parents in the community.
- *Do not ignore local religious resources.* Our group's connections to religious organizations helped us to find articles and spokespersons supporting curriculum standards that insisted that science, not creationism or religion, should be taught in science classes. Many mainstream religious organizations can be quite supportive of science education and of the separation of religion and government.
- *Use available internet resources.* The internet proved to be an indispensable source of information in support of our research. We had instant access to background material on the creationist movement, California state science curriculum standards, and relevant court decisions upholding the teaching of science. The NCSE web site is an excellent starting point: <http://www.natcenscied.org/>.
- *Use resources available from national organizations.* NCSE, the ACLU, and Americans United for Separation of Church and State provided information, guidance, and moral support. NCSE, in particular, served as a clearinghouse for information and for concerned individuals. NCSE initially connected our group members with one another. Special credit is due NCSE's Molleen Matsumura. The National Science Teachers Association and the National Research Council of the National Academy of Sciences also proved to be valuable sources of information. Through our contacts with these organizations, our group became more effective and appeared stronger than it might have otherwise.
- *Find at least one concerned parent in the local community.* Your arguments will carry more weight with the school district if they are made by parents who have children attending local schools. When our group initiated our complaint with the district, we did not know any parents of students in the school district. Not having the help of concerned parents in our group hampered our initial efforts to communicate the urgency of our concerns to the school district.
- *Once your homework is done, be willing to go public.* The local Public Broadcasting System affiliate, KVCR, offered our group an interview to rebut the earlier interview of the high school teacher. Disclosure to the school district of the willingness of our group's PhD geologist to participate in the rebuttal interview coincided with a timely and appropriate decision by the school district to limit science classroom instruction to established scientific theories.
- *Use e-mail to keep your group informed and current.* In our group, one member acted as the e-mail clearinghouse and made sure that all members had access to needed information. Not every e-mail went to every member of the group, but most did. Information sharing helped

to keep our group working as a team. Having a clearinghouse and conducting peer reviews of all correspondence kept members from hitting the "send" button and regretting it in the morning.

- *Know the strengths of your group's members and divide tasks accordingly*. In our case, we had individuals with expertise in geology, state and national science curriculum standards, science and theology issues, and the creationist movement and related legal issues. In our communication with the district, each member covered a different perspective according to members' expertise. One of our members had extensive experience in the education system and in the political processes surrounding state and national science education standards, and served as a mediator between our group and the school district.

Through teamwork, effective communication, and perseverance, our group succeeded in encouraging the local school district to ensure that students at the high school receive a sound science education. We are still following the situation to ensure that there is long-term compliance by the teacher with the district's instructions.

As I mentioned before, this has been a valuable learning experience for all of us. The final lesson we have learned is that individuals can, and do, make a difference in the quality of education offered in a community, but only if they are willing to stand up, speak out, and be heard. The following quote from Margaret Mead sums it up very well: "Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it is the only thing that ever has."

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The "Nature of Nature" Conference at Baylor University

Glenn R Morton

A conference entitled "The Nature of Nature" was held April 12–15, 2000 at Baylor University under the auspices of the Polanyi Center. Both the center and the conference topic are sources of controversy. The Polanyi Center was founded to study the relation of contemporary science with the humanities, the arts, and religion and to "pursue the mathematical development of design theoretic concepts in the natural sciences". The center was founded and staffed by 2 associates of the Discovery Institute with little consultation from Baylor's science, philosophy, and religion departments. The choice of William Dembski as the director of the center also alienated the faculty because Dembski is closely associated with Phillip Johnson's "Intelligent Design" (ID) movement.

The conference topic was controversial because it purported to address the relationship of a "designer" with nature. Ostensibly the designer could have been in the form of little green men from Betelgeuse, but they were rarely mentioned: the designer of choice was God. Because of these issues, the faculty senate at Baylor voted 26–2 to discontinue the center. But the president of Baylor University responded to the vote by insisting that the center will be retained.

The First Day

The conference began on April 12 with talks by philosophers. Robert Koons (University of Texas-Austin) argued that the cause of the fundamental laws of nature must be causally prior to the fundamental laws of nature, and, since the laws of nature pervade space and time, any cause of the laws of nature must come from outside space and time. The details of his argument required the assumption that elegant or simple laws are preferable — derived, perhaps, from Occam's Razor. This point was challenged vigorously during the question period.

Michael Williams (Northwestern) suggested that the way to avoid many philosophical problems is to take the pragmatic approach. Truth is what works and not what is assertable on current evidence. Truth, he said, is an expressive feature of language, not a property; objectivity is not illuminated by "truth talk". Science is constrained by theory and data, not by discussions of truth or falsity. And in a swipe at Koons, he said that simplicity is not equal to truth. During the question period, many people took Williams to task for his view of truth.

Michael Tooley (University of Colorado) gave a too-abbreviated account of the arguments for the existence of God. He spent most of his time on the anthropic principle — the notion that the universe inevitably produces intelligent (or even human) life — and on the anti-evolutionary arguments for the existence of God. The anti-evolutionary arguments for God's existence, he said, give the young-earth creationists only 2 choices — reject science or turn to Gosse and his appearance-of-age point of view. He said that although old-earth creationists allow organisms to evolve, they make false claims, such as there being no transitional forms and no beneficial mutations. Tooley also charged Michael Behe with misquotation and said that Behe's irreducible complexity argument does not take into account pathways in the development of com-

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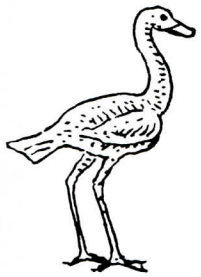
plex systems that involve chemicals that act as supports until better replacements are found.

The Second Day

The conference resumed on the morning of April 13 with papers by Alvin Plantinga (Notre Dame) and William Talbott (University of Washington-Seattle) concerning whether the reliability of our belief systems indicates that they were shaped by extranatural forces. Plantinga argued that a rational belief system that is capable of being reliable cannot evolve. Talbott took the opposite position. He replaced the word "naturalism" with the word "God" in Plantinga's argument and followed the same logic toward the conclusion that one cannot believe God exists.



Historians followed the philosophers. Everett Mendelsohn (Harvard) started his talk with a swipe at the way the Polanyi Center had been formed. He then described how religion was expelled from discipline after discipline during the 19th century. Ernan McMullin (Notre Dame) stated that evolutionary ideas go far back in Christian history and cited Augustine as an example. Indeed, he made Augustine sound like a modern evolutionist. Ronald Numbers (University of Wisconsin) concurred with Mendelsohn that the expansion of science coincided with the exclusion of religion. He also pointed out that it was Christians who first embraced what the ID group calls "methodological naturalism".

During the afternoon, there were concurrent sessions that were badly scheduled: there was almost no opportunity to attend different talks in different sessions. I managed to attend 2 talks in 2 different sessions. Paul Nelson (Discovery Institute) gave a fascinating talk on the problems involved in altering an organism's developmental program, particularly on what he called the marching band problem. Each cell must have the directions of how they are to change prior to their getting "on the field" — things must be planned out. Altering pathways early in development means that the directions get scrambled and the organism dies.

Robert De Haan (University of Chicago) presented a model of phylogeny in which supernatural infusion of information was high in the Precambrian, and then declined and ultimately ended with the Cambrian Explosion. From there on, evolution took over. His thesis was that taxa arose, developed, and then became senescent — a view reminiscent of some early 19th-century paleontologists. He also said that the giantism of the Pleistocene animals was evidence of senescence. I pointed out that human predation, rather than senescence, is a more plausible explanation for the disappearance of these species; De Haan agreed that it was a possibility.

One of the most fascinating contrasts in talks occurred in the last session on April 13, which featured Stephen Weinberg (University of Texas-Austin) and Henry Schaeffer III (University of Georgia). Weinberg came straight to the point and called all gods fairies. There was an audible gasp from the audience. Weinberg told the conference that he saw no more reason to spend time looking for fairies than to spend time reading his crank mail. He could not understand why religious people are naturalistic about the weather report, which does not invoke fairies, but want to invoke fairies when it came to evolution.

Schaeffer presented an entertaining, but canned, speech. Instead of dealing intelligently with the issues with which Weinberg and all of us struggle, Schaeffer merely cited quotation after quotation by scientists to the effect that it was all right to be a Christian and a scientist. The contrast in intellectual content was very stark.

The Third Day

The next day of the conference, April 14, began with a talk by Simon Conway Morris (Cambridge) entitled "What's Inevitable in Evolution?" His position is opposite to that of Stephen Jay Gould. Morris believes that the phenomenon of convergence indicates that there is a limited number of solutions to biological problems. He compared the similarities among animals of vastly different lineages that occupy similar ecological niches. The most striking comparison was between the mantis shrimp and the praying mantis. Despite their different lineages and very different habitats, the structural similarities of the animals is amazing. Thus, Morris argued, in contrast to Gould, that replaying the "tape of life" would produce animals similar to those that actually evolved on earth—not identical, but similar.

Michael Behe (Lehigh) said that the true test of evolution would be to wipe out a system and see if it would re-evolve. In *Finding Darwin's God*, Kenneth Miller claimed that just such a test had been conducted and that the system — involving the *lac* genes of bacteria — re-evolved (Miller 1999, 145-6). Behe countered that only one component of the system had been knocked out, so Miller's case did not meet his criterion. He then took on Russell Doolittle's criticism of irreducible complexity, in which Doolittle claimed that a mutation that eliminated blood-clotting in a mouse lineage was restored by a second mutation. He said that even the second mutation left the mice nonviable.

Behe then said that ID could be disproven by showing just one case in which an unintelligent process created a biological system. During the question period, I asked Behe what he thought would work if evolution did not. He said, "Well, I think I tried to make clear what was a reasonable hypothesis is that the system was designed. Which means that there was information—exclusive infor-

mation—added to the system at some point, maybe in the beginning, maybe along the way, to enable these systems to be produced." So Behe believes that the information for life was inserted at the beginning of time or over geologic history as organisms evolved. In the question period after a later talk, Michael Tooley quoted from *Darwin's Black Box* (1996: 227-8) in which Behe asserted that it is entirely possible that all information for all living systems was placed into the first living cell but not turned on until later as evolution proceeded, and asked whether anyone had searched for those genetic systems that had not yet been turned on in living organisms. In contrast to his answer to my question earlier, Behe said that he did not believe that all of the information was placed in the first living cell.

In his talk, Christian de Duve (Université Catholique de Louvain) demonstrated that random processes and certainty of outcome are not incompatible. He said that it is 99.9% certain that, after 10 flips of a coin, heads will appear at least once. Although this is true, it is unlikely to convince the anti-evolutionist that random chance can create living systems. However, de Duve's best argument was that, given observed rates of mutations and about 20 billion cell divisions, each and every point substitution in the genome can be accomplished. These 20 billion cell divisions would take only a month with most eukaryotic cells, 1 day with a bacteria, and 2 hours with human stem cells. The large number of events required to produce the certainty of a rare outcome occurs on a regular basis.

Mark Ptashne (Sloan-Kettering) complimented Behe on getting the facts of blood-clotting correct, remarking that most expositions do not succeed as well. But he went on to criticize Behe for believing that present complexity says anything about the origin of that complexity. He also indicated that Behe's concept of evolution was wrong. Ptashne argued that evolution occurs not only by changing the coding proteins but also by changing the regulatory genes. The genetic regulatory system was fairly crude, he said, like a child with Tinkertoys® and Velcro®.

The most fascinating exchange of the conference occurred at the end of Stephen Meyer's talk. Meyer (Discovery Institute and Whitworth College) tried to define the contrast between complexity and specified complexity. Random processes create complexity with nonsense sequences, he said, but only an intelligent agent can create specified complexity, such as this sentence. Meyer ignores the fact that apparently random sentences can actually be specified, as in the case of encrypted messages. In the question period, Ptashne asked Meyer, "So where the genes are different, did God come down and line up the nucleotides?" Meyer said, "Not necessarily." The weakness of that answer underscores the fact that the ID group has no theoretical framework on which to ground their claims.

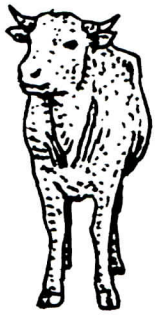
Sahotra Sarkar (University of Texas-Austin) presented an model for the development of the information content of the human genome, which required only one generation per year throughout geologic time. Mutating the genome of living systems just once each year for the past 3.8 billion years would allow the entire human genome to evolve. Given that most nonhuman organisms have shorter generation times than one year — the bacterium *E. coli* has a generation time of 15 minutes, for example — there should be no problem in generating the human genome in the time allowed.

Alan Guth (MIT) examined the anthropic principle, concluding that no one can be sure either that the universe is finely tuned for life or, conversely, that life is finely tuned for the universe. He also said that advocates of ID invoke the "design" explanation inconsistently. For example, there are apparently no arguments that God causes high-temperature superconductivity, despite its being currently unexplained by physicists. Not everything that is unexplained requires the supernatural.

Howard Van Till (Calvin College) presented a case for what he called the Robust Formational Economy Principle, the claim that the universe was given the ability to self-organize. He criticized advocates of ID at the conference for celebrating the inabilities of the creation.

William Lane Craig (Biola) gave a talk on the Big Bang, saying that every effort to avoid the theological implications of a beginning to the universe in fact affirmed the beginning. He said that the only possible scientific cause of the universe would have to be an outside cause. Guth responded by noting that quantum events are uncaused. This is true, but quantum events occur in the pre-existing vacuum and so have a basis in that substrate, which itself requires a cause.

The Fourth Day



The final day of the conference, April 15, began with 2 talks on the evolution of ethics and morality. Larry Arnhart (Northern Illinois University) gave what I believe to be the most outlandish talk of the session, saying that evolution gave rise to ethics. Dallas Willard (University of Southern California) said that ethics had to arise from outside Nature. There was nothing remarkable about either speech.

Edward Zalta (Stanford) and Mark Wilson (University of Pittsburgh) discussed the effectiveness of mathematics for describing the real world, which some ID advocates have invoked as evidence of design. Both Zalta and Wilson seemed to be on the same side, saying that there is a lot of mathematics that has no application; science is simply picking and choosing what is useful for its purposes. Thus the effectiveness

of mathematics has no metaphysical significance.

William Dembski (Baylor) presented a case against genetic algorithms. It was obvious that his understanding of genetic algorithms was profoundly lacking. He assumed, wrongly, that genetic algorithms know the topology or metric of the fitness function prior to the search. He claimed, wrongly and absurdly, that the genetic algorithm utilizes the information of the fitness function to locate the target, leading only to reshuffling information. He assumes, wrongly, that a genetic algorithm must find the highest fitness peak in the entire search space. It was surprising that someone who is touted to be a great mathematician, indeed the next Isaac Newton, used not a single equation in the text or notes of his paper. At the end of his talk, Dembski looked a bit unsettled at the sight of a forest of upraised hands. Many people pointed out during the question period that genetic algorithms are used to design things in industry today. Dembski denied it.

The final session was on consciousness and included John Searle (Berkeley), Nancey Murphy (Fuller Theological Seminary), and Howard Ducharme (University of Akron). This session contained little data and lots of philosophizing. A more complete account of this session (as well as all the sessions) can be found at <http://www.flash.net/~mortongr/wacoconf.htm>.

To conclude, I want to emphasize that the quality of the convention was great. I really must congratulate the ID folks: they put together some really interesting talks (along with some less stellar ones). This type of conference at the university level is wonderful in presenting opposing data to those who do not generally listen to alternatives. So it is a shame that the Polanyi Center is likely to be discontinued, because the conference they put on was excellent — indeed an intellectual feast.

The conference also exposed some of the weaknesses in the ID movement to many of their supporters — something the ID advocates would not want. One Christian apologized to me for Henry Schaeffer's talk. One mother told me that she could see that Christians were not preparing their children for what they would see in college. Another was disturbed by the contrast in the quality of the presentations. And John Baumgardner, a young-earth creationist, told me that he was unhappy with the way the naturalists were dominating the conference. He could not understand why the ID folks invited all those "atheists".

It was starkly clear to most of the attendees that the ID movement offered no research program, avoided making empirical predictions, and basically engaged in philosophizing about, rather than explaining, the nature of Nature. This may be the last conference sponsored by the Polanyi Center, which is unfortunate, because it succeeded in exposing the intellectual weaknesses of the ID movement.

REFERENCES

Behe MJ. *Darwin's Black Box.* New York: The Free Press, 1993.

Miller K. *Finding Darwin's God.* New York: HarperCollins, 1999.

AIG Dedicates Museum Site

On June 17, Answers in Genesis (AIG), the evangelical Christian ministry headed by Ken Ham, dedicated the future site of its "Creation Museum and Family Discovery Center" in Boone County, Kentucky. The museum will also serve as the new headquarters for the fiercely antievolutionary ministry (*see* RNCSE *19 [4]: 5 and 18 [2]: 22, 23*).

In attendance at the 47-acre site were over 250 people, including John D Whitcomb, coauthor (with Henry M Morris) of *The Genesis Flood*, which Ham said was "the first major creation book" he read. Whitcomb invoked God's blessing on the museum, praying for God to "remove it from the face of the earth" if it was ever used to disgrace "Him or His Word".

Now that the struggle over zoning approval for the museum has finally been resolved in AIG's favor (*see* RNCSE *19 [6]: 9*), construction of the 95 000-square-foot edifice is expected to begin on March 15, 2002. The lead architect for the museum is George Nielsen of Cincinnati's A M Kinney Associates, which is reportedly donating "a significant portion of its services" to AIG.

Scheduled for completion in the summer of 2002, the museum is slated to present "a 'walk-through' visual history of the world, beginning with the Bible's very first verse, and will use dinosaur models, interactive displays, videos and dioramas to proclaim biblical authority." Among the displays will be exhibits originally at the now defunct Columbus Center in Baltimore, from which AIG bought 19 truckloads of material at public auction (*see the Lexington [Kentucky]* Herald-Leader, *May 30, 1999, B1, B7*).

AIG boasts that the museum will be within one day's drive of two-thirds of the US population.

[For further information, see the on-line reports at <http://www.answersingenesis.org/docs2/4318news6-2-2000.asp>, <http://www.answersingenesis.org/docs2/4330news6-19-2000.asp>, and <http://www.answersingenesis.org/docs2/4332news6-21-2000.asp>.]

Minnesota Court Upholds School's Right to Decide Curriculum

Molleen Matsumura
Network Project Director

In the last issue of *RNCSE*, Eugenie Scott reported on a lawsuit filed by Faribault, Minnesota, teacher Rodney LeVake, who had been re-assigned to teach a high-school general science course after telling school administrators that he could not teach the district's biology curriculum without also teaching supposed "problems" with evolution. He claimed that the re-assignment violated state and federal constitutional protections of his religious liberty and free speech rights (*see* RNCSE *1999 [3]: 24-6 and* RNCSE *1999 [6]: 8-9*).

LeVake was represented by an attorney from the Midwest office of the American Center for Law and Justice, a "Religious Right" legal organization, and it seemed that there might be a "show trial" in the making. LeVake had been interviewed for a segment of a CNN program that was aired in mid-March. His attorneys planned to call as an expert witness Jonathan Wells, a Fellow of the Center for Renewal of Science and Culture, a Seattle think-tank actively promoting "intelligent design" (*see "Anti-Evolutionists Open a New Front", p 6)*. The school district's attorneys, in turn, asked NCSE's Executive Director Eugenie C Scott to testify.

Instead, on June 20, 2000, District Court Judge Bernard E Borene granted the school attorneys' motion for a summary judgment and dismissed the case.

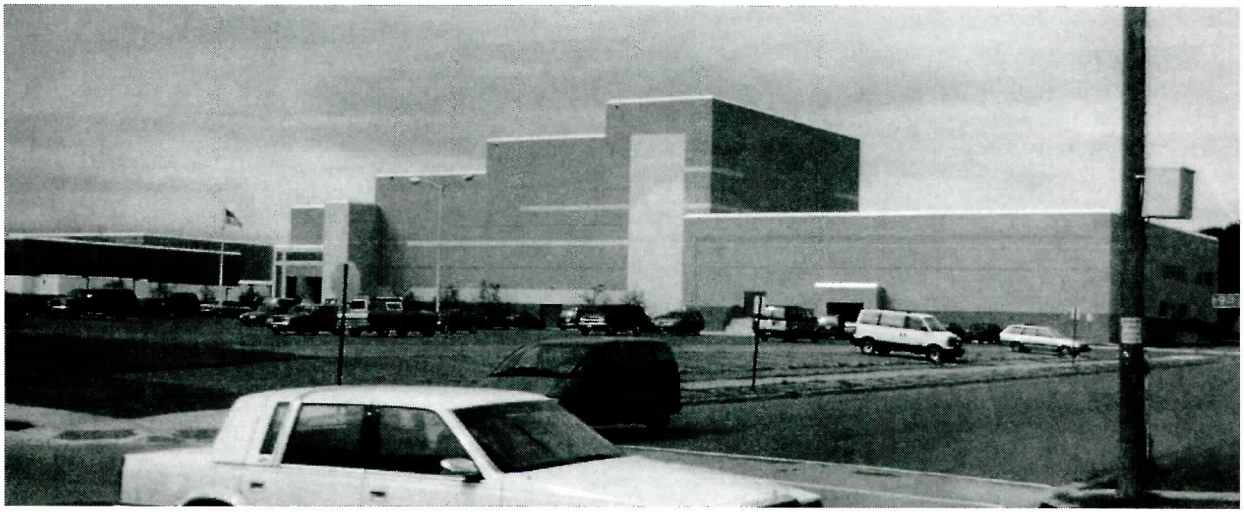
Much of Borene's reasoning consisted of findings that LeVake had not offered any evidence to support his allegations. For example, Borene wrote, "[w]ithout any facts demonstrating religious factors in Defendants' decision-making, Plaintiff cannot make out a violation of the Free Exercise Clause in this case" (*LeVake v Independent School District #656*, p 16).

However, the decision also addresses legal principles relevant to LeVake's claims concerning both freedom of religion and freedom of speech. There is a large body of case law upholding schools' right to determine the curriculum and require teachers to teach it, including cases concerning the teaching of evolution specifically (such as *John E Peloza v Capistrano School District* and *Webster v New Lenox School District*).

Anti-evolutionists have most recently developed a legal strategy based on the premise that teachers have a right, as a matter of "free speech" or of "academic freedom", to teach "alternatives to" or "evidence against" evolution. A recent variation on the theme is the claim that exclusion of "creation science" or of "intelligent design theory" from public school science curricula is unconstitutional "viewpoint discrimination" (see, for example, DeWolf and others 1999). Borene's decision does not explicitly mention "viewpoint discrimination", but decisions addressing this issue have discussed whether schools had created specific kinds of "public forums" (for example, *Rosenberger v Rector*); it is in the context of such forums that "viewpoint discrimination" may be found unconstitutional.

Borene bluntly stated that "[i]n the instant case, Plaintiff asserts a

SOME OF THE STORIES IN OUR NEXT ISSUE



Faribault (MN) Senior High School

free speech right to teach the criticisms of evolution in the biology classroom. Plaintiff's position is wrong."

Borene's analysis distinguished a classroom from a public forum [in the following excerpt, ellipses represent case citations, which are included in the references at the end of this article; otherwise, the text is taken verbatim from the decision]:

> The rights of free speech and assembly, while fundamental in our democratic society, still do not mean that everyone with opinions or beliefs to express may address a group at any public place and at any time.... In particular, a school classroom is a *nonpublic* forum and, like the owner of property, the District may legally preserve the property [the classroom] under its control for the use to which it is dedicated.... Plaintiff's classroom at the high school is a *nonpublic* forum, and the District has the right to limit the speech in that classroom to the teaching of the designated curriculum. The District bears the responsibility of assuring "that participants learn whatever lessons the activity is designed to teach."... In the District's 10th grade biology curriculum, one of those lessons is evolution. When Plaintiff is standing before his students in the classroom, he is not in the position of a citizen on the public square with a right freely to express his opinion as he sees fit. Rather, he is acting as an employee of the school charged with teaching the prescribed curriculum and is in a location which the District has reserved for the purpose of teaching students the prescribed curriculum. To rule that Plaintiff has a free speech right to teach the curriculum as he sees fit would be literally to make a federal case out of every dispute between a teacher and his superiors. This the Court will not do. (*LeVake v Independent School District #656*, p 20-1, emphases added, insertions in square brackets as in original).

Although the decision in *LeVake v Independent School District #656* is the latest of several court decisions affirming that schools may require the teaching of evolution, it is not the end of the story. On July 24, LeVake's attorneys filed an appeal for reversal of Judge Borene's decision. It is also certain that similar lawsuits will be filed in other states. When this happens, NCSE stands ready as always to assist school administrators and to keep its members informed.

References

DeWolf DK, Meyer SC, DeForrest ME. *Intelligent Design in Public School Science Curricula: A Legal Guidebook*. Richardson, TX: Foundation for Thought and Ethics, 1999. <http://law.gonzaga.edu/people/dewolf/fte2.htm>. Last accessed April 9, 2000.

Rodney LeVake v Independent School District #656 et al, Order Granting Defendants' Motion for Summary Judgment and Memorandum, Court File Nr. CX-99-793, District Court for the Third Judicial District of the State of Minnesota (2000).

John E Peloza v Capistrano Unified School District, 34 F.3d. 517 (1994).

Ronald Rosenberger, et al, v Rector and Visitors of the University of Virginia et al, 513 U.S. 959, 115 S.Ct. 417, 1301 L.Ed.2d. 333.

Webster v New Lenox School District #122, 917 F.2d. 1004 (1990).

Citations in the quotation from Judge Borene's decision

Cox v Louisiana, 379 U.S. 536, 554; 85 S.Ct. 453; 13 L.Ed.2d. 471 (1965).

Lamb's Chapel v Center Moriches Union Free School Dist., 508 U.S. 384, 391; 113 S.Ct. 2141; 124 L.Ed.2d. 352 (1993).

Miles v Denver Public Schools, 944 F.2d. 773, 777 (10th Cir. 1991).

Hazelwood School District v Kuhlmeier, 484 U.S. 260; 108 S.Ct. 562; 98 L.Ed. 592 (1988).

Science Standards Safe in South Carolina

Robert Dillon
College of Charleston

The new South Carolina Science Standards received unanimous approval at the State Board of Education meeting in Columbia on January 12, 2000. An anticipated threat from creationists did not materialize, though there was some cause for worry. The South Carolina curriculum is based on the Science Education Standards developed by the National Research Council, and has a strong evolutionary component. The "first reading" version was posted for public scrutiny in November 1999 and may be viewed at <http://www.state.sc.us/sde/educator/standard/science/2science.htm>.

At least a couple of the members of the state board are known to harbor creationist sympathies. On January 5, the chair of the state curriculum committee, Lisa Van Riper, sent a memo to State Superintendent of Education Inez Tenenbaum objecting to certain evolutionary items in the life science standards for both 8th grade (A.2) and high school (C.1 and C.2). Van Riper wrote that "for some, the word 'evolution' has become synonymous only with 'macroevolution' which, for some, has become synonymous with a god-absent view of origins." Thus she recommended, in discussing macroevolution, "present a full range of information. If there is information that is in serious dispute or information that is not yet complete, present it."

On January 10, Linda Sinclair, the state science coordinator, asked several science faculty from the Columbia and Charleston areas to be available to respond to any anti-evolutionary concerns that might arise in the curriculum committee meeting the next day. So on Tuesday, January 11, six of us drove up to Columbia — Mitch

Colgan and Bob Nusbaum from Geology, Dana Cope from Anthropology, Bill Anderson and I from Biology, and Guy Consolmagno, the (rather prominent) planetary geologist from the Vatican Observatory.

The January 11 curriculum committee meeting was quite well attended (about 12 members and 40 observers). Among the other observers I noticed John Carpenter and Michael Howell of the USC Geology Department and Jim Knight of the State Museum. Sinclair offered several fairly lengthy lists of proposed changes to the science curriculum standards (elementary, middle, and secondary), most of which she characterized as "wordsmithing". Van Riper expressed only 2 concerns. She objected to the inclusion of a quotation from the rotunda of the National Academy of Sciences describing science as, among other things, an "eternal guide to truth". It was agreed that this particular quotation should be deleted. She offered a more guarded description of science itself — a quotation from a San Diego science teacher on the "tentative" nature of the enterprise. Howell rose to object that this particular quotation casts science in a negative rather than a positive light. Neither Van Riper nor any other member of the curriculum committee expressed any overtly creationist sentiments, however, and the amended standards passed unanimously.

On the morning of January 12, the Charleston *Post & Courier* ran a fairly extensive article headlined "State Board of Education Ponders Standards, Evolution" on page B-1. The general thrust of the article was quite accurate — that after several months in the public eye, the new science standards were expected to draw fire from creationists during the public comment period that day.

But although one visitor from Bob Jones University was present, no anti-evolutionist rose to the microphone at the full board meeting on January 12. The room was packed, with broadcast and print media in attendance. The only members of the public to offer comment were me, John Carpenter, Michael Howell, Jim Knight, and Carol Tempel (who spoke for the educators who were directly involved in the process). We 4 scientists simply expressed our support for the standards as currently drafted, avoiding mention of the e-word altogether. The standards were passed unanimously (with Van Riper abstaining), and the gallery broke into applause.

I am not certain why rigorous science standards passed with so little objection in South Carolina, while similarly worthy documents have suffered outrageous fortunes in Kentucky, Illinois, Oklahoma, Ohio, Kansas, and several other states. I do know that a show of support from the local scientific community helped. Even though only one of the approximately 10 scientists present at the curriculum committee meeting on January 11th was called upon to speak, my colleagues and I were repeatedly and sincerely thanked simply for our presence. I think that we kept the discussion honest.

Communication with state science educators was also important. A close working relationship developed between Sinclair and several college and university science faculty, who called and e-mailed their friends to spread the word on exactly what room to be in at what day and hour.

A third key was that we were all willing to work in uncertainty. We never knew when or if a creationist challenge might come, or on what basis. So we simply had to be ready for anything at any time. A credible defense does not require that a large number of scientists rally on the statehouse lawn, but it does require patience and flexibility on the part of at least a respectably-sized team.

When compared to the years of effort dedicated to the science standards by scores of South Carolina educators, a couple of trips to the state capital and 2 minutes in front of a microphone seem a small contribution to make.

Readers may view the science education standards approved in January by the South Carolina Department of Education on the department's web site at <http://www.state.sc.us/sde/educator/standard/science/>.

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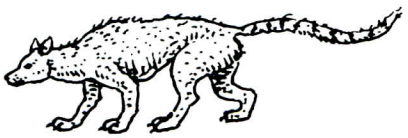

Baylor University Faculty Object to Polanyi Center

Richard Duhrkopf
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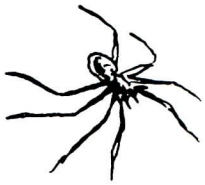
Baylor University

Baylor University is the location for the newly-funded Polanyi Center — an institution devoted to the study and promotion of "Intelligent Design Theory". Several faculty in different departments raised concerns about the Polanyi Center at an annual meeting with the university's president sponsored by Baylor's Faculty Senate. Richard Duhrkopf reports on the comments of faculty and the president's response.

On March 2, 2000, Baylor University President Robert Sloan participated in the annual exchange with the faculty, in which he answered a number of written questions from the faculty. Two of the questions specifically addressed the Polanyi Center.

The first question asked whether establishing the Polanyi

Center at Baylor has institutionalized the propagation of a position, "Intelligent Design" creationism, which is contrary to the prevailing assumptions of the majority of the world's scientists, specifically the scientific commitment to methodological naturalism. Arguing for a controversial position is one thing, the questioner argued, but institutionalizing it is another. Moreover, the question continued, the fact that those associated with the center are described by their own colleagues outside of Baylor as part of a "new generation of creationists" constituting a "coalition to bring down evolution" is causing serious problems for the reputation of Baylor's science and premedical programs. The question concluded by expressing the concern of some of the faculty that the center was established by the administration without an awareness of these implications and the hope of other faculty members that the president will step in and preserve the integrity of the university and its science programs.



The second question concerned the connection between existing departments and programs and new institutions formed on campus. Since the establishment of an institution such as the Polanyi Center has far-reaching implications for areas of the university such as the biology and psychology departments, it asked whether faculty members from those departments ought to be consulted when such an institution is being considered.

Sloan's answers to these questions were not what we in the Department of Biology were hoping for. First he described the 4 goals of the Polanyi Center: to promote dialog between the sciences and religion, to study the historical/philosophical constructs of science, to promote an understanding of science, and to carry out a program of scientific research aimed at investigating the concept of design in nature.

Sloan cited his prior resistance against creationists, but he admitted that his opposition was because he believed that their theology, not their science, was bad. He went on to say that he has discussed these issues with Polanyi Center Director William Dembski and Associate Director Bruce Gordon, and that both have assured him in no uncertain terms that they are not creationists. He feels that they are men of good will and should be taken at their word!

After he had been made aware of the concerns of the science departments, Sloan said, he initiated discussions as to how better oversight could be established to review the scientific program of the center. When pressed as to why the science departments were not consulted, he said that they were; however, no one in the Department of Biology was among those consulted, not could I find any other colleagues in the sciences who were asked to participate.

Sloan also said that he had read Dembski's *The Design Inference* and felt that it had many intriguing notions that we ought to allow Dembski the institutional resources to develop. As a university, he argued, it is Baylor's mission to investigate all sides of an issue and to allow all to present their views. He said that Dembski had been quite adamant that he is looking only for a fair opportunity to investigate his ideas scientifically; if they prove to be incorrect, that will be the end of it. When he was asked what he thought a reasonable time would be to expect some results of the Polanyi Center's scientific program, his answer was that it is too early to tell. It looks from here as though we may be in this for the long haul.

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Juicy Fruit or Spearmint in West Virginia

Karl D Fezer

Kanawha County, West Virginia, contains the state capitol, 3 four-year liberal arts colleges, and a thriving chemical industry. The Technical Center of Union Carbide employs 1800 chemists and related professionals. The Charleston *Gazette* has exhibited sustained outrage against special privilege, injustice, corruption, and tom-foolery.

Such ingredients of an enlightened community exist side-by-side with the legacy of the infamous 1974 textbook controversy. Back then, one school board member led the charge against many of the textbooks in a number of subjects proposed for use in the county's schools. These texts were described as promoting diverse evils — all alleged to be the consequences of the "religion" of secular humanism. Protests involved shootings, beatings, school closings, boycotts, strikes, and even a couple of dynamite explosions on school property. One minister served jail time for the bombing; another urged people to pray for God to strike the opposing school board members dead. The school board finally adopted textbook guidelines consistent, at least in part, with the demands of the protesters.

FAST FORWARD TO THE 1990S

In the late 1980s, the Kanawha County school administration issued a regulation that stated, "Creation science is not to be taught." Then, in 1990, the school board adopted a policy on instruction involving controversial issues. The policy required that issues selected for classroom consideration be "relevant to state

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learning outcomes and county programs of studies" and that they meet other guidelines, notably some spelled out under the heading "unbiased presentation".

In 1991, the Institute for Creation Research (ICR) held a "Back to Genesis" rally in Charleston's Municipal Auditorium. This led to my debating Duane Gish on my home turf, 90 miles south of Charleston (*see my articles in* Creation/Evolution *1993; 13 [1] nr 32: 45-9* and *13 [2] nr 33: 5-21*). Over subsequent years, the Charleston *Gazette* printed occasional columns and letters to the editor on the controversy, including quite a few from members of the Kanawha Creation Science Group. Its most active member was and is Karl C Priest, a middle-school mathematics teacher. I have had a friendly correspondence with Priest, and I sent him my 2 articles critical of Henry Morris and Duane Gish. I asked him to tell me if there was anything unfair or unreasonable in either article. He sent them on to ICR for comment; eventually he told me that Morris and Gish had explained everything to his satisfaction, but it would be futile to convey those explanations to me, since I am too biased to appreciate them.

A Proposed Resolution

Early in 1999, Priest wrote to the West Virginia Department of Education to urge statewide adoption of a resolution that included the following statement: "Whenever evolutionary theory is taught, students and teachers are encouraged to discuss the scientific information that supports and questions evolution and its underlying assumptions, in order to promote the development of critical thinking skills. This discussion would include only the scientific evidence for and against evolutionary theory, as it seeks to explain the origin of the universe and the diversity of life on our planet." Priest failed to make headway with the state agency, but he did find an especially sympathetic member of the current Kanawha County Board of Education, Betty Jarvis. She contrived to get the board's attorney to draw up a resolution that advises teachers that they may "teach any and all subjects and theories in their respective subject areas, including, but not limited to, theories for and against the theory of evolution", provided they do so "objectively and impartially", identify expressions of their opinions and beliefs as their own, and meet the other conditions of the board's 1990 policy on teaching controversial subjects (*see* RNCSE *1999; 19 [5]: 10-2*).

Advocates of the proposed resolution insisted that they were not advocating the teaching of "creation science". However, Priest has clearly stated that he believes that he can disprove the possibility of evolution mathematically. He seems neither to understand the assumptions on which those calculations are based nor to realize that there probably are no scientists who advocate the implied scenario. One must conclude that, had the resolution passed, Priest would have taught his argument to his mathematics classes — without identifying the underlying assumptions and their inappropriateness.

I sent the proposed resolution to NCSE for comment. Executive Director Eugenie C Scott described it as "a can of worms". She remarked:

> The resolution just calls attention to existing regulations, which in themselves are not really objectionable — they allow some academic freedom to K-12 teachers and attempt to set boundaries for the teaching of controversial issues. What is missing from the Kanawha statutes (and in some others we have seen) is a recognition that such activities are constrained by law — the First Amendment. Teachers in general can discuss their own opinions and beliefs, but they may not proselytize to students, and in fact, the courts have been pretty clear that teachers should not discuss their religious beliefs with students because of the role model status of a teacher and the fact that this activity could be seen as trying to influence the students' religious beliefs. The classroom must be religiously neutral.

Scott also pointed out that the highlighting of evolution signaled an attempt to bypass the existing "do not teach creation science" policy. She said, "They are ill-advised to single out evolution from all other curriculum topics, as this [strategy] has been struck down by the courts. Yet if they do not single out evolution, they are just reiterating their old policy, which makes the resolution immaterial." Yet, she added, the *resolution* does go beyond the old policy by encouraging teachers to teach "any and all subjects and theories in their respective subject areas", whereas the *policy* focuses on topics that are already in the curriculum. The board, she said, was opening itself up to relinquishing its control of the curriculum. "It is the administrators who will suffer if this policy goes into effect."

Action and Reaction

Initial newspaper reports indicated that 2 Kanawha Board members were opposed to the proposed resolution, 2 were in favor of it, and 1 was mum. The board circulated the proposal to principals, teachers, and others for comment. Final comments from the public, and a decision on the resolution, were scheduled for Thursday, December 16, 1999. At 3 earlier board meetings, the board heard vigorous support for the resolution from various clergymen and opposition from only one person, the Rev Terry Moore of the local Unitarian/Universalist Fellowship.

As December 16 approached, the board member who had ini-

tially supported Betty Jarvis announced that, for practical reasons, he would vote against the resolution, and the one who had been mum explained to me that, since the board had circulated the resolution for comment, he did not want to announce his position before the comments were received. He too opposed the resolution. It looked like the resolution would be defeated 4 to 1. Yet each side thought that the outcome might be influenced by testimonials at the board meeting.

James Haught, editor of the Charleston *Gazette*, wrote editorials opposed to the resolution. I sent Scott's comments and other materials to all the board members, and I recruited several others to attend the board meeting and testify against the resolution. Most effective in rousing opposition, however, was Moore, whose Unitarian/Universalist Fellowship includes a number of Union Carbide chemists, as well as other citizens, willing to speak out.

Statement Approved by the Faculty Senate at the University of Oklahoma, April 10, 2000

The faculty of the University of Oklahoma at the Norman Campus takes very seriously its charge to educate the future generations of Oklahomans. We therefore oppose the imposition of political constraints on the methods or results of academic disciplines in public schools at any level. Academic intellectual enterprises should expose theories and opinions to spirited professional review by peers. Requirements of disclaimers, provisional acceptances or other such restrictions on textbooks or other classroom materials compromise both the intellectual process and the results, and therefore are unacceptable.

Enter Dr Mastropaolo

Several weeks before the showdown, Haught, Moore, and I received word from Priest that one Dr Joseph Mastropaolo would be in Charleston the entire week of the board meeting, that he would be giving lectures at various churches, and that he would like to participate in a debate. All 3 of us declined the invitation, in spite of increasingly insistent messages from Mastropaolo. He accused me of "hiding behind the skirts of Eugenie Scott"; his e-mail screamed, "I am calling you out. Debate or lose by default."

In keeping with the Unitarian principle of a "free pulpit", Moore did offer Mastropaolo one-half hour to speak to his Fellowship during its Sunday service, which Mastropaolo accepted. Mastropaolo used up his entire half hour lecturing, so there was no time for questions. However, Haught and I went to lunch afterward with Mastropaolo, Priest, and Jarvis, together with several of our spouses, so we were able to find out more about the speaker.

In our e-mail correspondence preceding Mastropaolo's visit, I had suggested to him that he read Priest's copy of my critique of Duane Gish. He replied, "I represent myself, not ICR. Your difficulties with ICR are your problem, not mine." Then, after his talk to the Unitarians, he handed out copies of the November 1999 ICR *Impact* article 317, "Evolution Is Biologically Impossible", of which he is the sole author (*see Bill Thwaites's critique in* RNCSE *19[5]: 27-9*). In this article, he is identified as "adjunct professor of physiology for the ICR Graduate School".

Mastropaolo's talk to the Unitarians was devoted to several topics — evidently the same ones he hammered home all week, and the same ones he summarized in his testimony before the board. These are: (1) his scientific credentials, including a number of physiology research grants and publications in "top journals"; (2) his claim that laws of thermodynamics and probability calculations preclude the possibility of abiogenesis (*see* Impact *317*); (3) Francis Hitching's critique of the claim that natural selection accounts for the neck of the giraffe; (4) alleged flaws in the "peppered moth" data; (5) Haeckel's exaggeration of the degree of similarity in early vertebrate embryos; (6) the Piltdown Man hoax; and (7) the danger to students' lives of what they are taught about sickle cell anemia.

The Board Listens and Acts

The board met to vote on the resolution on December 16. Outside, proponents of the resolution held a candlelight prayer vigil. Inside, to speak to the board, people had to request time before the meeting began. Each speaker was given up to 3 minutes, with the proviso that each person could give some or all of his or her time to someone else. However, no one would be allowed to speak more than 10 minutes. Reportedly, 72 people requested time. Some gave their time to others, and some left before their turn came. Ultimately, over a period of nearly 4 hours, 44 people spoke to the board — 24 of them against the resolution that would have advised teachers to teach "theories for and against evolution".

The first speaker asked, "Which would you choose, Juicy Fruit or Spearmint gum?" — and insisted on an answer from each board member. This was intended to illustrate his point that the resolution was about choice, about options, about the many ways there are to explore the world. Earlier claims that the resolution allowed only scientific arguments and not the teaching of "creation science" quickly disappeared amid condemnations of evolution and of the "oligarchy of ACLU intellectuals and church haters". Some of the preachers who thus waxed eloquent reminded me of what I had read about the Scopes trial: that oratorical skill was especially appreciated and applauded by the locals. The preachers

returned to their seats to be met with expressions of admiration from their friends and congratulatory handshakes all around.

Not surprisingly, a recurring theme among proponents of the resolution was that evolution is a religious belief. John Dewey's endorsement of the *Humanist Manifesto* and an article from a 1983 issue of *The Humanist* that allegedly advocated using classrooms to promote the humanist agenda were cited in support.

The executive director of the American Civil Liberties Union of West Virginia told the board that she did not consider the resolution itself to be unconstitutional, but her organization would certainly take legal action if any teacher used the resolution to teach "creation science". An attorney representing the American Family Center for Law and Policy said that it had assured the board that, in the event of a lawsuit, it would defend the board at no cost and that the board would win. But another attorney said that the board would lose any such lawsuit.

Various speakers urged the board to have courage, or blasted it for lacking backbone. One speaker (who was against the resolution) said that he was an unsuccessful candidate for the board in 1984, and he belatedly wanted to thank the voters for not embroiling him in this debacle.

Among speakers against the resolution, George Keller, a Union Carbide chemist and a member of the National Academy of Engineering, described his survey of creationist web sites to see if creationists could cite any Nobel Prize winners as favorable to their claims. Given the opportunity, they certainly would do so. But he found none. He also said the proposed resolution would deprive the schools of quality control and, for example, that it would allow racists who describe others as "mud people" to expound their so-called "theories".

Karl Priest claimed that a survey of secondary school science teachers showed that 81% were in favor of the resolution. I learned later that he had conducted that survey himself. The county's science supervisor told me that there was very little response to circulation of the proposed resolution. He thought that most teachers wanted nothing to do with it.

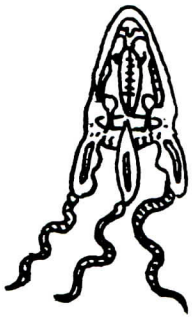
> The opinion-page editor of the Charleston Gazette despaired of the never-ending, no-progress stream of letters on certain issues — abortion, homosexuality, gun control, and creation/evolution. So he instituted an on-line forum for each of these and similar subjects at the paper's web site: <http://wvgazette.com/static/forums.html>.
>
> After the first month, the most popular forum was the one devoted to the creation/evolution issue, with more than 300 postings.

By virtue of advance request and donated time, Mastropaolo had the last 10 minutes of testimony, all of which was actually given by Betty Jarvis, who graciously agreed to respond to leading questions asked by Mastropaolo. A transcription of that session follows:

> **Q.** Have you heard my presentations of the scientific evidences from scientific journals and books on the subjects treated in chapters 9, 10, and 11? **Jarvis**: Yes.
>
> **Q.** Did the scientific evidence documented in the scientific literature confirm the treatment of evolution in chapters 9, 10, and 11? **Jarvis**: No.
>
> **Q.** Or did it confirm that the treatment was based on absurdities like abiogenesis, fallacies like the neck of the giraffe, forgeries like the Piltdown Man, and frauds like Haeckel's embryos? **Jarvis**: Yes.

It is important to point out that the challenged textbook, Holt's *Biology*, presents extensive *legitimate* evidence of human evolution, and nowhere in it is Piltdown mentioned as a part of this evidence. One wonders what definition of fraud allows Mastropaolo to misrepresent the textbook in this way while railing against biology texts that supposedly mislead our youth.

Mastropaolo concluded his line of questioning by leading Jarvis to agree that passage of the resolution was necessary for the civil rights, education, health, and survival of students. The resolution was defeated 4 to 1, and each board member explained his or her vote. Karl Priest protested by donning his gorilla headdress.



Selection of New Textbooks

During the school year 2000–2001, Kanawha County will select new textbooks. A 9-member advisory committee has been appointed to help to select new science texts for public schools. The committee includes Karl Priest, 2 other creationists, the Rev Terry Moore, and 2 PhD Union Carbide chemists. A different teacher committee will actually propose which books to buy. A *Gazette* editorial worried that the teacher committee and school board might "succumb to creationist pressure and choose watered-down, wishy-washy science books that are silent about evolution". But so far, no teacher is advised by the Kanawha County school board "to present theories for and against evolution".

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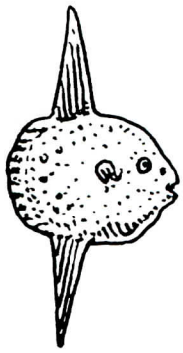
UPDATES



Alabama: Judge Roy S Moore, best known for defying a federal circuit court order to remove the Ten Commandments from the wall of his courtroom and refrain from opening court sessions with a prayer, is seeking the Republican nomination for a seat on the state supreme court. Moore has already signaled how he would vote on any evolution/creation case the court might have to decide. On June 5, *The New York Times* reported that Moore said in a speech to the Childersburg Kiwanis Club, "While truth and law were founded upon the God of all creation, Man through law now denies Him and calls it separation. Children are told they can't pray in school and they teach them evolution. Why can't they see the fear of God is the only true solution?" <www10.nytimes.com/library/national/060500judge-moore.html>

Arizona: An anti-evolution bill identical to the one now being considered in Ohio (see below) was reported out of committee but not passed by the lower house of the legislature.

Arkansas: NCSE members have just reported that in late 1999, despite opposition, Arkansas adopted a Science Curriculum Framework that explicitly covers evolution and clearly explains the nature of science. The Framework begins by defining "theory" — "in science, a well-substantiated explanation of some aspect of how the *natural* world works..." (p 2, emphasis added); explains that science deals with "events or things that can be measured, observed or detected"; and differentiates theories from "systems of belief" dealing with such issues as "the meaning of life" (p 3). It calls for students in grades 5-8 to "[u]nderstand that a scientific theory is based on current, accepted evidence" (p 9) and to be able to "[d]escribe how environmental changes and genetic mutation cause species to evolve over time" (p 12). The Framework is available at <http://arkedu.state.ar.us/Science_1999.PDF>.

California, Colton: NCSE members report that district adminstrators have instructed middle school teacher John McIntosh not to present creationist materials or concepts, but to adhere to the state science curriculum. McIntosh had earlier appeared on a local television program and stated that he was teaching about the scientific method by describing his participation in efforts to find Noah's Ark, and offering "the other side of the coin" when discussing geology (*see "The search for Noah's Ark in the science curriculum?", p 7*).

California, Castro Valley: In response to questions from concerned citizens, the Board of Education removed from draft science curriculum guidelines a requirement that students compare evolution to creationism. NCSE members in the district are concerned that the issue may reappear in the form of a policy statement ostensibly expressing "sensitivity" to diverse opinions of students, and are continuing to monitor proposals presented to the board.

Idaho: Judge Daniel Eismann has been elected to a seat on the state Supreme Court. Before the election, the May 9 issue of the Idaho *Statesman* reported that Eismann had said, "I have studied evolution in great detail. I think you can prove scientifically that evolution has not and cannot occur", to explain his response to a questionnaire distributed by a committee of the state Christian Coalition (which, NCSE has been told, has now disavowed the questionnaire).

Idaho: During its annual business meeting on April 1, the Idaho Academy of Science adopted a resolution in response to the Kansas State Board of Education's (SBE) 1999 decision to adopt science standards from which coverage of evolution had been deleted (*see* RNCSE *1999; 19[4]: 8-9*).The resolution was the same one that had earlier been adopted by the American Academy of Science (AAAS) shortly after the SBE adopted the flawed standards.The text of the resolution, in which the AAAS was joined by the National Science Teachers Assocation and the National Academy of Sciences, is at <http://project2061.aaas.org/newsinfo/kansas.htm>

Kansas: In the aftermath of the August 1999 adoption by the Kansas State Board of Education of science standards that distorted evolution and opened the door for classroom use of creationist materials (*see* RNCSE *1999; 19 [3], 6 and* RNCSE *1999; 19 [4]: 7-9, 10-3)*, many districts around the state have exercised the "local control" that the SBE advocated. Some have simply continued to teach evolution; others voted to adopt the standards as originally written — and unofficially distributed by Kansas Citizens for Science (KCSF). The SBE action was a major issue in the August elections, and a series of events commemorating the 75th anniversary of the Scopes trial focused on races for SBE positions in the primary elections. [*Read about the election results in our next issue.*]

Kansas, Pratt: This district walked through the door opened by the State Board of Education. Following months of effort by community members and some local school board members to get approval for using the "intelligent design" textbook *Of Pandas and People*, the local board of education voted on April 3 that "the superintendent or his designee is requested to establish dialog with the science teachers at Pratt High School, and revise the PHS biology standards to incorporate instruction methods using critical analysis which both supports and questions the theory of evolution before school starts."

Kentucky: A bill introduced in the House that would have forbid-

den teaching human evolution failed to become law in April.

Michigan, Belleville: The local school board has voted 3–2 to approve a biology textbook that some board members and others had attacked for supporting evolution. It rejected a proposal to use the "intelligent design" textbook *Of Pandas and People* and refused to consider an evolution disclaimer.

Minnesota, Faribault: On June 20, a state district court dismissed a lawsuit by Rodney LeVake, a teacher who had been reassigned from a biology class to a general science class when he told administrators he was determined to continue teaching "evidence against evolution" (*see* RNCSE *1999; 19[3]: 24–6,* RNCSE *1999; 19[6]: 8–9, and related story on page 13*).

Ohio: State representative Ron Hood has re-introduced his 1996 bill calling for teaching evidence "supporting…[and] not supporting" evolution (*see sidebar*). The difference, worried NCSE members note, is that this time the bill has several cosponsors. Action on this bill is not expected before September, and NCSE's Ohio members are hard at work (again!) organizing opposition to it.

Oklahoma: A bipartisan conference committee of both houses of the state legislature unanimously recommended that the House "recede from" amendments to Senate legislation concerning the State Textbook Commission. The amendments would have required adoption of science texts acknowledging "one God of the universe" and authorized the commission to attach disclaimers to any textbooks (*see* RNCSE *1999; 19 [5]: 7–8 and* RNCSE *1999; 19 [6]: 11–12*). At press time, the Senate had taken no action on the recommendations. Meanwhile, observers were speculating that the governor might extend the legislative session because it seemed unlikely that the legislature could act on a large backlog of bills before its summer adjournment.

Citizens' groups continue to circulate petitions opposing the Textbook Commission's disclaimer, and the University of Oklahoma Faculty Senate overwhelmingly approved a statement characterizing disclaimers as unacceptable (*see sidebar page 18; Norman* Transcript, *April 11, 2000, A1, A2*). In Tulsa, a coalition including NCSE members and the Interfaith Alliance has sponsored a series of community meetings on the issue.

Washington, Burlington-Edison: Readers of *RNCSE* may recall that on March 12, CNN aired "In the Beginning", including a segment on this district's continuing controversy over efforts by science teacher Roger DeHart to teach "intelligent design" theory. DeHart had been ordered to limit his use of excerpts from the "intelligent design" text *Of Pandas and People* and to balance such materials with information on the evolutionary concepts they criticized. (*See* RNCSE *1997; 17 [4]: 7,* RNCSE *1998; 18 [1]: 9,* RNCSE *1998; 18 [3]: 6,* RNCSE *1999; 19 [1]: 6,* RNCSE *1999; 19 [3]: 6, and* RNCSE *1999; 19 [6]: 9.*) In May 2000, DeHart submitted a new list of supplemental materials after the deadline, and high school principal Beth Van der Veen refused to approve those materials. (*Watch for more details from NCSE activists in the area in a future issue of* RNCSE.)

West Virginia, Kanawha County: Following the Kanawha County Board of Education's decision not to purchase copies of the "intelligent design" textbook *Of Pandas and People* for distribution to teachers, who might then share the book with students (*see* RNCSE *1999; 19 [6]: 12*), board members are discussing a proposal to accept donation of the book to school libaries. (*See "Juicy Fruit or Spearmint in West Virginia", p 16.*)

National: On June 19, the US Supreme Court declined to review an appeal of lower court decisions ruling unconstitutional the Tangipahoa Parish School Board's policy of requiring teachers in its district to read aloud a disclaimer whenever they taught about evolution. (*See "Supreme Court Rejects Evolution Disclaimer", p 4.*)

NCSE thanks Ken Atkins, Gary Bennett, Karl Black, Liz Craig, Jerry Day, Jim Derby, Steve Edinger, Frank Fire, Jr, Kevin Greene, George Gumbert, Jim Huff, Kim Johnson, Matthew Kaser, Jama Kolosick, Adrian Melott, James Murray, Carol Smith, Robert "Mac" West, and Thair Witmer for information used in this article.

Text of the Ohio Bill

Regular Session
1999–2000 H. B. No. 679

Representatives Hood-Young-Jordan-Netzley-Callender-Buchy-Clancy-Trakas-Hoops

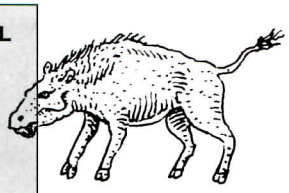
A BILL

To enact section 3313.6012 of the Revised Code to require that, whenever the theory of evolution is included in the instructional program of a school district or educational service center, the scientific evidence both supportive and not supportive of the theory be included.

Be it enacted by the General Assembly of the State of Ohio:

Section 1. That section 3313.6012 of the Revised Code be enacted to read as follows:

Sec. 3313.6012. Whenever a theory of the origin of humans or other living things that might commonly be referred to as "evolution" is included in the instructional program provided by any school district or educational service center, both scientific evidence supporting or consistent with the theory and scientific evidence not supporting or inconsistent with the theory shall be included.



NCSE NEWS

NCSE Board Selects *Friend of Darwin* Awardees

The "Friend of Darwin" award recognizes NCSE members for their outstanding efforts to support NCSE and advance its goals. After reviewing staff recommendations, the NCSE Board of Directors has made awards for 1999 to:

David E Thomas

Many *RNCSE* readers will immediately recognize the name of the author of the winning essay in the "Tangible Benefits of Evolution" contest published in the last issue (*see* RNCSE *1999; 19 [6]: 13*); but there is much more to tell. Thomas is the long-time editor of the newsletter of New Mexicans for Science and Reason (NMSR), and has held several offices of that group. He counters pseudoscience in many forms — for example, by analyzing claims that the corpse of a "space alien" was found in Roswell, New Mexico, and refuting claims that biblical texts contain coded prophecies of modern events (*see* RNCSE *1997; 17 [4]: 23*). He is deeply appreciated by his colleagues in NMSR for years of effort, not only contributing personally to improving science education in New Mexico, but keeping fellow scientists informed of countless opportunities to help. Thomas has consulted with the New Mexico State Board of Education (NMSBE) staff during development of science content standards, testified before the NMSBE at countless hearings, testified at legislative committee hearings and advised individual legislators who were supportive of science education, provided informed comment to the press, published opinion essays about creation–evolution controversies inside and outside New Mexico, and helped judge at science fairs.

Marshall Berman

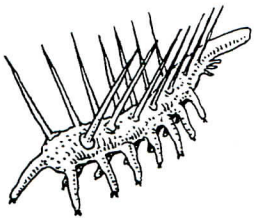
Marshall Berman was the founding president of the New Mexico group Citizens for Excellence in Science Education (CESE). CESE was founded to give citizens a way of working within political processes to improve science education, spurred on initially by the adoption in 1996 of state science content standards that opened the door to teaching "creation science". After helping to build a coalition of scientists, educators, clergy, and concerned citizens, Berman himself successfully ran for a seat on the New Mexico State Board of Education (see RNCSE *1998; 18 [1]: 6, 7*). In August 1999, shortly after evolution was removed from Kansas's science standards, Berman and other board members returned evolution to New Mexico's standards. However, Berman's objectives were much broader than merely reversing earlier mistakes. He has worked to improve the Board of Education's long-term policy planning and use of technology, and has taken an active role in national organizations dedicated to improving education. One of his projects has been the provision of internet resources designed to be useful to all participants in science education (*see related article, p 23*).

Gary L Bennett

Gary Bennett, whose reports on science education policy in Idaho have been a consistent feature of recent issues of *RNCSE*, has led the effort of NCSE members and others to assure that Idaho's students will learn about evolution. Bennett coordinated input on science standards by scientists and others for countless hearings before the Idaho Board of Education and its committees, and subsequent legislative review. He built coalitions with other organizations, including the state affiliates of the American Civil Liberties Union and the Interfaith Alliance. He also coordinated opposition to adoption of the "intelligent design" textbook *Of Pandas and People* for use in science classrooms, providing curriculum commissioners with a detailed critique of the book (*see p 31*). Bennett is currently working with other scientists on planning an interdisciplinary evolution symposium to be presented at the Idaho Academy of Science annual meeting in 2001.

John Banister-Marx

John Banister-Marx takes every opportunity to reach outside the science classroom to improve science education. He participated in committees advising the Arizona Board of Education on the science curriculum, and alerted NCSE and other concerned citizens to the absence of evolution from science content standards. His efforts helped ultimately to lead to the improvement of the standards (*see* RNCSE *1998; 8 [1]: 7–9, 25, 26*). Banister-Marx also conducts workshops and develops resources on teaching evolution for K–12 science teachers. Whether giving a workshop or attending one, he shares information about NCSE with teachers wherever he goes. He is currently working with fellow NCSE member Larry Flammer and Outreach Coordinator Eric Meikle on a joint project of NCSE and the Institute of Human Origins to develop World Wide Web resources for teaching about human evolution.



Friend of Darwin Awardee Launches On-Line Education Resource

Marshall Berman, NCSE member and a 1999 recipient of NCSE's Friend of Darwin award, wants your help.

Berman is the Executive Director of the Internet Learning Network (ILN), a web-based initiative of the Council on Competitiveness, aimed at stimulating improvement in K-12 science and mathematics education. The ILN web site is at <http://www.getsmarter.org>. ILN's objectives are to:

- Provide students a free, first-hand, no-risk opportunity to see how their science and mathematics skills measure up against those of other students around the world.
- Develop powerful content designed to link self-assessment with learning and self-improvement.
- Provide leverage for education reform efforts in science and mathematics.

The site provides practice opportunities, hints, tutorials, and links to other sites geared towards middle school audiences. Materials for elementary and high school students will be added in the fall and winter of 2000. Since March, the site was visited by over 150 000 users from every US state and 86 foreign countries.

Where do you come in? ILN needs ideas for content science and mathematics material at the 3rd, 4th, 7th and 8th, and 12th grade levels. ILN is also looking reviewers to evaluate and offer suggestions to improve the hints, links, and learning aids on the ILN web site. The time commitment is minimal and flexible. Reviewers' contributions will be gratefully acknowledged on the site.

If you can help, or know anyone who can help, please get in touch with Kim Grzankowski at <kgrzanko@compete.org> or (202) 682-4292.

NCSE Launches Outreach Project, Hires Eric Meikle

Molleen Matsumura
Network Project Director

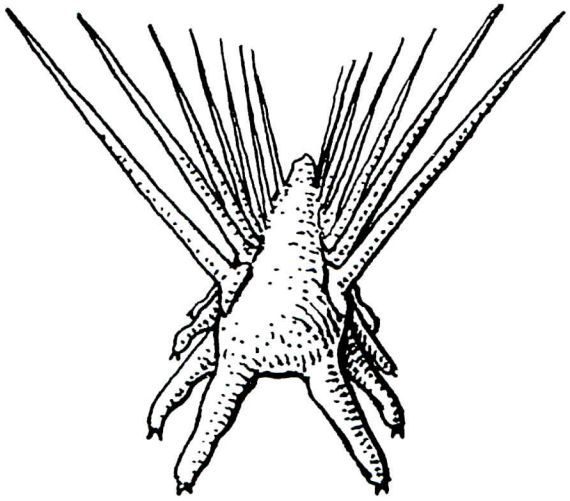
In April 2000, NCSE began a new "Outreach Project" with the assistance of a grant from the Dallas Foundation. "From the time NCSE was founded," Executive Director Eugenie C Scott explained, "we have had a twofold mission: both to defend evolution education from sectarian attack, and to educate the press and public about evolution and science as a way of knowing. As a matter of necessity, we have had to emphasize the first part of our mission. With this new project, we can do that job even better, and expand our work increasing public understanding of evolution."

Dr Eric Meikle, the new Outreach Coordinator, will develop a speakers' bureau, set up a program for regularly informing the press of important developments in the evolution/creation controversy, help to develop educational materials and expand the information available on NCSE's web site, and help to assist communities that are coping with efforts to undermine evolution education.

Meikle comes to NCSE with more than 25 years of experience researching and teaching about evolution. Most recently he worked at the Institute of Human Origins (IHO), a non-profit, multidisciplinary research organization dedicated to the recovery and analysis of the fossil evidence for human evolution. While IHO's primary mission is research, it is also strongly committed to education, and Meikle was responsible for many programs providing information to the press and public, and arranging school programs and teacher workshops. In these capacities he frequently cooperated with NCSE.

After completing a PhD in physical anthropology, Dr Meikle edited or contributed to several books and published scholarly papers. He has taught at the college level, and participated in a number of programs to improve public understanding of evolution and to help classroom teachers develop curricula for teaching about human evolution. He worked with NCSE advising on content for the "Stones and Bones" project jointly developed by the Los Angeles Unified School District, the Los Angeles County Museum, and the LSB Leakey Foundation. This nationally disseminated project produced casts of fossils and laboratory materials for use in high school biology, general science, and anthropology courses.

Please join us in welcoming this valued new member of our staff, and in watching for developments in the Outreach Project. Very soon we will be able to say "Yes!" to the many NCSE members who have asked whether we could send speakers to their communities.



In Memory of Bob Schadewald

Eugenie C Scott, NCSE Executive Director

On March 12, 2000, Robert J Schadewald, former NCSE President, died in Minneapolis, Minnesota, at age 57 of complications from cancer.

Bob was a technical writer by profession, but he was known to NCSE members and many others as a researcher of the scientifically quirky. The creation/evolution issue occupied much of his time, but his true specialty was the turn-of-the-century flat-earth, geocentric, and hollow-earth movements. It would not be an exaggeration to say that he was truly *the* authority on these early pseudosciences, about which he wrote several articles.

He assembled an unusually complete library of materials on these enthusiasms, including original books and pamphlets as well as copies of obscure and one-of-a-kind items archived at libraries in the US and abroad. Bob was a bibliophile's bibliophile: whenever he visited a city, he inevitably would check the library's holdings, and he always made the rounds of used book stores. Bob's library reflected his fascination with how science could be distorted, spun around, and turned inside out to justify false claims, whether those of special creation, or the even more bizarre "theory" of a hollow earth.

He delighted in pointing out similarities in how geocentrists, flat-earthers, and creationists marshaled their arguments. One of his prize possessions was a framed certificate declaring him a member of the International Flat Earth Society, headed by Charles K Johnson, of Lancaster, California. He was always happy to relate the story of how Johnson rescinded his membership after he discovered that Bob possessed "spherical tendencies".

When I broke the news of his death to various friends and associates, the universal response was dismay that Bob had died so young, depriving us of his intelligence, his knowledge, his wit, and his company. "He knew so much!" was a common lament, and indeed, Bob had a wealth of information, seemingly retrievable on a moment's reflection. I know that I relied a lot on his mental encyclopedia as well as on his keen insight into the people and ideas of the creationism controversy.

For Bob, more than any of us, personally knew and was friends with many of the people whose ideas we disagree with. Readers of *RNCSE* (and its predecessor, *NCSE Reports*, which Bob once edited) will recall Bob's published analyses of quadrennial International Creationism Conferences, which he faithfully attended. There was never any question that he disagreed profoundly with the "research" presented at these meetings, and he gave no quarter in vigorous debate with the creationists participating in these meetings, but he saw no contradiction in going out afterward for a beer with these same adversaries.

He made a distinction between creationists whom he considered sincere and who treated the scientific data on evolution fairly (even if they rejected it), and others whom he considered "snake-oil salesmen". When one creationist recently lost most of his personal library in a fire, Bob generously boxed up duplicate copies of his books on the creation/evolution controversy and shipped them off. There are a number of creationists who personally will miss Bob, even though they may not miss his barbed criticisms of their scientific statements or his astute dissections of their logic.

Bob resigned from the NCSE Board of Directors in the mid-1990s, citing increased demands of work as well as some personal reasons. But he remained an "on-call" advisor to me and our board members, and was a strong proponent of NCSE to the general public. He maintained informal email connections to many other "creationism fighters", sharing information and suggesting strategy up until the last week of his life.

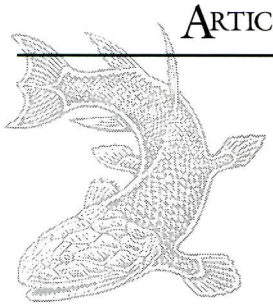
Once, after a typically long NCSE board meeting, a group of us had gone out for dinner. Immersed as we were in the creation and evolution controversy, after a few drinks, we started talking about creationist "scientific models" — laughing about the convolutions of data and theory required to accommodate scientific data within a 6-day creationist model. Much of the conversation consisted of "and can you believe that they actually think...?" as we regaled one another with examples of creationists' apparent ability to believe at least 7 impossible things before breakfast. We were having a pretty good time at the opposition's expense, when Bob looked up and said, "You know, somewhere, there's probably a bunch of creationists sitting around a table, drinking beer and saying, 'those evolutionists! Can you believe they actually think...?'"

We're going to miss him.

SCHADEWALD MEMORIAL FUND

Bob Schadewald had an extraordinary library of books, pamphlets, journals, and other printed material on a wide variety of pseudosciences, including flat-earthism, hollow-earthism, geocentrism, creationism, perpetual motion machines, and other examples of science's being enlisted into support of an ideology. He was concerned that his library holdings in these areas remain intact and that the results of his many years of collecting be made available to researchers. NCSE has therefore established the Robert J Schadewald Memorial Fund, the major purpose of which is to secure an appropriate resting place or places for the components of Bob's library. Bob's widow Wendy is in full agreement.

Tax-deductible donations can be sent to the NCSE address on the back cover of this issue. Mark donations "Schadewald Memorial Fund", and they will be appropriately credited. We and future scholars thank you for your generosity.



Of Mousetraps and Men: Behe on Biochemistry

Niall Shanks and Karl H Joplin

In *Darwin's Black Box: The Biochemical Challenge to Evolution*, biochemist Michael Behe claims that biochemical systems exhibit a special kind of complexity — *irreducible complexity* — that cannot possibly have evolved and must have resulted from *intelligent design*. Like other intelligent-design creationists, Behe is vague about both the identity and methods of his intelligent designer, though he does distinguish between the hypothesis of natural design (by space aliens, perhaps) and that of supernatural design (1996, 248–9).

As Behe is aware, postulating intelligent design by space aliens only postpones a confrontation with the problem of the origins of complexity. After all, who designed the designers? Thus the unwary reader is pointed in the direction of a supernatural, undesigned designer. But if you were puzzled by biochemical complexity in the first place, this latter hypothesis, involving as it does an unknown supernatural being that employs unknown materials and methods, can hardly result in a net reduction of mystification.

Luckily we do not have to settle this matter. It turns out that Behe's intelligent design hypothesis is the result of his failure to consider relevant natural processes when trying to account for the origins of biochemical complexity. This problem arises in turn because Behe thinks about biochemical complexity with the aid of a misleading mechanical analogy — the well-designed mousetrap. The mechanical mousetrap is to Michael Behe what the mechanical watch was to William Paley. And it goes without saying that machines have designers.

Niall Shanks is a professor of philosophy and an adjunct professor in the department of biological sciences at East Tennessee State University. He is currently engaged in research into the philosophical foundations of evolutionary theory. Karl H Joplin is an associate professor of biological sciences at East Tennessee State University. His field of specialty is molecular aspects of insect development. Shanks and Joplin are currently engaged in research into the role of self-organization and chaotic dynamics in insect behavior.

So how should we think about design and designers? We will argue first that the historical process of the intelligent human design of technological artifacts, such as mousetraps, needs to be sharply differentiated from the hypothetical magical process of supernatural design and creation *ex nihilo* (literally from nothing). In fact, Behe's case derives its appeal from a failure to examine the details of the human design process. Naturally, he provides no details whatsoever of the hypothetical supernatural design process. Secondly, we will show why the mousetrap analogy fails to do justice to the richness of biochemical complexity. And thirdly, we will offer a conceptual framework that explains the origins of the *irreducible complexity* Behe finds so mysterious (see also Behe 2000). The key, as we shall argue, is that most real biochemical systems exhibit a type of complexity that we term *redundant complexity*: a form of complexity that results from natural evolutionary processes amenable to scientific study.

The Mousetrap Model of Biochemical Complexity

Behe's central thesis is that the biochemical systems we find in living organisms manifest *irreducible complexity*. He further contends that processes of the kind invoked in evolutionary biology cannot explain the origin of *irreducibly complex* biochemical systems. Behe explains:

> By *irreducibly complex* I mean a single system composed of several well-matched, interacting parts that contribute to the basic function, wherein the removal of any one of the parts causes the system to effectively cease functioning. An irreducibly complex system cannot be produced directly (that is, by continuously improving the initial function, which continues to work by the same mechanism) by slight, successive modifications of a precursor system, because any precursor to an irreducibly complex system that is missing a part is by definition nonfunctional (1996: 39).

Behe contends that although intelligent design processes of the kind we find in engineering, for example, can give rise to irreducibly complex systems, evolutionary processes cannot.

Behe employs an analogy with well-designed mousetraps. A mousetrap has several components, all of which are necessary for catching mice. A precursor "trap" that lacked one of the components — the spring, the trigger, or the platform, perhaps — could not trap mice. Lacking even minimal function, it could not be improved through incremental adaptive evolution to become a functioning trap. We already know that mousetraps require intelligent human designers. Behe argues that functioning biochemical systems are like mousetraps. They could not have evolved through incremental adaptive evolution, and must be the products of superhuman intelligent design. This argument, like all design arguments, has a surface plausibility. It is too bad that those who rely on design arguments have never taken the time to think clearly about what is actually involved in the intelligent human design of technological artifacts.

The Origin of Artifacts

It is essential to differentiate between the actual behavior of intelligent human designers on the one hand and the hypothetical action of a supernatural being on the other hand. Human engineers do not create or manufacture anything *ex nihilo*, nor are the processes of design secular miracles; to suggest otherwise is misleading. For ordinary objects like mousetraps, we can infer that they are designed without having any knowledge of their designer. Why? Because we all know that mousetraps are artifacts, and by definition artifacts have designers.

Naturalistic evolutionary hypotheses exist to explain the *same* features that lead Behe to ... a designer.

But, by studying the history of artifacts and engaging in reverse engineering, we can often uncover the identities of actual human designers, as well as the methods and materials they employed. That is why it is important to study the *processes* of human design, and not just the design itself. Can we analogously study the design process of the hypothetical supernatural designer? No proponent of supernatural design — not St Thomas Aquinas, not Archdeacon Paley, not Michael Behe and his numerous sympathizers — has ever offered the slightest clue about how this could be done scientifically.

Intelligent design theorists, noting that various biochemical systems give the appearance of being designed, aim to argue that they are, like artifacts, actually the products of design. However, if they are not like artifacts — if the *appearance* of design is deceiving — then all bets are off. Although a biochemical system might give the *appearance* of being designed, the conclusion that the system *actually* results from design could be made evidentially respectable only if, for example, we can find some compelling scientific evidence concerning the methods and materials employed, and also some compelling historical evidence concerning the identity of the designer.

Why should this be so? The reason lies in a fundamental difference between things such as mousetraps or watches, on the one hand, and things such as biochemical systems, on the other. Mousetraps and watches are antecedently known to be artifacts, and hence to have human designers (even if their identities and methods are obscure). For these objects, the question of design can often be safely separated from the questions of how designed and by whom.

But in the case of the alleged intelligent design of biochemical systems, these questions are all inextricably intertwined precisely because it is *not* known antecedently that biochemical systems result from deliberate design by a non-human agent (or agents) of supernatural origin. The very claim of design itself requires evidential justification. Providing evidentially grounded answers to the questions of how and by whom these systems were designed would simultaneously provide powerful evidence that the systems were indeed designed - a matter sorely in need of justification. This issue is made all the more acute because naturalistic evolutionary hypotheses exist to explain the *same* features that lead Behe to postulate a designer; one is presented below. For this reason, the features of biochemical systems that Behe points to cannot simply be viewed as the registered trademark of the creator or the hallmark of design. Behe has made an extraordinary claim, and its validation will require extraordinary evidence. Behe makes no attempt to meet this evidential requirement.

Moreover, in his argument Behe cavalierly ignores common facts about the human design process, which, like biological evolution itself, involves *descent with modification.* The intelligent human design of artifacts is frequently a historical process resulting from the generation of variation on existing technological themes along with selective retention of specific variants for further elaboration. Human engineers have long known that the problem-solving process is a historical, tinkering, trial-and-error process.

Indeed, it is the ability to produce multiple variants on themes, by varying parameters, that makes modeling and simulation such a powerful tool in the design of technological artifacts such as aircraft (Vincenti 1990). Even at the dawn of powered flight, the Wright brothers built, tested, and discarded numerous models in wind-tunnel tests. Many variants based on existing glider designs were tried, but only a few were chosen and selected for further elaboration. The ultimate fruit of this trial-and-error process was a powered machine adapted to an aerial niche! It was not magically created by some human intellectual whirlwind using pieces of junkyard scrap.

The concept of supernatural intelligent design

derives at least some of its appeal from the fact that we humans have actual experience of the intelligent design of artifacts. But when what is involved in human design is properly understood, do we really want to understand the hypothetical supernatural design process by analogy with the bungling, tinkering, trial-and-error process of our own experience? And if the supernatural process is different from the human process, how is it different? And how could we settle disputes between rival hypotheses about the details of the supernatural design process? Until these issues are addressed, biochemistry's mysteries will not be solved through the invocation of supernatural design, because until they are dealt with, the appeal to supernatural design will be effectively no different from the claim that it all happened by magic. If ever there was an explanatory *black box*, this is it!

Perhaps our point is now clear. But if it is not, let us elaborate using some examples given by Gary Cziko:

> In 1793, Eli Whitney's cotton gin that removed seeds from short-stapled cotton was based on the Indian *charka*, which had been in use for thousands of years to remove seeds from long-stapled cotton. Joseph Henry's electric motor of 1831 copied many of the mechanisms involved in the steam engine. The development of the first transistor at Bell Laboratories in 1947 ... owed much to the work of German physicist Ferdinand Braun who, in the 1870s, found that certain crystals conduct electricity in only one direction (1995: 163).

What at first glance might appear to be an ahistorical special human creation is really an artifact belonging to an historical lineage, where new artifacts result from the same variation-and-selection processes that are the staple of evolutionary explanations.

Horizontal Transfer

To see how this works, consider intelligently designed jet engines. These are clearly a different species of technological artifact from intelligently designed water-wheels. Yet over the last 300 years we can trace a line of descent from water–wheels to water turbines, and then from water turbines to steam turbines, gas turbines, and jet engines, with variation-and-selection processes playing important roles in all the major engineering transitions.

Needless to say, jet engines did not descend in a simple linear fashion from water–wheels. Rather, these artifacts emerged through processes involving *horizontal* transfers of modules from other evolving technological lineages (for example, fuel technologies, metallurgical technologies, and so on). The new modules were further modified as they were gradually incorporated through trial-and-error processes leading to the development of symbiotic relationships.

Interestingly, although there are some obvious and important differences between technological and biological evolution — the former is best explained in terms of intelligent (human) design, whereas the latter is not — they do not differ with respect to having benefited from horizontal module exchanges.

Horizontal transfers play an important role in biological evolution. Modules evolving in one lineage can be transferred to other lineages, where they typically undergo further evolutionary modification. For instance, changing the example from jet engines to eukaryotic cells, evolutionary biologists now see the mitochondrial power plants as the fruits of a symbiotic union between at least two distinct prokaryotic lineages — the integrated endosymbiotic whole is greater than the sum of its prokaryotic parts.

Behe's mousetrap is in fact ... descended with modification from earlier traps... .

Nor should the evolutionary theorist ignore horizontal plasmid exchanges by means of which genetic information in one bacterial lineage can find its way into another, distinct, lineage. On a larger scale, there is, of course, horizontal exchange through hybridization. In this process, of great importance in plant evolution, first-generation hybrids show a genuine mixture of characteristics from the distinct parental lineages.

And what of the origin of mousetraps? Variation-and-selection processes have played an important role here too. Since the US Patent Office opened in 1838, it has granted more than 4400 mousetrap patents. Currently, about 40 new mousetrap patents are issued each year. Ten times that many patents are turned away, mostly because they are not minimally functional. The Patent Office mousetrap taxonomy recognizes 39 subclasses, including "Impalers", "Smiters", "Swinging Strikers", "Choking or Squeezing", "Constricting Noose", and "Electrocuting and Explosive" (Hope 1990: 92)

Devices that kill mice by hitting them have a long and interesting technological evolutionary history — see Hornell (1940). The spring-loaded trap discussed by Behe appeared in the 1890s, and was patented in 1903 (nr. 744379) by John Mast, a Pennsylvania coleslaw manufacturer with a serious rodent problem. The spring-loaded trap did not result from design and creation from nothing — a secular miracle in Pennsylvania. Rather, Mast had studied existing mousetrap patents and had borrowed from 5 or 6 of them — thus showing the importance of horizontal information transfers — before filing his own patent application in October 1899 (Hope 1990: 94). Behe's mousetrap is in fact a technological hybrid, descended with modification from earlier traps in a complex historical evolutionary process. Although the mousetrap is intelligently designed, it did not appear by a magical, ahistorical

process of special creation, the details of which are forever hidden from public view!

Biochemical Complexity and the Mousetrap Analogy

But what of the mousetrap analogy of biochemical complexity? Here we will present some examples from biochemistry that call into question the general biochemical relevance of the mousetrap analogy. We will argue first that Behe's mousetrap analogy leads him to ignore a crucial aspect of the biochemical complexity we observe in nature: the phenomenon of *redundant biochemical complexity*. Redundant biochemical complexity represents the biochemical and molecular footprints of evolutionary processes in action. Having explained and illustrated this concept, we will then argue that redundant complexity provides the key for a natural, evolutionary understanding of the origins of irreducible complexity. We do not pretend to have a complete account of evolutionary biochemistry. We suspect that the details will eventually emerge from continuing scientific research. But rather than speculate about these matters, we will focus instead on what we do know about biochemical systems.

Behe's mousetrap analogy leads him to ignore ... the phenomenon of *redundant biochemical complexity.*

While biochemical complexity has many sources, one of the key concepts underlying our current understanding of biochemical evolution is that of *gene duplication*, a process whereby a gene is doubled in a genotype. As a result of this process, one gene can continue the old function, while the duplicate is freed up to be co-opted to serve novel functional ends — the duplicate gene acquires mutations that change its activity. These mutations may be preserved or eliminated through the operation of natural selection. If preserved, these mutations can lead to new functions. More importantly for our purposes, gene duplication is also a central evolutionary source of some of the *redundant complexity* we actually observe in biochemical systems (Shanks and Joplin 1999). So what is redundant biochemical complexity?

We see redundant complexity when we notice that many actual biochemical processes do not involve simple linear sequences of reactions, with function destroyed by the absence of a given component in the sequence. Instead, they are the product of a large number of overlapping, slightly different — hence redundant — processes. Redundant complexity is also embodied in the existence of back-up systems, which can take over if a primary system fails. Finally, redundant complexity is observed in the phenomenon of convergent biochemical evolution, wherein systems with different evolutionary histories, perhaps using different mechanisms, nevertheless achieve similar biochemical functions.

Redundant complexity turns out to lie at the heart of the stability that biochemical processes manifest in the face of perturbations that ought to catastrophically disrupt systems like Behe's well-designed, minimalist mousetrap — the absence of any component of which should render the system unable to perform its function. To understand redundant complexity better, it will help to look at some examples.

Redundant Pathway Complexity

If we examine the central catabolic pathway of glycolysis (the interconnected series of reactions by which glucose is broken down to release usable energy), it looks superficially as though the product of one reaction in the series is required as the substrate for the next reaction in the sequence. Thinking of glycolysis on the mousetrap model, one would expect that removing one component — enzyme, substrate, or product — would shut down the pathway and prevent the continual production of energy. In fact, almost every step in this pathway is redundantly complex. As an example, let us look at a key step, the production of glucose-6-phosphate from glucose, catalyzed by the enzyme hexokinase.

Not only does hexokinase activate the relatively stable glucose (Bennett and Steitz 1978), but it is a multipurpose enzyme that in part controls the rate of the first part of the glycolytic pathway by directing the chemistry of glucose either to build up more complex molecules (anabolism) or to harvest the energy stored in glucose (catabolism). The direction of chemical activity is dependent only on the concentration of the substrates, products, and various components of the pathway (Voet and Voet 1995).

One might assume, therefore, that here we have a good example of Behe's irreducible complexity. Remove the enzyme and the reaction should stop. But this intuition rests only on a superficial characterization of this step in the pathway. Looking at the fine details — where the devil proverbially lurks — reveals an unexpected complexity in what initially appeared to be a simple, straightforward chemical situation.

In typical vertebrate tissue, redundant complexity is manifested in the existence of several different variants (*isoforms*) of hexokinase. *All* of these are present, as a result of gene duplication and differential expression, in varying proportions, in different tissues. The proportions of the variants differ for the specialized functions of the tissues in which they are present, depending on whether the tissue requires rapid utilization of energy (as in muscles) or is involved in converting glucose into the storage form glycogen (as in the liver). Removal of a given variant of hexokinase does not disrupt glycolysis, although it may have an effect on the efficiency with which a function is achieved. So there is redundant complexity here, in the first, seemingly simple and straightforward, step of the glycolytic pathway.

Each of the other components of the rest of the glycolysis pathway manifests similar redundancies. Remove glucose, and the pathway can utilize numerous other hexose (6-carbon atom) sugars to supply the next product. Knock out one enzyme variant, and the other variants in the tissue can take over its function — maybe not quite as efficiently, but as Behe concedes, efficiency can be improved by natural selection over evolutionary time. There are back-up systems too. For example, if all the variants of hexokinase were removed, there are alternative pathways, such as the pentose phosphate pathway, that can supply the needed products (Martini and Ursini 1996).

It is a hallmark of many evolved biochemical systems that there are typically multiple causal routes to a given functional end, and where one route fails, another can take over. The existence of variants of a given enzyme are evolutionary legacies — legacies by means of which one and the same enzyme can be adapted to serve different specialized functions in different specialized tissues.

Genetic Knockout

Another way in which we can see the general inadequacy of the mousetrap analogy of biochemistry is simply to remove specific sections of an organism's genome. This procedure has recently been applied to mammals. Researchers can now target a specific gene in mice and "knock it out" (Travis 1992). Such *knockout mice* are valuable models for human diseases in gene function experiments. However, such mice do not always give the expected result — they do not exhibit the predicted functional deficits — due to the type of redundant complexity we have been discussing.

One example concerns the gene *p53*, which was originally identified as a tumor suppression gene, but has subsequently been found to be involved in a number of fundamental cell processes. For example, it plays roles in gene transcription, the cell cycle, programmed cell death (*apoptosis*), DNA replication, and DNA repair processes (Elledge and Lee 1995).

If you thought of this case as a genetic mousetrap, you might be tempted to think that the removal of this gene, involved as it is in all of these vital processes, would lead to catastrophic collapse of the developmental process — a bit like removing the spring, trigger, or platform from Behe's mousetrap. But this is not the case, since *p53* knockouts in mice yield offspring that are viable and fertile, although susceptible to the early appearance of spontaneous tumors (Dowehower and others 1992). This suggests the following dilemma: either *p53* is not required for embryonic development or there are redundant ways in which the function of the missing component is compensated for (Elledge and Lee 1995). The evidence at hand supports redundant complexity, since there are at least 400 proteins associated with the proper control of the cell cycle alone (Murray and Hunt 1993), and it would appear that some of these other proteins pick up the slack created by the missing *p53*. Such mice can still be caught in mousetraps!

Genomics

We are discovering more and more about the nature and role of redundant complexity. Consider the new field of *genomics*. The study of genome sequences has revealed some startling findings about the complexity and organization of biological organisms. The genome of the yeast *Saccharomyces cerevisiae* contains many redundant sequences. Fifty-three duplicated gene clusters, making 30% of the yeast genome, have been identified (Clayton and others 1997). Such findings concerning gene duplication lead to an interesting question concerning Behe's use of the mousetrap analogy. That is, how few genes does it take to maintain a free-living organism? Experiments at Celera Genomics are currently underway to knock out all nonessential genes from *Mycoplasma pneumoniae.*

If these experiments succeed, the resulting minimal organism will be noteworthy as a genuine example of a genetic version of Behe's mousetrap. If the organism really is genetically minimal, the absence of any component will be fatal. And such a minimal organism will be peculiar precisely because it will be a laboratory artifact — a drastic artificial modification of a redundantly complex natural system.

Redundant Origins of Irreducible Complexity

The existence of redundant complexity is evidence of the operation of evolutionary processes at the biochemical level. But it does not show that Behe is wrong to point to the existence of irreducible complexity. Let us suppose that some of his candidate examples of irreducible complexity are correct. Redundant complexity gives us the tools to explain the origins of what Behe found so mysterious. To see how redundant complexity might explain the origins of irreducible complexity, let us borrow an architectural image from AG Cairns-Smith, a biochemist interested in the origins of biochemical complexity (1986: 59–60).

Consider a free-standing arch of stones. It manifests irreducible complexity in that the keystone at the top of the arch is supported by all the other stones in the arch, yet these stones themselves cannot stand without the keystone. In other words, all the component stones depend on each other. Take away any stone, and the arch collapses.

Notwithstanding this fact about arches, it is nevertheless possible to construct them in gradual stages. You cannot gradually build a self-supporting, free-standing arch using only the component stones, piling them up, one at a time. But if you have scaffolding — and a pile of rocks will suffice to support the growing structure — you can build the arch one stone at a time until the keystone is in place and the

structure becomes self-supporting. When this occurs, the now redundant scaffolding can be removed to leave the free-standing structure.

The study of developmental processes suggests that an important biological role is played by removable scaffolding in the formation of all manner of elaborate structures, including body parts and neural pathways. For example, developmental scaffolding, in the form of an initial superabundance of cells, can be removed by programmed cell death (apoptosis). This process plays a crucial role in the developmental sculpting of such structures as fingers and toes (Campbell 1996: 980; Lewis 1995: 15).

Natural evolutionary processes give rise to the redundant complexity we observe in biochemical systems. But these redundancies may also provide, in concert with extant functional systems and structures, the *biochemical scaffolding* to support the gradual evolution of systems that can ultimately manifest irreducible complexity when the scaffolding is reduced or removed. By the operations of natural selection, some of these *biochemical arches* will be retained for further evolutionary elaboration, while others will be eliminated. In effect, *irreducible complexity* results from the evolutionary reduction of redundancy in *redundantly complex* systems — systems that are themselves the fruits of evolutionary processes.

In an earlier paper (Shanks and Joplin 1999), we argued that self-organizing chemical reactions — many of which are suitable for demonstration in the classroom or laboratory — can give rise to irreducibly complex chemical systems. Our claim here is that redundant complexity provides another natural evolutionary route to the same end. We are a long way from having to abandon natural science in favor of supernatural hypotheses concerning the origins of biochemical complexity.

Conclusions

Although there is much that we do not know about the biochemistry of living systems, and Behe points to some good examples, we do know that they are not like designed artifacts such as mousetraps. Behe's case against evolution is a good example of the perils of being trapped by a metaphor — a metaphor that Behe has not properly understood. A closer look at human intelligent design processes reveals not secular versions of theological design and creation *ex nihilo*, but instead complex manifestations of analogs of evolutionary processes — this time in the domain of the cultural evolution of technological artifacts. Descent with modification is as important in the origin of artifacts as it is in the origin of species.

We have also argued that many evolved biochemical and molecular systems exhibit *redundant complexity*. This kind of complexity simultaneously accounts for the stability of evolved biochemical systems and processes in the face of even quite radical perturbations, for biochemical and metabolic plasticity, and, mainly as a result of gene duplication, for the co-optation of extant structures and processes in the course of evolutionary time to serve novel functional ends.

More importantly, redundant biochemical complexity points to the general biochemical inadequacy of the mousetrap analogy while providing a natural evolutionary basis for the appearance of biochemical systems manifesting irreducible complexity. Of course, for some types of engineering problem, intelligent human designers build in redundancy and back-up systems. Perhaps Behe might want to argue that the resulting artifacts, with their engineered redundancy, suggest a more sophisticated *design* analogy. The trouble here is that naturalistic, evolutionary processes give rise to similar biochemical redundancies—and do so without appeals to supernatural biochemical designers of unknown identity, using unknown materials and methods.

References

Behe MJ. *Darwin's Black Box: The Biochemical Challenge to Evolution*. New York: The Free Press, 1996.

Behe MJ. Self-organization and irreducible complexity: A reply to Shanks and Joplin. *Philosophy of Science* 2000: 67:155–62.

Bennett WS Jr, Steitz TA. Glucose-induced conformational changes in yeast hexokinase. *Proceedings of the National Academy of Sciences, USA* 1978; 75: 4848–52.

Cairns-Smith AG. *Seven Clues to the Origin of Life*. Cambridge: Cambridge University Press, 1986.

Campbell NA. *Biology*. New York: Benjamin Cummings, 1996.

Clayton RA, White O, Ketchum KA, Venter JC. The first genome from the third domain of life. *Nature* 1997; 387: 459–62.

Cziko G. *Without Miracles: Universal Selection Theory and the Second Darwinian Revolution*. Cambridge (MA): The MIT Press, 1995.

Darwin C. *The Origin of Species*, 6th edition. New York: Norton, 1975 [originally published in 1859].

Dowehower LA, Harvey M, Slagle BL, McArthur MJ, Montgomery, CA Jr, Butel JS, Bradley A. Mice deficient for *p53* are developmentally normal but susceptible to spontaneous tumors. *Nature* 1992; 356: 215–21.

Elledge RM, Lee WH. Life and death by *p53*. *BioEssays* 1995; 17: 923–30.

Hope J. A better mousetrap. *American Heritage* 1996 Oct; 90–7.

Hornell J. Old English dead-fall traps. *Antiquity* 1940; 14: 395–403.

Lewis R. Apoptosis activity: Cell death establishes itself as a lively research field. *The Scientist* 1995; 9: 15.

Martini G, Ursini MV. A new lease of life for an old enzyme. *BioEssays* 1996; 18: 631–7.

Murray A, Hunt T. *The Cell Cycle*. Oxford: Oxford University Press, 1993.

Shanks N, Joplin KH. Redundant complexity: A critical analysis of intelligent design in biochemistry. *Philosophy of Science* 1999; 66: 268–82.

Travis J. Scoring a technical knockout in mice. *Science* 1992; 256: 1392–4.

Vincenti WG. *What Engineers Know and How They Know It: Analytical Studies from Aeronautical History*. Baltimore: Johns Hopkins University Press, 1990.

Voet D, Voet JG. *Biochemistry*, New York: Wiley, 1995.

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Of Pandas and People: The Central Question of Biological Origins, 2nd edition

A Review of the Proposed Use of a Supplementary "Intelligent Design" Textbook in Idaho's Public Schools

by Gary L Bennett

[*Throughout the country, school boards are receiving offers of free or low-cost copies of the supplementary textbook,* Of Pandas and People: The Central Question of Biological Origins, *by Dean Kenyon and Percival Davis. NCSE member Gary Bennett completed a comprehensive review of* Pandas *last fall to assist the Idaho Department of Education in its decision on whether to adopt the book as a recognized classroom resource. This abbreviated version of his review to accompanies the annual bibliography by Frank Sonleitner listing recent scientific research that addresses the issues raised by* Pandas.]

Consistency with Department of Education Position Statement on Science

The book *Of Pandas and People* (hereafter, *Pandas*) is inconsistent with the Idaho position statement on science, which bases its acceptance decisions on the publications of the American Association for the Advancement of Science (AAAS) and the National Science Teachers Association (NSTA). Both the AAAS and the NSTA have consistently supported the teaching of the scientifically accepted theory of evolution. In contrast, under the guise of an alternative approach known as "intelligent design", *Pandas* does little more than attack the theory of evolution. I was unable to find any peer-reviewed scientific literature on the "theory of intelligent design" either cited in the text or in professional scientific research journals. Furthermore, published work dealing with "intelligent design" by the authors of *Pandas* has not been found in respected science journals. Since legitimate scientists are not working on so-called "intelligent design", this book should not be used in any science class.

Consistency with State Exiting Standards

By attacking the theory of evolution, *Pandas* fails to support Idaho's draft high school exiting standards:

> Unifying Concepts of Science, Section I.D of the Science Standards, states that "[t]he student will demonstrate an understanding of the process of evolution as it relates to the gradual changes in the universe and of equilibrium as a physical state".
>
> Section V (Interdependence of Organisms and Biological Change) states that "[t]he student will understand the theory of biological evolution" and that "[t]he student should explain the interdependence of organisms".

Science is based on finding natural explanations for why the universe works as it does. *Pandas* invokes a supernatural belief called "intelligent design" (which looks like nothing more than the latest manifestation of the discredited belief system known as "creationism") to explain the origins of life and the creation of the different species of life. Science does not address the supernatural, which is beyond scientific measurement, so *Pandas* does not qualify as a science textbook.

Scientific Contents

Does the book provide accurate, reliable, scientific information?

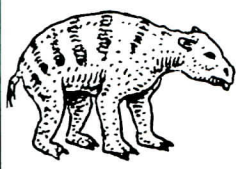
No. Instead of utilizing peer-reviewed scientific information from the accepted science journals (for example, *Science* and *Nature*) and a wealth of literature on the best and most current scientific thinking, *Pandas* engages in sophistry to advance its agenda. In Suggested Reading/Resources, it tends to cite discredited creationist books. The book uses quasireligious arguments and special pleading to try to discredit the theory of evolution. Many of these arguments attack science of a much earlier era (for example, Oparin's hypothesis, the Miller-Urey experiment, and so on) and are therefore outdated. The authors of *Pandas* ignore or seem unaware of the tremendous strides that have been made in biology in the intervening decades.

Does the book present scientific theory?

No. The authors provide no scientific documentation for the claim that "intelligent design" is an alternative to the accepted theory of evolution. The National Academy of Sciences, America's premier scientific body, has defined "theory" as "[i]n science, a well-substantiated explanation of some aspect of the natural world that can incorporate facts, laws, inferences, and tested hypotheses". Since "intelligent design" is not well-substantiated in the accepted scientific literature, it does not qualify as a scientific theory.

Is the scientific method emphasized?

No. Although there is no rigid definition of the scientific method,



one can say in general that it is a way of thinking in which hypotheses are tested against systematic observations of the natural universe. Classically, the scientific method is often defined as a process or method in which a problem is identified, relevant data are gathered, a hypothesis is formulated on the basis of these data, and the hypothesis is then empirically tested. This can be done by conducting laboratory experiments and/or gathering information (such as collecting fossils or observing stars). Critics or skeptics of the hypothesis should be able to conduct their own experiments or make their own scientific observations to test the hypothesis. *Pandas* fails to use the scientific method; instead, it appeals to an unidentified supernatural agent.

Instead of using the scientific method, what *Pandas* has done is to produce what philosophers call a "closed system". As the thinker and writer Arthur Koestler wrote:

> A closed system has three peculiarities. Firstly, it claims to represent a truth of universal validity, capable of explaining all phenomena, and to have a cure for all that ails man. In the second place, it is a system which cannot be refuted by evidence, because all potentially damaging data are automatically processed and reinterpreted to make them fit the expected pattern. The processing is done by sophisticated methods of casuistry, centered on axioms of great emotive power, and indifferent to the rules of common logic; it is a kind of Wonderland croquet, played with mobile hoops. In the third place, it is a system which invalidates criticism by shifting the argument to the subjective motivation of the critic, and deducing his motivation from the axioms of the system itself. ... *In fine*, the mentality of a person who lives inside a closed system of thought ... can be summed up in a single formula: He can prove everything he believes, and he believes everything he can prove. The closed system sharpens the faculties of the mind, like an over-efficient grindstone, to a brittle edge; it produces a scholastic, Talmudic, hair-splitting brand of cleverness which affords no protection against committing the crudest imbecilities.

The theory of evolution would be overturned tomorrow if scientifically verifiable information were uncovered showing that humans lived alongside dinosaurs. The notion of "intelligent design" cannot be falsified, however, because, if confronted with evidence against their belief, the advocates will simply shrug and say, "Well, that is how the intelligent designer did it".

Is the learning experiential? How does it relate to real life issues?

The learning is not experiential. *Pandas* provides no scientifically conclusive experiments that could be performed to prove that an intelligent designer exists. Worse, putting a religiously inspired textbook into a good science class where students are taught to question orthodoxy would expose the narrow religious views in *Pandas* to the kind of sharp questioning that could undermine the religious beliefs of some students.

Pandas does not relate well to real life issues such as biomedical concerns. For example, many in the scientific and medical communities are worried about the ever-evolving bacteria around us. Scientists find that bacteria are evolving immunity to the antibacterial medications that have been developed to control them. If we are going to survive, we need to understand evolution, because it describes how bacteria and other organisms change and it describes how our genetic makeup came to be. To teach "intelligent design" is little different from teaching shamanism as a way to eliminate diseases, since it does not engage the scientific method and prior scientific knowledge to understand and solve problems in human society.

SHOULD THE BOOK BE ADOPTED?

Absolutely not! This book does not teach science; it misrepresents science. Students and teachers without a good grounding in biology and the methods of science could be seduced by this book into rejecting well-established science. It is nothing more than a cleverly-worded tract espousing an unscientific belief system. Rather than teaching students how to think objectively, this book teaches students how to twist words and quotations to advance unsupported suppositions. On a more practical level, most biology courses spend very little time on the origins of life so there is no need for a separate book on that subject. And if a separate book on origins is desired, it should be a *real* science book.

ADDITIONAL OVERALL COMMENTS

This book suffers from an inordinate focus on the origins of life, which is usually a small part of any introductory biology course. Since most biology courses focus on cells, plants, animals, and their constituent parts, it is not clear that this book would be a useful supplement. In the areas of known science, it adds nothing new, and in the area of the origin of life, despite its protestations otherwise, it advances a particular religious belief under the rubric "intelligent design". There is no peer-reviewed scientific work in the standard scientific literature that supports the assertions of this book. In short, this book follows the cliché-ridden creationist approach of attacking evolution while providing no scientific

work to support its position. Saying that an intelligent designer did something that cannot be explained says nothing. People once said that an intelligent designer caused thunder and lightning and the motion of the planets. "Intelligent design" is a mystical, Dark Ages, anti-science philosophy trying to disguise itself as science.

Pandas is based on the assumption that evolution and "intelligent design" are competing theories. Nothing could be farther from the truth. As a working scientists, I am not aware of any serious scientific work being done on so-called "intelligent design". The fact that evolution has occurred is accepted by most qualified scientists, whose views are based upon thousands of research results in such diverse fields as anthropology, astronomy, biology, physics, chemistry, and geology.

The theory of evolution, which is a well-substantiated scientific explanation for what has occurred, deals with changes in organisms with time:

> **Evolution:** change in the hereditary characteristics of groups of organisms over the course of generations (NAS 1998).

The above definition was given in the publication *Teaching About Evolution and the Nature of Science*, published by the National Academy of Sciences, the nation's premier science organization (chartered by Congress in 1863). The glossary on pages 149–51 of *Pandas* does not coincide with accepted definitions.

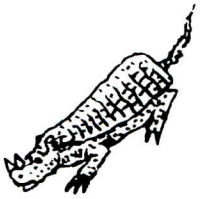
The theory of evolution is silent on how life originated and it makes no claims about religious beliefs. The fact that evolution has occurred is evident from the fossil record, which is a long record of modifications in the characteristics of animals and plants from the simpler to the more complex over hundreds of millions of years. Scientific work in such diverse fields as astronomy, geology, physics, chemistry and biology overwhelmingly supports the theory that life has evolved on the earth.

What is "Intelligent Design"?

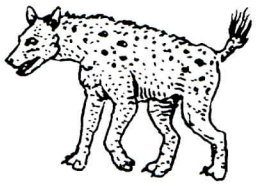
Pandas never really provides a scientific definition of "intelligent design". On page 14, *Pandas* states: "Intelligent design, by contrast, locates the origin of new organisms in an immaterial cause: in a blueprint, a plan, a pattern, devised by an intelligent agent". But nowhere does *Pandas* provide a scientifically testable definition or theory of the "intelligent agency". What properties does it have? How would a scientist detect it? What measurements could be made? What predictions could be made?

On pages 99–100, *Pandas* states that "[i]ntelligent design means that various forms of life began abruptly through an intelligent agency, with their distinctive features already intact—fish with fins and scales, birds with feathers, beaks, and wings, and so on." But this is contrary to the fossil evidence. For example, *Pandas* states that "[n]o creatures with a partial wing or partial eye are known", yet in Padian and Chiappe 1998 we find the so-called "partial wing" in *Archaeopteryx* and its relatives, and in Pennisi and Roush 1997 we find a summary of some evolutionary studies indicating that the ancestral bilateral animal may have had a simple photoreceptor. Using the "partial eye" argument has been an old favorite erroneous criticism offered by creationists, who do not seem to recognize that any light-sensitive organ would give an animal an advantage over its blind companions. Dawkins (1986) gives a good discussion about how an eye could evolve. Even Darwin, despite the limited knowledge of the fossil record of his day, gave a good explanation of how the eye might have developed (Darwin 1859/1979). Finally, it should be noted that hundreds of thousands of the single-celled amoeba named *Dictyostelium* have been observed coalescing into something that resembles a multicellular creature with some amoebas acting as eyes (Zimmer 1998). It is surprising that the *Pandas* authors are continuing to advance objections refuted long ago.

However, what is perhaps worse about pages 99–100 is that *Pandas* puts itself into the discredited camp of abrupt creation, that is, with those who believe the earth is only 10 000 years old and that every kind of plant and animal was created at once with no changes since (see also page 92). The fossil and geological record clearly shows the earth is older than 10 000 years and that whole species have evolved and died out—there have been fantastic changes!



On page 150, *Pandas* defines "intelligent design (cause)" as "[a]ny theory that attributes an action, function, or the structure of an object to the creative mental capacities of a personal agent. In biology, the theory that biological organisms owe their origin to a pre-existent intelligence". There are a number of problems with this definition, beginning with the fact that it is a circular definition, that is, it defines "intelligent design" in terms of itself. What is a "personal agent"? Secondly, "intelligent design" is not a theory in any sense of the word in the field of biology. The National Academy of Sciences defines "theory" as "[i]n science, a well-substantiated explanation of some aspect of the natural world that can incorporate facts, laws, inferences, and tested hypotheses" (NAS 1998). "Intelligent design" fails this definition.



Finally, given the definition on page 150 and the discussions on pages 14 and 99–100, the reader is left in total confusion. Are the authors of *Pandas* talking about "intelligent design" or an "intelligent agency" or a "personal agent" or a "preexistent intelligence"? *Pandas* is so confused and circular in its reasoning that it clearly does not meet the test of a good science book; however, it would

fit in nicely in a comparative religion class or a class on investigating pseudoscience and the uses of propaganda.

Been There, Done That?

The crux of the issue is that so-called "intelligent design", which has been described as one of the latest evolutions of the ever-evolving creationist movement, is based on supernatural intervention. In effect, "intelligent design" assumes that God was involved at various points in the evolutionary process, but it provides no evidence in support of this belief. Given that the Catholic Church and the mainstream Protestant community have accepted evolution as the way God created the millions of species, one wonders why the creationists still insist upon a literal reading of Genesis. Theologian Langdon Gilkey has stated that creationists come "very close, yes, very close indeed to the *first, and worst, Christian heresy!*" (emphasis in original) because they try to separate the act of creation from God as if there were two gods, which was the heretical position of the Gnostics (Gilkey 1985). Thus, not only is creationism or "intelligent design" bad science, it is also arguably bad theology!

Professor of Philosophy and Zoology Michael Ruse has written this about *Pandas*:

> And, let me (for what seems the millionth time in my life) protest at the Creationists appropriating exclusively unto themselves the mantle of religion. The world of life may or may not be designed. But the argument is not that the choice is between an exclusive disjunction of evolution and design. I believe that if God chooses to do things through unbroken law, then that is God's business, not ours. What is our business is the proper use of our God-given powers of sense and reason, to follow fearlessly where the quest for truth leads. Where it does not lead is to the pages of the book *Of Pandas and People* (Ruse 1989).

"Intelligent design" suffers from a fatal philosophical flaw:

> [O]ne might suppose that if organisms are not ideally adapted, if they have characteristics that are not adaptations, they could not have been intelligently designed —or at least the designer couldn't come up with the right materials or the right plan. A designer wouldn't equip organisms with useless appurtenances; yet every species has vestigial structures that may once have been adaptive but are adaptive no longer. Every species also has characteristics that are not now and never were adaptive—characteristics that are the "side effects" of genes that serve some other adaptive function (Futuyma 1995: 128–9).

Presumably the intelligent designer is not so intelligent!

Natural and Supernatural

The premise of *Pandas* is the faulty notion that science should proceed from the supernatural to the natural. Science, by definition, is based on studying the natural world. We do not have Hindu science or Mormon science or Catholic science or Protestant science; we just have science. If the apparently fundamentalist-inspired *Pandas* is allowed into the classroom, then every religious group can claim with equal justification to have its books included too.

In the 1982 Arkansas court case on teaching creationism (*Rev Bill McLean et al. v Arkansas Board of Education*), Judge William R Overton defined science in his ruling against the teaching of creationism (Gilkey 1985; Pennock 1999):

1. It is guided by natural law;
2. It has to be explanatory by reference to natural law;
3. It is testable against the empirical world;
4. Its conclusions are tentative, that is, they are not necessarily the final word; and
5. It is falsifiable.

"Intelligent design" fails these tests. Furthermore, Overton (and others) found that "intelligent design" promotes a particular sectarian view in violation of the First Amendment.

Pandas co-author Percival Davis has exposed his biblical literalist bias in a book (*A Case for Creation*) that he wrote with Wayne Frair: "We accept by faith the revealed fact that God created living things. We believe God simultaneously created those crucial substances (nucleic acids, proteins, and so on) that are so intricately interdependent in all of life's processes, and that He created them already functioning in living cells" (quoted in Pennock 1999, 162). The notion that God operated in an evolutionary way (as accepted by the Catholic Church, mainstream Protestant churches, and various American Jewish organizations) seems not to have affected Davis.

The other co-author, Dean Kenyon, was "an erstwhile origin of life researcher who became discouraged about the whole field and subsequently [lent] his name in support of YEC [young-earth creationist] activism..." (Pennock 1999, 162). With no scientific support, *Pandas* tries to be both "young earth" and "old earth" (see page 92). Young-earth creationists believe that the earth along with the entire universe was created 6000 to 10 000 years ago. To date, there is no recognized scientific support in any field of science for such a belief. There have been many years of student complaints about Dean Kenyon's teaching at San Francisco State University, mainly centered on allegations that he is more interested in what amounts to religious proselytizing than in teaching peer-reviewed biology (Scott 1994). From the foregoing, one would suspect that if *Pandas* were adopted in biology

continued on page 39

Twelve Tips for Testifying at School Board Meetings

Eugenie C Scott, NCSE Executive Director

1. Show up, stand up, and speak up. Elected school board officials respond to numbers, so try to get as many people as possible to attend the meeting—the school board must not think that opponents of evolution are the only voices in the community. Scatter yourself throughout the audience and applaud those on your side.

2. Plan ahead. There is usually little time available for testifying. Avoid redundancy and ensure that all of your essential points are made by deciding which group members will discuss which topics.

3. Be civil. You want to persuade, not bludgeon. Be friendly advisors, not hostile critics. Avoid personal attacks on the opposition

4. Say why you care. Parents want their children to have the best possible education; teachers, as professionals, want to teach accepted state-of-the-art science; professors want their future students to be appropriately educated; scientists want to see their disciplines correctly presented; employers want to have scientifically literate employees; and so forth. If you have travelled from outside the community to speak at the meeting, briefly justify your presence.

5. Define the controversy correctly. It is not about whether or not God exists; it is not about whether or not God created the world. It is about the scientific evidence. And the scientific evidence clearly indicates that the universe changes over time, that the galaxies, solar systems, and planets of today have changed over time, that life on earth was different in the past, and that animals and plants today are descended from earlier forms and are different from them.

6. Watch your words. Be careful using the words *belief*, *theory*, and *fact*. *Belief* is frequently associated with faith, so do not say that you *believe* in evolution, say instead that you *accept* evolution—as the best scientific explanation for the facts of astronomy, biology, geology, and other areas of science. Explain that in science *theories* are not guesses or hunches but *explanations*: evolution is the theory that *explains* the facts, including the fossil record, the geological strata, and the genealogical relationships among the species. *Fact* frequently connotes certainty and dogmatism, so do not say that evolution is a *fact* without explaining that you mean only that it is overwhelmingly supported by the scientific evidence.

7. Challenge creationist doublespeak. After teaching "creation-science" in the public schools was ruled unconstitutional, creationists tried to rescue it by renaming it: abrupt appearance theory, initial complexity theory, and, recently, intelligent design theory. Also popular is the idea that students should be taught, in addition to evolution, the "evidence against evolution"—which turns out to be creation science all over again. It is harder to counter these strategies because they are less obviously religious. In your testimony, try to demonstrate the parallels between old-fashioned creation science and new-fangled intelligent design theory.

8. Highlight the scientific consensus. Cite the statements in support of evolution from scientific organizations reprinted in NCSE's *Voices for Evolution*. Also cite the National Academy of Science's *Science and Creationism: A View from the National Academy of Sciences*. Find scientists in your area to testify that creationism (or intelligent design theory, abrupt appearance theory, and so forth) is bad science.

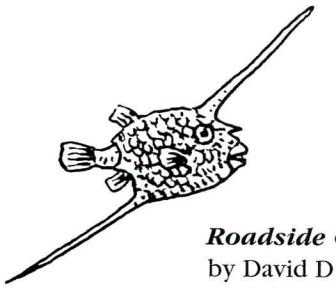
9. Call on the clergy. Pro-evolution clergy are essential to refuting the idea that evolution is incompatible with faith. *Voices for Evolution* contains useful statements from mainline religious organizations (Catholic, Protestant, Jewish) affirming that evolution is compatible with their theology. If no member of the clergy is available to testify, be sure to have someone do so—*the religious issue must be addressed in order to resolve the controversy successfully.*

10. Rebut the "fairness" argument. If the opposition argues that it is only fair to teach creationism if evolution is taught, cite the statements from educational organizations in *Voices for Evolution*—the succinct statement from the National Science Supervisors Association (p S-6 in the Addendum) is especially useful. Teachers can testify on the following points:

- Science is not democratic. We do not decide what to teach based on the desires of pressure groups. We teach what has stood the test of time and been accepted by the scientific community: evolution, not creationism.
- There is precious little time in the curriculum for science already. Why waste it by teaching ideas, like creationism, that have no scientific validity?
- Not teaching students about evolution leaves them unprepared for college. Evolution is presented matter-of-factly at every decent college and university in the United States, including religious institutions such as Brigham Young, Baylor, and Notre Dame.

11. Mention the legal issues. In 1987, the United States Supreme Court held in *Edwards v Aguillard* (482 U.S. 578) that it is unconstitutional to require the teaching of creation science. In subsequent rulings, district courts held that individual teachers may not advocate creation science (for example, *Webster v New Lenox School District #122*, 917 F. 2d. 1004; *John E. Peloza v Capistrano Unified School District*, 37 F. 3d. 517). Gently remind the school board that including creationism in the science curriculum is likely to provoke a lawsuit—and lawsuits are expensive.

12. Stay in touch. Keep NCSE informed about your situation. We are here to help—and we love to spread the good news about ideas that work!



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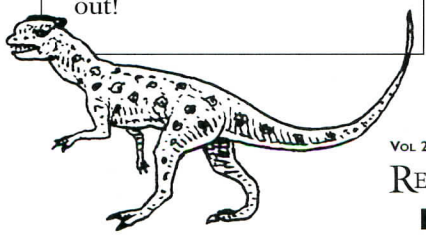

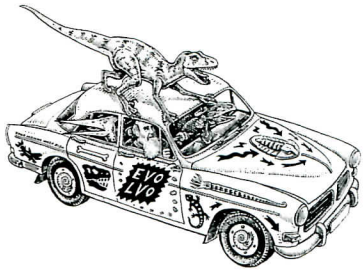

NCSE on the Road

A Calendar of Special Events, Presentations, and Lectures

Date September 21, 2000
City Missoula MT
Presenter Eugenie C Scott
Title How Not to Teach Evolution
Event Sigma Xi Lecture
Time 12:00 noon
Location TBA
Contact George D Stanley
fossil@selway.umt.edu

Date September 22, 2000
City Missoula MT
Presenter Eugenie C Scott
Title 75 Years After the Scopes Trial: Creationism and Evolution in Y2K
Event Public Lecture
Time 7:00 PM
Location TBA
Contact George D Stanley
fossil@selway.umt.edu

Date October 14, 2000
City Sacramento CA
Presenter Eugenie C Scott
Title Ancestors, Transitional Fossils, and Evolution
Event California Science Teachers Association Annual Meeting
Time TBA
Location TBA
Contact Sharon Janulaw
sjanulaw@aol.com

Date October 24, 2000
City Manhattan KS
Presenter Eugenie C Scott
Title Why NOT Creationism in the Public Schools!
Event Lou Douglas Lecture Series
Time 7:30 PM
Location Forum Room, Student Union
Contact Olivia Collins
o_collins@hotmail.com

Date October 27, 2000
City Fremont NE
Presenter Eugenie C Scott
Title Maiben Lecture
Event Nebraska Association of Teachers of Science
Time 7:00 PM
Location Camp Calvin Crest
Contact Susan Kobas
kobas@ops.org

Date November 16, 2000
City San Francisco CA
Presenters Eugenie C Scott & Eric Meikle
Title Teaching Evolution
Event American Anthropological Association Annual Meeting
Time 9:00 AM – 12:00 noon
Location San Francisco Hilton
Contact Lucille Horn,
LHORN@aaanet.org

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Of Pandas and People cont. from p 34

classes, the next step would be to insist that anthropology, geology, physics, chemistry, and astronomy courses be changed to fit with a literal interpretation of the Bible.

Professor Douglas J Futuyma summed up the issue best with his observation:

> Suppose creationism had equal time in science classes. What would be taught? If creationists teach that the universe and all its inhabitants were suddenly created a few thousand years ago, and that all of extinction and all of geology were caused by a universal flood, what more can they say? Shall they provide scientific evidence that explains why blue-green algae are in the lowest geological strata and flowering plants in the uppermost? Shall they explain, in terms of modern biology, how a million or more species of animals fit into the ark? Shall they provide evidence from modern physics that explains away the fact that we can perceive light from stars that are billions of light years away, and took billions of years to get here? Shall they provide a testable hypothesis to explain the genetic similarity of apes and humans? Will they describe experiments that elucidate the mechanisms of creation, as geneticists have the mechanisms of evolution? You will seek in vain for answers... (Futuyma 1995, 215–6).

Pandas commits the philosophical error of assuming that because our minds see order there must be an intelligent designer. But a number of laboratory experiments (see, for example, Amabilino and Stoddart 1994, Futuyma 1995, and Ingber 1998) have shown that matter can self-organize. Scientists have even observed single-celled amoebas self-organizing into a sort of multicellular creature (Zimmer 1998).

Studies in the mathematical field of complexity theory have shown that chaotic systems can exhibit patterns that look like order. Computer studies have shown how evolution can work (see, for example, Dawkins 1986 and chapter 2 of Pennock 1999). In short, *Of Pandas and People* fails to deal with the very real probability that order is intrinsic in nature and not superimposed.

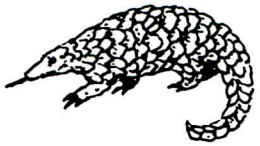
Finally, by assuming that life originated by "intelligent design", *Pandas* opens up a number of questions it fails to answer, such as "Who or what is the intelligent designer?" and "Who or what created the intelligent designer?"

Using the arguments in *Pandas,* one could equally well support the view advanced by the Raëlian Movement "that intelligent aliens landed here millennia ago in spaceships and formed all of life on earth, including human beings, using highly advanced genetic engineering" (Pennock 1999, 234). If one put *Pandas* in the classroom, in fairness one would also have allow others from "Claude Vorilhon's Raëlian model to the Swami Prabhupade's cyclical Hindu model, and so on. As they say, this way lies madness" (Pennock 1999, 368).

Pandas tries to bias the reader by the choice of words the authors use to describe the two positions they discuss. Scientists are referred to as "Darwinists" as if to say that all scientists are followers of some religious guru named Darwin. In light of new information, evolutionary science has moved beyond Darwin's original ideas and so scientists working in the field of evolution should properly be referred to as "scientists". Using the verbal tactics of the authors of *Pandas*, one would have to refer to advocates of "intelligent design" as "Morrisites" (in acknowledgment of the biblical literalist Henry M Morris who was instrumental in founding the modern fundamentalist belief known as creationism or "intelligent design").

Perhaps Kevin Padian, Professor of Integrative Biology and Curator in the Museum of Paleontology at the University of California, Berkeley, said it best:

> *Of Pandas and People* is a tract on hard-shell fundamentalist creationism in disguise. This underlying theme never speaks its name in this tract, but it is there nonetheless. It is hard to say what is worst in this book: the misconceptions of its sub-text, the intolerance for honest science, or the incompetence with which science is presented. In any case, teachers should be warned against using this book (Padian 1989).



The complete list of references is contained in the longer "Review of the book *Of Pandas and People: The Central Question of Biological Origins* (second edition)" by Gary L Bennett, which will be available soon on *The Textbook Letter* web site.

References

Amabilino D, Stoddart F. Molecules that build themselves. New Scientist 1994 Feb 19: 25–9.

Darwin CR. *On The Origin of Species By Means of Natural Selection or the Preservation of Favored Races in the Struggle for Life*. NY: Avenue Books, 1979 [originally published in 1859].

Dawkins R. *The Blind Watchmaker*. NY: WW Norton & Company, 1986.

Futuyma DJ. *Science on Trial: The Case for Evolution*. Sunderland (MA): Sinauer Associates, Inc, 1995.

Gilkey L. *Creationism on Trial: Evolution and God at Little Rock*. Minneapolis (MN): Winston Press, Inc, 1985.

Ingber DE. The architecture of life. *Scientific American* 1998 Jan; 278 (1): 48–57.

NAS (1999) *Science and Creationism: A View from the National Academy of Sciences*, 2nd edition. Washington (DC): National Academy Press, 1999.

Padian K. Gross misrepresentation. *Bookwatch Reviews* 1989; 2 (11): 2–4.

Padian K, Chiappe LM. The origin of birds and their flight. *Scientific American* 1998 Feb; 278 (2): 38–47.

Pennock RT. *Tower of Babel: The Evidence against the New Creationism*. The MIT Press, Cambridge (MA), 1999.

Pennisi E, Roush W. Developing a new view of evolution. *Science* 1997 Jul 4; 277 (5322): 34–7.

Ruse M. They're here! *Bookwatch Reviews* 1989; 2 (11): 4.

Scott EC. Dean Kenyon and "intelligent design theory" at San Francisco State U. *NCSE Reports* 1993/1994; 13 (4)/14 (1): 1, 5, 13.

Zimmer C. The slime alternative. *Discover* 1998 Sep; 19 (9): 86–93.

PANDAS UPDATE

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In 1989, Kenyon and Davis published the first edition of *Of Pandas and People* as a supplementary biology text. In both the first and second editions, the authors claim that there is scientific evidence against evolution in a number of fields of scientific research. Since 1995, I have searched the scientific literature in those fields identified in *Pandas* as being problematic for evolution and reported on it in our members' publications. As expected, a number of questions in the sciences were unanswered at the time of the original publication of *Pandas* in 1989. By the publication of the second edition in 1993, more of these issues were resolved, but new questions were also raised.

Once again this year, *RNCSE* presents a brief summary and a bibliography of recent works, organized to parallel the structure of *Of Pandas and People*. On each topic there is active and ongoing research in the appropriate sciences as well as a growing bibliography of resources for those interested in specific topics. By contrast, in the 11 years since the publication of the first edition of *Pandas* and the 6 years in which I have been preparing these summaries, the scientific triviality of the "intelligent design" theory is, and has been, manifest in the lack of any primary research reports based on "intelligent design" in the peer-reviewed scientific literature.

CHAPTER 1: THE ORIGIN OF LIFE

Before investigating the possible origin of life, one ought to know what it is. The difficulties of defining "life" are reviewed by Holmes (1998). Radetsky (1998) and Joyce and Orgel (1998) summarize current ideas about the origin of life.

The Space Connection

Strong polarization of infrared light has been observed in the star-formation regions of the Orion nebula. Such polarization at short wavelengths might result in "left-handed" interstellar organic molecules that could have found their way to earth in comets, meteors, and interplanetary dust. This process would account for one of the most characteristic features of biological molecules — namely the overwhelming preference for "left-handed" over "right-handed" forms of organic compounds associated with all living things on earth (Bailey and others 1998). Recreating the environment of outer space in the lab produces many organic compounds representing some of the key ingredients of life that condense on simulated dust grains, including lipid-like molecules that can form cell-like vesicles (Schueller 1998).

The Martian meteorite still engenders debate (Kerr 1998a; Gibbs 1998). Several new studies (such as Bada and others 1998) indicate that the organic material in the meteorite is the result of terrestrial contamination. Research on the possible extraterrestrial organic materials in other meteorites continues. The Murchison meteorite contains over 70 different kinds of amino acids, many uniquely extraterrestrial (Pizzarello and Cronin 1998). Brainard (1998) speculates that even though Martian microbes may exist, they may be very scarce and hard to find on Mars.

Scientists are also reporting more evidence about the materials and conditions elsewhere in our solar system that could have supported the origin of life. Highly detailed pictures of Europa's surface by the Galileo spacecraft continue to reinforce the hypothesis that a watery ocean is hidden beneath the icy surface (Holden 1998). The paucity of craters on the surface is interpreted as showing that the surface is an active young surface (Kerr 1998b). Other evidence for an ocean is the detection of absorption bands in reflectance spectra indicating hydrated salts on the surface (McCord and others 1998). Evidence for induced magnetic fields is interpreted as evidence for subsurface oceans on both Europa and Callisto (Kivelson and others 1998). Svitil (1998) discusses the possibility of large amounts of methane and other organic compounds on Saturn's moon Titan.

As to the question of whether life could have arisen on planets elsewhere in the universe, astronomers continue to find evidence for extrasolar planets (Semeniuk 1998; Cowen 1998a). Most are inferred from observed wobbles in their stars' paths. Others are inferred from irregularities in a star's dusty disk (Cowen 1998b; Kalas 1998). One has been

imaged directly (Leutwyler 1998). The known extrasolar planets now outnumber the planets of the solar system.

Extremophiles

Researchers continue to find organisms in habitats previously thought to be too extreme for life to exist. Priscu and others (1998) describe the microbes existing in Antarctic lake ice. Cary and others (1998) report on tube worms living on the outer walls of deep-sea hydrothermal vents where the temperatures may be as high as 81°C. General reviews of extremophiles are given by DeLong (1998) and Pain (1998a). Cossins (1998) reviews Michael Gross's book *Life on the Edge: Amazing Creatures Thriving in Extreme Environments* (1998). Pain (1998b) discusses the microorganisms that live deep in the earth's crust.

Researchers also claim to have found tiny nanobacteria in rocks and in the Martian meteorite. Other workers are skeptical of the existence of these organisms (Vogel 1998). Kajander and Ciftcioglu (1998) report on finding such ultramicroorganisms in biological materials.

Prebiotic Chemistry

Research continues into the production billions of years ago of organic molecules typical of living things on earth. Cleaves and Miller (1998) have demonstrated that many organic polymers and inorganic ions dissolved in the early ocean would act as ultraviolet absorbers, protecting the organic compounds farther below the surface and thus allowing them to accumulate. Canfield (1998) proposes a new model for Proterozoic ocean chemistry in which sulphide, rather than oxygen, is responsible for removing iron from ocean waters. Although there was some oxidation at the earth's surface around 2000 million years before the present (MaBP), aerobic deep-ocean waters did not develop until about 1000 MaBP. Boctor and others (1998) report that nitrogen reduction can be brought about through mineral catalysis under conditions typical of hydrothermal vents.

Nitta and others (1998) report that ribosomal RNA can produce peptide bonds. Similarly, utilizing test-tube evolution, Zhang and Cech isolated a pure RNA pseudoribosome that could link amino acids together (Cohen 1998). Carmi and others (1998) report on "deoxyribozimes" (for example, a DNA molecule) that can act as an enzyme and cleave single-stranded DNA oligonucleotides. Unrau and Bartel (1998) report the creation, by test-tube evolution, of an RNA molecule that can synthesize a pyrimidine nucleotide from its phosphate, sugar, and base constituents.

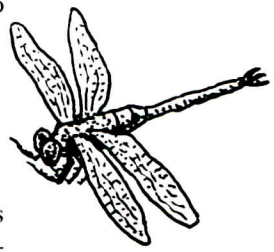
Some theorists favor a high-temperature origin of life near oceanic hydrothermal vents (Balter 1998). Levy and Miller (1998) report that this is unlikely because the nucleotide bases are not sufficiently stable at such high temperatures. Huber and Wachtershauser (1998) claim that amino acids can be activated and condensed into peptides under conditions like those prevailing near vents. Another idea is that mineral surfaces may have aided in the production of polymers (Edwards 1998; Smith 1998; Parsons and others 1998). Along these lines, Luther and others (1998) describe a self-replicating chemical system involving solid support for the chemical templates that can increase the concentration of oligonucleotide analogues exponentially.

Poole and others (1998) describe a Darwinian model for the evolution of life from the late stages of the RNA world through to the emergence of eukaryotes and prokaryotes. In connection with this, Jeffares and others (1998) derive criteria for identifying ribozyme relics of ancient RNA structures in modern microorganisms and creating a model of the last ribo-organism before the advent of protein-directed catalysis.

The Rise of Eukaryotes

Eukaryotes are thought to have arisen from prokaryotes when archaebacteria engulfed eubacteria, which eventually became mitochondria and chloroplasts. Martin and Muller (1998) put forward the hypothesis that this process was not just an accident but the development of a symbiosis: the orginal host was a methanogen that consumed hydrogen and carbon dioxide and produced methane. The symbiont that eventually became the mitochondrion was a bacterium that made hydrogen and carbon dioxide as its waste products.

A rich find of unicellular eukaryotic fossils along with bacteria have been found in 800-million-year-old rocks on Canada's Victoria Island (Monastersky 1998b). South African researchers have found evidence that primitive unicells may have lived in soil on land 2000–2200 MaBP (Monastersky 1998a). Recent experiments suggest that multicellular colonies may evolve from unicells as a defense against predation. Unicellular predators found the colonies too big to ingest (Blackman 1998).



Chapter 2: Genetics and Evolution

Mutation

Current research demonstrates how mutations can produce variations with positive outcomes; mutation is not universally, or even generally, a bad thing. Rainey and Travisano (1998) describe the rapid evolution of an aerobic bacterium when exposed to novel environmental conditions in multiple ecological niches. Boyce (1998) reports that mutations that appear to be neutral may have subtle effects under stressful conditions. After experiencing heavy DNA damage, bacteria may increase their mutation rates by partially disabling their DNA repair systems in order to generate new genotypes that might be evolutionarily useful (Goodman 1998; Brookes 1998).

Genomes exhibit many diverse phenomena and genetic information is often stored in complex ways. A gene, for example, may be split into exons and introns, the latter being excised as "junk" when the gene is transcribed into messenger RNA. Similarly, some proteins that are produced by ribosomes consist of *exteins* and *inteins,* the latter being excised from the polypeptide chain to make the final form of the protein. Wu and others (1998) describe such a protein and its gene in the microbe *Synechocystis*. An added complication is that the gene itself is split into 2 parts found in 2 different parts of the chromosome. Each part codes for an extein and *part* of the one intein. Only after the 2 polypeptides are formed do they join to form the complete intein, which then excises itself to form the final protein molecule!

Genetic information is often stored in complex ways

Pennisi (1998b) reviews the ways in which genomes can change, including transposable elements, shuffling or duplication of material, mutational hotspots, and inaccurate copying of 2- and 3- base repeats which may affect the function of neighboring genes. Max (1998) discusses pseudogenes, short and long interspersed elements, retroviruses, and retroposons as evidence for evolution. The numbers of multiple elements are still increasing in mouse species (Anonymous 1998); the house mouse has 3000 of them! Vogel (1998) and Pennisi (1998a) review modern ideas and experiments concerning the evolution of the genetic code. Van den Burg and others (1998) were able to utilize mutations to modify a bacterial enzyme to work at very high temperatures.

Natural Selection

Sargent and others (1998) review the phenomenon of industrial melanism. Losos and others (1998) explore the role of historical contingency in influencing adaptive radiation of *Anolis* on different islands in the Caribbean. A special section of *Science* (Hines and Culotta 1998) contains a number of papers reviewing hypotheses about the evolution of sex, including the possible adaptive value of sex (Barton and Charlesworth 1998) and tests of the various hypotheses (Wuethrich 1998).

A number of papers dealt with sexual selection. Arnqvist (1998) discusses the possibility that the shape of male genitalia evolved under sexual selection. Evans (1998) tests the hypothesis that sexual selection produced the long tail streamers of male swallows, discovering that the length of the tail is governed by natural selection. Call duration in tree frogs may be used by females to select males with superior genetic quality (Welch and others 1998). In swordtail fish, females prefer larger swords (Rosenthal and Evans 1998). In stalk-eyed flies, females prefer males that have longer stalks (Wilkinson and others 1998). The long eye stalk condition is linked to the possession of a Y chromosome that suppresses the meiotic drive of a "selfish" X chromosome that biases the sex ratio in favor of females.

Designing with Evolution

Petit (1998) gives a popular description of the use in industry of genetic algorithms to design engineering systems, directed (test-tube) evolution to produce new drugs, and genetic programming to evolve computer programs. Taubes (1998) discusses research on FPGA (Field Programmable Gate Array) chips, which allow computer hardware to be programmed by genetic algorithms. Lenski (1998) provides an informative book review on artificial life's existing and evolving in computers.

Landweber and others (1998) review the successes in ribozyme engineering using test-tube evolution. They list 2 dozen new ribozymes "evolved" either from some precursor RNA or from random sequences of RNA. Macbeath and others (1998) used test-tube evolution to redesign enzyme topology. Crameri and others (1998) describe DNA shuffling, a technique used to speed up test-tube evolution.

Genomes

The genomes of more organisms continue to be sequenced. In 1998, the genomes of 5 microorganisms and 1 multicellular animal were sequenced. These include the hyperthermophilic bacterium *Aquifex aeolicus* with about 1.5 million base pairs (Mbp; Deckert and others 1998), the tuberculosis microbe *Mycobacterium tuberculosis* with about 4.4 Mbp and 4000 genes (Cole and others 1998), the syphilis spirochete *Treponemas pallidum* with about 1.3 Mbp and 1041 genes (Fraser and others 1998), the intracellular human pathogen *Chlamydia trachomatis* with about 1 Mbp (Stephens and others 1998), the typhus microbe *Rickettsia prowazekii* with about 1.1 Mbp and 834 genes, many of which are similar to mitochondrial genes (Andersson and others 1998), and the first animal to have its genome completely sequenced, the nematode worm *Caenorhabditis elegans* with 97 Mbp and 19 000 genes (Hodgkin and others 1998; Hodgkin and Herman 1998). The *Drosophila* genome sequence will be finished soon. Work continues on sequencing the plant model *Arabidopsis* (the European Union [EU] *Arabidopsis* Genome Project 1998; Meinke and others 1998). Huynen and Bork (1998) report on a comparative study of 9 microbial genomes.

It is estimated that a typical vertebrate may have between 50 000 and 100 000 genes, while invertebrates may have fewer than 25 000. Simmen and others (1998) estimate that the invertebrate chordate *Ciona* has about 15 000 genes. Evidence indicates that at least 2 rounds of polyploidy occurred in the vertebrate ancestors after the separation of *Amphioxus* and the craniates (Pebusque and others 1998; Postlethwait and others 1998).

The extensive data on microbial sequences point to the possibility that early in the evolution of life, before the 3 domains (Bacteria, Eukarya, and Archaea) emerged, there was much horizontal transfer of genetic material (Pennisi 1998; Koga and others 1998; Woese 1998; Katz 1998). Miller (1998) discusses horizontal gene transfer occurring today, since it could allow genetically engineered microbes to pass their genes to other species in the environment with unintended results. Katz (1998) reviews the latest ideas on the evolution of eukaryotes. She presents evidence that the eukaryote archezoans, which do not possess mitochondria, have secondarily lost those organelles. Aravalli and others (1998) report that Archaea, originally considered to be confined to extreme environments, are much more widespread, being found in soils, lake sediments, marine picoplankton and deep-sea locations. Microbiologists have estimated that there are 5×10^{24} bacteria living on earth in the ocean, in the soil, beneath the surface, in the air, and inside animals. Soil and subsurface habitats account for 94%; the insides of animals account for only a fraction of 1 percent. In the oceans, any given bacterial gene is estimated to undergo an average of 4 mutations every 20 minutes (Anonymous 1998).

Chapter 3: The Origin of Species

Brookes (1998) gives a popular account of the concepts of species and speciation. Orr and Smith (1998) explore the role of ecological divergence in the rise of reproductive isolation and speciation. Galis and Metz (1998) discuss the roles of sexual selection and niche differentiation on the explosive speciation of cichlid fishes in Lake Victoria. Geiser and others (1998) describe cryptic speciation in a fungus.

On the basis of computer simulations, Kondrashov and Shpak (1998) report that assortative mating can give rise both to reproductive isolation and to sympatric speciation. Gavrilets and others (1998) report on computer simulations that indicate the possibility of rapid speciation in subdivided populations without the need of founder effects, complete isolation, or the existence of distinct adaptive peaks. Ting and others (1998) investigate the speciation role of a rapidly evolving homeobox found in a male sterility gene in *Drosophila.* Swanson and Vacquier (1998) investigate gamete interactions in abalone involving egg lock/sperm key proteins that open the vitelline envelope of the egg to allow the sperm to enter, and how these can evolve to produce reproductive isolation and new species. Waugh O'Neal and others (1998) investigate the roles of undermethylation and retroelement activation in chromosome remodeling in interspecific hybrids.

Chapter 4: The Fossil Record

The Cambrian Explosion

Evidence is accumulating that complex animals evolved long before they appeared as fossils in the "Cambrian explosion". Seilacher and others (1998) report finding of worm burrows in 1000-million-year-old Precambrian rocks, but there is much controversy over the dating of the rocks and the interpretation of the fossils. Xiao and others (1998; see also Gould 1998) have discovered almost perfectly preserved fossils of algae and animal embryos in 570-million-year-old phosphorites in southern China — 20 Ma before the Cambrian Period. Molecular dating techniques also indicate a much earlier evolution of metazoans (about 680–830 MaBP) in the Precambrian (Gu 1998; Bromham and others 1998). Thomas (1998) reconsiders the Cambrian Explosion in light of these new findings. Cooper and Fortey (1998) review the evidence for metazoan evolution prior to the Cambrian fossil record.

Li and others (1998) report the finding of Precambrian sponges. Moldowan and Talyzina (1998) report biogeochemical evidence for dinoflagellate ancestors in the early Cambrian. Jensen and others (1998) report on the occurrence of Cambrian ediacarans (vendobionts). McMenamin (1998) reports on a new interpretation of ediacarans as a separate "metacellular" kingdom. Morris and Gould (1998) debate the interpretation of the Burgess Shale fauna. Morris (1998) claims that this fauna can be classified into existing phyla. Orr and others (1998) discuss the conditions under which the Burgess Shale animals were preserved. Hecht (1998) discusses the possibility (reported last year) that during Cambrian times, the earth's crust slipped around the core almost 90 degrees. The changing climatic conditions may have spurred rapid evolution. On the other hand, geologists report evidence of long geologically stable periods in the Precambrian (Anonymous 1998). The late Precambrian provides evidence for glaciation in what are now tropical latitudes. Hoffman and others (1998) explain this by a "snowball" earth hypothesis, while Williams and others (1998) prefer to invoke a change in the orientation of the earth's spin axis.

Complex animals evolved long before they appeared as fossils in the "Cambrian Explosion".

Mass Extinctions

The end-Cretaceous Chicxulub impact event is discussed by Johnson (1998), Cerveny (1998), and Pope and others (1998). Jablow (1998) describes the discovery of the Chicxulub structure. Kyte (1998) reports on the finding of a possible fragment of the asteroid in the sediments of the northern Pacific ocean. Shukolyukov and Lugmair (1998) present geochemical evidence that the asteroid had a carbonaceous chondrite composition. Evidence has been reported

(Anonymous 1998a) that the impact fractured the edge of the continent, resulting in gigantic submarine landslides and giant tsunamis.

Cowen (1998) describes the possible causes of a comet shower that may have done in the dinosaurs. Smith and Jeffery (1998) discuss the selectivity of sea-urchin extinction due to this event. Jablonski (1998) discusses the molluscan recovery. Research on plankton extinctions that occurred before the event and of plankton that survived the event is discussed in (Anonymous 1998b). Erwin (1998) discusses recoveries from mass extinctions in general. Spray and others (1998) report evidence of a late Triassic multiple impact event. Bowring and others (1998) report geochronological evidence that the end-Permian extinction event lasted less than 1 million years. Ward (1998) reports evidence that the end-Permian land animals suffered from intense global warming. Schultz and others (1998) report a Pliocene impact event in Argentina. Wynn and Shoemaker (1998) describe an impact in Arabia that occurred in historic times. Gibbs (1998) describes the search for an impact crater in Greenland that formed in December 1997.

A new fossil of a mouse-sized flightless animal ... suggests that the ancestors of bats hung from tree branches by all four legs.

New Fossils

New fossil finds include Devonian myriapods from Australia (Edgecombe 1998) and ants in amber from New Jersey 92 MaBP (Agosti and others 1998). Plant fossils include complex rooted plants from the early Devonian 390 MaBP (Jensen 1998), a Jurassic angiosperm (Sun and others 1998), and an upper Cretaceous monocot (Gandolfo and others 1998). The discovery of late Jurassic pollinating Brachyceran flies (Ren 1998) supports the Jurassic origin of angiosperms. New fish fossils include a lobe-finned fish with "fingers" (Daeschler and Shubin 1998) and a complete primitive rhizodont lobe-finned fish from Australia (Johanson and Ahlberg 1998). New dinosaur fossils include an early Carboniferous tetrapod (Clack 1998), a fish-eating dinosaur from Africa (Sereno and others 1998), sauropod dinosaur eggs and embryos from the upper Cretaceous of Patagonia (Coria and others 1998), a 16-inch-long claw resembling that of *Velociraptor* from Patagonia (Menon 1998), an early Cretaceous sea turtle (Hirayama 1998), a new species of predatory dinosaur from Madagascar (Sampson and others 1998), a giant Cretaceous dinosaur coprolite (Chin and others 1998), a Jurassic ankylosaur dinosaur (Carpenter and others 1998), and a small theropod dinosaur fossil from Italy with soft tissue preservation (Sasso and Signore 1998). Other new vertebrate fossils include a new Eocene archaeocete whale from India (Bajpai and Gingerich 1998), new specimens of giant armadillo from Florida (Anonymous 1998b), and a 53-Ma-old jaw representing the tiniest known mammal (only 1.3 grams) from Wyoming (Monastersky 1998a).

Adrain and others (1998) discuss Ordovician trilobite diversity. The osteolepiform (lobe-fin fish) ancestors of the tetrapods are discussed by Ahlberg and Johanson (1998). Clark and others (1998) report fossil evidence that early pterosaurs were quadripedal. Evidence that Cretaceous plesiosaurs ate ammonites is reported by Sato and Tanabe (1998). New primitive skeletons from Japan shed light on the origin of ichthyosaurs (Motani and others 1998). Fossils of Cretaceous duck-billed dinosaurs have been found in Antarctica (Monastersky 1998a). Late Cretaceous fossils of champsosaurs, large crocodilelike reptiles, have been found in the high Canadian Arctic (Tarduno and others 1998), suggesting that the poles had a warm climate at that time.

Traces of bone tumors are found in dinosaur vertebrae (Anonymous 1998c). Growth layers in dinosaur bones indicate that large sauropods grew fast and attained their full size in about 10 years (Stokstad 1998). Some Cretaceous sail-backed dinosaurs may have actually been humpbacked (Anonymous 1998a). Studies of the bone growth of high-latitude Australian dinosaur fossils revealed no growth lines, indicating that they might have been endothermic and grown continuously (Monastersky 1998b).

New, more complete specimens of the Late Cretaceous mammal *Deltatheridium* (Rougier and others 1998) shed light on the evolutionary relations of basal marsupials and early mammals. Flynn and Wyss (1998) review recent knowledge of South American mammal fossils. Meng and McKenna (1998) discuss mammalian faunal turnovers in the early Tertiary. Shoshani (1998) reviews elephant evolution. DNA analysis of the excrement of the extinct ground sloth reveals the plant species in its diet (Poinar and others 1998). Zimmer (1998c) recalls the 19th-century discovery of the early whale *Basilosaurus*. A new fossil of a mouse-sized flightless animal, *Phenocolemur*, suggests that the ancestors of bats hung from tree branches by all four legs (Hecht 1998). Zimmer (1998a) discusses bats and their evolution.

Grande (1998) describes the fossil-rich Eocene lake deposits of Wyoming. Zimmer (1998b) gives an in-depth review of the evolution of amphibians from fishes and the evolution of whales from land mammals. Lockley (1998) reviews the data on fossil footprints. Such fossil tracks, found all over the world, are one of the most direct lines of evidence indicating that the geologic strata were not laid down continuously by a giant world-wide flood. Erdmann and others (1998) report on the finding of modern coelacanth populations (*Latimeria*) off the coast of Indonesia.

Birds

Britt and others (1998) have discovered passageways for air sacs in *Archaeopteryx* specimens, demonstrating that the hollow postcranial bones were pneumatized and reinforcing the idea that they are homologous with similar pneumatized bones in the skeletons of non-avian theropod dinosaurs. Controversy over the dinosaurian origin of birds continues: Padian and Chiappe (1998), Thomas and Garner (1998), and Ostrom and others (1998) summarize the opposing views; Hicks and others (1998) debate Rubin's 1997 claim that the theropod lung could not have evolved into a bird lung. Questions over whether the 3 digits in a bird's wing are homologous to the 3 digits in a theropod's arm are discussed in (Anonymous 1998).

A theropod that might have had a feathered crest (Chen and others 1998) and 2 feathered dinosaurs (Ji and others 1998) have been found in the Lower Cretaceous formations in China. Ackerman (1998) summarizes the discovery of these animals in an article with many beautiful illustrations. The early Cretaceous Chinese fossil site yielding these discoveries is described by Wang (1998); Chiappe (1998) describes the Spanish site yielding early Cretaceous birds. The skull of a Late Cretaceous relative of *Mononykus* has been found in Mongolia (Chiappe and others 1998). The oldest Coelurosaurian theropod (from the Early Jurassic) is reported from China (Zhao and Xu 1998).

Forster and others (1998) report on a primitive Late Cretaceous bird with a large sickle-like claw similar to those of dromaeosaurid dinosaurs. Stidham (1998) reports on a Late Cretaceous parrot fossil. Bones of a large (possibly 140 kg) flightless bird of the Late Cretaceous, *Gargantuavis*, have been found in France. This species may have produced the hundreds of fossil eggs found in the region previously thought to be dinosaur eggs (Holden 1998). Two more books on the origin of birds appeared this year (Dingus and Rowe 1998; Shipman 1998).

Miscellaneous

Babcock (1998) gives a good introduction to the literature on taphonomy, the science of what happens after an animal dies and under what conditions it will fossilize. Hazard (1998) offers suggestions how to teach about transitional forms.

Human Evolution

Two 45-Ma-old primate fossils found in Southeastern China are the smallest known, being less than 1 cm tall (Anonymous 1998a). They may represent the most primitive anthropoids. Gibbons (1998b) suggested that one ape line that returned to Africa from Asia may be the ancestor of the modern apes. New evidence suggests that the Miocene ape *Oreopithecus* was bipedal (Anonymous 1998b). A recent anatomical study has revealed that the chimpanzee brain exhibits asymmetry similar to that of the human brain in an area associated with language (Bower 1998a).

Several previous finds have been re-evaluated. The purported Neandertal bone flute appears to have been gnawed and punctured by an animal, perhaps a wolf (Bower 1998b). Rock art in Australia previously dated at between 50 000 and 75 000 years old has been redated to about 10 000 years by different dating methods (Bird and others 1998).

McKinney (1998) re-evaluates the "neotenic ape" model of the origin of humans. The 117 000-year-old footprints of anatomically modern humans found in 1995 near Langebaan Lagoon in South Africa will be moved to the safety of a museum (MacKenzie 1998). They are no longer the oldest known such footprints. Another set, the Nahoon prints, which have been in a South African museum for the past 34 years, have been dated at about 200 000 years old (Holden 1998a). Agnew and Demas (1998) discuss the preservation of the Laetoli footprints. The discovery of a complete *Australopithecine* skull and limb bone material in the Sterkfontein caves of South Africa was announced in December (Gee 1998). Computer simulation of Lucy's legs indicate that she walked in a human manner, not with a chimp-like gait (Lincoln 1998).

Computer imaging techniques have measured the endocranial capacity of a South African *Australopithecus africanus* specimen at about 515 cc — smaller than previous estimates. The endocranial capacities of other early hominids may also be too large (Conroy and others 1998). New specimens of *Australopithecus anamensis* confirm its age as younger than *Ardipithecus ramidus* and older than *Australopithecus afarensis* (Leakey and others 1998). Recent reports suggest that *A africanus* has more apelike body proportions than *A afarensis* (Svitil 1999). A 1-million-year-old skull with a mixture of *Homo erectus* and *H sapiens* characters has been found in Eritrea (Albianelli and others 1998). A skeleton of a modern human child has been found in the Nile valley dating from a time (55 000 years) when many anthropologists think modern humans were about to invade Europe and Asia (Copley 1998).

The 117,000-year-old anatomically-modern human footprints [from] ... South Africa ...are no longer the oldest known.

Fission-track dating of stone tools and fossils on the island of Flores date at 900 000 years ago, suggesting that *Homo erectus* was capable of crossing open water in some kind of watercraft (Morwood and others 1998). Stone tools found in Israel's Hayonim cave have been dated at 200 000 years ago. Similar tools found at 2 other sites date to 250 000 years ago (Bower 1998c). Reexamination of the evidence

for fire at Zhoukoudian, China, does not reveal any direct evidence for *in situ* burning (Weiner and others 1998).

Recent discoveries have led anthropologists to conclude that the New World was invaded by humans long before 11 000 years ago (McDonald 1998). The first humans may have reached the New World 30 000 years ago. They may have included people of European ancestry (Lewin 1998a). Last year's analysis of Neandertal DNA indicated that they were not directly ancestral to modern *Homo sapiens*, but some anthropologists, such as Milford Wolpoff, question that conclusion (see Holden 1998b and related readings). The replacement of Neandertals by modern Cro-Magnons is discussed by Mellars (1998). The June 1998 issue of *Current Anthropology* (vol 39, supplement) has several articles on Neandertals and early modern humans (Brainard 1998).

[A]lthough humans and apes differ in only 1% of their genome, this amounts to 1 million base pairs

The anatomical requirements for language are discussed by Cartmill (1998). Investigations on the size of the hypoglossal canal, which transmits the nerves of the tongue, have led some authorities to conclude that Neandertals could talk as well as modern humans do (Kay and others 1998). According to Lieberman (1998), the origin of the cranial features characteristic of modern humans are related to reduction of the sphenoid bone. That ancient humans practiced cannibalism has been controversial. New evidence indicates that it occurred in the prehistoric American southwest and among the Aztecs, Maoris, and people in England 12 000 years ago (McKie 1998).

Analysis of human Y chromosomes supports the "out-of-Africa" hypothesis but also indicates that subsequently some populations returned to Africa (Hammer and others 1998). Patterns of mitochondrial genes and the non-recombining part of the Y chromosome suggest that humans had a small effective population size (about 10 000) during the Pleistocene (Harpending and others 1998). This same evidence rules out the multiregional hypothesis. Similar results come from studies of variation in the human dystrophin gene (Zietkiewicz and others 1998). This bottleneck may have been caused by climate changes caused by the eruption of Mount Toba in Sumatra about 71 000 years ago. This eruption was about 4000 more severe than the recent Mount St Helens eruption (Anonymous 1998c).

Although the apparent continuity of fossil and modern anatomy in China appears to support the multiregional hypothesis, a recent genetic study of Chinese populations (Chu and others 1998) does not. Rather, it indicates that the ancestors of East Asia entered from Southeast Asia. Comparison of mtDNA and Y-chromosome data seems to indicate that women had a migration rate 8 times that of men (Boyce 1998).

With the Human Genome Project in full swing, some researchers are beginning to look for the genes that distinguish us from apes. One such difference, in the human CMP-sialic acid hydroxylase enzyme (Gibbons 1998a), involves a 92-base-pair deletion, which also causes a frame shift. This finding has relevance for the argument of anti-evolutionists that although humans and apes differ in only 1% of their genome, this amounts to 1 million base pairs and hence 1 million favorable point mutations would have had to occur (Schroeder 1997: 120) Obviously, point mutations are not the only way in which 1 million base-pair differences could have occurred.

Problems with calibrating mtDNA mutation rates are reviewed by Gibbons (1998b). Recent forensic work (such as identifying the recently discovered bodies of Tsar Nicholas and his family) has discovered many cases of heteroplasmy — instances where an individual has more than one mtDNA sequence. More than one type of mitochondrion can be inherited from a person's mother because the egg contains hundreds of these bodies. Such differences arose by mutation, and their occurrence suggests much higher mutation rates than previously thought.

A special section on archaeology in the November 20, 1998, issue of *Science* (Appenzeller and others 1998) reviews the latest ideas and information on the origin of art (Appenzeller 1998), the development of communities (Balter 1998), the birth of agriculture (Pringle 1998), and the origin of language (Holden 1998c). Lewin's human evolution textbook (Lewin 1998b) provides an up-to-date exposition of all aspects of human evolution.

Chapter 5: Homology

Richardson and others (1997) published a paper that compared many vertebrate embryos to investigate the validity of the phylotype concept and, as an aside, claimed that Haeckel's figures illustrating recapitulation were inaccurate to the point of being fraudulent — a point not overlooked by anti-evolutionists. This paper produced a series of letters in *Science* in 1998 (Hanken and Richardson 1998; Richardson and others 1998). The authors of the original paper say that Haeckel was essentially correct: his drawings enhanced superficial similarities — mainly of the general outlines of the various embryos — but certainly did not concoct the similarities of pharyngeal slits, and so on, that were, in fact, known to all other 19th-century anatomists, including Haeckel's enemies. (The few illustrations of recapitulation that Darwin used in *The Descent of Man* were taken from other sources). The "fraud" has been fully exploited by anti-evolution-

ists in their attempts to discredit evolution (Behe and others 1998).

Gilbert (1998) summarizes recent conceptual breakthroughs in developmental biology. These include the ideas that genetic and biological mechanisms can indeed explain development, that the core of development involves various signal transduction mechanisms, that homologous genes and pathways exist among distantly related phyla, and that modularity in development and developmental changes can result in major evolutionary changes. Modern findings on signaling molecules in development are summarized by Strauss (1998). Transmembrane receptors including olfactory receptors may function as a cell surface code for assembling embryos (Dreyer 1998).

A number of papers document new homeobox genes and their role in macroevolution. Wray and Raff (1998) report that echinoderms use the same regulatory genes as other animals to make both their bilateral larvae and their radial adults. The expression pattern of *AmphiEn,* which initiates certain repeated body segments in vertebrates, is similar to that of *engrailed* in invertebrates. *Hox* genes in ribbonworms (Nemerteans) consist of 1 cluster of 6 genes (Kmita-Cunisse and others 1998), and their most closely related orthologs are found in the mouse or *Amphioxus.* This finding indicates that ribbonworms have diverged relatively little from the last common ancestor of protostomes and deuterostomes.

Martinez and others (1998) report that coelenterates do not possess a full complement of *Hox* genes. A new cluster of 3 *Hox*-like genes (the *ParaHox* cluster) has been found in *Amphioxus* (Brooke and others 1998). Henry (1998) reports on a *Hox* gene needed for endoderm development.

The general role of homeobox genes in evolution and the Cambrian explosion is discussed in a number of papers (Cameron and others 1998; Pendick 1998; Meyer 1998). The discovery of 7 *Hox* clusters in modern fish (tetrapods have only 4) may account for the wide diversity displayed by modern fishes (Amores and others 1998). *Hox* genes and their role in vertebrate hindbrain segmentation are discussed by Prince (1998). Holland and Holland (1998) report on the expression patterns of 5 *Hox* genes in *Amphioxus,* which indicate the presence of a forebrain.

Martindale and Henry (1998) discuss the evolution of bilaterality. Several papers summarize our knowledge of limb development (Gardiner and others 1998; Schwabe and others 1998). The wide variability in tetrapod limb morphology is probably due to the timing and sequence of expression of *Hox* genes. Duboule and Wilkins (1998) point out that most of our genes are shared with other organisms, so phylogenetic diversity depends not on evolution of new genes, but on differential use of the same component genes. Evolutionary "bricolage" (that is, tinkering) with the developmental system is very conservative.

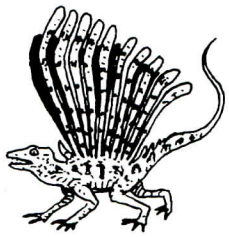
Tautz (1998) and Lee (1998) explore the use of the concept of homology in comparative and evolutionary studies. Modern techniques for reconstructing evolutionary trees are summarized by Lewin (1998). Hall (1998) presents a review of historical and recent research bearing on the germ-layer theory.

Over the years, *The Textbook Letter* has carried 3 articles about *Of Pandas and People,* leading off with a longish piece that told something about the book's origins. TTL has now posted those articles on its Web site. All 3 of them can be found at <http://www.textbook-league.org/53panda.htm>.

Contributed by Bill Bennetta.

Chapter 6: Biochemical Similarities

Molecular taxonomy is changing our conception of the relationships of the animal phyla. Maley and Marshall (1998) provide a brief summary of molecular systematics and some of the outstanding issues in the field. Collins (1998) compares hypotheses concerning the evolution of the Bilateria based on ribosomal RNA data. Bilaterians seem to be closely related to placozoans and cnidarians. Balavoine and Adoutte (1998) review the evidence from ribosomal RNA data for grouping the triploblastic phyla into 3 large groups; Anderson and others (1998) report *Hox* gene data that may indicate that the protozoan Myzozoa may be a degenerate metazoan.



Several molecular studies appear to conflict with morphological and paleontological data. Sequencing of the mitochondrial genome suggests that turtles may be more closely related to diapsid than to anapsid reptiles (Zardoya and Meyer 1998). Another mitochondrial genome study suggests a closer-than-expected relationship between hippopotamus and whale clades (Ursing and Arnason 1998), but these findings are not consistent with other studies. The most newly discovered ancient whale fossils weaken the link to mesonychids and make the artiodactyl connection more plausible (Normile 1998). A molecular time scale for vertebrate evolution (Kumar and Hedges 1998) indicates that many modern mammalian orders diverged in the Cretaceous rather than the Tertiary, yet the latest fossil evidence (Normile 1998) disputes this hypothesis. Gaut (1998) reviews the research done on molecular clocks using plant data.

Study of mitochondrial introns suggests the liverworts were the earliest land plants (Qiu and others

1998). De Ley and others (1998) use ribosomal DNA data to classify the nematodes. Springer and others (1998) use both mitochondrial and nuclear gene data to resolve ambiguities in the relationships of the marsupials. The studies have confirmed that the marsupials are a natural grouping. Schubart and others (1998) studied the mitochondrial genes of Jamaican land crabs and concluded that they are descended from one marine ancestor about 4 MaBP.

SUMMARY

Astronomers continue to find evidence of extrasolar planetary systems. More genomes are being completely sequenced, including the first genome to be sequenced of an animal, the nematode *Caenorhabditis elegans*, with about 19 000 genes. Darwinian evolutionary paradigms, in the form of genetic algorithms and test-tube evolution, are being used more and more to design engineering systems and to produce new enzymes, many of medical importance. Traces of animals that preceded the Cambrian explosion have been found, as have been feathered dinosaurs. New human fossils are being found that add variety and depth to the human family tree. The discovery of new homeobox-type genes are helping to elucidate developmental systems.

All these new findings are supportive of evolution and advance our knowledge of the history and variety of life beyond what we knew in 1989 when *Of Pandas and People* was first published. By contrast, the "intelligent design" theory presented in the pages of *Pandas* has yet to produce any scientific advances in the main areas of study laid out in the 6 chapters of the original (and revised) textbook.

REFERENCES

Chapter 1: The Origin of Life

General

Holmes B. Life is... *New Scientist* 1998 Jun 13; 158 (2138): 38–42.

Joyce GF, Orgel LE. The origins of life — A status report. *The American Biology Teacher* 1998 Jan; 60 (1): 10–2.

Radetsky P. Life's crucible. *Earth* 1998 Feb; 7 (1): 34–41.

The Space Connection

Bada JL, Glavin DP, McDonald GD, Becker L. A search for endogenous amino acids in Martian meteorite ALH84001. *Science* 1998 Jan 16; 279: 362–5. *Related reading:* Cowen R. Reports raise questions about Martian rock. *Science News* 1998 Jan 24 (4); 153: 54. Jull AJT, Courtney C, Jeffrey DA, Beck JW. Isotopic evidence for a terrestrial source of organic compounds found in Martian meteorites Allan Hills 84001 and Elephant Moraine 79001. *Science* 1998 Jan 16; 279: 366–9.

Bailey J, Chrysostomou A, Hough JH, Gledhill TM, McCall A, Clark S, Ménard F, Tamura M. Circular polarization in star-formation regions: Implications for biomolecular homochirality. *Science* 1998 Jul 31; 281: 672–4. *Related reading:* Cowen R. Starlight shows life the right path. *Science News* 1998 Aug 1; 154 (5): 68. Green MM, Selinger JV. Cosmic chirality [letter]. *Science* 1998 Oct 30; 282: 880–1. Guterman L. Why life on earth leans to the left. *New Scientist* 1998 Dec 12; 160 (2164): 16. Hecht J. Inner circles. *New Scientist* 1998 Aug 8; 159 (2146): 11. Irion R. Did twisty starlight set stage for life? *Science* 1998 Jul 31; 281: 626–7. Schneider D. Polarized life. *Scientific American* 1998 Oct 24; 279 (3): 24.

Brainard J. Any Mars life would be hard to find. *Science News* 1998 Aug 29; 154 (9): 135. *Related reading:* Hecht J. Mission impossible. *New Scientist* 1998 Aug 29; 159 (2149): 20.

Cowen R. Exploring new worlds. *Science News* 1998a Aug 1; 154 (6): 88–90. *Related reading:* Cowen R. A dozen new planets ... and still counting. *Science News* 1998 Sep 26; 154 (13): 197. Cowen R. Star motions yield four more planets. *Science News* 1998 Dec 5; 154 (23): 362.

Cowen R. Epsilon Eridani: An early solar system? *Science News* 1998b Aug 8; 154 (6): 91. *Related reading:* Schilling G. Hints of a nearby solar system? *Science* 1998 Jul 10; 281: 152–3.

Gibbs WW. Endangered. *Scientific American* 1998 Apr; 278 (4): 19–21.

Holden C. Ocean sighting confirmed. *Science* 1998 Mar 13; 279: 1639. *Related reading:* [Anonymous]. Planets, moons, a supernova, and more. *Discover* 1999 Jan; 20 (1): 74. [Anonymous]. A world of ice. *Discover* 1998 Mar; 19 (3): 22. [Anonymous]. Slush on Europa? *Discover* 1998 May; 19 (5): 16. Cowen R. Craft eyes new evidence of a slushy Europa. *Science News* 1998 Mar 7; 153 (10): 149. Hecht J. Galileo gets slushy with Europa. *New Scientist* 1998 Mar 7; 157 (2124): 5. Seife C. To the iceworld. *New Scientist* 1998 Feb 14; 157 (2121): 20.

Kalas P. Dusty disks and planet mania. *Science* 1998 Jul 10; 281: 182–3

Kerr RA. Requiem for life on Mars? Support for microbes fades. *Science* 1998a Nov 20; 282: 1398–1400. *Related reading:* Cowen R. Fossils from Mars: Point, counterpoint. *Science News* 1998 Jan 3; 153 (1): 11.

Kerr RA. Planetary scientists sample ice, fire, and dust in Houston. *Science* 1998b Apr 3; 280: 38–9.

Kivelson MG, Stevenson DJ, Schubert G, Russell CT, Walker RJ, Polanskey C, Khurana KK. Induced magnetic fields as evidence for subsurface oceans in Europa and Callisto. *Nature* 1998 Oct 22; 395: 777–80. *Related reading:* [Anonymous]. Other worlds, other oceans. *Discover* 1998 Sep; 19 (9): 20. Cowen R. An ocean for Callisto? *Science News* 1998 Nov 7; 154 (19): 296. Kerr RA. Geophysicists ponder hints of otherworldly water. *Science* 1998 Jan 2; 279: 30–1. Neubauer F. Oceans inside Jupiter's moons. *Nature* 1998 Oct 22; 395: 749–51.

Leutwyler K. New planet? *Scientific American* 1998 Aug; 279 (2): 22. *Related reading:* [Anonymous]. Planet poseur? *Discover* 1998 Aug; 19 (8): 24.

McCord TB, Hansen GB, Fanale FP, Carlson RW, Matson DL, Johnson TV, Smythe WD, Crowley JK, Martin PD, Ocampo A, Hibbitts CA, Granahan JC, and the NIMS Team. Salts on Europa's surface detected by Galileo's near infrared mapping spectrometer. *Science* 1998 May 22; 280: 1242–5. *Related reading:* [Anonymous]. Salty moon. *New Scientist* 1998 Mar 28; 157 (2127): 23. Cowen R. Europa's salty surface. *Science News* 1998 Jan 3; 153 (1): 11. Kargel JS. The salt of Europa. *Science* 1998 May 22; 280: 1211–2.

Pizzarello S, Cronin JR. Alanine enantiomers in the Murchison meteorite. *Nature* 1998 Jul 16; 394: 236.

Schueller G. Stuff of life. *New Scientist* 1998 Sep 12; 159 (2151): 30–5.

Semeniuk I. Real worlds of other suns. *SkyNews* 1998 Nov/Dec; 4 (4): 12–5.

Svitil KA. Hot times on Titan. *Discover* 1998 Mar; 19 (3): 29.

Extremophiles

Cary SC, Shank T, Stein J. Worms bask in extreme temperatures. *Nature* 1998 Feb 5; 391: 545–6. *Related reading:* Jensen M. Worms' hot ends set thermal record. *Science News* 1998 Feb 21; 153 (8): 126.

Cossins AR. Some like it hot. *Nature* 1998 May 21; 393: 227–8.

DeLong E. Archeal means and extremes. *Science* 1998 Apr 24; 280: 542–3.

Gross M. *Life on the Edge: Amazing Creatures Thriving in Extreme Environments.* New York: Plenum Press 1998.

Kajander EO, Ciftcioglu N. Nanobacteria: An alternative mechanism for pathogenic intra- and extracellular calcification and stone formation. *Proceedings of the National Academy of Sciences* 1998 Jul 7; 95 (14): 8274–9. *Related reading:* Folk RL. Life in miniature [letter]. *Science News* 1998 Sep 12; 154 (11): 163, 169. Travis J. The bacteria in the stone. *Science News* 1998 Aug 1; 154 (5): 75–7. Vogel G. Bacteria to blame for kidney stones? *Science* 1998 Jul 10; 281: 153.

Pain S. Extremeworms. *New Scientist* 1998a Jul 25; 159 (2144): 48–50.

Pain S. The intraterrestrials. *New Scientist* 1998b Mar 7; 157 (2124): 28–32.

Priscu JC, Fritsen CH, Adams EE,

Missing Links and the Origin of Biochemical Complexity

Barry A Palevitz

For years, evolution's critics picked on supposed gaps in the historical record—missing links between different forms or species in biologists' evolutionary lineages. Evolutionary leaps, say from dinosaurs to birds, are inconceivable without intermediates, so the reasoning went. Finding key fossils is no easy matter, but creationists interpreted the absence of evidence as evidence of absence—no links, no evolution, only supernatural design.

Paleontologists were patient, though. They predicted that the feathers so important in bird flight were probably co-opted from another function, most likely thermal insulation. If that is true, scientists should eventually find fossils of feathered flightless animals. Their patience paid off over the past few years as China's Liaoning province yielded spectacular specimens of feathered dinosaurs (Xu and others 1999). And birds are not alone. The same painstaking process of scientific discovery is illuminating the evolutionary history of flowering plants, whales, snakes, and—dare we say it—humans.

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Enter Biochemistry

But never say die—if cats have 9 lives, creationism has at least a dozen. Having lost the fossil wars, creationists turned to biochemical pathways and subcellular structures. How could a biochemical pathway, which may involve 20 or more separate steps catalyzed by a score of enzymes, evolve? They do not, according to a new breed of "neocreationists" rallying under the banner of Lehigh University's Michael Behe. Unfortunately, the argument is familiar. For example, surely a metabolic pathway with a specific function is "irreducibly complex" (Behe 1996), making stepwise evolution unlikely. Remove the feathers—er, an enzyme—and it doesn't fly. Right?

Wrong, say biochemists and evolutionary biologists. Now philosopher of science Niall Shanks has added his two cents. With colleague Karl Joplin at the University of East Tennessee in

Giovannoni SJ, Paerl HW, McKay CP, Doran PT, Gordon DA, Lanoil BD, Pinckney JL. Perennial Antarctic lake ice: An oasis for life in a polar desert. *Science* 1998 Jun 26; 280: 2095–8. *Related reading:* Knight J. On thin ice. *New Scientist* 1998 Jul 4; 159 (2141): 13. Milius S. Looking for life in all the worst places. *Science News* 1998 Jul 11; 154 (2): 27. Svitil KA. Life on ice. *Discover* 1998 Oct; 19 (10): 38.

Vogel G. Finding life's limits. *Science* 1998 Nov 20; 282: 1399.

Prebiotic Chemistry

Balter M. Did life begin in hot water? *Science* 1998 Apr 3; 280: 31.

Boctor NZ, Cody GD, Cooper BA, Hazen RM, Yoder HS, Brandes JA. Abiotic nitrogen reduction on the early earth. *Nature* 1998 Sep 24; 395: 365–7. *Related reading:* Chyba C. Buried beginnings. *Nature* 1998 Sep 24; 395: 329–30.

Canfield DE. A new model for Proterozoic ocean chemistry. *Nature* 1998; 450–453.

Carmi N, Balkhi SR, Breaker RR. Cleaving DNA with DNA. *Proceedings of the National Academy of Sciences* 1998 Mar 3; 95 (5): 2233–7. *Related reading:* Wu C. DNA scissors cleave their comrades. *Science News* 1998 Apr 4; 153 (14): 223.

Cleaves HJ, Miller SL. Oceanic protection of prebiotic organic compounds from UV radiation. *Proceedings of the National Academy of Sciences* 1998 Jun 23; 95 (13): 7260–3. *Related reading:* Brainard J. What was life's first sunblock? *Science News* 1998 Jul 11; 154 (2): 31.

Cohen P. Molecules of ancient life are born again. *New Scientist* 1998 Oct 17; 160 (2156): 10. *Related reading:* Zhang B, Cech TR. Peptide bond formation by in vitro selected ribozymes. *Nature* 1997 Nov 6; 390: 96–100.

Edwards MR. From a soup or a seed? Pyritic metabolic complexes in the origin of life. *Trends in Ecology and Evolution* 1998 May; 13 (5): 178–81.

Huber C, Wachtershauser G. Peptides by activation of amino acids with CO on (Ni,Fe)S surfaces: Implications for the origin of life. *Science* 1998 Jul 31; 281: 670–2. *Related reading:* Vogel G. A sulfurous start for protein synthesis? *Science* 1998 July 31; 281: 627–9.

Jeffares DC, Poole AM, Penny D. Relics from the RNA world. *Journal of Molecular Evolution* 1998 Jan; 46: 18–36.

Levy M, Miller SL. The stability of the RNA bases: Implications for the origin of life. *Proceedings of the National Academy of Sciences* 1998 Jul 7; 95 (14): 7933–8. *Related reading:* Knight J. Cold start. *New Scientist* 1998 Jul 11; 159 (2142): 10.

Luther A, Brandsch R, von Kiedrowski G. Surface-promoted replication and exponential amplification of DNA analogues. *Nature* 1998 Nov 19; 396: 245–8. *Related reading:* Day M. Did stones nurture the first life on earth? *New Scientist* 1998 Nov 21; 160 (2161): 6.

Nitta I, Kamada Y, Noda H, Ueda T, Watanabe K. Reconstitution of peptide bond formation with *Escherischia coli* 23s ribosomal RNA domains. *Science* 1998 Jul 31; 281: 666–9. *Related reading:* Schimmel P, Alexander R. All you need is RNA. *Science* 1998 Jul 31; 281: 658–9.

Parsons I, Lee MR, Smith JV. Biochemical evolution II: Origin of life in tubular microstructures on weathered feldspar surfaces. *Proceedings of the National Academy of Sciences* 1998 Dec 22; 95 (26): 15173–6.

Poole AM, Jeffares DC, Penny D. The path from the RNA world. *Journal of Molecular Evolution* 1998 Jan; 46: 1–17.

Smith JV. Biochemical evolution. I. Polymerization on internal, organophilic silica surfaces of dealuminated zeolites and feldspars. *Proceedings of the*

Johnson City, Shanks argued that biological systems exhibit "redundant complexity," not irreducible complexity, which makes Behe's idea a big oversimplification (Shanks and Joplin 1999). Enzymes come in multiple forms, or isozymes, that produce a variety of outcomes. Likewise, genes duplicate and specialize, thereby creating new pathways and functions (Ohno 1970). The evidence is obvious in a host of multigene families governing all sorts of processes. Redundancy is "like a scaffold" that supports pathways in the making, explains Shanks.

In essence, evolution co-opts parts from preexisting hardware—what Stephen Jay Gould and Elisabeth S Vrba called exaptation (Gould and Vrba 1982). Behe proposed a "special kind of complexity that cannot be explained in naturalistic terms," says Shanks, but "it *can* be explained naturally without magic or hocus pocus."

Eyes on Bacteria

The lens crystallins of eyes are some of the best examples of exaptations. Crystallins lend optical properties to lens cells important in light transmission. Various proteins have specialized as crystallins during eye evolution, some resulting from gene duplication followed by specialization, others retaining their original metabolic activities in a process Joram Piatigorsky of the National Eye Institute called recruitment by gene sharing (Piatigorsky and Wistow 1991). Lactate dehydrogenase, aldehyde dehydrogenase, and enolase have all been put to work as lens crystallins, while still acting as enzymes.

If the really important question in eye evolution is not gross anatomy but molecular pathways, as Behe believes, the answer is not in intelligent design or other supernatural handwaving, but more biochemistry and genetics. That also holds true for nitrogen-fixing rhizobial bacteria that inhabit the root nodules of legumes. According to J Peter Young of York University, United Kingdom, rhizobia may have borrowed genes from each other, fungi, and even host plants to patch together new biosynthetic pathways for *nod* factors, signaling molecules that let roots know the bacteria are around (Young 1999).

Biochemical Irreducibility— The Deep Freeze

A team led by Chi-Hing Cheng, senior research scientist in the Department of Ecology, Ethology and Evolution at the University of Illinois, Urbana, recently uncovered one of the nicest examples of biochemical exaptation, in fish that thrive in Antarctic waters where temperatures go below -2 degrees Celsius, lower than the freezing point of their blood. Plants and animals manufacture a variety of antifreeze proteins that block the growth of destructive ice crystals. Notothenioids like the Antarctic toothfish make antifreeze glycoproteins (AFGPs) that vary in molecular weight from 2600 to 34 000 daltons. The fish maintain high levels of glycoprotein in the blood because they have multiple genes, each encoding a "polyprotein" that is chopped into numerous AFGPs.

AFGPs consist of a repeating

National Academy of Sciences 1998 Mar 31; 95 (7): 3370–5.

Unrau PJ, Bartel DP. RNA-catalysed nucleotide synthesis. *Nature* 1998 Sep 17; 395: 260–3. *Related reading*: [Anonymous]. Dawn of life. *New Scientist* 1998 Sep 19; 159 (2152): 27. Robertson MP, Ellington AD. How to make a nucleotide. *Nature* 1998 Sep 17; 395: 223–5.

The Rise of Eukaryotes

Blackman S. Safety in numbers. *New Scientist* 1998 Mar 14; 157 (2125): 15.

Martin W, Muller M. The hydrogen hypothesis for the first eukaryote. *Nature* 1998 Mar 5; 392: 37–41. *Related reading*: Doolittle WF. A paradigm gets shifty. *Nature* 1998 Mar 5; 392: 15–6. Sandman K, Reeve JN. Origin of the eukaryotic nucleus [letter]. *Science* 1998 Apr 24; 280: 501–2. Travis J. The hydrogen hypothesis. *Science News* 1998 Apr 18; 153 (16): 253–5. Vogel G. Did the first complex cell eat hydrogen? *Science* 1998 Mar 13; 279: 1633–4.

Monastersky R. Fossil soil has the dirt on early microbes. *Science News* 1998a Mar 7; 153 (10): 151. *Related reading*: [Anonymous]. Getting the dirt on land life. *Earth* 1998 Aug; 7 (4): 14.

Monastersky R. Arctic fossils record evolutionary burst. *Science News* 1998b Nov 7; 154 (19): 294.

Chapter 2: Genetics and Evolution

Mutation

[Anonymous]. Still jumping. *New Scientist* 1998 Nov 14; 160 (2160): 30.

Boyce N. Good for nothing. *New Scientist* 1998 Jan 17; 157 (2117): 7.

Brookes M. Day of the mutators. *New Scientist* 1998 Feb 14; 157 (2121): 38–42.

Goodman MFJ. Purposeful mutations. *Nature* 1998 Sep 17; 395: 221–3.

Max EE. "New" persuasive evidence for evolution. *The American Biology Teacher* 1998 Nov/Dec; 60 (9): 662–70.

Pennisi E. The first codon and its descendents. *Science* 1998a Jul 17; 281: 330.

Pennisi E. How the genome readies itself for evolution. *Science* 1998b Aug 21; 281: 1131–4.

Rainey PB, Travisano M. Adaptive radiation in a heterogeneous environment. *Nature* 1998 Jul 2; 394: 69–72.

Van den Burg B, Vriend G, Veltman OR, Venema G, Eijsink VGH. Engineering an enzyme to resist boiling. *Proceedings of the National Academy of Sciences* 1998 Mar 3; 95 (5): 2056–60. *Related reading*: Seife C. Designer enzymes enjoy life in the hot seat. *New Scientist* 1998 Mar 7; 157 (2124): 10.

Vogel G. Tracking the history of the genetic code. *Science* 1998 Jul 17; 281: 329–31.

Wu H, Hu Z, Liu X-Q. Protein trans-splicing by a split intein encoded in a split DnaE gene of *Synechocystis sp.* PCC6803. *Proceedings of the National Academy of Sciences* 1998 Aug 4; 95 (16): 9226–31. *Related reading*: Vogel G. A two-piece protein assembles itself. *Science* 1998 Aug 7; 281: 763.

Natural Selection

Arnqvist G. Comparative evidence for the evolution of genitalia by sexual selection. *Nature* 1998 Jun 25; 393: 784–6. *Related reading*: Gwynne DT. Genitally does it. *Nature* 1998 June 25; 393: 734–5. Milius S. Why guys get fancy. *Science News* 1998 Aug 29; 154 (9): 140–1.

Barton NH, Charlesworth B. Why sex and recombination? *Science* 1998 Sep 25; 281: 1986–90.

Evans MRJ. Selection on swallow tail streamers. *Nature* 1998 Jul 16; 394: 233–4. *Related reading*: Hedenstrom A,

3-amino-acid sequence consisting of threonine-alanine-alanine. With 2 sugars attached to each threonine, AFGPs are the fish's version of ethylene glycol. But how did such unusual proteins arise? How did notothenioids get their antifreeze genes as Antarctic waters froze 10–15 million years ago? Cheng's group discovered that AFGP genes evolved from an ancestral gene encoding trypsinogen, a pancreatic protein that cleaves to produce the digestive enzyme trypsin (Chen and others 1997). The molecular footprints were obvious: AFGP and trypsinogen genes share significant sequence identity at several locations.

What clinched the story was Cheng's finding that trypsinogen contains a three-amino-acid sequence with no known function in the enzyme. You guessed it: threonine-alanine-alanine. In constructing AFGP, the tripeptide reiterated again and again, probably because the repetition had antifreeze properties strongly selected by ice-cold water. Most of the rest of the trypsinogen gene was discarded. By deleting parts of the trypsinogen gene and recruiting and amplifying others, evolution did its borrowing act.

Now for the icing on the cake: The toothfish contains not only genes for AFGP and trypsinogen, but a hybrid gene—a missing link?—encoding both AFGP and trypsinogen (Cheng and Chen 1999). The AFGP part occurs exactly where expected, near the beginning of the trypsinogen portion of the gene that previously encoded the ancestral tripeptide. Says Cheng, "We were able to catch notothenioid AFGP evolution 'in action', so to speak, because we believe the protease-AFGP split is a rather recent event in the evolutionary time scale." Cheng is now trying to find out if the hybrid protein has trypsin activity.

REFERENCES

Behe MJ. *Darwin's Black Box: The Biochemical Challenge to Evolution*. New York: The Free Press, 1996.

Chen LB, DeVries AL, Ceng C-HC. Evolution of antifreeze glycoprotein gene from a trypsinogen gene in Antarctic notothenioid fish. *Proceedings of the National Academy of Sciences* 1997 Apr 15; 94: 3811–6.

Cheng C-H, Chen L. Evolution of an antifreeze glycoprotein. *Nature* 1999 Sep 30; 401: 443–4.

Gould SJ, Vrba ES. Exaptation—a missing term in the science of form. *Paleobiology* 1982; 8: 4–15.

Ohno S. *Evolution by Gene Duplication*. Berlin: Springer-Verlag, 1970.

Piatigorsky J, Wistow G. The recruitment of crystallins: New functions precede gene duplications. *Science* 1991; 252: 1078–9.

Shanks N, Joplin KH. Redundant complexity: a critical analysis of intelligent design in biochemistry. *Philosophy of Science* 1999 Jun; 66: 268–82.

Xu X and others. A dromaeosaurid dinosaur with a filamentous integument from the Yixian formation of China. *Nature* 1999 Sep 16; 401: 262–6.

Young JPW. The evolution of rhizobia and their nodulation genes. XVI International Botanical Congress, 1999.

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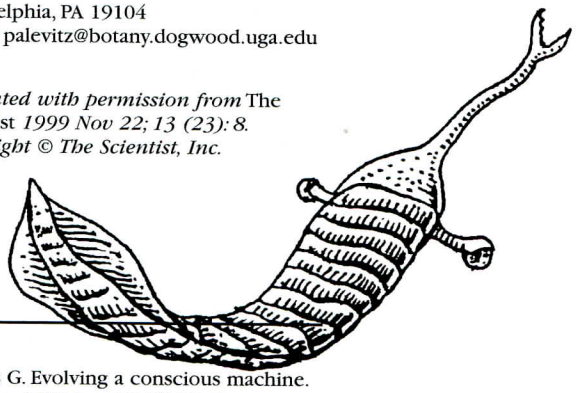

Moller AP. Length of tail streamers in barn swallows. *Nature* 1999 Jan 14; 397: 115.

Hines P, Culotta E. The evolution of sex. *Science* 1998 Sep 25; 281: 1979.

Losos JB, Jackman TR, Larson A, de Queiroz K, Rodriguez-Schettino L. Contingency and determinism in replicated adaptive radiations of island lizards. *Science* 1998 Mar 27; 279: 2115–8. *Related reading:* Vogel G. For island lizards, history repeats itself. *Science* 1998 Mar 27; 279: 2043.

Rosenthal GG, Evans CS. Female preference for swords in *Xiphophorus helleri* reflects a bias for large apparent size. *Proceedings of the National Academy of Sciences* 1998 Apr 14; 95 (8): 4431–6.

Sargent TD, Millar CD, Lambert DM. The "classical" explanation of industrial melanism: Assessing the evidence. *Evolutionary Biology* 1998; 30: 299–322.

Welch AM, Semlitsch RD, Gerhardt HC. Call duration as an indicator of genetic quality in male gray tree frogs. *Science* 1998; 280: 1928–30. *Related reading*: Pennisi E. Females pick good genes in frogs, flies. *Science* 1998 Jun 19; 280: 1837–8.

Wilkinson GS, Presgraves DC, Crymes L. Male eye span in stalk-eyed flies indicates genetic quality by meiotic drive suppression. *Nature* 1998 Jan 15; 391: 276–9. *Related reading*: Hurst LD, Pomlankowski A. The eyes have it. *Nature* 1998 Jan 15; 391: 223–4. Milius S. Female flies pick mates with sexy eyes. *Science News* 1998 Jan 17; 153 (3): 36.

Wuethrich B. Why sex? Putting theory to the test. *Science* 1998; 281: 1980–2.

Designing with Evolution

Crameri A, Raillard S-A, Bermudez E, Stemmer WPC. DNA shuffling of a family of genes from diverse species accelerates directed evolution. *Nature* 1998 Jan 15; 391: 288–91.

Landweber LF, Simon PJ, Wagner TA. Ribozyme engineering and early evolution. *BioScience* 1998 Feb; 48 (2): 94–103.

Lenski RE. Get a life. *Science* 1998 May 8; 280: 849–50.

MacBeath G, Kast P, Hilvert D. Redesigning enzyme topology by directed evolution. *Science* 1998 Mar 20; 279: 1958–61.

Petit CW. Touched by nature: Putting evolution to work on the assembly line. *U.S. News & World Report* 1998 Jul 27; 125 (4): 43–5.

Taubes G. Evolving a conscious machine. *Discover* 1998 Jun; 19 (6): 72–9.

Genomes

Andersson SGE, Zomorodipour A, Andersson JO, Sicheritz-Pont[eacute]n T, Alsmark UCM, Podowski RM, N[auml]slund AK, Eriksson A-S, Winkler HH, Kurland CG. The genome sequence of *Rickettsia prowazekii* and the origin of mitochondria. *Nature* 1998 Nov 12; 396: 133–40. *Related reading*: Gray MW. Rickettsia, typhus and the mitochondrial connection. *Nature* 1998; 396: 109–10. Pennisi E. Genome links typhus bug to mitochondrion. *Science* 1998 Nov 13; 282: 1243.

[Anonymous]. Whole lotta bugs. *Discover* 1998 Dec; 19 (12): 28.

Aravalli RN, She Q, Garrett RA. Archaea and the new age of microorganisms. *Trends in Ecology and Evolution.* 1998 May; 13 (5): 190–4.

Cole ST, Brosch R, Parkhill J, Garnier T, Churcher C, Harris D, Gordon SV, Eiglmeier K, Gas S, Barry CE, Tekaia F, Badcock K, Basham D, Brown D, Chillingworth T, R Connor R, Davies R, Devlin K, Feltwell T, Gentles S, Hamlin N, Holroyd S, Hornsby T, Jagels K, Krogh A,

Hammed!

Jere H Lipps

I've been Hammed! Answers in Genesis (AIG) Executive Director Ken Ham has taken me to task for my keynote address to *Dinofest '98* in Philadelphia. My talk was about American scientific illiteracy (extending to over 95% of adults), how the media contribute to it, and some remedies for the situation. I have given my talk perhaps 25 times from Limestone, Maine, to Long Beach, California, and the usual response I have had is "terrific", "great", "funny". But Ham did not like it, writing in the *Answers in Genesis Newsletter* (1998: 8) that I was "rather emotional ... critical, bitter, and intolerant of any view that differed from [my] own concerning evolution and dinosaurs — including a tirade against many beliefs, including creationism." Emotional? Well, I'd rather say that I was impassioned. Critical? Yes, but of the media — television in particular. Bitter and intolerant? Maybe I was, but not of creationism, UFOlogy, astrology, or a host of other pseudosciences, but of scientific illiteracy, which lets them flourish. But if Ham somehow equates creationism with scientific illiteracy, who am I to object?

I was "Hammed" because the good sense, reason and science literacy I call for are threats to creationists. They fear these, for their own tirades (or "battles", as they like to call them) against evolution will be less compelling if their audiences acquire these attributes. My point in writing here is to note just how sensitive Ham and his kind are, and how he twists reality to fit his own needs. He uses a common strategy on me, and a closer look at what he did may help us to understand how these folks work. Basically, I was simply a good excuse to rouse the troops.

In fact, Ham purposefully con-

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McLean J, Moule S, Murphy L, Oliver K, Osborne J, Quai MA, Rajandream M-A, Rogers J, Rutter S, Seeger K, Skelton J, Squares R, Squares S, Sulston JE, Taylor K, Whitehead S, Barrell BG. Deciphering the biology of *Mycobacterium tuberculosis* from the complete genome sequence. *Nature* 1998 Jun 11; 393: 537–3. *Related reading:* Young DB. Blueprint for the white plague. *Nature* 1998 Jun 11; 393: 515–6.

Deckert G, Warren PV; Gaasterland T; Young WG; Lenox AL; Graham DE; Overbeek R; Snead MA; Keller M; Aujay M; Feldman RA; Short JM; Olsen GJ; Huber R; Swanson RV. The complete genome of the hyperthermophilic bacterium *Aquifex aeolicus*. *Nature* 1998 Mar 26; 392: 353–8. *Related reading:* Doolittle RF. Microbial genomes opened up. *Nature* 1998 Mar 26; 392: 339–42.

The EU *Arabidopsis* Genome Project. Analysis of 1.9 Mb of contiguous sequence from chromosome 4 of *Arabidopsis thaliana*. *Nature* 1998 Jan 29; 391:485–8. *Related reading*: Ecker JR. Genes blossom from a weed. *Nature* 1998 Jan 29; 391: 438.

Fraser CM, Norris SJ, Weinstock JM, White O, Sutton GG, Dodson R, Gwinn M, Hickey EK, Clayton R, Ketchum KA, Sodergren E, Hardham JM, McLeod MP, Salzberg S, Peterson J, Khalak H, Richardson D, Howell JK, Chidambaram M, Utterback T, McDonald L, Artiach P, Bowman C, Cotton MD, Fujii C, Garland S, Hatch B, Horst K, Roberts K, Sandusky M, Weidman J, Smith HO, Venter JC. Complete genome sequence of *Treponema pallidum*, the syphilis spirochaete. *Science* 1998 Jul 17; 281: 375–88. *Related reading*: Pennisi E. Genome reveals wiles and weak points of syphilis. *Science* 1998 Jul 17; 281: 324–5. Seppa N. Reseachers solve syphilis genome. *Science News* 1998 Aug 11; 154 (5): 79.

Hodgkin J, Herman RK. Changing styles in *C. elegans* genetics. *Trends in Genetics* 1998 Sep; 14 (9): 352–7.

Hodgkin J, Horvitz HR, Jasny BR, Kimble J. *C. elegans:* Sequence to biology. *Science* 1998 Dec 11; 282: 2011. *Related reading*: Chalfie M. The worm revealed. *Nature* 1998 Dec 17; 396: 620–1. Ferry G. The human worm. *New Scientist* 1998 Dec 5; 160 (2163): 33–5. Pennisi E. Worming secrets from the *C. elegans* genome. *Science* 1998 Dec 11; 282: 1972–5. Travis J. Worm offers the first animal genome. *Science News* 1998 Dec 12; 154 (24): 372. Yam P. Worm genome project. *Scientific American* 1999 Feb; 87 (2): 26.

Huynen MA, Bork P. Measuring genome evolution. *Proceedings of the National Academy of Sciences* 1998 May 26; 95 (11): 5849–56.

Katz LA. Changing perspectives on the origin of eukaryotes. *Trends in Ecology and Evolution* 1998 Dec; 13 (12): 493–7.

Koga Y, Kyuragi T, Nishihara M, Sone N. Did archaeal and bacterial cells arise independently from noncellular precursors? A hypothesis stating that the advent of membrane phospholipid with enantiomeric glycerophosphate backbones caused the separation of the two lines of descent. *Journal of Molecular Biology* 1998 Jan; 46 (1): 54–63. *Related reading*: Barnett A. The second coming. *New Scientist* 1998 Feb 14; 157 (2121): 19.

Meinke DW, Cherry JM, Dean C, Rounsley SD, Koornneef M. *Arabidopsis thaliana*: A model plant for genome analysis. *Science* 1998 Oct 23; 282: 662–81.

Miller RV. Bacterial gene swapping in nature. *Scientific American* 1998 Jan; 278 (1): 66–71.

Pebusque M-J, Coulier F, Birnbaum D, Pontarotti P. Ancient large-scale genome duplications: phylogenetic and linkage analyses shed light on chordate genome evolution. *Molecular Biology and Evolution* 1998; 15 (9): 1145–59.

fuses the point of my talk. My talk was not about dinosaurs or even evolution. I know nothing much about dinosaurs, although I am an evolutionist through and through.

Because I only had 45 minutes rather than my usual hour and a quarter, I reduced my comments about almost everything except science illiteracy, the media hyping of pseudoscience, and what we can do to get reasonable science incorporated into television programs. One slide stated that religion, science, and pseudoscience are different ways to view the world, but I made no comment about religion at all. I showed another slide listing some paranormal beliefs, and creationism was on the list. But again I made no comment about it.

My example of pseudoscientific ignorance was UFO beliefs, because that is a very funny subject; whereas, by contrast, I find little that is humorous about creationism. I focused on scientific illiteracy in this country and how the media contributed to it with a variety of fraudulent programming, including "The Mysterious Origins of Man", a television program (and now a video series) that every good creationist should object to as much as evolutionists should (*see* NCSE Reports *1995; 15 [4]: 1*). I suggested how the media could present science in a reasonable, compelling, and profitable way, if it cared to.

Ham "Hammed" me on that too. He implores his readers to "join the battle" against us evolutionists who try to use "the media to brainwash the public in evolutionary thinking." (Ironically, Ham's own article ends with an appeal for creationists to use dinosaurs to teach people about creationism.) He emphasized that I wanted to recruit the media aggressively "to ensure that writers present evolution as science and as fact — and to do it often." Not true. What I said was that television writers, in particular, should present *science* — and present it often.

Insofar as evolution is part of science, it should be presented, too. But I am far more concerned with getting people to understand how science works than in presenting evolution. That will come when the demon-haunted world is no more.

Further Reading

These references, including the last one about creationism, put my views about scientific literacy, pseudoscience, and the media on record.

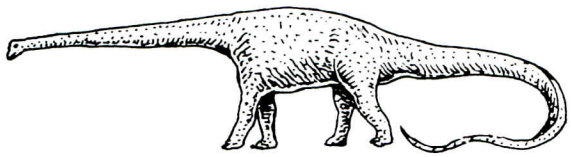
Ham K. The dinosaur agenda. *Answers in Genesis Newsletter* 1998 June; 5: 8. <http://www.answersingenesis.org/docs/3200.asp>. Last accessed August 7, 2000.

Lipps JH. The decline of reason? In: Scotchmoor J, McKinney FK, editors. *Learning from the Fossil Record*, Paleontological Society Special Papers 1996; 2: 3–10.

Lipps JH. The media, trash science and paleontology. *Palaeontologica Electronica* 1998. <http://www-odp.tamu.edu/paleo/1998_2/editor/jere_ed.htm>. Last accessed August 7, 2000.

Lipps JH. Beyond reason — Science in the mass media. In Schopf JW, editor. *Evolution, Facts and Fallacies*. San Diego (CA): Academic Press, 1999. p 71–90.

Lipps JH. Paleontology challenged! *Palaeontologica Electronica* 1999. <http://www-odp.tamu.edu/paleo/1999_1/editor/lipps.htm>. Last accessed August 7, 2000.



Pennisi E. Genome data shake tree of life. *Science* 1998 May 1; 280: 672–4.

Postlethwait JH, Yan Y-L, Gates M, Horne S, Amores A, Brownlie A, Donovan A, Egan E, Force A, Gong Z, Goutel C, Fritz A, Kelsh R, Knapik E, Liao E, Paw B, Ransom D, Singer A, Thomson M, Abduljabbar T, Yelick P, Beier D, Joly L, Larhammar D, Rosa F, Westerfield M, Zon L, Johnson S, Talbot W. Vertebrate genome evolution and the zebrafish gene map. *Nature Genetics* 1998 Apr; 18: 345–9. *Related reading*: Aparicio S. Exploding vertebrate genomes. *Nature Genetics* 1998 Apr; 18: 301–3.

Simmen MW, Leitgeb S, Clark VH, Jones SJM, Bird A. Gene number in an invertebrate chordate, *Ciona intestinalis*. *Proceedings of the National Academy of Sciences* 1998 Apr 14; 95: 4437–40.

Stephens RS, Kalman S, Lammel C, Fan J, Marathe R, Aravind L, Mitchell W, Olinger L, Tatusov RL, Zhao Q, Koonin EV, Davis RW. Genome sequence of an obligate intracellular pathogen of humans: *Chlamydia trachomatis*. *Science* 1998 Oct 23; 282: 754–9. *Related reading*: Hatch T. *Chlamydia*: Old ideas crushed, new mysteries bared. *Science* 1998 Oct 23; 282: 638–9.

Woese C. The universal ancestor. *Proceedings of the National Academy of Sciences* 1998 Jun 9; 95 (12): 6854–9.

Chapter 3: The Origin of Species

Brookes M. The species enigma. *New Scientist* 1998 Jun 13; 158 (2138). *Inside Science* supplement nr 111.

Galis F, Metz JAJ. Why are there so many cichlid species? *Trends in Ecology and Evolution* 1998 Jan; 13 (1): 1–2.

Gavrilets S, Li H, Vose MD. Rapid parapatric speciation on holey adaptive landscapes. *Proceedings of the Royal Society of London Series B* 1998; 265: 1483–9.

Geiser DM, Pitt JI, Taylor JW. Cryptic speciation and recombination in the aflatoxin-producing fungus Aspergillus flavus. *Proceedings of the National Academy of Sciences* 1998 Jan 3; 95: 388–93.

Kondrashov AS, Shpak M. On the origin of species by means of assortative mating. *Proceedings of the Royal Society of London Series B* 1998 Dec 7; 265 (1412): 2273–8.

Orr MR, Smith TB. Ecology and speciation. *Trends in Ecology and Evolution*. 1998 Dec; 13 (12): 502–6.

Swanson WJ, Vacquier VD. Concerted evolution in an egg receptor for a rapidly evolving abalone sperm protein. *Science* 1998 Jul 31; 281: 710–2. *Related reading*: Cohen P. Promiscuity helps the abalone evolve into a new species. *New Scientist* 1998 Aug 8; 159 (2146): 19.

Ting C-T, Tsaur S-C, Wu M-L, Wu C-I. A rapidly evolving homeobox at the site of a hybrid sterility gene. *Science* 1998 Nov 20; 282; 1501–4. *Related reading*: Cohen P. Splitting heirs. *New Scientist* 1998 Nov 28; 160 (2162): 11. Nei M, Zhang J. Molecular origin of species. *Science* 1998 Nov 20; 282: 1428–9.

Waugh O'Neill RJ, O'Neill MJ, Marshall Graves JA. Undermethylation associated with retroelement activation and chromosome remodelling in an interspecific mammalian hybrid. *Nature* 1998 May 7; 393: 68–72.

Chapter 4: The Fossil Record

The Cambrian Explosion

[Anonymous]. A billion years of stability. *Discover* 1998 Sep; 19 (9): 19.

Bromham L, Rambaut A, Fortey R, Cooper A, Penny D. Testing the Cambrian explosion hypothesis by using a molecular dating technique. *Proceedings of the National Academy of Sciences* 1998 Oct 3; 95 (21): 12386–9.

Darwinism in "Crisis" — Again

Steven B Hunter

When I heard of a conference that would introduce a scientific means of proving divine intervention in the natural world, thereby falsifying evolution, I knew I had to be there. So, on the evening of December 1, 1999, I headed off to La Mirada, a suburb of Los Angeles, to witness "Darwinism in Crisis — The New Challenge From Intelligent Design Theory".

The event was presented by the Master of Arts program in Christian Apologetics of Biola University (formerly the Bible Institute of Los Angeles). When all was said and done, it was quite clear that the purpose of the evening was to provide Christian apologetics and not science. We were to meet in an 800-seat lecture hall, but 1800 people showed up. The overflow was moved to the gymnasium where a closed circuit TV link had been set up.

By the time I settled into my seat in the bleachers overlooking the Biola Eagles' basketball court, the greetings and introductions had been completed and Phillip E Johnson, professor of law at UC Berkeley and author of *Darwin on Trial*, was holding forth on his idea of the Wedge. The Wedge is Johnson's strategy for separating science from philosophical naturalism, which he insists is the only basis upon which evolution could be accepted. Once he, as the sharp tip of the Wedge, has exploited the philosophical flaws in atheistic evolution to undo its death grip on modern theories of origins, others — scientists, philosophers, and theologians, the wide end of the Wedge — would rush in to fill the void with a more "God-centered" theory.

Representatives of the wide end of the Wedge followed Johnson to the podium. A scheduling snafu caused the cancellation of the next planned talk, "DNA by Design", by Stephen C Meyer, PhD. I was disappointed to miss one of the 2 scheduled scientists. After all, I had come to see a scientific falsification of the theory of evolution. Someone remarked that to demonstrate that there was real science going on there would be slides and a laser pointer.

Paul A Nelson, PhD, a philosopher of science, was next, with a talk on "Intelligent Design and the Cambrian Explosion". He began with a chart illustrating Darwin's prediction that the history of life should exhibit ever-increasing

Cooper A, Fortey R. Evolutionary explosions and the phylogenetic fuse. *Trends in Ecology and Evolution* 1998 Apr; 13 (4): 151–6.

Gould SJ. On embryos and ancestors. *Natural History* 1998 Jul/Aug 8; 107 (6): 20–2, 58–65.

Gu X. Early metazoan divergence was about 830 million years ago. *Journal of Molecular Evolution* 1998 Sep; 47 (3): 369–71.

Hecht J. Tilt-a-world. *Earth* 1998 Jun; 7 (3): 34–7. *Related reading*: Kirschvink JL, Ripperdan RL, Evans DA. Evidence for a large-scale reorganization of early Cambrian continental masses by inertial interchange true polar wander. *Science* 1997 Jul 25; 277: 541–5.

Hoffman PF, Kaufman AJ, Halverson GP, Schrag DP. A neoproterozoic snowball earth. *Science* 1998 Aug 28; 281: 1342–6. *Related reading*: Jenkins GS, Scotese CR. An early snowball earth? [letter] *Science* 282 Nov 27: 1644–6. Kerr RA. Did an ancient deep freeze nearly doom life? *Science* 1998 Aug 28; 281: 1259–60; Monastersky R. Popsicle planet. *Science News* 1998 Aug 29; 154 (9): 137–9.

Jensen S, Gehling JG, Droser ML. Ediacara-type fossils in Cambrian sediments. *Nature* 393: 567–9.

Li C-W, Chen J-Y, Hua T-E. Precambrian sponges with cellular structures. *Science* 1998 Feb 6; 279: 879–82. *Related reading*: Kerr RA. Pushing back the origins of animals. *Science* 1998 Feb 6; 279: 803–4.

McMenamin MAS. *The Garden of Ediacara: Discovering the First Complex Life*. New York: Columbia University Press, 1998. *Related reading*: Daviss B. Cast out of Eden. *New Scientist* 1998 May 16; 158 (2134): 26–30.

Moldowan JM, Talyzina NM. Biogeochemical evidence for dinoflagellate ancestors in the early Cambrian. *Science* 1998 Aug 21; 281: 1168–70.

Morris SC. *The Crucible of Creation: The Burgess Shale and the Rise of Animals*. Oxford: Oxford University Press, 1998.

Morris SC, Gould SJ. Showdown on the Burgess Shale. *Natural History* 1998 Dec/Jan; 107 (10): 48–55.

Orr PJ, Briggs DEG, Kearns SL. Cambrian Burgess Shale animals replicated in clay minerals. *Science* 1998 Aug; 281: 1173–5.

Seilacher A, Bose PK, Pfluger F. Triploblastic animals more than 1 billion years ago: Trace fossil evidence from India. *Science* 1998 Oct 2; 282: 80–3. *Related reading*: Azmi RJ. Fossil Discoveries in India [letter]. *Science* 1998 Oct 23; 282: 627. Brasier M. From deep time to late arrivals. *Nature* 1998 Oct 8; 395: 547–8. Hecht J. Worms dig holes in evolutionary ideas. *New Scientist* 1998 Oct 10; 160 (2155): 6. Kerr RA. Track of billion-year old animals? *Science* 1998 Oct 2; 282: 19–21. Kerr RA. Fossils challenge age of billion-year-old animals. *Science* 1998 Oct 23; 282: 601. Kerr RA. Earliest animals old once more? *Science* 1998 Nov 6; 282: 1020. Monastersky R. Questions raised about oldest animal. *Science News* 1998 Oct 17; 154 (16): 255. Monastersky R. A rock that lies about its age. *Science News* 1998 Nov 21; 154 (21): 332. Morris SC and others. Fossil Discoveries in India: Continued [letters]. *Science* 1998 Nov 13; 282: 1265.

Thomas ALR. Cambrian explosion blown out of the water. *Trends in Ecology and Evolution* 1998 Apr; 13 (4): 129. *Related reading*: Budd GE, Jensen S. Trace fossils and the Cambrian explosion [letter]. *Trends in Ecology and Evolution* 1998 Dec; 13 (12): 507–8. Horne DJ, Thomas ALR. Cambrian explosion still in the water [letters]. *Trends in Ecology and Evolution* 1998 Aug; 13 (8): 322.

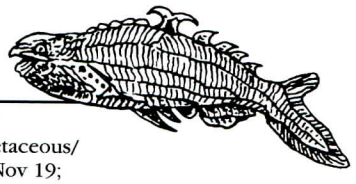
diversity. He then compared it to his own bar graph showing the diversity of phyla as greatest during the Cambrian, then reducing and holding constant until the present. "There will never be an explanation", he insisted, for the paleontological record's being at such odds with Darwin's theory. No mention was made of the poor quality of the Precambrian and Cambrian fossil record nor of how including classes, orders, families, genera, and species might affect his bar graph nor of any number of evolutionary factors that are relevant to such a discussion. Nor did Nelson discuss how evolutionary biology has changed and matured since Darwin's early formulation of the theory.

He followed up with an argument from developmental biology. He contended that the genetic mechanisms that control cell differentiation and organization in a complex animal must have been in place and fully functional before the evolutionary processes that theoretically created them could have any effect. This is the same sort of cart-before-the-horse argument as Michael Behe's irreducible complexity, except at a larger scale — and it has the same flaws. There is no recognition of the fact that nature rarely gets from point A to point B via a straight line. A bat's wing, for example, did not develop as a wing one bone at a time. It was adapted from an arm for climbing, which in turn was adapted from a limb for crawling, which in turn was adapted from a fin for swimming.

Nelson's talk was to be the extent of the scientific discourse for the evening. I was left with the impression that the closest we had come to real science was indeed the inclusion of slides and a laser pointer. That joke was not so funny after all.

Philosophers JP Moreland and John Mark Reynolds completed the program with talks on "Intelligent Design and Human Personhood" and "Intelligent Design: The History of a Concept", respectively. Moreland expounded on the idea that atheistic evolution is in direct opposition to human dignity, justice, and human rights. Reynolds described how society had come to be in the evil grip of such a vile concept as godless naturalism. I heard no new insights. There was no scientific proof of anything.

It is worth noting that the common thread of all of these talks was that the theory of evolution is necessarily atheistic and is therefore the cause of all of the major ills of Western society. Whether this is a straw man argument cynically used to whip up the faithful or an honest misunderstanding of the nature of science, the result is the same. There will be no easing of the passionate opposition to the teaching of evolution until this concern is effectively addressed.



Williams DM, Kasting JF, Frakes LA. Low-latitude glaciation and rapid changes in the earth's obliquity explained by obliquity-oblateness feedback. *Nature* 1998 Dec 3; 396: 453–8. *Related reading*: Hecht J. Sweltering in Siberia. *New Scientist* 1998 Dec 5; 160 (2163): 4.

Xiao S, Zhang Y, Knoll AH. Three-dimensional preservation of algae and animal embryos in a Neoproterozoic phosphorite. *Nature* 1998 Feb 5; 391: 553–8. *Related reading*: [Anonymous]. Interpreting late Precambrian microfossils [technical comments]. *Science* 1998 Dec 4; 282: 1783. Bengtson S. Animal embryos in deep time. *Nature* 1998 Feb 5; 391: 529–30. Svitil KA. Searching for the first animal. *Discover* 1999 Jan; 20 (1): 52.

Mass Extinctions

[Anonymous]. Earth shattering. *New Scientist* 1998a Apr 18; 158 (2130): 23. *Related reading*: [Anonymous]. Surf's up, dinos are down. *Discover* 1998 Jul; 19 (7): 20.

[Anonymous]. The long good-bye. *Earth* 1998b Jun; 7 (3): 16.

Bowring SA, Erwin DH, Jin YG, Martin MW, Davidek K, Wang W. U/Pb Zircon geochronology and tempo of the end-Permian mass extinction. *Science* 1998 May 15; 280: 1039–45. *Related reading*: Kerr RA. Biggest extinction looks catastrophic. *Science* 1998 May 15; 280: 1007. Monastersky R. Death swept earth at end of Permian. *Science News* 1998 May 16; 153 (20): 308.

Cerveny R. The day the dinosaurs died. *Weatherwise* 1998 Jul/Aug; 51 (4): 13–9.

Cowen R. Dino death: A stellar weapon ... or a high-energy flash? *Science News* 1998 Jan 31; 153 (5): 79.

Erwin DH. The end and the beginning: Recoveries from mass extinctions. *Trends in Ecology and Evolution* 1998 Sep; 13 (9): 344–9.

Gibbs WW. The search for Greenland's mysterious meteor. *Scientific American* 1998 Nov; 279 (5): 72–9.

Jablonski D. Geographic variation in the molluscan recovery from the end-Cretaceous extinction. *Science* 1998 Feb 27; 279: 1327–30. *Related reading*: Lewin R. Survival strategy. *New Scientist* 1998 Mar 1; 157 (2124): 23.

Jablow V. A tale of two rocks. *Smithsonian* 1998 Apr; 29 (1): 32–5.

Johnson KR. Moon over Chicxulub: Will night finally fall on the dinosaur-extinction debate? *American Scientist* 1998 Nov/Dec; 86 (6): 568–71.

Kyte FT. A meteorite from the Cretaceous/Tertiary boundary. *Nature* 1998 Nov 19; 396: 237–9.

Pope KO, D'Hondt SL, Marshall CR. Meteorite impact and the mass extinction of species at the Cretaceous/Tertiary boundary. *Proceedings of the National Academy of Sciences* 1998 Sep 15; 95 (19): 11028–9.

Schkolyukov A, Lugmair GW. Isotopic evidence for the Cretaceous-Tertiary impactor and its type. *Science* 1998 Oct 30; 282: 927–9. *Related reading*: [Anonymous]. Bits and pieces of Armageddon. *Discover* 1999 Mar; 20 (3); 24. Monastersky R. Chunk of death-dealing asteroid found. *Science News* 1998 Nov 21; 154 (21): 324.

Schultz PH, Zarate M, Hames W, Camilion C, King J. A 3.3-Ma impact in Argentina and possible consequences. *Science* 1998 Dec 11; 282: 2061–3. *Related reading*: Kerr RA. Argentina, and perhaps its life, took a hit. *Science* 1998 Dec 11; 282: 1965–6.

Smith AB, Jeffrey CH. Selectivity of extinction among sea urchins at the end of the Cretaceous period. *Nature* 1998 Mar 5; 392: 69–71. *Related reading*: Marshall CR. Mass extinction probed. *Nature* 1998 Mar 5; 392: 17–20.

An Interview with Edward J Larson

Karl W Giberson
Donald A Yerxa

[Edward J Larson won a Pulitzer Prize in 1998 for his book Summer for the Gods *— a re-examination of the events surrounding the Scopes trial and of the people involved in it. During a visit to Eastern Nazarene College on October 21, 1999, Larson spoke with Karl Giberson and Donald Yerxa. We have excerpted portions of that interview to present to readers of RNCSE. Larson did not receive, review, or revise the published text of the interview.]*

Giberson: Can you give our readers some background about yourself, particularly mentioning your formative religious experiences?

Larson: I was raised in rural central-southern Ohio. My parents were members of the Congregational Church, which was probably the most liberal church in my hometown. We were not very active at all, though we did go to church occasionally. Evolution was just assumed in my high school. I took a lot of science classes and was very interested in the sciences. I believe that we used the Biological Sciences Curriculum Study (BSCS) texts, but we might have used a revised edition of Truman Moon's *Modern Biology*.

Yerxa: Have there been any instances in your life when you struggled over issues related to science and religion?

Larson: Not really. I mostly come from a science background, and I have not noticed any particular conflict in my own mind. I have not studied it closely, but to the extent that I have, I think that Stephen Jay Gould's "non-overlapping magisteria" is a nice way to articulate it.

Yerxa: What prompted you — a recipient of multiple high school science awards — to pursue both a doctorate in history at Wisconsin and a law degree at Harvard?

Larson: In high school I took a lot

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Spray JG, Kelley SP, Rowley DB. Evidence for a late Triassic multiple impact event on earth. *Nature* 1998 Mar 12; 393: 171–3. *Related reading*: [Anonymous]. Chain of craters. *Discover* 1998 Aug; 19 (8): 29. Kent DV. Impacts on earth in the late Triassic. *Nature* 1998 Sep 10; 395: 126. Melosh HJ. Craters unchained. *Nature* 1998 Jul 16; 394: 221–3.

Ward PD. The greenhouse extinction. *Discover* 1998 Aug; 19 (8): 54–8.

Wynn JC, Shoemaker EM. The day the sands caught fire. *Scientific American* 1998 Nov; 279 (5): 65–71.

New Fossils

Adrain JM, Fortey RA, Westrop SR. Post-Cambrian trilobite diversity and evolutionary faunas. *Science* 1998 June 19; 280: 1922–5. *Related reading*: Irion R. Parsing the trilobites' rise and fall. *Science* 1998 June 19; 280: 1837.

Agosti D, Grimaldi D, Carpenter JM. Oldest known ant fossils discovered. *Nature* 1998 Jan 29; 391: 447. *Related reading*: Hagmann M. Amber ants. *Discover* 1999 Jan; 20 (1): 52.

Ahlberg PE, Johanson Z. Osteolepiformes and the ancestry of tetrapods. *Nature* 1998 Oct 22; 395: 792–4. *Related reading*: Janvier P. Forerunner of four legs. *Nature* 1998 Oct 22; 395: 748–9.

[Anonymous]. Humpbacked dinosaurs. *Discover* 1998a Apr; 19 (4): 12.

[Anonymous]. There were giants on the earth in those days. *Discover* 1998b Apr; 19 (4): 14–8.

[Anonymous]. Saurian sore. *Discover* 1998c Oct; 19 (10): 26.

Bajpai S, Gingerich PD. A new Eocene archaeocete (Mammalia, Cetacea) from India and the time of origin of whales. *Proceedings of the National Academy of Sciences* 1998 Dec 22; 95 (26): 15464–8. *Related reading*: Monastersky R. Fossil jaw tells tale of whale evolution. *Science News* 1998 Oct 10; 154 (15): 229.

Carpenter K, Miles C, Cloward K. Skull of a Jurassic ankylosaur (Dinosauria). *Nature* 1998 Jun 25; 393: 782–3.

Chin K, Tokaryk TT, Erickson GM, Calk LC. A king-sized theropod coprolite. *Nature* 1998 Jun 18; 393: 680–2. *Related reading*: Andrews P, Fernandez-Jalvo Y. 101 uses for fossilized faeces. *Nature* 1998 June 18; 393: 629. [Anonymous]. Dino dung. *New Scientist* 1998 Jun 20; 158 (2139): 27. [Anonymous]. Ordure of magnitude. *Discover* 1998 Oct; 19 (10): 32. Monastersky R. Getting the scoop from the poop of *T. rex*. *Science News* 1998 Jun 20; 153 (25): 391.

Clack JA. A new early Carboniferous tetrapod with a melange of crown-group characters. *Nature* 1998 Jul 2; 394: 66–9. *Related reading*: Shubin N. Evolutionary cut and paste. *Nature* 1998 Jul 2; 394: 12–3.

Clark JM, Hopson JA, Hernandez RR, Fastovsky DE, Montellano M. Foot posture in a primitive pterosaur. *Nature* 1998 Feb 26; 391: 886–9. *Related reading*: [Anonymous]. Of pterosaur ptoes. *Discover* 1998 May; 19 (5): 11. Monastersky R. Flat-footed fossil of former flyer. *Science News* 1998 Mar 14; 153 (11): 172.

Coria RA, Dingus L, Jackson F, Chinsamy A, Fox M, Chiappe LM. Sauropod dinosaur embryos from the Late Cretaceous of Patagonia. *Nature* 1998 Nov 19; 396: 258–61. *Related reading*: [Anonymous]. Huevos dinosauros. *Discover* 1999 Feb; 20 (2): 24.

Daeschler EB, Schubin N. Fish with fingers? *Nature* 1998 Jan 8; 391: 133.

Edgecombe GD. Devonian terrestrial arthropods from Gondwana. *Nature* 1998 Jul 9; 394: 172–5. *Related reading*: Lincoln T. Ancient Australian arthropods. *Nature* 1998 Jul 9; 394: 127.

Erdmann MV, Caldwell RL, Moosa MK. Indonesian "king of the sea" discovered. *Nature* 1998 Sep 24; 395: 335. *Related*

of science and math, but I always loved history. As a kid I just thoroughly enjoyed reading history, and, even though I did not get much history instruction in high school, I taught myself history and went ahead and took the Advanced Placement exams in both European and American history at the end of my high school years. When I was an undergraduate at Williams College, I learned that there was a field called the history of science. Williams had a historian of science named Donald Beaver, and I took his class and suddenly it brought together 2 interests, my persistent love of nature and the understanding of how nature operates — which is why I like science — and my love of history. So suddenly I could study the history of science.

Yerxa: What was the topic of your doctoral dissertation?

Larson: Initially, my major professor Dave Lindberg encouraged me to cross disciplines and get a law degree. The law courses served as my minor for the PhD at Wisconsin, but beyond that, law enriched my scholarship. I thought that I was going to write in the area of eugenics, but the untimely death of Bill Coleman, a historian of biology at Wisconsin, presented me with the opportunity to have Ronald Numbers as my major professor. and I ended up working with him. He pushed me in a direction that I would not otherwise have gone in, but have ever after found interesting. Since Numbers was working on the history of the creation/evolution controversy, and he knew I had this legal background, he encouraged me to work on the legal history of the creation/evolution controversy, so that is primarily what my dissertation dealt with. It was a little broader than that in the sense that it deals with how courts deal with legal questions, but it primarily deals with the creation/evolution controversy throughout history. The dissertation became my first book, *Trial and Error*.

Yerxa: How did you decide to write a book on the Scopes trial? Did you feel that there was some sort of misunderstanding of the trial in the historical literature?

Larson: It was a bit serendipitous. Certainly in the background there was the fact that I knew the trial was not very well understood. During my dissertation research, I had looked a little bit into the Scopes trial, and in *Trial and Error* there is a very small passage, a couple of pages, on it. But in researching just that little snippet on the Scopes trial, I had discovered that there was a rich body of archival literature on the trial that no historian had ever used. The last serious book on the Scopes trial was from the 1950s, and that relied almost exclusively on a reading of newspapers in the period. And I knew the ACLU archives were available and open. Of course Bryan's archives had been open, but they had not been used very much. Clarence Darrow's papers were available, but I also knew that there were some additional sources of information. In particular, Judge Hicks, who had been one of the prosecutors, had saved all the correspondence among members of the prosecution team, and he had subsequently put it into the

reading: Forey P. A home from home for coelacanths. *Nature* 1998; 395: 319–20. Glausiusz J. The old fish of the sea. *Discover* 1999 Jan; 20 (1): 49. Gordon AL. Coelacanth populations may go with the flow [letter]. *Nature* 1998 Oct 15; 395: 634. Milius S. Second group of living fossils reported. *Science News* 1998 Sep 26; 154 (13): 196.

Flynn JJ, Wyss AR. Recent advances in South American mammalian paleontology. *Trends in Ecology and Evolution* 1998 Nov; 13 (11): 449–54.

Gandolfo MA, Nixon KC, Crepet WL. Oldest known fossils of monocotyledons. *Nature* 1998 Aug 6; 394: 532–3.

Grande L. This land: Fossil lake. *Natural History* 1998 Jul/Aug; 107 (6): 66–9.

Hecht J. Branching out. *New Scientist* 1998 Oct 10; 160 (2155): 14.

Hirayama R. Oldest known sea turtle. *Nature* 1998 Apr 16; 392: 706–8. *Related reading*: [Anonymous]. Turtle tears. *Discover* 1998 Aug; 19 (8): 28. Gee H. The eyes have it. *Nature* 1998 Apr 16; 392: 651. Monastersky R. A sea turtle's salty tale. *Science News* 1998 May 30; 153 (22): 351.

Jensen M. Modern climate has roots in Early Devonian. *Science News* 1998 Feb 14; 153 (7): 103.

Johanson Z, Ahlberg PE. A complete primitive rhizodont from Australia. *Nature* 1998 Aug 6; 569–3.

Lockey MG. The vertebrate track record. *Nature* 1998 Dec 5; 396: 429–32.

Meng J, McKenna MC. Faunal turnovers of Palaeogene mammals from the Mongolian Plateau. *Nature* 1998 Jul 23; 394: 364–7. *Related reading*: Hartenberger J-L. An Asian grande coupure. *Nature* 1998 Jul 23; 394: 321. Monastersky R. Climate did in giant Mongolian mammals. *Science News* 1998 Aug 1; 154 (6): 95.

Menon S. King claw. *Discover* 1998 Apr; 19 (4): 30.

Monastersky R. Wyoming wonder: Tiniest mammal ever? *Science* News 1998a Oct 17; 154 (16): 255. *Related reading*: Leutwyler K. Mini-mammal. *Scientific American* 1998 Dec; 279 (6): 26.

Monastersky R. Dinosaur denizens of the dark. *Science News* 1998b Mar 14; 153 (11): 172. *Related reading*: [Anonymous]. Dinosaur bridge. *New Scientist* 1998 Feb 14; 157 (2121): 21.

Monastersky R. Dinosaurs kept warm in the polar chill. *Science News* 1998c May 30; 153 (22): 351. *Related reading*: Anderson I. In frŏm the cold. *New Scientist* 1998 Apr 18; 158 (2130): 13.

Motani R, Minoura N, Ando T. Ichthyosaurian relationships illuminated by new primitive skeletons from Japan. *Nature* 1998 May 21; 393: 255–7. *Related reading*: [Anonymous]. Fishy mystery. *New Scientist* 1998 May 23; 158 (2135): 27.

Poinar HN, Hofreiter M, Spaulding WG, Martin PS, Stankiewicz BA, Bland H, Evershed RP, Possnert G, Pääbo S. Molecular coproscopy: Dung and diet of the extinct ground sloth *Nothrotheriops shastensis*. *Science* 1998 Jul 17; 281: 402–6. *Related reading*: Monastersky R. Paleoscatology: Prying DNA from dated dung. *Science News* 1998 Jul 18; 154 (3): 38. Stokstad E. A fruitful scoop for ancient DNA. *Science* 1998 Jul 17; 281: 319–20.

Ren D. Flower-associated Brachycera flies as fossil evidence for Jurassic angiosperm origins. *Science* 1998 Apr 3; 280: 85–8. *Related reading*: [Anonymous]. Fossil flies. *Discover* 1998 Aug; 19 (8): 33. Labandeira CC. How old is the flower and the fly? *Science* 1998 Apr 3; 280: 57–9.

Rougier GW, Wible JR, Novacek MJ. Implications of *Deltatheridium* specimens for early marsupial history. *Nature* 1998 Dec 3; 396: 459–63.

Sampson SD, Witmer LM, Forster CA, Krause DW, O'Conner PM, Dodson P,

University of Tennessee archives. Up to that point those documents simply had not been used by any other historian.

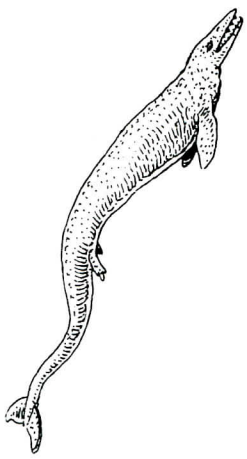
So I now knew that there was quite a bit of archival material. Moreover, the main treatments of the trial were written in the shadow of McCarthyism and the threat to popular and individual liberty based on mob action and emotionalism. *Inherit the Wind* and *Six Days or Forever?: Tennessee v John Thomas Scopes* (Ray Ginger's scholarly book of the same period) were consciously and explicitly written with McCarthy-era witch hunts of communists and socialists in mind and were looking back at the Scopes trial as an earlier episode of all this. Then in the 1990s we have a new perspective on fundamentalism and anti-evolutionism. They are still alive in the US; they were not slain in Dayton. And that was always part of the premise of *Inherit the Wind* and *Six Days or Forever?* — that exposing Bryan killed these movements. But it did not. So now in a sense we have better historical perspective for looking at those documents. And that is the foundation for doing constructive history — new archival material and a new perspective that previous historians haven't been able to bring to bear on the topic.

The actual precipitant that made *Summer for the Gods* happen was much more pedestrian, however. During the middle of the OJ Simpson trial, one of my colleagues suggested, out of the blue, that I write a book on the Scopes trial. Not knowing any of what I knew about the archival material or the added perspective, he knew that I wrote legal history and was trained in the history of science. While he was watching the OJ Simpson trial, he concluded that I was one of the few people he knew with expertise in both of those fields. He kept hearing during the Simpson trial coverage about the other trials of the century, and in particular about the Scopes trial. Here was one event in history that seemed to involve law and science together. And when he said that, it just clicked immediately. It made sense, and I immediately thought that it was a great topic.

Yerxa: What would you like the reader to take away from *Summer for the Gods*?

Larson: I usually do not try to put myself in the reader's mind. I am trying just to tell a story that I enjoy telling, and whatever readers draw from it is their business. I appreciate the richness of a historical event and how nothing important in history is ever simple. There are many currents and crosscurrents and factors involved. I don't see these individual characters as sort of simple, 2-dimensional figures, but 3-dimensional figures with a richness and dignity. And I would hope that people would draw out the richness of the historical event and the many factors that play into it.

I did not go into the Scopes trial doing the research for *Summer for the Gods* with a particularly high opinion of either Clarence Darrow *or* William Jennings Bryan. What has impressed me throughout my life is that whenever you treat people honestly at their own level, when you get to understand them more, you get to appreciate them more.



Ravoavy F. Predatory dinosaur remains from Madagascar: Implications for the Cretaceous biogeography of Gondwana. *Science* 1998 May 15; 280: 1048–51. *Related reading*: [Anonymous]. A new *T. rex* cousin. *Discover* 1998 Aug; 19 (8): 22.

Sasso CD, Signore M. Exceptional soft-tissue preservation in a theropod dinosaur from Italy. *Nature* 1998 Mar 26; 392: 383–7. *Related reading*: [Anonymous]. Bambinosaurus. *Discover* 1998 Jun; 19 (6): 20. [Anonymous]. A dino with guts. *Earth* 1998 Aug; 7 (4): 17. Leutwyler K. Dinosaur innards. *Scientific American* 1998 Jun; 278 (6): 20. Monastersky R. Getting to the guts of a dinosaur. Science News 1998 Apr 18; 153 (16): 252.

Sato T, Tanabe K. Cretaceous plesiosaurs ate ammonites. *Nature* 1998 Aug 13; 394: 629–30. *Related reading*: [Anonymous]. A bellyful of jaws. *Discover* 1998 Nov; 19 (11): 36.

Sereno PC, Beck AL, Dutheil DB, Gado B, Larsson HCE, Lyon GH, Marcot JD, Rauhut OWM, Sadleir RW, Sidor CA, Varricchio DD, Wilson GP, Wilson JA. A long-snouted predatory dinosaur from Africa and the evolution of spinosaurids. *Science* 1998 Nov 13; 282: 1298–302. *Related reading*: Hecht J. Fish swam in fear. *New Scientist* 1998 Nov 21; 160 (2161): 5. Holtz TR Jr. Spinosaurs as crocodile mimics. *Science* 1998 Nov 13; 282: 1276–7. Monastersky R. Fish-eating dinosaur found in Africa. *Science News* 1998 Nov 14; 154 (20): 308.

Shoshani J. Understanding proboscidean evolution: a formidable task. *Trends in Ecology and Evolution* 1998 Dec; 13 (12): 480–7.

Stokstad E. Young dinos grew up fast. *Science* 1998 Oct 23; 282: 603–4.

Sun G, Dilcher DL, Zheng S, Zhou Z. In search of the first flower: A Jurassic angiosperm, *Archaefrustus*, from northeast China. *Science* 1998 Nov 27; 282: 1692–5. *Related reading*: Crepet WL. The abominable mystery. *Science* 1998 Nov 27; 282: 1653–4. Hecht J. Floral pioneers were blooming ugly. *New Scientist* 1998 Dec 5; 160 (2163): 6.

Tarduno JA, Brinkman DB, Renne PR, Cottrell RD, Scher H, Castillo P. Evidence for extreme climatic warmth from late Cretaceous arctic vertebrates. *Science* 1998 Dec 18; 282: 2241–4. *Related reading*: Huber BT. Tropical paradise at the Cretaceous poles? *Science* 1998 Dec 18; 282: 2199–2200. Yam P. Arctic warmth. *Scientific American* 1999 Mar; 87 (3): 28.

Zimmer C. Into the night. *Discover* 1998a Nov; 19 (11): 102–15.

Zimmer C. *At the Water's Edge: Macroevolution and the Transformation of Life*. New York: The Free Press, 1998b.

Zimmer C. The equation of a whale. *Discover* 1998c Apr; 19 (4): 78–84.

Birds

Ackerman J. Dinosaurs take wing. *National Geographic* 1998 Jul; 194 (1): 74–99.

[Anonymous]. Counting the fingers of birds and dinosaurs. *Science* 1998 Apr 17; 280: 355.

Britt BB, Makovicky PJ, Gauthier J, Bonde N. Postcranial pneumatization in *Archaeopteryx*. *Nature* 1998 Sep 24; 395: 374–6.

Chen P-J, Dong Z-M, Zhen S-N. An exceptionally well-preserved theropod dinosaur from the Yixian Formation of China. *Nature* 1998 Jan 8; 391:147–52. *Related reading*: [Anonymous]. A feathered dinosaur? *Discover* 1998 May; 19 (5): 19. Unwin DM. Feathers, filaments and theropod dinosaurs. *Nature* 1998 Jan 3; 391:119–20.

Chiappe LM. Wings over Spain. *Natural History* 1998 Sep; 107 (7): 30–3. *Related reading*: [Anonymous]. Old Gobi bird. *Discover* 1998 Sep; 19 (9): 20.

I read much of what Bryan and Darrow wrote and tried really to immerse myself in them, so I could understand them as people. And I ended my research with a much higher opinion of those 2 great Americans than when I started. I am not asking that my readers also end with a higher opinion of Bryan and Darrow. But since I came out that way, I would hope that they would as well. I would hope that they would treat them on their own terms and grow to respect what Clarence Darrow and William Jennings Bryan were doing. And when we understand what they were doing, and we understand what was at stake, I think that it makes the situation today more understandable.

Yerxa: Has winning the Pulitzer Prize changed your life significantly?

Larson: With the prize come more distractions — invitations to speak, invitations to write on topics that don't have any relevance to what I am doing. It is far more difficult to control my own schedule. But there are also wonderful opportunities that come, for example, chances to go out and meet Jerome Lawrence, the co-writer of *Inherit the Wind*, and opportunities to speak at interesting occasions and to meet other people and to try to help students and help the cause of history. I am in this respect first and foremost a historian, and I am interested in the discipline of history. Now people ask me about historical questions and about becoming a historian and the value of doing history, and I can be an evangelist for history and the role of history. I enjoy that. So it is a mixed blessing, and the challenge is to maximize the good out of it while not being sucked into the bad and not losing my own control over what I think my career should be.

Yerxa: What are your current projects?

Larson: I am working on a book on the history of scientific research on the Galapagos Islands, which has the same advantage as a book on the Scopes trial in the sense that I think that it is an absolutely fabulous topic. Everybody has heard of the Galapagos Islands just as everybody has heard of the Scopes trial, but nobody has ever written a history of the scientific research on the Galapagos Islands. There is a wonderful recent book on the Grants' work called *The Beak of the Finch*, but it is just about the work of Peter and Rosemary Grant. It is not a history of scientific research. It certainly does not deal with the past. I hope that I will be able, as with the Scopes book, to reach an audience beyond historians of science but that will include historians of science.

Yerxa: You have been involved in some sociology of science lately with your colleague Larry Witham. You have revisited James Leuba's 1914 and 1933 surveys of scientists to get a sense of how both rank and file scientists as well as the scientific elite view belief in God. What are your findings in a nutshell?

Larson: Well, it is a curious survey to have to repeat Leuba's question, because he had a very par-

Chiappe LM, Norell MA, Clark JM. The skull of a relative of the stem-group bird *Mononykus*. *Nature* 1998 Mar 19; 392: 276–8.

Dingus L, Rowe T. *The Mistaken Extinction: Dinosaur Evolution and the Origin of Birds*. New York: WH Freeman and Company, 1998.

Forster CA, Sampson SD, Chiappe LM, Krause DW. The theropod ancestry of birds: New evidence from the late Cretaceous of Madagascar. *Science* 1998 Mar 20; 279: 1915–9; *Related reading*: Gibbons A. Missing link ties birds, dinosaurs. *Science* 1998 Mar 20; 279: 1851–2. Monastersky R. On the line from dinosaurs to birds. *Science News* 1998 Apr 18; 153 (16): 252. Padian K. Bird, dinosaur link [letter]. *Science* 1998 May 15; 280: 986–7. Zimmer C. A sickle in the clouds. *Discover* 1998 June; 19 (6): 32.

Hicks JW, Farmer CG, and others. Lung ventilation and gas exchange in theropod dinosaurs [letters]. *Science* 1998 Jun 26; 281: 45–48.

Holden C. Big bird laid "dino" eggs? *Science* 1998 Jan 9; 279: 183. *Related reading*: Hecht J. Funny old bird. *New Scientist* 1998 Jan 10; 157 (2116): 18.

Ji Q, Currie PJ, Norell MA, Ji S-A. Two feathered dinosaurs from northeastern China. *Nature* 1998 Jun 25; 393: 753–61. *Related reading*: Fischman J. Feathers don't make the bird. *Discover* 1999 Jan; 20 (1): 48–9. Gibbons A. Dinosaur fossils, in fine feather, show link to birds. *Science* 1998 Jun 26; 280: 2051. Monastersky R. Feathered dinosaurs found in China. *Science News* 1998 Jun 27; 153 (26): 404. Padian K. When is a bird not a bird? *Nature* 1998 Jun 25; 393: 729–30.

Ostrom JH, Padian K, Martin L. Bones of contention [letters]. *The Sciences* 1998 Sep/Oct; 38 (5): 3, 9, 46–7.

Padian K, Chiappe LM. The origin of birds and their flight. *Scientific American* 1998 Feb; 278 (2): 38–47. *Related reading*: Feduccia A, Martin L, Hou L-H, Dodworth A. [Letters]. *Scientific American* 1998 Jun; 278 (6): 8–8A.

Shipman P. *Taking Wing: Archaeopteryx and the Evolution of Bird Flight*. New York: Simon & Schuster, 1998. *Related reading*: Swartz S. Into Jurassic air. *Science* 1998 Jul 17; 281: 355–6.

Stidham TA. A lower jaw from a Cretaceous parrot. *Nature* 1998 Nov 5; 396: 29–30.

Thomas ALR, Garner JP. Are birds dinosaurs? *Trends in Ecology and Evolution* 1998 Apr; 13 (4): 129–30.

Wang J. Scientists flock to explore China's "site of the century". *Science* 1998 Mar 13; 279: 1626–7.

Zhao X, Xu X. The oldest coelurosaurian. *Nature* 1998 Jul 16; 394: 234–5. *Related reading*: [Anonymous]. Pioneer biped. *Discover* 1998 Apr; 19 (4): 29.

Miscellaneous

Babcock LE. Experimental investigation of the processes of fossilization. *Journal of Geosciences Education* 1998 May; 46 (3): 252–60.

Hazard EB. Teaching about "intermediate forms". *The American Biology Teacher* 1998 May; 60 (5): 359–61.

Human Evolution

Agnew N, Demas M. Preserving the Laetoli footprints. *Scientific American* 1998 Sep; 279 (3): 44–55.

Albianelli A, Azzaroli A, Benvenuti M, Tesfamariam B, Bruni P, Cipriani N, Clarke RJ, Ficcarelli G, Macchiarelli R, Napoleone G, Papini M, Rook R, Sagri M, Tecle TM, Torre D, Villa I, Abbate E. A one-million-year-old *Homo* cranium from the Danakil (Afar) Depression of Eritrea. *Nature* 1998 Jun 4; 393: 458–60. *Related reading*: [Anonymous]. A million-year-old

ticular definition of God that may exclude many people. He was asking about belief in sort of a traditional theistic God that would resonate with traditional Jews, Muslims, or Christians. Indeed you might want to call them *orthodox* Jews, Muslims, and Christians. There was a lot of talk back at the turn of the century that positivism and science were routing belief in God, and so he did a survey of both the rank and file scientists and the elite scientists — surveys that we were able to reproduce. Leuba found about 40% belief in this sort of God among the rank and file and much lower levels of belief among elites, and that is exactly what we found.

He received many objections that "this God does not capture my God". He would get people who would write back and say that "I do not believe in any God, but I am deeply religious." He would also get people who said, "Well, I believe in a God that is immanent in nature, and I do not believe that this is a God that you can talk to or who can answer questions. Your question does not capture what I am talking about." We received the same sort of reactions, and I sympathize with them because I think they are right, but the only way you can do a longitudinal survey is to ask the same questions. As a historian, I was interested in Leuba's survey because it had been so important in the Scopes trial and Bryan's anti-evolution crusade. He had made it a centerpiece. His prime evidence against evolution was this disbelief among scientists, so I was interested in the precise question. And we found that it was basically constant over time.

Yerxa: What is it about the US that makes it so receptive to anti-Darwinian notions?

Larson: Partly because we're democratic. We have a democratic, anti-elitist tradition. There is a rooting for the underdog, and there is a suspicion of elites in the US that just is not as present in, say, France, Germany, or Scandinavia where they have a traditional hierarchical society and where the people are more willing to defer automatically to elites in any particular area of expertise. We have more of a tradition in the US where citizens get to make up their own minds on everything, everyone is an expert and everyone is an authority, and no one should automatically follow other peoples' decisions — people should think for themselves. So that makes the US open to questioning the pronouncements of the scientific elite and to want to think through these questions for themselves and come to their own conclusions.

Yerxa: How do you explain the Phillip Johnson phenomenon and the emergence of "intelligent design" in the origins discussion?

Larson: I think that Johnson is a very articulate speaker and advocate. He is obviously a skilled lawyer, and he's raising popular concerns and questions in the sense that if you believe in a traditional Christian God — and it doesn't have to be a fundamentalist God — do you not believe that God could interfere in nature? And if you believe that God could interfere in nature, do you not believe that God did interfere in

relative. *Discover* 1998 Sep; 19 (9): 26. Bower B. Ancient skull fills big fossil gap. *Science News* 1998 Jun 6; 153 (23): 356. Gibbons A. Old, old skull has a new look. *Science* 1998 Jun 5; 280: 1525.

[Anonymous]. Small beginnings. *Earth* 1998a Aug; 7 (4): 11–2.

[Anonymous]. An upstanding ape. *Discover* 1998b Feb; 19 (2): 14.

[Anonymous]. A global winter's tale. *Discover* 1998c Dec; 19 (12): 30.

Appenzeller T. Art: Evolution or revolution? *Science* 1998 Nov 20; 282: 1451–4.

Appenzeller T, Clery D, Culotta E. Archaeology: Transitions in prehistory. *Science* 1998 Nov 20; 282: 1441.

Balter M. Why settle down? The mystery of communities. *Science* 1998 Nov 20; 282: 1442–5.

Bird M, Olley J, Galbraith R, Lawson E, Laslett G, Yoshida H, Jones R, Fullagar R, Jacobsen G, Hua Q, Roberts R. Optical and radiocarbon dating at Jinmium rock shelter in northern Australia. *Nature* 1998 May 28; 393: 358–62. *Related reading*: Bower B. Australian site jumps forward in time. *Science News* 1998 May 30; 153 (22) 343. Gibbons A. Young ages for Australian rock art. *Science* 1998 May 29; 280: 1351.

Bower B. Chimp brains show humanlike tilt to left. *Science News* 1998a Jan 10; 153 (2): 22.

Bower B. Doubts aired over Neandertal bone "flute". *Science News* 1998b Apr 4; 153 (14): 215.

Bower B. Cutting-edge pursuits in Stone Age. *Science News* 1998c Apr 11; 153 (15): 238.

Boyce N. Go west, young woman. *New Scientist* 1998 Oct 31; 160 (2158): 11.

Brainard J. Giving Neandertals their due. *Science News* 1998 Aug 1; 154 (5): 72–4. *Related reading*: Bahn PG. Neanderthals emancipated. *Nature* 1998 Aug 20; 394: 719–21. *Current Anthropology* 1998 Jun: 39: Supplement.

Cartmill M. The gift of gab. *Discover* 1998 Nov; 19 (11): 56–64.

Chu JY, Huang W, Kuang SQ, Wang JM, Xu JJ, Chu ZT, Yang ZQ, Lin KQ, Li P, Wu M, Geng ZC, Tan CC, Du RF, Jin L. Genetic relationship of populations in China. *Proceedings of the National Academy of Sciences* 1998 Sep 29; 95 (20): 11763–8. *Related reading*: Bower B. Asian DNA enters human origins fray. *Science News* 1998 Oct 3; 154: 212. Cavalli-Sforza LL. The Chinese Human Genome Diversity Project. *Proceedings of the National Academy of Sciences* 1998; 95 (20): 11501–3. Piazza A. Towards a genetic history of China. *Nature* 1998 Oct 15; 395: 636–9.

Conroy GC, Weber GW, Seidler H, Tobias PV Kane A, Brunsden B. Endocranial capacity in an early hominid cranium from Sterkfontein, South Africa. *Science* 1998 Jun 12; 280: 1730–1. *Related reading*: [Anonymous]. Endocranial Capacity of Early Hominids. *Science* 1999 Jan 1; 283: 9. Falk D. Hominid brain evolution: Looks can be deceiving. *Science* 1998 Jun 12; 280: 1714. Holloway RL, and others. Hominid brain volume [letter]. *Science* 1999 Jan 1; 283: 34–35.

Copley J. Nearly out of Africa. *New Scientist* 1998 Oct 10; 160 (2155): 12. *Related reading*: [Anonymous]. The ancient tomb of a young child. *Discover* 1998 Nov; 19 (11): 28. Bower B. Ancient child's burial on the Nile. *Science News* 1998 Oct 10; 154 (15): 235.

Gee H. The face of Cinderella. *Nature* 1998 Dec 10; 396: 521. *Related reading*: Bower B. Ancient ancestor reveals skeletal stamina. *Science News* 1998 Dec 19/26; 154 (25/26): 389.

Gibbons A. New study points to Eurasian ape as great ape ancestor. *Science* 1998a

nature? And if God did interfere in nature, then how can you understand natural phenomena without at least considering God as the author of those? So his argument against philosophical naturalism in science, as he likes to put it, has an instinctive appeal to many Americans who believe in that sort of God.

Yerxa: Does this line of reasoning appeal to you?

Larson: Johnson has got to bring scientists into the debate, and there has to be a controversy within the scientific community. There have to be scientists who start doing "intelligent design" as science. And I have not yet seen that happen. But in the end, if he is going to change science, it is going to have to be through scientists and not through the general public.

Yerxa: You used the phrase "'intelligent design' as science". What would that look like?

Larson: That is for the *scientists* to decide. I can say that I am neither a scientist nor a philosopher. I am sort of a philosopher of science, and I take a mundane definition of science. I know you can come up with wonderful definitions about what science is: it is a falsifiable enterprise and a set of shifting paradigms, and so on, but I take the journeyman's view that science is what scientists do and that scientists define their professions just as other people define their profession. So I think the key test for "intelligent design" will come if and when *scientists* start doing "intelligent design" research. And only if and when they start doing it will we know what an "intelligent design" science looks like. And, as a historian, I am not a very good person to answer that question.

Giberson: Part of the reason for the success of Phillip Johnson is the perception that there are people like Richard Dawkins out there who are missionaries for naturalism with an agenda that goes far beyond just trying to help people understand evolution. Can you comment on the way people like Dawkins, Peter Atkins, even EO Wilson, are their own worst enemies in that they make science unpopular in American culture by attaching it to an aggressively anti-religious stance.

Larson: I do not think that they are their own worst enemies. I think that they are reaching a broad and powerful audience. Their works are inspirational to many people. And I think for all the people they turn off, they inspire a whole other group. Wilson's teaching at Harvard is inspirational; his writings are inspirational. Certainly he makes the feminists furious, but he also inspires a lot of critical thought. Dawkins makes many religious people furious, but he inspires them to think harder and debate the issue harder. I think that he wants that. I think that he wants to raise those questions, and I have met many students who have been profoundly inspired to go into science and make a career in science because of books like Dawkins's *The Blind Watchmaker*. So these writers are doing missionary work for science that is inspirational because

Jul 31; 281: 622–3. *Related reading*: Lewin R. Getting back to our routes. *New Scientist* 1998 Aug 1; 159 (2145): 14.

Gibbons A. Which of our genes make us human. *Science* 1998b Sep 4; 281: 1432–4. *Related reading*: Chou H-H, Takematsu T, Diaz S, Iber J, Nickerson E, Wright KL, Muchmore EA, Nelson DL, Warren ST, Varki A. A mutation in human CMP-sialic acid hydroxylase occurred after the *Homo–Pan* divergence. *Proceedings of the National Academy of Sciences* 1998; 95 (20): 11751–6. Leigh SR and Ryder OA. Chimp research [letters]. *Science* 1998 Oct 2; 282: 47.

Gibbons A. Calibrating the mitochondrial clock. *Science* 1998c Jan 2; 279: 28–9.

Hammer MF, Karafet T, Rasanayagam A, Wood ET, Altheide TK, Jenkins T, Griffiths RC, Templeton AR, Zegura SL. Out of Africa and back again: Nested cladistic analysis of human Y chromosome variation. *Molecular Biology and Evolution* 1998 Apr; 15 (4): 427–41.

Harpending HC, Batzer MA, Gurven M, Jorde LB, Rogers AR, Sherry ST. Genetic traces of ancient demography. *Proceedings of the National Academy of Sciences* 1998 Feb 17; 95 (4): 1961–7.

Holden C. Humanity's baby steps. *Science* 1998a Nov 27; 282: 1635. *Related reading*: [Anonymous]. Out of Africa: Footprints in the sands of time. *Discover* 1999 Mar; 20 (3): 24.

Holden C. How much like us were the Neandertals? *Science* 1998b Nov 20; 282: 1456. *Related reading*: Wolpoff MH. Neandertals: Not so fast [letter]. *Science* 1998 Dec 11; 282: 1991. Wong K. Ancestral quandary: Neanderthals not our ancestors? Not so fast. *Scientific American* 1998 Jan; 278 (1): 30–2.

Holden C. No last world on language origins. *Science* 1998c Nov 20; 282: 1455–8.

Kay RF, Cartmill M, Balow M. The hypoglossal canal and the origin of human vocal behavior. *Proceedings of the National Academy of Sciences* 1998 Apr 28; 95 (9): 5417–9. *Related reading*: [Anonymous]. Not so dumb. *New Scientist* 1998 May 2; 158 (2132): 23. Bower B. Language origins may reside in skull canals. *Science News* 1998 May 2; 153 (18): 276. Motluk A. Early spinal cords were a talking point. *New Scientist* 1998 Apr 18; 158 (2130): 11.

Leakey MG, Feibel CS, McDougall I, Ward C, Walker A. New specimens and confirmation of an early age for *Australopithecus anamensis*. *Nature* 1998 May 17; 393: 62–6. *Related reading*: [Anonymous]. The first man? *New Scientist* 1998 Jun 6; 158 (2137): 24. Bower B. Early hominid rises again. *Science News* 1998 May 16; 153 (20): 315.

Lewin R. Young Americans. *New Scientist* 1998a Oct 17; 160 (2156): 24–8.

Lewin R. *Principles of Human Evolution*. Malden (MA): Blackwell Science, Inc, 1998b.

Lieberman DE. Sphenoid shortening and the evolution of modern human cranial shape. *Nature* 1998 May 14; 393: 158–62.

Lincoln T. Lucy takes a stroll. *Nature* 1998 Jul 23; 394: 325.

MacKenzie D. Walk this way. *New Scientist* 1998 Mar 7; 157 (2124): 24.

McDonald KA. New evidence challenges traditional model of how the New World was settled. *The Chronicle of Higher Education* 1998 Mar 13; 44 (27): A22–3. *Related reading*: [Anonymous]. The first Americans circa 20 000 BC. *Discover* 1998 Jun; 19 (6): 24.

McKie R. The people eaters. *New Scientist* 1998 Mar 14; 157 (2125): 43–6.

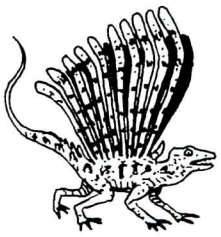
McKinney ML. The juvenilized ape myth — Our "overdeveloped" brain. *BioScience* 1998 Feb; 48 (2): 109–16.

Mellars P. The fate of the Neanderthals. *Nature* 1998 Oct 8; 395: 539–40.

Morwood MJ, O'Sullivan PB, Aziz F, Raza A.

of their tremendous skill as writers. And so I think that if you had to weigh the pluses and minuses against each other — and I do not think that I could do the final reckoning — they would be quite pleased with what they have accomplished.

Giberson: If you look at the premier popularizers of science, the ones who are capable of inspiring young people to go into science — people like Dawkins, Carl Sagan, Stephen Jay Gould, EO Wilson, and Stephen Weinberg — none of these people is religious in any conventional sense. Do the people who read them get a distorted perception of what the scientific community is like because these public spokespersons happen to have atheistic worldviews? And does it then become generalized in the popular mind that science itself is an atheistic enterprise, so that what Phillip Johnson says about the naturalism of science rings true?



Larson: When you put it that way, I do think that Phillip Johnson, by his own terms, was enraged and energized by reading *The Blind Watchmaker*. And I think that he uses them as examples of atheism in science. Yet even Johnson is probably raising up people to go into science, at first to refute them, but later they get involved with science and end up becoming good scientists participating in the scientific enterprise. I have great respect for the people you named. Every one of those people that I know personally, I have tremendous respect for as scholars and as honorable people. And I think that they welcome this debate and discussion, and they would rather have these issues out in the open and discussed and debated in the US so people can think about these issues.

But certainly I do think that they are lightning rods, and they raise controversy. As a result of the controversy they raise, there is a perception in the US that there is a warfare between science and religion. One of the reasons that our initial survey of science and religious beliefs got so much attention was that it found that 40% of scientists in the US believe in something like the traditional God of Judaism, Islam, and Christianity. And that was newsworthy. It is not newsworthy when a dog bites a person; it is newsworthy when a person bites a dog, and this was a person-bites-dog story. It was just the reverse, by the way, when Leuba first published his survey. It was also front-page news, but then it was *only* 40% believe in God. Now it is newsworthy for the opposite reason; 40% is a higher percentage than people today would have thought. Something must have given the impression at least to the US news media that it is surprising that 40% of US scientists believe in God. And that partly comes out with the public voice of science.

Giberson: In thinking about the creation/evolution controversy, what I find attractive about scientific creationism is the simplicity of its model. It is a tidy system based upon the priority of the Bible. What is attractive about Dawkins and that group is the same sort of simplicity. It is metaphysically consistent; it all fits together. In the middle are the

Fission-track ages of stone tools and fossils on the east Indonesian island of Flores. *Nature* 1998 Mar 12; 392: 173–6. *Related reading*: Bower B. Human ancestor may have taken to sea. *Science News* 1998 Mar 14; 153 (11): 164. Gibbons A. Ancient island tools suggest *Homo erectus* was a seafarer. *Science* 1998 Mar 13; 279: 1635–7. Thwaites T. Ancient mariners. *New Scientist* 1998 Mar 14; 157 (2125): 6; Kunzig R. Erectus Afloat. *Discover* 1999 Jan; 20 (1): 80.

Pringle H. The slow birth of agriculture. *Science* 1998 Nov 20; 282: 1446–50.

Schroeder GL. *The Science of God*. New York: The Free Press, 1997.

Svitil K. No, after you, *Afarensis*. *Discover* 1999 Jan; 20 (1): 81.

Weiner S, Xu Q, Goldberg P, Liu J, Bar-Yosef O. Evidence for the use of fire at Zhoukoudian, China. *Science* 1998 Jul 10; 281: 251–3. *Related reading*: [Anonymous]. Investigating the possible use of fire at Zhoukoudian, China. *Science* 1999 Jan 15; 283: 299. Bower B. Ancient fire use flickers inside cave. *Science News* 1998 Jul 11; 154 (2): 22. Wheeler DL. 'Earliest campfire' now placed in doubt. *The Chronicle of Higher Education* 1998 Jul 17; 44 (45): A22. Wuethrich B. Geological analysis damps ancient Chinese fires. *Science* 1998 Jul 10; 281: 165–6.

Zietkiewicz E, Yotova V, Jarnik M, Korab-Laskowska M, Kidd KK, Modiano D, Scozzari R, Stoneking M, Tishkoff S, Batzer M, Labuda D. Genetic structure of the ancestral population of modern humans. *Journal of Molecular Evolution* 1998 Aug; 47: 146–55.

Chapter 5. Homology

Amores A, Force A, Yan Y-L, Joly L, Amemiya C, Fritz A, Ho RK, Langeland J, Prince V, Wang Y-L, Westerfield M, Ekker M, Postlethwait JH. Zebrafish *hox* clusters and vertebrate genome evolution. *Science* 1998 Nov 27; 282: 1711–4. *Related reading*: Vogel G. Doubled genes may explain fish diversity. *Science* 1998 Aug 21; 281: 1119–21.

Behe MJ, Sander K, Bender R. Embryology and evolution [letters]. *Science* 1998 Jul 17; 281: 348–9. *Related reading*: Richardson MK. Haeckel's embryos, continued [letter]. *Science* 1998 Aug 28; 281: 1289.

Brooke NM, Garcia-Fernandez J, Holland PWH. The *ParaHox* gene cluster is an evolutionary sister of the *Hox* gene cluster. *Nature* 1998 Apr 20; 392: 920–2.

Cameron RA, Peterson KJ, Davidson EH. Developmental gene regulation and the evolution of large animal body plans. *American Zoologist* 1998; 38 (4): 609–20.

Dreyer WJ. The area code hypothesis revisited: Olfactory receptors and other related transmembrane receptors may function as the last digits in a cell surface code for assembling embryos. *Proceedings of the National Academy of Sciences* 1998 Aug 4; 95 (16): 9072–7.

Duboule D, Wilkins AS. The evolution of bricolage. *Trends in Genetics* 1998 Feb; 14 (2): 54–9.

Gardner DM, Torok MA, Mullen LM, Bryant SV. Evolution of vertebrate limbs: Robust morphology and flexible development. *American Zoologist* 1998; 38 (4): 659–71.

Gilbert SF. Conceptual breakthroughs in development biology. *Journal of Biosciences* 1998 Sep; 23 (3): 169–76.

Hall BK. Germ layers and the germ-layer theory revisited: Primary and secondary germ layers, neural crest as a fourth germ layer, homology, and demise of the germ-layer theory. *Evolutionary Biology* 1998; 30: 121–86.

Hanken J, Richardson MK. Haeckel's embryos [letter]. *Science* 1998 Feb 27; 279: 1288.

people trying to carve out the theistic evolution models that somehow bring these 2 together, and they end up being ambiguous and fraught with difficulty and so on. What do you think of the attempts to create theistic evolutionary models?

Larson: It is nice to have simplistic answers to your views on origins or your worldview, but when people are thinking about their view of origins, they think about it with more richness than they are often given credit for. If they focus on this, they think about the options of, well, could God create the evolutionary process? Could that be the means of creation, or is it a purely naturalistic process? Or does God work in successive creations as Cuvier once thought? Or is the human soul separate as the Pope would say: the body evolved with the human soul separate? And they can come up with different reconciliations of those different views. I think that you do an injustice to the issue to think that people just have to put it simplistically into one category. To the extent that they focus on the issue, people can come up with some personal reconciliation of the 2 and then go ahead with their lives. I think that it does them an injustice to think that they are going to read an account by a scientist or by a religious person, and just say, that is it.

[*This feature is adapted from a longer article appearing in* Books and Culture: A Christian Review *1999 Nov/Dec; 5 [6]: 30; reprinted and adapted with permission.*]

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American Geophysical Union Re-affirms Support for Teaching Evolution

Earth History and the Evolution of Life Must Be Taught: Creationism is not Science

The American Geophysical Union affirms the central importance of scientific theories of earth history and organic evolution in science education. An educated citizenry must understand these theories in order to comprehend the dynamic world in which we live and nature's complex balance that sustains us.

Science employs a logical and empirical methodology to understand the natural world. Scientific research entails observation of natural phenomena, formulation of hypotheses as tentative, testable statements to explain these phenomena, and experiments or observations to test these hypotheses. Scientific theories, like evolution and relativity and plate tectonics, are hypotheses that have survived extensive testing and repeated verification. Scientific theories are therefore the best-substantiated statements that scientists can make to explain the organization and operation of the natural world. Thus, a scientific theory is not equal to a belief, a hunch, or an untested hypothesis. Our understanding of earth's development over its 4.5-billion-year history and of life's gradual evolution has achieved the status of scientific theory.

"Creation science" is based on faith and is not supported by scientific observations of the natural world. Creationism is not science and does not have a legitimate place in any science curriculum.

AGU opposes all efforts to require or promote teaching creationism or any other religious tenets as science. AGU supports the National Science Education Standards, which incorporate well-established scientific theories including the origin of the universe, the age of earth, and the evolution of life.

(Adopted by AGU Council December 1981; reaffirmed May 1990 and May 1994; expanded and reaffirmed December 1999; available at <http://www.agu.org/sci_soc/policy/evolution.html>.)

Henry GL, Melton DA. Mixer, a homeobox gene required for endoderm development. *Science* 1998 Jun 26; 281: 91–6.

Holland LZ, Holland ND. Developmental gene expression in *Amphioxus*: New insights into the evolutionary origin of vertebrate brain regions, neural crest, and rostrocaudal segmentation. *American Zoologist* 1998; 38 (4): 647–58.

Kmita-Cunisse M, Loosli F, Bierne J, Gehring WJ. Homeobox genes in the ribbonworm *Linea sanguineus*: Evolutionary implications. *Proceedings of the National Academy of Sciences* 1998 Mar 17; 95 (6): 3030–5.

Lee MSY. Similarity, parsimony and conjecture of homology: The chelonian shoulder girdle revisited. *Journal of Evolutionary Biology* 1998 May; 11: 379–87.

Lewin R. Family feuds. *New Scientist* 1998 Jan 24; 157 (2118): 36–40.

Martindale MQ, Henry JQ. The development of radial and biradial symmetry: The evolution of bilaterality. *American Zoologist* 1998; 38 (4): 672–84.

Martinez DE, Bridge D, Masuda-Nakagawa LM, Cartwright P. Cnidarian homeoboxes and the zootype. *Nature* 1998 Jun 25; 393: 748–9.

Meyer A. *Hox* gene variation and evolution. *Nature* 1998 Jan 15; 225–8.

Pendick D. When life got legs. *Earth* 1998 Aug; 7 (4): 26–33.

Prince VE. *Hox* genes and segmental patterning of the vertebrate hindbrain. *American Zoologist* 1998; 38 (4): 634–6.

Richardson MK, Hanken J, Gooneratne ML, Pieau C, Raynaud A, Selwood L, Wright GM. There is no highly conserved embryonic stage in the vertebrates: Implications for current theories of evolution and development. *Anatomy and Embryology* 1997; 196: 91–106.

Richardson MK, Hanken J, Selwood L, Wright GM, Richards RJ, Pieau C, Raynaud A. Haeckel, embryos, and evolution [letter]. *Science* 1998 May 15; 280: 983–5.

Schwabe JWR, Rodriguez-Esteban C, Belmonte JCI. Limbs are moving: where are they going? *Trends in Genetics* 1998 Jun; 14 (6): 229–35.

Strauss E. How embryos shape up. *Science* 1998 Jul 10; 281: 166–7.

Tautz D. Debatable homologies. *Nature* 1998 Sep 3; 395: 17–18.

Wray GA, Raff RA. Body builders of the sea. *Natural History* 1998 Dec/Jan; 107 (10): 38–47.

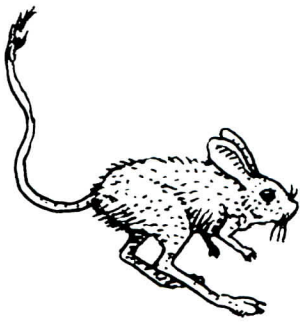
Chapter 6: Biochemistry

Anderson CL, Canning EU, Okamura B. A triploblast origin for Myxozoa? *Nature* 1998 Mar 26; 392: 346.

Balavoine G, Adoutte A. One or three Cambrian radiations? *Science* 1998 Apr 17; 280: 397–8.

Collins AG. Evaluation of multiple alternative hypotheses for the origin of Bilateria: An analysis of 18S rRNA molecular evidence. *Proceedings of the National Academy of Sciences* 1998 Dec 22; 95 (26): 15458–63.

De Ley P, Garey JR, Liu LX, Scheldeman P, Vierstraete A, Vanfleteren JR, Mackey LY,



Money Floods Anti-Evolutionists' Coffers

John R Cole, Contributing Editor

There are several measures of the task NCSE faces in promoting science education. We do a good job on the intellectual front: we can rally massive factual and theoretical information to counter creationist claims. Reaching the public and the makers of public policy is more difficult than simply marshaling facts, however. In short, money talks. Making a case is expensive, and deep pockets can carry more weight than deep thoughts.

Thus a glance at the budgets of a few creationist organizations is instructive. It is instructive to look at summaries of the financial statements of a number of creationist organizations posted at a nonprofit internet site <http://www.guidestar.org>. Some creation ministries are not listed there, presumably because they are registered with the Internal Revenue Service (IRS) as churches. For example, D James Kennedy's Fort Lauderdale Coral Ridge Church is not listed, but the site does list his creationist media ministry, Coral Ridge Ministries Media, Inc. Creation Science Evangelism, the large and growing creationist organization run by Kent Hovind ("Dr Dino"), is also not listed. Countless small organizations are not listed, probably because organizations that earn less than $25 000 annually are not required to file IRS Form 990.

I did not record the many organizations in the database that had no financial data available or tiny incomes (the Ark Foundation had 1997 revenues of $8153, for example), and I no doubt missed others simply because I was unable to track them down. The following list, then, is incomplete. If anything, however, it *underestimates* the revenue and expenditures of organizations that oppose evolution.

Other organizations have devoted significant attention to creationism/anti-evolutionism as part of a larger "religious right" agenda. These include the Family Research Council in Washington DC ($14 618 789 reported income, $14 499 602 reported expenditures) and Focus on the Family in Colorado Springs,

Dorris M, Frisse LM, Vida JT, Thomas WK, Blaxter ML. A molecular evolutionary framework for the phylum Nematoda. *Nature* 1998 Mar 5; 392: 71–6. *Related reading*: Anderson RC. Out of order [letter]. *Nature* 1998 May 14; 393: 10. Nielsen C. Sequences lead to tree of worms. *Nature* 1998 Mar 5; 392: 25–6.

Gaut BS. Molecular clocks and nucleotide substitution rates in higher plants. *Evolutionary Biology* 1998; 30: 93–120.

Kumar S, Hedges SB. A molecular timescale for vertebrate evolution. *Nature* 1998 Apr 30; 392: 917–20. *Related reading*: Gibbons A. Genes put mammals in age of dinosaurs. *Science* 1998 May 1; 280: 675–6. McDonald KA. Mammals diversified earlier than believed. *The Chronicle of Higher Education* 1998 May 29; 44 (38): A21.

Maley LE, Marshall CR. The coming of age of molecular systematics. *Science* 1998 Jan 23; 279: 505–6.

Normile D. New views of the origins of mammals. *Science* 1998 Aug 7; 281: 774–5. *Related reading*: Wong K. Cetacean creation. *Scientific American* 1999 Jan; 87 (1): 26–30.

Qiu Y-L, Cho Y, Cox JC, Palmer JD. The gain of three mitochondrial introns identifies liverworts as the earliest land plants. *Nature* 1998 Aug 13; 394: 671–4. *Related reading*: [Anonymous]. The Ur-plant. *Discover* 1998 Nov; 19 (11): 26.

Schubart CD, Diesel R, Blair-Hedges S. Rapid evolution to terrestrial life in Jamaican crabs. *Nature* 1998 May 28; 363–5. *Related reading*: Tromans A. Land-loving crabs. *Nature* 1998 May 28; 393: 305.

Springer MS, Westerman M, Kavanagh JR, Burk A, Woodburne MO, Kao DJ, Krajewski C. The origin of the Australasian marsupial fauna and the phyogenetic affinities of the enigmatic monito del monte and marsupial mole. *Proceedings of the Royal Society of London Series B* 1998 Dec 22; 265 (1413): 2381–6.

Ursing BM, Arnason U. Analyses of mitochondrial genomes strongly support a hippopotamus-whale clade. *Proceedings of the Royal Society of London Series B* 1998 Dec 7; 265 (1412): 2251–5.

Zardoya R, Meyer A. Complete mitochondrial genome suggests diapsid affinities of turtles. *Proceedings of the National Academy of Sciences* 1998 Nov 24; 95 (24): 14226–31. *Related reading*: [Anonymous]. Don't mess with me — my cousin's a dinosaur. *New Scientist* 1998 Nov 28; 160 (2162): 25. Monastersky R. Turtle genes upset reptilian family tree. *Science News* 1998 Dec 5; 154 (23): 358.

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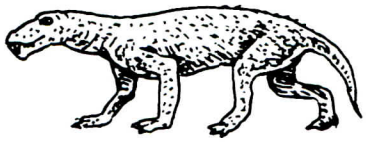


Colorado ($103 886 009 reported income, $98 048 762 reported expenditures for 1997). Charles Colson's Prison Ministries Fellowship, which frequently blasts evolution in its broadcasts and publications, had a 1998 reported income of $42 936 674. Coral Ridge Media Ministry ($26 300 289 reported income) similarly devotes only part of its attention to creationism, but its D James Kennedy is one of the anti-evolutionist stars. A bit further afield are the numerous creationist-oriented television stations, cable channels, and program syndicators. Trinity Broadcasting of Tustin, California, for example, which devotes a considerable amount of time to creationist broadcasts, had a 1997 income of $35 158 289.

In addition to thousands of churches, schools and colleges not listed here, there are a number of more politically conservative organizations and publications such as *The American Spectator*, Concerned Women of America, the Eagle Forum, the Christian Roundtable, and the Christian Coalition that actively promote anti-evolutionism without making it their trademark issue. The Intercollegiate Studies Institute (ISI) received $6 046 163 in 1997. Focused on cultural and economic conservativism, ISI publishes occasional articles on the evils of materialism and Darwin rather than on creationism per se.

The American Center for Law and Justice (ACLJ) was founded by televangelist Pat Robertson as a sort of reverse ACLU and now has several branches. Among its other activities, the ACLJ provides attorneys and research to support creationist challenges to school policies and laws that forbid creation science teaching. Its reported 1998 income was $12 711 803. The Rutherford Institute takes on a broader spectrum of conservative political cases (recently including the Paula Jones lawsuit). Its 1998 income was a mere $4 431 907.

The Seattle-based Discovery Institute (DI) has recently acquired a new subgroup called the Center for the Renewal of Science and Culture, which consists mostly of the leading "intelligent design" spokesmen such as Phillip Johnson, Paul Nelson, and Jonathan Wells. The DI budget in 1997 lists revenue of $1 832 398 and expenditures of $1 323 899. It is not clear what percentage of this budget is allocated to the CRSC, which accounts for most of the 1999 DI publicity and visible activity. A number of (nonresident) CRSC Fellows reportedly are paid stipends of $40 000.

Walter Olson reported recently in his article "Dark Bedfellows" in the January 1999 issue of *Reason* (available at <http://reason.com/9901/co.wo.darkbedfellows.html>) that the Discovery Institute newsletter listed a recent donation of $1.5 million to the CRSC by Howard Ahmanson. His goal was to "cure Western culture" of naturalism, a pernicious product of the Enlightenment, with a research and publicity program to "unseat not just Darwinism but also Darwinism's cultural legacy." Ahmanson has long supported the Chalcedon Institute, which advocates converting America to Old Testament law and theocracy, and is a board member of the Claremont Institute, which lists as its mission "to restore the principles of the American Founding to their rightful, preeminent authority in our national life" <http://www.claremont.org/1_aboutus.cfm>.

By way of comparison, the National Center for Science Education reported for the 1998 fiscal year revenues of $258 957 and expenditures of $268 730. The NCSE balance sheet for 1999 will perhaps show temporarily better numbers due to the rush of publicity caused by the Kansas Board of Education's vote to drop evolution from state exam requirements, but in no way does the NCSE budget approach the creationist war chest.

ANNUAL INCOME AND EXPENDITURES OF CREATIONIST ORGANIZATIONS

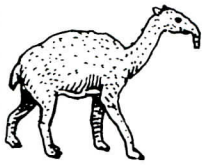
ORGANIZATION	REVENUE	EXPENDITURES
Access Research Network (formerly Students for Origins Research)	$59 311	$82 548
Answers in Genesis, KY (Ken Ham)	$3 702 800	$3 492 904
Creation Education Society, TN	$19 508	?
Creation Evidence Museum, Glen Rose TX	$420 460	$365 816
Creation Illustrated Ministries, Auburn CA	$202 950	$198 414
Creation Moments (formerly Bible-Science Association)	$292 318	$284 846
Creation Research Society, San Antonio TX (1997)	$263 391	?
Creation Resource Foundation, El Dorado CA	$66 756	$68 102
Creation Science Association for Mid-America	$34 714	$40 103
Creation Science Fellowship, Pittsburgh PA	$51 193	$22 671
Creation Worldview Ministries, Orlando FL	$114 604	$93 076
Creation-Science Association for Mid-America	$34 712	$40 103
Genesis Institute, Mead WA	$62 464	$63 695
Institute for Creation Research	$4 167 547	$3 997 419

Figures are for fiscal year 1998 unless noted.

RESOURCES

The Search for Common Ancestry

The *Journal of Molecular Evolution* devoted a special issue (volume 49, number 4, 1999) on the last common ancestor (LCA) of all living organisms, with a dozen interesting articles concerning evidence for what the LCA was like. Connect to <http://link.springer.de/link/service/journals/00239/tocs/04904.html#xml=> to view the table of contents and abstracts of the articles. Here is a list of the articles appearing in that issue:



Antonio Lazcano, Patrick Forterre.
The Molecular Search for the Last Common Ancestor

Nikos Kyrpides, Ross Overbeek, Christos Ouzounis.
Universal Protein Families and the Functional Content of the Last Universal Common Ancestor

Antonio Lazcano, Stanley L Miller.
On the Origin of Metabolic Pathways

Nicolas Glansdorff.
On the Origin of Operons and Their Possible Role in Evolution Toward Thermophily

Purificación López-García.
DNA Supercoiling and Temperature Adaptation: A Clue to Early Diversification of Life?

Jose Castresana, David Moreira.
Respiratory Chains in the Last Common Ancestor of Living Organisms

Bernard Labedan, Anne Boyen, Margot Baetens, and others.
The Evolutionary History of Carbamoyltransferases: A Complex Set of Paralogous Genes Was Already Present in the Last Universal Common Ancestor

Jocelyne DiRuggiero, James R Brown, Allison P Bogert, Frank T Robb.
DNA Repair Systems in Archaea: Mementos from the Last Universal Common Ancestor?

James R Brown, W Ford Doolittle.
Gene Descent, Duplication, and Horizontal Transfer in the Evolution of Glutamyl- and Glutaminyl-tRNA Synthetases

Philippe Lopez, Patrick Forterre, Hervé Philippe.
The Root of the Tree of Life in the Light of the Covarion Model

Hervé Philippe, Patrick Forterre.
The Rooting of the Universal Tree of Life Is Not Reliable

Piero Cammarano, Roberta Creti, Anna M Sanangelantoni, Peter Palm.
The Archaea Monophyly Issue: A Phylogeny of Translational Elongation Factor G(2) Sequences Inferred from an Optimized Selection of Alignment Positions

[*Thanks to Sverker Johansson for letting us know about this special issue.*]

New Books On Chinese Fossils

Chronicle of Zhoukoudian (1927–1937) is a new book released in commemoration of the 70th anniversary of the discovery of the first skull of "Peking Man". Chinese and English bilingual. Editor in Chief: Jia Lanpo. September 1999. ISBN: 7-5323-5301-X/N.93. 151 pages. Hardcover. Price: US$73 (surface); US$83 (airmail).

Chinese Fossil Horses of Equus *and Their Environment* (Chinese edition with English summary, p 129–53). Edited by Deng Tao and Xue Xiangxu. July 1999, ISBN: 7-5027-4772-9. 158 pages + 20 plates. Hardcover. Price: US$46 (surface); $53 (airmail).

A Study On the Lithic Artifacts of *Sinanthropus — Palaeontologia Sinica* 1985; 168 (12), New Ser D (Chinese edition with English summary). Edited by Pei Wenzhong and Zhang Senshui. 277 pages + 45 plates. Hardcover. Price: US$46.

The mandibles and dentition of *Gigantopithecus — Palaeontologia Sinica* 1962 146 (11), Ser D (Chinese edition with English abstracts). Edited by Woo Ju-Kang. 94 pages + 18 figures and 18 plates. Paperback. Price: US$54.

Evidence for Evolution — Essays in Honor of Prof. Chungchien Young on the Hundredth Anniversary of His Birth (Chinese edition with English abstracts). Edited by Tong Yongsheng and others. 1997. ISBN: 7-5027-4308-1. 253 pages. Paperback. Price: US$35.

Proceedings of the Seventh Annual Meeting of the Chinese Society of Vertebrate Paleontology (Chinese edition with English abstracts). Edited by Wang Yuanqing and others. 1999. ISBN: 7-5027-4538-6. 274 pages / Paperback. Price: US$39.

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By e-mail
Please e-mail your order to the following:
hceis@public3.bta.net or
hceis@mx.cei.gov.cn

Payment
Check, bank transfer, or international post money on receipt of book.

Ancestors On Line

The anthropology department of the American Museum of Natural History has a web site devoted to fossil evidence of human evolution and the common ancestry of humans and apes. The site, located at <http://www.amnh.org/enews/anthro.html>, includes images as well as interesting (and useful) links. Downloading the free plug-in Shockwave allows the viewer to rotate the images and examine them from multiple perspectives, making this site even more enjoyable.

[*Contributed by Jim Moore.*]

Report Rates Accuracy of State Science Standards

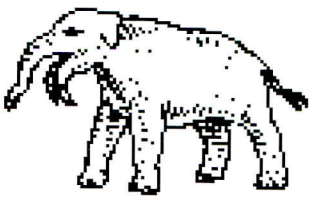
Molleen Matsumura
Network Project Director

The State of State Standards 2000

In January 2000, the Fordham Foundation released its second report evaluating state academic standards nationwide. Every state's content standards for each subject (science, mathematics, English, and so forth) were evaluated by numerous criteria, and states' procedures for holding schools accountable were also evaluated. The section on science standards was prepared by a team led by Lawrence Lerner, professor emeritus of physics at California State University, Long Beach (Lerner's summary of the 1998 report was published in *RNCSE* 18 [1]: 25–6).

Appendix E of the report is particularly useful for people seeking a quick overview of science education in general, and evolution in particular, in their states. The appendix explains in detail the criteria used for evaluating science standards and reports the scores for each state on each criterion. For example, a column in Table E3 lists scores for "Consistency with Scientific Theory", and a column in Table E6 indicates whether a state "Eschews Pseudo-Science, Quackery" in its standards (*see <http://www.edexcellence.net/library/soss2000/2000soss.html#AppendixE>*).

Readers can order a free copy of *The State of State Standards 2000* by calling 1-888-TBF-7474 or e-mailing Kelly Amis at <KLAmis@aol.com>. The complete report is available on line at <http://www.edexcellence.net/library/soss2000/standards2000.html>.



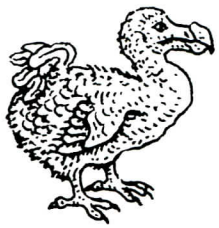
BOOKREVIEW

Genes, Peoples, and Languages

By Luigi Luca Cavalli-Sforza [translated by Mark Seielstad]. San Francisco: North Point Press, 2000. 228 pages.

Reviewed by Jeffrey M Otto, Genaissance Pharmaceuticals

This book has the ambitious goal of combining relevant information from the fields of population genetics, archeology, and linguistics into a series of extended essays on human evolution. According to the jacket notes, "*Genes, Peoples, and Languages* comprises five lectures that serve as a summation of the author's work over several decades, the goal of which has been nothing less than tracking the past 100 000 years of human evolution." Cavalli-Sforza is a premier researcher in this field, with over 20 peer-reviewed papers published within the last 5 years (176 total), all in high ranking prestigious journals. Perhaps most interesting of these was an article with the same title as this book, published in the *Proceedings of the National Academy of Sciences* in 1997 (*PNAS* 1997; 94: 7719–24). Strangely, even though a quick review of the *PNAS* article shows that both it and the book cover similar material, it was left out of the bibliography of *Genes, Peoples, and Languages*.



In the preface, Cavalli-Sforza states that he believes that, although scientific jargon increases precision and speed of communication between professionals, it hampers communication between disciplines. Consequently, he sought to minimize jargon as much as possible throughout the text. I believe that he succeeded in this task: the book is easy to read and quickly makes important points accessible to a general reader. I was impressed with the ease with which Cavalli-Sforza explained some fairly complex concepts in population genetics without employing jargon or mathematics. He handled with clarity the complexities surrounding the ancestral "Eve" and genetic studies of mitochondrial DNA, as well as analyses of the male-specific Y chromosome. Particularly pleasing were his explanations of the arbitrariness of race and of how superficial characteristics used to mark racial boundaries are only vague reflections of the underlying genetics. I found his perspective on race and genetics to be refreshing and a strong challenge to works such Richard J Herrnstein and Charles Murray's *The Bell Curve*.

Thanks to this book, I also learned a great deal regarding both linguistics and the history of the human species. I was particularly fascinated by the last 2 chapters of the book, which focused on the evolution of language and culture. That the development of language could be considered the major driving force of culture and progress was a novel concept to me — although it might be considered old hat by anthropologists or linguists. In my mind, that is the main strength of this book. Although I learned very little about my own field (genetics), I came away feeling very enlightened in the fields of both human archeology and linguistics. It was very refreshing to see genetics applied in these other disciplines. I suspect that professionals from the reciprocal fields will have the same opinion. I regard this book as aimed primarily at a lay audience, or educators and researchers whose fields lie outside the scope of the book. If you feel that you belong to one of these categories, then I can recommend this book without reservation.

However, as a researcher and scientist, I found 2 aspects of the book frustrating. My main complaint is with the way that references are used — or, rather, not used. There is a bibliography (86 references), but it seems a bit on the light side considering the scope of the book. I found the lack of referenced sources in the text frustrating because, when I find something interesting, I like to follow up with the references to get further information. In a text like this, where concepts are treated very generally and supporting data are often left out, the lack of references is a glaring omission. I sincerely doubt that the lay reader drawn to a book like this one would be discouraged by citations in the text, and the serious student or researcher would find them highly beneficial. If a second edition of this book is published, it would benefit greatly if sources were cited within the text and the bibliography expanded.

A second caveat is that the book has a tendency to meander and jump around quite a bit. This led to a very "folksy" feel to the translation, and made it comfortable to read. However, if the text were a bit tighter and more linear, I think that it would have been even easier to read and, on the whole, less confusing.

To conclude, I found the strengths of *Genes, Peoples, and Languages* to be its success in presenting complex concepts and relating them to several scientific disciplines. On the other hand, its weaknesses are its lack of in-depth detail, analyses, and, especially, references that the motivated reader can use to learn more about the topics. The audiences most likely to benefit or enjoy this book are lay persons who are genuinely interested in human evolution but who lack formal exposure to the discipline. I also believe that high school or college educators could easily use this book to link the 3 disciplines — population genetics, archaeology, and linguistics — together. However, researchers or professionals in the fields are likely to be disappointed by the general lack of depth in the text. To be fair, one has to choose an audience to write to, and it is pretty clear that Cavalli-Sforza had in mind a general readership when he wrote this book.

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Letters to the Editor

A follow-up letter on a success story! The Lagrange, Illinois, grade school in District 102 has resolved its problems relating to including the word "evolution" in its science curriculum.

After an hour of community input — 5 minutes per person — and another hour of discussion by the school board, "evolution" was incorporated into the District's statement. Following a suggestion by Tom Dracka, who set up the District's Science Lab 10 years ago, a statement of "overarching goals" taken from the National Research Council's *Standards for Science Education* was added to the curriculum. The word "evolution" is now included. In addition, the community/faculty committee will continue its work to see how biological natural selection can be integrated into the K–8 curriculum. The board's vote was unanimous.

The discussions on how best to construct a science curriculum were spirited and civil. One local creationist spoke, and he came off quite badly. He said 3 times, "I am a scientist", without ever indicating his field or place of employment. He mentioned "Nebraska man" and what he considered to be other scientific failures. The audience of about 30 people, which included several working scientists who identified their employers, listened politely, but provided no apparent support for his position.

I left the meeting with a heightened awareness of the importance of state standards. Dracka said that Illinois standards had been the board's focus. If teaching evolution had been in the Illinois guide, it probably would have been in District 102's curricular outline automatically, and the local controversy would not have developed.

Educators, in my view, continue to be driven by pedagogical fashions. Right now they seem to be thinking of little else than "meeting the standards"—whatever they may be. The Illinois History/Social Studies Standards show evidence of influence by anti-evolutionists.

Brant Abrahamson
Brookfield IL
E-mail: teacherspr@aol.com

I must express disappointment and dismay with the NCSE Recommended Policy Statement on Science and Evolution (*RNCSE* 1999 Mar/Apr; 19 [2]: 23). The policy states: "By definition, these [religious] explanations of origins are outside of science, since they presuppose supernatural forces, and they cannot be changed by new data." Surely NCSE does not mean that explanations invoking supernatural forces may not be supplanted by scientific theories. Is young-earth creationism immune to the evidence from geological dating techniques for an old earth? Is the possible origin of morality in evolutionary processes not a valid area of scientific study? Is it inappropriate to subject alleged paranormal phenomena to statistical analyses? Surely not.

The policy statement continues: "In science classes, as in all subjects, teachers should maintain appropriate sensitivity to students' religious and philosophical views; evolution should not be singled out for special treatment." Evolution is so pervasive in science — certainly in biology, agriculture, and medicine —that to illustrate the fundamental principle is to single it out for special treatment.

In attempting to illustrate that evolution is just one example of a scientific theory, the policy states that evolution "explains how the universe — stars, galaxies, the planet earth, and life on earth — has changed over time." This formulation obscures the fact that the evolution of most concern is organic evolution as a consequence of random variation, natural selection, and survival of the fittest. These factors are not generally considered to operate on stars and galaxies.

I may be misreading the policy but, if so, perhaps others do also.

Allan D Halderman
Oregon City OR

In her review of Robert Pennock's *Tower of Babel* (*RNCSE* 1999 Nov/Dec; 19 [6]: 40–2), Eugenie Scott appears to define philosophical materialism as the view that there are no supernatural forces in the universe. Is this really the case, or is it the view that there is no evidence for the existence of supernatural forces in the universe? It makes a big difference. If it is the former definition, then philosophical materialism should be roundly rejected as unprovable by all rational thinkers. If it is the latter, then it should be properly stated.

In the same review, Scott writes, "the methodological materialism of science ... says that science cannot use supernatural causes to explain the natural world." I suggest that it would be better to say that the methodological materialism of science says that science cannot use supernatural causes, without evidence for their existence, to explain the natural world. This would help to blunt some of the objections of creationists. Who knows: God may materially reveal Himself tomorrow, for all we know.

Both Pennock and Scott seem to make the point that creationists err in failing to understand methodological naturalism's dictum that to say nothing of God is not to say that God is nothing. I do not think it *is* an innocent error on the part of the creationists: I think that it is a deliberate misrepresentation, and I think that we should make that point whenever possible. Intelligent and rational creationists have repeatedly been reminded of such distinctions over the years, yet they persist in continuing to perpetuate the confusion. In my book, that is lying.

Ken Herrick
Oakland CA

WEB LOCATIONS VISITED IN THIS ISSUE

NEWS

TOPIC Anti-Evolutionists Open a New Front
OWNER American Geological Institute Government Affairs Program
LOCATION <http://www.agiweb.org/gap/legis106/id_update.html>.
LAST VISIT August 3, 2000

TOPIC Resolution in Support of Evolution Education
OWNER American Association for the Advancement of Science
LOCATION <http://www.project2061.org//newsinfo/kansas.htm>
LAST VISIT August 5, 2000

TOPIC Arkansas Science Curriculum Framework Includes Evolution
OWNER Arkansas Department of Education
LOCATION <http://arkedu.state.ar.us/Science_1999.PDF>
LAST VISIT August 5, 2000

TOPIC Science Standards Safe in South Carolina
OWNER South Carolina Department of Education
LOCATION <http:// www.state.sc.us/sde/educator/standard/science/>.
LAST VISIT August 5, 2000

FEATURES

TOPIC Money Floods Anti-Evolutionists' Coffers
OWNER Philanthropic Research, Inc
LOCATION <http://www.guidestar.org>
LAST VISIT August 5, 2000

TOPIC Book Reviews: *Of Pandas and People*
OWNER The Textbook League
LOCATION <http://www.textbookleague.org/53panda.htm>
LAST VISIT August 1, 2000

NCSE NEWS

TOPIC Internet Learning Network
OWNER Internet Learning Network
LOCATION <http://www.getsmarter.org>
LAST VISIT August 5, 2000

TOPIC NCSE's Internet Book Sales Flourish
OWNER NCSE
LOCATION <http://www.natcenscied.org/bookcat.html>
LAST VISIT August 5, 2000

INSTRUCTIONS FOR CONTRIBUTORS

Reports of the National Center for Science Education (RNCSE) welcomes contributions from its readers and from anyone interested in issues related to evolution as the foundation for the biological sciences, to the place of evolution in the science curriculum, or to the public perceptions of scientific method and practice. These contributions may be submitted in one of two forms.

News, commentaries, and features describe events or experiences that we wish to relate to our readers and members. These may include reports of school-board elections or local organizing by parent and teacher groups, political or governmental decisions and policies, first-person accounts of experiences with anti-evolutionist speakers, curriculum, or organizations, other reports of information related to our primary concerns of promoting good science in education and public life, and, of course, humor related to creation/evolution issues.

Articles include book reviews, scholarly articles, and formal essays. These may explore specific arguments raised by anti-evolutionists, relate new information that may be helpful in promoting evolution, or present original research related to the public understanding of evolution. We also welcome case reports and classroom action research that assess the outcome(s) of strategies for strengthening the understanding of evolution in educational practice.

All articles should be written for a general audience, and authors should provide definitions or descriptions of technical terms and concepts that might not be understood by a non-specialist. All article manuscripts are submitted to reviewers for comments on their technical content and suitability for a general audience. All items will be edited before publication. Acceptance for publication does not take into account the author's formal academic background or profession. We encourage query letters from any prospective author.

Style and Format

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Smith FZ. Geocentrism re-examined. *Journal of Nice Things* 1985; 21 (3): 19–35.

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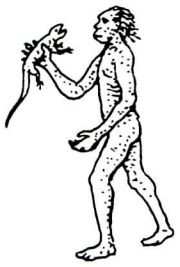

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