# REPORTS OF THE NATIONAL CENTER FOR SCIENCE EDUCATION

DEFENDING THE TEACHING OF EVOLUTION IN THE PUBLIC SCHOOLS

**Volume 26, Number 3** **MAY-JUN, 2006**

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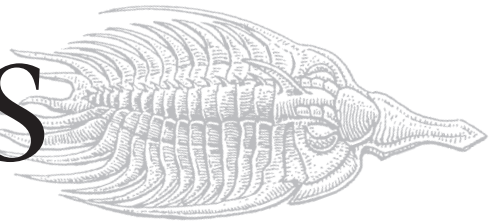

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Cover: Transmission electron micrograph of the anterior end of a *Dinobryon cylindricum* cell, showing the axoneme of one of the two emergent flagella of this alga in longitudinal section. Courtesy of and ©Heather A Owen, 2006.




Of all the material that they read for the survey of life sciences course, my former students at Philadelphia's University of the Arts were most impressed by one thing: the statement by Lynn Margulis and Dorion Sagan in *What is Life?* that there are more bacteria in one's mouth than people in New York City. This was their introduction to the fact that most of life is smaller than we imagine, yet still operates under the same principles and with the same fundamental biological processes as the larger, more familiar forms of life. In the last few decades, our knowledge of molecular and cell biology has undergone an explosive growth, and many of the seemingly intractable questions of the evolution of these fundamental processes have yielded to the persistence and dedication of researchers in these fields. At the same time, many of the complaints of anti-evolutionists have also experienced explosive growth in their misuse of this research to try to weaken evolution education.

Our scientific articles in this issue focus on some of the recent complaints by "intelligent design" proponents and explain that the answers that they seek to shroud with confusion are already well established. Finn Pond reviews the current state of research on the evolution of complexity in cellular structure and processes. He points out that there are several models that have been studied experimentally and that appear to provide strong evidence for naturalistic processes that allow cells to derive these complex features from pre-existing components.

Michael Buratovich takes on a particular issue arising from the Discovery Institute's bibliography provided to the state school board in Ohio (see *RNCSE* 2002 Jul/Aug; 22 [4]: 11–3). He shows that what appear to be significantly different enzymes — especially between prokaryotes and eukaryotes — share basic biochemical properties and engage nucleoside molecules in essentially the same ways. These studies show a fundamental unity of process, even though some of the specific molecules appear to be quite different. And even those that operate differently — such as those of certain infectious agents — can be explained by the preservation of these variants by selection as a way to keep ahead of hosts' immune systems. In a nutshell, the Discovery Institute misinterpreted these studies quite significantly.

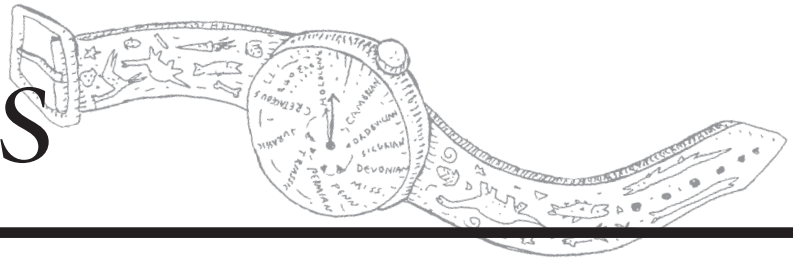
## IN THE NEWS

In what may be the biggest news on the evolution education front, the Ohio State Board of Education eliminated the "Critical Analysis of Evolution" model lesson and the corresponding science education standard. This appears to be, in part, a response to the *Kitzmiller v Dover* decision last winter. Furthermore, Kansans again rebuked their state board of education for weakening evolution by defeating enough anti-evolution incumbents to produce a pro-evolution majority on the board next year — no matter who wins the November elections.

Robert Camp reports on his experience at a Biola University event where "intelligent design" proponents were supposed to face their toughest critics. It was a evening of evasion, confusion, and playing to a sympathetic audience; but there were never more than partial answers to serious questions. The main problem, of course, was that the set-up of the event prevented focused follow-up to the presenters' non-answers. So, when Paul Nelson and Stephen Meyer argued that scientific consensus is not the golden standard, but has been overturned in the past, nobody got to make the obvious point that when the scientific consensus was overturned in the past, it was on the strength of scientific research — something that "intelligent design" still has not produced in its 17 years as a supposedly scientific theory.

*RNCSE 26 (3) was printed in October 2006.*

# NEWS



## The "Grill the ID Guys" Event at Biola, or, "We may not know where we're going, but we're certainly not going away"

*Robert Camp*

On the way to the "Intelligent Design Under Fire" event (also referred to as "Grill the ID Guys") at Biola University, my wife asked me what she should expect. I considered for a few moments and replied, "Well, if the past is any indication you will probably see responses from the 'intelligent design' (ID) guys that begin with a good bit of geniality, and then make a cursory attempt to address the question before digressing into something unrelated about which they wish to talk; that and complaining that a question is unfair, or else ignoring it altogether." As we merged with the crowd meandering toward the auditorium, we noticed that some were wearing shirts with Bible excerpts on the back. "Oh, and watch the audience," I said. "Depending on how it's played, this whole thing could end up being about them."

### Waiting for the coals

John Bloom, the event's organizer, took the stage and explained how it all came about. He had noticed that the best part of similar events he had attended were the Q&A sessions, so he put together two panels he thought might produce an interesting discussion. One panel consisted of "intelligent design"'s leading proponents — Stephen Meyer, Jonathan Wells, Michael Behe, Guillermo Gonzalez, and Paul Nelson — and another representing ID's "toughest critics" (see sidebar, p 7) — philosopher Antony Flew, columnist and philosopher Charlotte Laws, television correspondent Keith Morrison, retired geology professor Larry Herber, and three faculty members from California State University at Fullerton — James Hofmann (Professor and Chair of Liberal Studies), Craig M Nelson (lecturer in comparative religion), and Bruce Weber (Professor of Biochemistry). Morrison and Laws described themselves as confused but interested outsiders. During the event, Herber made one comment which ended up being more of a clarification of uniformitarianism, and Flew never spoke. It was Hofmann, Weber, and Nelson who asked most of the informed questions.

After introducing both panels, Bloom had Stephen Meyer present a short primer on ID. Once Meyer finished his introduction to ID (essentially undiluted and unrebutted boilerplate), Bloom started things off by encouraging a question from the critics. This format — critic asks question, ID proponents answer — could be effective, but one of its drawbacks is that the interaction can become unfocused. What I have tried to do in this account is to focus on the advertised purpose of this event, the salient questions asked, and the answers given.

### Let the grilling begin

*Question 1*. Morrison began by asking, "What kind of intelligent being are you proposing, or are you proposing any specific intelligent being?" Meyer looked to his mates briefly, and, after a digression into how the media report ID poorly, he explained that there is a difference between the theory and the religious beliefs of those who hold it. He repeated that ID infers only intelligence, not a specific entity. Critics of ID are quite familiar with this non-response. Thus the first question is met with hand-waving and evasion. Not an auspicious beginning.

*Q2*. Morrison continued, observing that ID is being embraced by people who take the Bible literally, while scientists and progressive Christians largely dismiss it. He wondered if those on the ID panel were comfortable with that. Michael Behe answered that he was not, but then protested, "Most people don't understand 'intelligent design', and try to fit it into pre-existing categories. Certainly that's true of the scientific community; most people have a skewed view of 'intelligent design' there." Behe went on to expound on initial reactions to the Big Bang (the first of several Big Bang excursions) and how the cell is "incredibly sophisticated technology" (one among many "machine" references). Behe can be credited with a half-answer to this question.

After a bit more discussion, John Bloom got the Fullerton contingent involved. Hofmann suggested that ID can attain legitimacy only by way of evaluation at the relevant conferences and in the appropriate journals, not at Biola (formerly called the Bible Institute of Los Angeles). This brought murmurs of disapproval. Hofmann then introduced Bruce Weber.

*Q3*. Weber presented several slides that documented studies examining exaptation as a reasonable naturalistic explanation for the evolution of "irreducible complexity" (IC). He noted that research on exaptation is a work in progress, but with very real research results. In contrast, where, he asked, is the ID research? And "why would a scientist abandon the productive research program of the Darwinian modern evolutionary synthesis for one informed by 'intelligent design'?" Behe responded with the opaque observation that what Weber had shown is not really new or supportive research, but "just regular biochemistry which is being spun in a Darwinian fashion." He went on to ignore the question and renew his battle with Ken Miller by showing slides and repeating previous arguments. After Weber tried to

*Robert Camp is a writer who concentrates on issues of science and religion. Some of his work can be found on-line on his Nightlight blog: <http://litcandle.blogspot.com>.*

get back to his question, Behe attempted to refute recent research on the evolution of complexity (Bridgham and others 2006). Soon thereafter Meyer jumped in and digressed into possible Type III secretory system arguments, asserted that Behe has not been proved wrong and suggesting that proposed naturalistic pathways do not cut it. "Intelligent design" proponents typically attempt to cover the deficiencies of the IC argument in this way — shifting the burden of proof. But the criticism from biologists is of the in-principle argument that there *cannot* be an evolutionary explanation, and as such does not call for tested and replicated research; it simply requires empirically defensible hypotheses.

At this point, Paul Nelson joined the discussion. He continued Meyer's impassioned defense of Behe, directly addressing the crowd as he complained bitterly about "two sets of rules" preventing guys like Behe from publishing in the scientific literature. The audience applauded vigorously. Meyer carried on playing to the house by recounting the supposedly unfair treatment of Richard von Sternberg in the aftermath of his resignation as editor of the *Proceedings of the Biological Society of Washington* after accusations that he manipulated the peer-review process to publish Meyer's paper on the Cambrian explosion. Finally, he asserted that "we cannot take peer-review … [as] the gold standard of scientific literacy." This elicited more applause.

And Weber's long-forgotten question remained unanswered.

*Q4.* Trying to get back on track, Hofmann talked about research on human chromosome #2 and the data that strongly support a fusion event in the evolution of humans. The point was about specificity of empirical questions (where, when, and how?) in preparation for his next question. For ID to be taken seriously as a science, Hofmann said, it must address two questions: *When* did a design event take place and *how* did it take place?

Meyer quickly responded to this with a protest directed primarily to the audience. He complained that design critics set forth rules on the methodology of science, assume their acceptance, and then proceed to dismiss ID on the basis of not following these methodological rules. Returning to the question, he argued that his own work shows that the Cambrian is a good candidate for when an act of design might have taken place (Meyer 2004). He added that the origin of life and the origin of intelligence are other possibilities. "So in fact we do say when, and moreover we say how," he argued, "we say it was done by an act of intelligence." Of course Hofmann meant that ID needs to address these questions empirically. Meyer ignored the need to test his hypothesis (a designer) as well as the requirement to establish testable mechanisms by which the intelligent intervention occurred. Meyer repeated his disdain for the "rules," suggesting that they be changed to accommodate different kinds of explanation.

Jonathan Wells took advantage of the ensuing lull to return to the question of "consensus". He argued that because of previous changes in the scientific consensus (for example, failed ideas such as geocentrism and the fact that at one time even Darwinism was considered incorrect), we should not be so willing to trust the consensus. Hofmann responded that those failed ideas were overturned as a result of the scientific process. Despite Meyer's sparest of partial answers, another question lingered in limbo.

*Q5.* After some discussion of information, Weber proceeded to ask Behe whether the blood-clotting cascade qualifies as a case of intelligent intervention. Behe replied that "these are difficult questions to address" and that we should not jump to "premature and unjustified conclusions." Meyer interceded to mention again how intelligence is necessary to build digital code, at which point Weber circled back to the earlier issue and suggested that there are natural mechanisms that can produce an increase in information. Meyer decided to answer Weber with a question: "Do you all have an explanation for the information that is necessary for the origin of life?" Weber noted that it is an active area of research. Meyer repeated the question, then scuttled off into an argument about ribozyme engineering.

Behe judged this a good time for him to turn the tables with a question as well, so he asked Weber and the others if they did not already agree that science has reached its limits on these biological questions, "When would you think so?" The audience chuckled knowingly. Meyer complained again about the "rules" of scientific materialism. Weber's question received only more questions.

*Q6.* Hofmann then asked how far they would be willing to go in abandoning methodological naturalism. Paul Nelson agreed readily that science cannot appeal to magic, and then appealed to the vanity of the audience, musing that "no natural law, no physical process, no algorithm can possibly explain what we're doing here. … It's not spooky, but it's not strictly material either," he said. Upon reflection, his point reduces to: "There's science, there's magic, and then there's the nonmaterial causal agency that we like to infer." Unfortunately, he neglected to explain how this last category is empirically distinguishable from magic. Hofmann responded that science must operate by way of methodological naturalism, otherwise causal inference might be left open to miracles. Behe rejoined with another question: "How would you categorize the Big Bang?"

*Q7.* Hofmann now got Craig M Nelson involved. Nelson returned to the notion of consensus and asked when ID panelists would consider such a thing important. Meyer answered that they are not saying consensus is not important (of course, in fact they *had* just said exactly that!); rather, Meyer complained that the position of ID proponents is not even being considered, because their detractors simply appeal to consensus and never listen to what they have to say. It did not seem to occur to Meyer that what they have to say has been considered and rejected. An excellent reason for which rejection might be nonresponsive performances such as the one occurring this very evening.

*Q8.* Bloom brought Charlotte Laws into the discussion. Laws observed that ID is being pushed into schools and asked the panel for their views as to why. Meyer noted that the debate involves the intersection of cultural and scientific ideas regarding origins and implied that people generally get carried away with the religious implications of ID theory. Laws tried to get back to the question, saying that she thinks the movement might have something to do with a general distrust of science, an observation that science currently appears to be vul-

nerable, and the influence of postmodernism. She also admitted that she thinks it is fine for ID to be in classrooms because it is philosophy and wondered how the panel felt it should be taught.

Wells remarked that they do not advocate required teaching of ID. In fact, he went on to say, ID is already in the textbooks, making reference to a stack of textbooks that he says include a section on ID. (Wells is not always reliable about the content of textbooks; see Camp 2005.) Paul Nelson picked up on this theme, noting that prominent evolutionary biologist George Williams wrote a book in which he discusses whether the vertebrate eye is "wise" design (Williams 1992: 72–3). During further discussion, Meyer came back to the subject of methodological naturalism. He opined that this rule prevents us from concluding design. Of course it does not; archaeologists and forensic scientists conclude design all the time. This is another case of ID proponents' using ambiguous language to confuse listeners to their advantage. Meyer went on to offer another reverse question, asking: "Let's just say, for the sake of argument: The universe really is designed. Would you ever be able to tell, as a scientist, if you held that rule … ?" The gathering rumbled its approval. Laws's query was largely ignored.

*Q9*. Craig M Nelson extrapolated from Meyer's question to ask one of his own, wondering why theistic evolution is not an acceptable explanation. Is there some reason God could not have worked in that fashion? Behe answered that God can do whatever he wants. Aside from Behe's dismissive non-answer, there was no response to Nelson's query.

*Q10*. In wrapping up the evening, Bloom reserved to himself the right to ask one last question of the ID panel. "What do you think it would take for 'intelligent design' to be accepted in scientific circles?" Wells answered first. He agreed with an earlier observation that ID needs to be fruitful. He then said that there is real ID research going on around the world. Meyer prodded Wells to talk about his "cancer research". Wells allowed that he *would* be doing some ID-inspired work that *may* have cancer implications. Meyer, not content with waiting for the results of the study, proceeded to drive home his point, saying Wells's work is a "direct application of irreducible complexity and design".

Paul Nelson answered next. He agreed with Wells, accepting that scientists want to see results and "new knowledge". Meyer followed by taking issue with Nelson and Wells. He stated that ID does not need to lead to new knowledge and it is already fruitful. Then he mentioned recent studies that suggest "Darwinism has been unfruitful". He moved on to assert that ID is attracting a following and implied that it is only the entrenched majority that is denying "intelligent design" its due. This will come, he suggested, as a result of retirement and turnover in academia.

Behe lined up with Meyer. "It's nice to make a prediction," he said, but the "question is: 'Does this idea explain what we see?'" Judging from the alternative he offers, Behe apparently does not feel the idea must "explain what we see" in an empirically testable fashion. After this, Bloom invited the audience to give the critics (who were offered no chance to comment on the last question) a standing ovation. "They took a lot of heat," Bloom acknowledged, and the proceedings closed with applause.

### I went to a cookout…

Let me emphasize that there was much more discussion than could be captured in this short note, but I have tried to concentrate on those moments when questions got asked and answers were attempted. As I tally it, critics asked ten significant questions, including Bloom's softball at the end. The responses to those ten questions included three half-answers (Q2, Q4, and Q10), three evasions (Q1, Q6, Q7), three ignored questions (Q3, Q8, Q9), and one (Q5) answered with a question (though reverse questions also played a part in other responses). Much of the time was spent in digression into matters of dubious relevance.

### …and all I got was this bun

The tiny, hopeful part of me that thought, "maybe this time it'll be different" took a severe thrashing once again. My sardonic side, however, was pretty puffed up after this was over. Most of my pessimistic predictions were fulfilled, though familiarity with the history of these events would have led anyone else to the same sad expectations. There was nothing new to be heard this night. In fact, looking back on how few of the questions actually got answered and the form the responses took, it is hard to conclude that there is any acceptance on the part of the ID spokesmen that the "tough questions" even exist. They were either dodged, dismissed, or met with other questions.

One problem with the evening was that the encounter took place in front of an ID-sympathetic crowd. It is hard not to be cynical about the motives for this event when so much of the time ostensibly intended for answering "tough questions" was instead spent reading from the playbook and pumping up the home fans. But the biggest drawback was the clear lack of fortitude on the part of "ID's Top Proponents" to engage the inquiry they invited. The critics, especially Hofmann, Weber, and Craig M Nelson, tried to press them in some cases, but there was no mechanism for detailed examination such as was available in the trial in Dover. Thus, the advertised purpose of the event was swamped by a tide of tired complaints about persecution, repetition of stock talking points, and pronounced public-relations efforts to rally the faithful. It was a sharp portrait of "intelligent design" as a movement with few guiding principles other than the desire to continue to hang onto political market share. Though slowed by the events in Dover, it is clear that the ID machine is still rolling, if with no more scientific direction than before.

### References


Bridgham JT, Carroll SB, Thornton JW. 2006. Evolution of hormone-receptor complexity by molecular exploitation. *Science* 312: 97–101.

Camp R. 2005. Do biology textbooks pit evolution against theism? —A response to Jonathan Wells. Available on-line at <http://litcandle.blogspot.com/2005/06/do-biology-textbooks-pit-evolution.html>. Last accessed July 25, 2006.

Meyer SC. 2004. Intelligent design: The origin of biological information and the higher taxonomic categories. *Proceedings of the Biological Society of Washington* 117 (2): 213–39.

Williams G. 1992. *Natural Selection: Domains, Levels, and Challenges.* Oxford: Oxford University Press.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# "Critical analysis" defeated in Ohio

*Glenn Branch*
*NCSE Deputy Director*

The Ohio Board of Education voted 11–4 at its February 14, 2006, meeting to remove both the "Critical Analysis of Evolution" model lesson plan and the corresponding indicator — which called for students to be able to "describe how scientists continue to investigate and critically analyze aspects of evolutionary theory" — in the state standards. Board member Martha Wise, who spearheaded the drive to eliminate the anti-evolution material, told the *Cleveland Plain Dealer* (2006 Feb 15), "I'm ecstatic ... It's a win for science, a win for students and a win for the state of Ohio."

### The genesis of "critical analysis"

The "Critical Analysis of Evolution" lesson plan corresponds to a similarly controversial indicator in the Ohio state science standards, which called for students to be able to "describe how scientists continue to investigate and critically analyze aspects of evolutionary theory." When the indicator was introduced, it was widely feared that it would provide a pretext for the introduction of creationist misrepresentations of evolution. The lesson plan proved these fears to be justified. As originally submitted, entitled "The

## ID's "toughest critics"?

At the end of the event at Biola, John Bloom, the evening's moderator, asked the audience to give the critics — Antony Flew, Keith Morrison, Charlotte Laws, Bruce Weber, Jim Hofmann, Craig M Nelson, and Larry Herber — a standing ovation, remarking, "They took a lot of heat." Bloom was not referring to the night's intellectual exchanges, but to the response to the invitation from the scientific community. Because they assumed that this event likely would not serve its advertised purpose, many critics declined the invitation to sit on the panel. Those who did accept received some mild criticism for (a) agreeing to dignify the proceedings, (b) not being prominent ID critics, and c) not having the appropriate scientific credentials (Rennie 2006). As one of those asked to join the panel of critics and one of those who declined, I wanted to take a moment to offer my perspective on this issue.

Taken in reverse order, I find (c) above to be unwarranted overreaction. Although the "intelligent design" movement is unquestionably an attack on the foundations of science, the "theory"'s miscalculations lie substantially in how its arguments are formulated, not in the empirical data. Even the most "scientific" of design arguments involves a tedious cataloging of biological complexity that ultimately resolves to arguments from incredulity. Investigating and exposing these problems does not require an advanced degree in science (though it certainly demands a familiarity with the literature).

As for the dearth of more prominent ID critics, there is little doubt that the event would have received more publicity and might have been more intellectually incisive had Eugenie Scott, Ken Miller, and Robert Pennock replaced some of the less informed members of the panel. But the truth is that the many difficulties with ID are well known and understood among the community that engages in the defense of science. It is not necessary or practical to expect these few defenders of science to be present every time the tough questions need to be asked. Local responses to ID can be effective, and, from my perspective, Hofmann, Weber, and Nelson did a good job overall, given the limitations of the setting.

This brings me to (a): Should ID even be engaged in this way? There are those who believe it only helps the "intelligent design" movement to present, as these kinds of events can, an image of scientific equivalence. Others feel that the illogic of ID must be demonstrated, that the spurious arguments should not be left unchallenged. Though I have sympathy for both sides, my refusal to participate in the Biola event makes clear which view I favor. The following are my reasons for taking this position.

I was not satisfied that there would be any real opportunity for pursuit of relevant answers. If an event is to be a pleasant experience for panelists and audience alike, cordiality and respect must be preserved. But, however valuable these qualities are in an intellectual conversation, they work *against* intense scrutiny of individual statements. If there is no mechanism for stopping and evaluating each element of an answer — essentially cross-examination — then responses can be evasive and wandering. I saw no prospect for holding the ID side to its vow to answer the tough questions.

As much as we all try to cut through to the content, it is an unfortunate reality that showmanship influences everyone's perception of expertise and integrity. These encounters often boil down to personality and performance. Most of the top ID advocates have much more experience, and some are quite good, at this sort of thing. Content often becomes secondary to stage presence.

Most important, I regard "intelligent design" as institutionally dishonest. I accept, because it would be presumptuous of me not to, that individual ID proponents may be sincere. But it is clear that there is an inherent corruption in the house of ID that is ignored in deference to the greater mission. That corruption is the overarching religious impetus behind both the movement's theoretical content and its political activities. ID may not be methodologically religious, but it is deliberately methodologically unconstrained so as to directly allow religious inference. "Intelligent design" exists because of, and in service of, the religious motivations of its "theorists" and adherents. And it is an avowed attempt to redefine science such that it is more accommodating of a religious worldview. These realities are not acknowledged by an ID marketing machine that prefers to maintain plausible deniability. It is a thread of duplicity that runs throughout the entire "intelligent design" enterprise and, with no prospect of significant change, will continue to obstruct prospects for progressive discourse.

#### References

Rennie J. 2006. ID rigs its own trial. Available on-line at <http://blog.sciam.com/index.php?p=179&more=1&c=1&tb=1&pb=1#more179>. Last accessed July 25, 2006.

Great Macroevolution Debate", it was riddled with scientific inaccuracies and pedagogical infelicities, and it even explicitly relied on a number of creationist publications.

Facing such criticisms, the proponents of the lesson plan revised it, but only cosmetically — removing the references to creationist publications and eliminating a number of the glaring errors, but leaving intact the basic structure, the choice of topics (which is indebted to Jonathan Wells's notoriously misleading book *Icons of Evolution*), and the overall goal of instilling scientifically unwarranted doubts about evolution. Even as revised, the lesson plan was condemned by the National Academy of Sciences and the Ohio Academy of Sciences, which told Ohio governor Bob Taft (R) that it was "defective because it is not science and has no place in the science curriculum."

Nevertheless, the revision was enough to satisfy a majority of the members of the board. On March 9, 2004, a motion to reject the lesson plan failed by a vote of 10–7, and the whole model curriculum, including the flawed "Critical Analysis of Evolution" lesson plan, was then adopted by a 13–5 vote. Although teachers were not required to use the model curriculum, it was expected to be widely used because it is based on the standards that also provide the basis for statewide testing. Although there was talk shortly after the March 2004 vote of the possibility of a lawsuit over the lesson plan, the public discussion of the plan subsided for a time.

A related controversy surfaced, though, involving a primary author of the lesson plan, Bryan Leonard. In addition to teaching biology at a high school in the Columbus suburb of Hilliard, Leonard was also pursuing a doctoral degree in science education from the Ohio State University. Testifying at the "kangaroo court" hearings on evolution in Kansas in May 2005, Leonard told a subcommittee of the Kansas state board of education, "the way in which I teach evolution in my high school biology class is that I teach the scientific information, or in other words, the scientific interpretations both supporting and challenging macroevolution."

Leonard's testimony in Kansas aroused the curiosity of three OSU professors, who ascertained the topic of Leonard's dissertation: "When students are taught the scientific data both supporting and challenging macroevolution, do they maintain or change their beliefs over time? What empirical, cognitive and/or social factors influence students' beliefs?" They consequently wrote in a letter to the interim dean of the graduate school, "We note a fundamental flaw: There are no valid scientific data challenging macroevolution. Mr Leonard has been misinforming his students if he teaches them otherwise" (quoted in *The Lantern* 2005 Jun 23).

The composition of Leonard's dissertation committee was also disputed. *Inside Higher Ed* (2005 Jun 10) reported, "Under Ohio State rules, two members of Leonard's dissertation committee should have been in the science education division. But the three members of the committee were in the fields of technology education, entomology and nutrition." Two of those three are supporters of the "intelligent design" movement. After the graduate school representative on the committee that was to hear Leonard's defense of his dissertation resigned and was replaced by the Dean of the College of Biological Sciences, the defense was postponed, apparently at the request of Leonard's advisor.

A spokesman for the university was eager to disavow Leonard's dissertation research, telling *Inside Higher Ed*, "It's a mischaracterization to say that the university was about to award a degree supporting 'intelligent design' or anything else. What we had was a dissertation defense scheduled," adding, "The university was not anywhere close to legitimizing anything that was not close to the caliber for which we give doctoral degrees." Nevertheless, the "Critical Analysis of Evolution" lesson plan to which Leonard contributed was still in place, with the board's imprimatur, and it was unclear whether it would be challenged.

### "Critical analysis" challenged

Then, on December 20, 2005, in the neighboring state of Pennsylvania, the decision in *Kitzmiller v Dover* was issued: teaching "intelligent design" in the public schools was found to be unconstitutional. Subsequently, the prospect of a lawsuit over the lesson plan was re-ignited in Ohio. Robin Hovis, a member of the board, told the *Columbus Dispatch* (2006 Jan 8), "I think the ruling is a wake-up call to our board that we are out of compliance, at least in that judge's opinion," adding, "I think it would be very unfortunate of us to subject the state of Ohio to costly litigation."

Adding to the pressure on the board was the revelation that the lesson plan was adopted by the board despite warnings from the Ohio Department of Education, whose experts described it as wrong, misleading, and even manifesting "fringe thinking". A marvelously detailed article in the weekly *Cleveland Free Times* (2006 Jan 31) reported, "at least one unnamed ODE staff scientist debunked all eight arguments Leonard had used to challenge evolution. The scientist's comments run the gamut of 'the challenging answer oversimplifies' to 'the challenging answer is wrong' to 'off-topic' to 'the underlined sentence about transitional fossils is a lie.'"

These warnings about the flaws in the "Critical Analysis of Evolution" lesson plan were contained in documents obtained by Americans United for Separation of Church and State pursuant to a public records act request. Joseph Conn, a spokesman for Americans United, told the *Dispatch* (2006 Jan 8), "We've only gotten part of what we've asked for, but we see much of the same pattern of introducing religion through a backdoor means." Patricia Princehouse, a philosopher and evolutionary biologist at Case Western Reserve University and a leader of Ohio Citizens for Science, added, "The documents demonstrate this board had a religious intent and that board members who said they had no idea this was bad science lied."

The state's major newspapers editorially urged the board to take the opportunity to remove the lesson plan and even the corresponding standard. The *Dispatch*, for example, observed (2006 Jan 10), "It's misleading for the standards to require that Ohio students describe how 'scientists today continue to investigate and critically analyze aspects of evolutionary theory.' The not-so-subtle suggestion is that evolution is on shakier scientific ground than all other theories," and

concluded, "The board should do Ohio children a giant favor and, at the same time, spare taxpayers the risk of costly litigation. Drop this bogus standard and its 'disclaimer'."

At the January 10, 2006, meeting of the board, however, a proposal, introduced by Martha Wise, to remove the lesson plan from the model curriculum was narrowly defeated in a 9–8 vote. The meeting was reportedly acrimonious; the *Dispatch* (2006 Jan 11) reported that after Wise observed that it had been the intention of at least two members to introduce "intelligent design" into the state science standards, her fellow board members Michael Cochran and Deborah Owens-Fink — both firm supporters of the lesson plan — took umbrage. Robin Hovis reminded the board that Owens-Fink had, in fact, introduced a proposal to teach "intelligent design" previously.

The acrimony was not confined to the members of the board. After reviewing videotapes of the meeting, the *Dispatch* (2006 Jan 20) described a number of board members — particularly Cochran and Owens-Fink — as "badgering and berating" the witnesses who testified about the flaws in the lesson plan. At one point, Cochran began to read a newspaper while Brian McEnnis, a professor of mathematics at the Ohio State University, was speaking; when McEnnis remonstrated, Cochran interrupted both McEnnis and then the president of the board when she sought to intervene. Interviewed by a *Dispatch* reporter, Cochran and Owens-Fink offered no apology (although they reportedly did later, at the February board meeting).

Both the vote to retain the lesson plan and the behavior of the board members who supported it received criticism from the state's newspapers. The *Toledo Blade*'s editorial (2006 Jan 14) was especially outspoken, describing the nine board members who voted in favor of the lesson plan as "right-wing ideologues" and the board as a whole as "a painful carbuncle on the posterior of state government." The *Dispatch* (2006 Jan 15) noted that "[r]egardless of how board members cast their votes, they owe the people who come before them their attention and respect" and recommended that voters bear it in mind at the next election.

## The demise of "critical analysis"

During the January meeting, Cochran tried to defend the lesson plan by referring to the grade of B that Ohio's science standards recently received in a report conducted by the Fordham Foundation, as if to imply that the authors of the report approved of the lesson plan as well. In response, the authors, led by the eminent biologist Paul R Gross, issued a statement reading, in part, "Any suggestion that our 'B' grade for Ohio's standards endorses sham critiques of evolution, as offered by creationists, is false. ... If creationism-driven arguments become an authorized extension of Ohio's K–12 science standards, then the standards will deserve a failing grade."

The furor over the meeting evidently sparked the interest of Governor Taft, who told the *Dispatch* (2006 Feb 3) that there should be a legal review of the lesson plan to ensure that the state is not vulnerable to a lawsuit. "The governor also said he should have asked his previous appointees to the State Board of Education more questions about their position on the controversial issue and that he will be asking about it before making future appointments," the *Dispatch* also reported. Eight of the seats on the board of education are appointed by the governor, and four of these are due to be vacant at the end of the year; Governor Taft's term expires in 2007.

Meanwhile, in a letter addressed to Governor Taft dated February 7, 2006, a large majority (75%) of the members of the Science Content Standards Advisory Committee, which helped to develop the Ohio state science standards in 2002, protested the "Critical Analysis of Evolution" lesson plan, describing it as "a pointed attempt to insert old and discredited creationist content in Ohio's science classrooms," "wholly without merit," and "a disservice to Ohio's children and an insult to the intelligence of its good citizens".

A further hopeful sign, in addition to the remarks of Governor Taft and the letter from the members of the advisory committee, was that one of the two members of the board who were absent from the January 10 meeting, Virgil Brown, told the *Dispatch* (2006 Jan 12) that he was ready to "withdraw or amend" the "Critical Analysis of Evolution" lesson plan, encouraging defenders of evolution education in the Buckeye State. Although consideration of the lesson plan was not on the agenda for the next meeting, it was clear that pressure was mounting on the board to take action.

At the February meeting of the board, Colleen Grady presented a proposal, seconded by Carl Wick, for the board to ask the state attorney general to conduct a legal analysis of the standards and the lesson plan. Martha Wise then introduced a motion, seconded by Robin Hovis, to amend Grady's proposal by substituting her own, which called for the removal of both the "Critical Analysis of Evolution" model lesson plan and the corresponding indicator in the state standards. Wise's proposal included a provision to reinstate the Ohio Academy of Science's definition of science in the standards; Eric Okerson introduced a motion, seconded by Sam Schloemer, which substituted a charge to the board's Achievement Committee to consider whether to replace the removed lesson plan and indicator.

After a protracted discussion, the president of the school board called for a vote. First the Okerson amendment was approved by a vote of 14–1, with only Deborah Owens-Fink opposed, and then the Wise amendment to the Grady proposal was approved by a vote of 11–4, with Grady, Owens-Fink, Cochran, and Sue Westendorf opposed. The Grady proposal as amended (see sidebar, p 10) was then approved by a vote of 11–4, with Grady, Owens-Fink, Cochran, and Westendorf again opposed. Voting for the removal were Lou Ann Harrold, Martha W Wise, GR "Sam" Schloemer, Virgil E Brown Jr, Jim Craig, Jennifer Stewart, Jane Sonenshein, Robin C Hovis, Stephen M Millett, Eric C Okerson, and Carl Wick; absent from the meeting were John W Griffin, Richard Baker, Emerson J Ross Jr, and Jennifer L Sheets. (Minutes of the meeting are available on-line at <http://www.ode.state.oh.us/board/meetings/february06/minutes.asp>.)

## Reactions and prospects

Anti-evolutionism was no longer enshrined in Ohio's public education system, and groups that con-

## Resolution of the Ohio Board of Education

RESOLVED, That the Superintendent of Public Instruction be, and she hereby is, directed to take the following actions immediately:

Delete the model lesson plan, "Critical Analysis of Evolution," from the State-Board-approved curriculum and remove its availability from print sources, technology sources, and any other State Board of Education/Ohio Department of Education mechanism that makes it available for use.

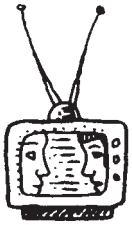
Delete the following sentences from the Grade 10 Life Science Benchmark H:

> "Describe how scientists continue to investigate and critically analyze aspects of evolutionary theory. (The intent of this benchmark does not mandate the teaching or testing of intelligent design.)"

and delete Indicator 23 in its entirety, and adjust all print sources, technology sources, and any other State Board of Education/Ohio Department of Education documents to reflect the removal.

The Achievement Committee of the State Board of Education is charged to consider whether the deleted model lesson, Benchmark H, and Indicator 23 should be replaced by a different model lesson, benchmark and indicator, and if so, to present any recommendation to the entire State Board for adoption.

Communicate the fact of the above actions to all public school superintendents and high school principals in Ohio.



tributed to the victory were gratified. Foremost among them was Ohio Citizens for Science, which commented in a press release, "The Directors and members of Ohio Citizens for Science applaud the Ohio State Board of Education for removing the creationist material from the State Standards and Model Curriculum. We are pleased that Members of the Board have affirmed the importance of honest science education in Ohio public schools, and we stand ready to assist the Board however we can in advancing that effort."

Additionally, NCSE's executive director Eugenie C Scott described the vote as "a stunning triumph for the students of Ohio's public schools and a stunning repudiation of the all-too-successful attempts of creationists to undermine evolution education in the Buckeye State. Let's hope that all such attempts to introduce creationism by the back door meet the same fate." The Reverend Barry Lynn of Americans United for Separation of Church and State similarly commented, "This is a great victory for Ohio public school students."

The state's newspapers also hailed the vote editorially. The *Cincinnati Enquirer* (2006 Feb 18) described it as "a wise, pragmatic move that could save Ohio money from lawsuits, save schools from the distraction this debate has brought, and preserve students' best interests in receiving a sound scientific education," and the *Toledo Blade* (2006 Feb 20) argued that "Ohio school children owe a majority of members on the Ohio Board of Education their gratitude. By a vote of 11–4, board members eliminated a disputed evolution lesson plan, that, like the barred Pennsylvania plan, was really religion masquerading as science."

Patricia Princehouse told the *Chicago Tribune* (2006 Feb 15) that although the anti-evolution materials would be removed immediately, Ohio Citizens for Science plans to monitor board meetings to ensure that the material is not reintroduced in a new form. "The one thing we learned about creationists," she explained to the *Tribune*, "is that they never give up." That was a sentiment echoed by the *Columbus Dispatch* (2006 Feb 23), which observed, "Ohio is not out of the woods yet," warning, "Intelligent-design supporters surely will be back to take another shot at evolution."

The board's Achievement Committee was charged with the task of deciding whether it is necessary to provide a replacement for the controversial indicator in the state standards. The *Dispatch* (2006 Feb 20), noting that it was the same committee that approved the controversial indicator in the first place, quipped, "Meet the new committee, same as the old committee." Commenting that on the committee "opinions differ, with both sides accusing the other of being motivated more by politics than science," the Associated Press (2006 Feb 22) concluded, "The debate is likely to take months."

Meanwhile, Steve Rissing, a professor of biology at Ohio State University, prepared a lesson plan on speciation, to illustrate how "current areas of active inquiry and discussion in biology can be presented with grade-appropriate rigor in a pedagogically effective manner." The lesson plan (which is available on-line at Ohio Citizens for Science's website <http://www.ohioscience.org>) presents the current controversy over sympatric speciation, referring in the process to the evolutionary biology of two pests (apple maggot fly and corn root worm) that damage Ohio agriculture.

The broader significance of the board's vote was in its repudiation of the strategy of undermining evolution education by calling for the "critical analysis" of evolution. Although the language of the indicator calling for students to be able to "describe how scientists continue to investigate and critically analyze aspects of evolutionary theory" was innocuous on its face, it was twisted in the service of the creationist agenda. Not only was the "Critical Analysis of Evolution" lesson plan developed under the aegis of the indicator, but it also proved to be grist for the creationist propaganda mill, which constantly claimed that Ohio was in the vanguard of a movement to challenge evolution in the public schools. (For a discussion of such claims with respect to New Mexico and elsewhere, see *RNCSE* 2005 May–Aug; 25 [3–4]: 4–8.)

Will the creationists who have cited Ohio's embrace of "critical analysis" as precedent for their own efforts elsewhere now follow

Ohio's lead in repudiating it? It is unlikely: the board's vote was characterized by representatives of the Discovery Institute as "an outrageous slap in the face" and as a triumph of "censorship" (United Press International 2006 Feb 15; *Cincinnati Enquirer* 2006 Feb 15), rather than as a necessary corrective. But certainly it is open to the defenders of the integrity of science education across the country to applaud the Ohio board of education's repudiation of "critical analysis" and to recommend that policymakers elsewhere emulate it. NCSE will be there to help them to do so.

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**Ohio Citizens for Science's** website <http://www.ohioscience.org> provides further details on the Ohio Board of Education's historic vote, including the full text of the motion that was approved, MP3 audio files of the board's deliberations preceding the vote, a listing of how the various members of the board voted, and a detailed explanation of "the circuitous route to approval" that the motion took. The website also contains (under "Lesson Plans") detailed descriptions of the scientific and pedagogical flaws of the "Critical Analysis of Evolution" lesson plan that was repudiated by the board's vote.

# Conservative Ohio Values Led to Change in Evolution Policy

*Martha Wise*

I believe in God the creator. I believe in freedom. I believe in America, and the state of Ohio, and the Republican Party, fiscal conservatism, fairness, and honesty.

These values guided me last week to lead the Ohio Board of Education to remove creationism from our state's Science Standards and Model Curriculum.

You may ask: Why would being a creationist make me want to remove "critical analysis"/"intelligent design" creationism from the standards? It's simple, really:

> It is deeply unfair to the children of this state to mislead them about the nature of science.

The future of Ohio's prosperity depends on a well-educated workforce that understands science. The future of religious freedom in this country depends on the electorate understanding that modern science is not a threat to faith. Atheists who say science disproves God are misrepresenting science just as badly as the most disingenuous "creation-science" peddlers.

Creationism is religion and deserves to be respected as religion, and protected. Creationists do not all believe exactly the same thing. This may be the best-kept secret in the whole creationist movement. So if we were going to teach creationism or other religious concepts in school, how would we decide whose view to teach? How can we be fair to all people of faith? The founding fathers came to the conclusion that the only way to protect religion was for the government to keep its nose out of it. I believe the founding fathers were right.

At last year's "Pennsylvania Panda Trial," Christians, Jews, scientists, and parents convinced the conservative federal judge John Jones that good science is not a red state–blue state issue. The judge ruled that evolution is good science, it's not atheism, it's accepted by many religious people, and that the elected officials who promoted ID repeatedly lied to conceal their true agenda — imposing their own religious view about creation on public school students with diverse religious beliefs. There is no scientific controversy — only a religious one.

Jones said ID and other manufactured controversies are "a mere relabeling of creationism." He said school board officials were lying when they claimed they were attacking evolution so kids can learn "critical thinking".

Until last week, Ohio had its own relabeling program for creationism, using the term "critical analysis" instead of ID. If it had gone to court here in Ohio, some of the evidence would have come from the Freedom of Information Act documents that Ohio Citizens for Science and Americans United for Separation of Church and State collected from the Department of Education. These documents demonstrate:

> At least one backer of "critical analysis" on the board expressed religious motivation.
>
> Evolution was singled out, specifically targeted for disparaging and denigrating treatment. Other sciences were not.
>
> The science lesson writing committee was packed with creationists.

Our board had to decide whether to waste millions of taxpayer dollars to hear a federal judge tell them the same thing Judge Jones told the Dover, Pennsylvania, board. We chose to stand up for kids, for the state of Ohio, for freedom of religion, and for the integrity of science.

The public trusts us to uphold first-class standards and to protect democracy and religious freedom. So we set aside our differences and did the right thing for Ohio and Ohio's children.

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*Martha Wise of Avon, Ohio, is an elected member of the Ohio Board of Education, representing Erie, Huron, Lorain, Lucas, Wood, and parts of Ottawa and Seneca counties. Her term ends in 2006. She is also a Republican candidate for Ohio Senate in the 13th district.*

# UPDATES

**Alabama:** The *Birmingham News* (2006 May 22) asked the four candidates for governor a variety of questions about educational issues, including, "Do you support the teaching of 'intelligent design' in public schools?" Stressing her unwavering belief in a creator, lieutenant governor Lucy Baxley (D) answered that she would not initiate legislation calling for the teaching of "intelligent design" and adding, "I can't think of a situation under which I would personally be supportive of it." Roy Moore (R) — the former chief justice of the Alabama Supreme Court, who was removed from office for defying a federal judge's order to remove a Ten Commandments monument from the state Supreme Court building — answered, "If that's what parents want," and characterized excluding "intelligent design" as "a type of tyranny." Incumbent Bob Riley (R) answered, "It's not that I would mandate teaching of ID. But I would always support the idea that any teacher has the ability and option to talk about alternate philosophy, beliefs and ideas," and rejected the idea that to present the story of Genesis in a biology class is to interject religion in the public schools. Former governor Don Siegelman (D) answered, "I think that religion should not be taught in public school. That should be something that is reserved for parents and preachers and their children." In the June 6, 2006, primary election, Riley defeated Moore with 66% of the vote and Baxley defeated Siegelman with 60% of the vote.

**Alaska, Matanuska-Susitna Borough:** "Intelligent design" surfaced at the November 15, 2005, meeting of the Matanuska-Susitna ("Mat-Su") Borough School Board, according to the *Mat-Su Valley Frontiersman* (2005 Nov 20). First, Kenni Psenak, the school board's student representative, addressed the board on the topic, reporting that the Student Advisory Council adopted a position statement saying, "Intelligent design shall be addressed in the social studies department, if it is addressed at all." Psenak explained that her fellow students concluded that "intelligent design doesn't meet any of the state's science criteria and that it shouldn't be brought forward in the science curriculum." Subsequently, school board member Larry DeVilbiss, who during the last election campaign endorsed the idea of teaching creationism along with evolution (see *RNCSE* 2004 Nov/Dec; 24 [6]: 4–9), asked chief school administrator Bob Doyle what the district's stand on "intelligent design" was. Doyle replied that the district is currently aligning its local curriculum to conform to the new science standards (in which evolution is emphasized thanks to a last-minute campaign; see *RNCSE* 2005 Jan–Apr; 25 [1–2]: 12–16); proposals to expand the curriculum beyond what is mandated by the standards can be considered after the alignment is complete.

**California:** The recent lawsuit — *Association of Christian Schools International et al v Roman Stearns et al* — that charges the University of California system with violating the constitutional rights of applicants from Christian schools whose high school coursework is deemed inadequate preparation for college is apparently going to proceed. In what the Associated Press described (2006 Jun 28) as a "tentative ruling," Judge S James Otero stated that he was not inclined to rule in favor of a motion by the university system to dismiss the suit. (For background, see *RNCSE* 2005 May–Aug; 25 [3–4]: 12–13.)

The lawsuit was originally filed in federal district court in Los Angeles on August 25, 2005, on behalf of the Association of Christian Schools International, the Calvary Chapel Christian School in Murrieta, California, and six students at the school (none of whom has, in fact, been refused admission to the University of California). Representing the plaintiffs are Robert H Tyler, a lawyer with a new organization called Advocates for Faith and Freedom, and Wendell R Bird of the Atlanta law firm Bird and Loechl, a former staff attorney for the Institute for Creation Research.

The plaintiffs object, among other things, to the university system's policy of rejecting high school biology courses that use textbooks published by Bob Jones University Press and A Beka Books as "inconsistent with the viewpoints and knowledge generally accepted in the scientific community." The policy, they allege, infringes on their rights to "freedom of speech, freedom from viewpoint discrimination, freedom of religion and association, freedom from arbitrary discretion, equal protection of the laws, and freedom from hostility toward religion."

During the hearing, Judge Otero reportedly expressed concern that Calvary was the only school to be a party to the lawsuit, observing that Catholic, Jewish, and Islamic schools "seem to have students move through the system with no problem." Afterwards, however, Tyler told the *Riverside Press-Enterprise* (2006 Jul 27), "Based upon today's hearing, we're optimistic that the religious liberty concerns of this lawsuit will go forward to a full trial."A written ruling on the defendants' motion to dismiss the case is expected from Otero, although he did not indicate when he would issue it.

**Florida:** *Biology: The Dynamics of Life*, a high school textbook published by Glencoe, a subsidiary of McGraw-Hill, was in the news throughout Florida, due to concerns about a passage alluding to creationism:

> Common to human cultures throughout history is the idea that life on Earth did not arise spontaneously. Many of the world's major religions teach that life was created on Earth by a supreme being. The followers of these religions believe that life could only have arisen through the direct action of a divine force.

> A variation of this belief is that organisms are too complex to have developed only by evolution. Instead, some people believe that the complex structures and processes of life could not have formed without some guiding intelligence.

First, in **Palm Beach County**, the Palm Beach County School District decided not to adopt the textbook; Palm Beach County School Board member Paulette Burdick told the Fort Lauderdale *Sun-Sentinel* (2005 Nov 23) that the district will not use any book that discusses "intelligent design". A Glencoe representative told the *Sun-Sentinel* that it was not intending to promote a religious point of view; rather, the passage "presents teachers with an option to have their students apply [critical thinking] skills to other viewpoints regarding origins of life."

Then a similar controversy arose in **Broward County**, home to the nation's fifth largest school district. NCSE's deputy director Glenn Branch told the *Miami Herald* (2005 Dec 3) that *Biology: The Dynamics of Life* was a far cry from the "intelligent design" textbook *Of Pandas and People*: "This book is not presenting creationism in any form as a scientifically credible view. ...The people in Broward County who are worried or entranced by the possibility [*Biology: The Dynamics of Life*] is presenting intelligent design or creationism are, I think, mistaken." Nevertheless, the *Herald* editorially opined (2005 Dec 5), "This is a bow to the controversy stirred up by supporters of intelligent design who want their beliefs taught in science courses" and urged the Broward County School District not to adopt the book. Subsequently, Glencoe offered to produce a version of the book without the offending passage, but in the end, a committee of biology teachers in the district decided to adopt the Florida edition of *Holt Biology* instead. (The Fort Lauderdale *Sun-Sentinel* noted [2005 Dec 9], however, that both textbooks were somewhat revised in reaction to creationist pressure during the 2003 round of textbook adoptions in Texas; see *RNCSE* 2003 Sep–Dec: 23 [5–6]: 4–7.) A spokesperson for the school district told the *Miami Herald* (2006 Feb 26) that the passage alluding to creationism played no role in the committee's decision: "It was selected because of the science in the book. ...They have a number of criteria. It has to do with the layout, the look, the way it's written, the photography." Likewise, *Biology: The Dynamics of Life* was not adopted in **Hillsborough County** and **Pinellas County**, but the offending passage was reportedly not a factor in the book's rejection (see, respectively, *Tampa Tribune* 2006 Jan 9 and *St Petersburg Times* 2006 Feb 8).

Finally, in **Brevard County**, on February 28, 2006, a committee of teachers and parents unanimously recommended that the Brevard County public schools adopt a version of *Biology: The Dynamics of Life* from which the passage alluding to creationism was deleted. "I don't think anyone really objected to the statement, but I don't think they thought it really belonged in a science textbook," Ginger Davis, the district's secondary science resource teacher, told *Florida Today* (2006 Mar 5). A member of the school board, Amy Kneessy, subsequently urged that the district adopt the book complete with the passage; *Florida Today* (2006 Mar 12) reported, "She thinks the passages in question simply provide cultural context, integrating social studies and science without promoting alternatives to evolution." Nevertheless, on March 14, 2006, the Brevard County school board adopted the version of the book without the passage by a 4–1 vote.

**Kansas:** The newest platform of the Republican Party of Kansas, adopted on January 28, 2006, declares, "Kansas students should be allowed and encouraged to fully discuss and critique all science-based theories for the origin of life in science curricula" (see <http://www.ksgop.org/images/ks/AdoptedPlatform.pdf>). In the context of the state's ongoing battle over the place of evolution in the state science standards, it is clear that the platform in effect endorses the version of the standards adopted by the state board of education in November 2005 and condemned by the Kansas Association of Science Teachers, the National Science Teachers' Association, the National Academy of Sciences, the American Association for the Advancement of Science, and the committee that wrote the original standards. The Republican parties of Alaska, Oklahoma, Oregon, South Dakota and Texas call for teaching creation science and/or "intelligent design" along with evolution; the Republican parties of Iowa, Minnesota, and Missouri call for referring the decision whether to teach such "alternatives" to local school districts. No state political party, whether Democratic or Republican, specifically endorses evolution education. (For details on South Dakota, see below; for details on other states, see *RNCSE* 2004 Nov/Dec; 24 [6]: 4–9.)

**Kansas:** With the results of the August 1, 2006, primary election in Kansas, the pendulum swung in favor of the integrity of evolution education. In November 2005, the state board of education voted 6–4 to adopt a set of state science standards that were rewritten, under the tutelage of local "intelligent design" activists, to impugn the scientific status of evolution. Now, no matter who wins in the November 2006 general election, two of the members of the board who voted for the standards will be replaced by two new members who have condemned them.

In District 1, incumbent Janet Waugh, a supporter of evolution education, handily defeated her antievolution challenger Jesse L Hall in the Democratic primary.

In District 3, antievolution incumbent John W Bacon prevailed over challengers Harry E McDonald III and David A Oliphant in the

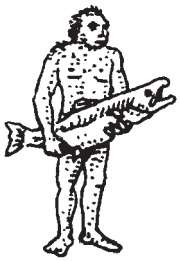
Republican primary, and will face Don Weiss, a supporter of evolution education, in November.

In District 5, Sally Cauble, a supporter of evolution education, defeated antievolution incumbent Connie Morris in the Republican primary, and will face Tim Cruz, a supporter of evolution education, in November.

In District 7, antievolution incumbent Ken Willard prevailed over challengers Donna Viola and MT Liggett in the Republican primary, and will face Jack Wempe, a supporter of evolution education, in November.

In District 9, where antievolution incumbent Iris Van Meter was not seeking re-election, Jana Shaver, a supporter of evolution education, defeated antievolution candidate Brad Patzer, Van Meter's son-in-law, in the Republican primary, and will face Kent Runyan, a supporter of evolution education, in November.

The races attracted national attention, with *The New York Times* (2006 Aug 1) observing, "God and Charles Darwin are not on the primary ballot in Kansas on Tuesday, but once again a contentious schools election has religion and science at odds in a state that has restaged a three-quarter-century batle over the teaching of evolution," and the Associated Press (2006 Aug 1) describing the primary as "the latest skirmish in a seesawing battle between faith and science that has opened Kansas up to international ridicule." Both the Kansas-based Intelligent Design Network and the Discovery Institute engaged in massive publicity campaigns in Kansas prior to the election, putatively in defense of the standards themselves. Details in a future issue of *RNCSE*.



**Michigan:** Michigan's House Bill 5251 passed the House Education Committee by a vote of 15–2 on June 28, 2006, according to a report in the *Saginaw News* (2006 Jun 29). The bill originally called for the state board of education to revise the state science standards to ensure that students will be able to "(a) use the scientific method to critically evaluate scientific theories including, but not limited to, the theories of global warming and evolution [and] (b) Use relevant scientific data to assess the validity of those theories and to formulate arguments for or against those theories," but the references to global warming and evolution were reportedly removed in committee. HB 5251 then proceeded to the House for its second reading.

The primary sponsor of HB 5251, Representative John Moolenaar (R–District 98), denied that permitting the teaching of "intelligent design" was the point of the bill. Yet Moolenaar was a cosponsor of explicit anti-evolution legislation in Michigan in the previous (2003–2004) legislative session: HB 4946, which would have amended the state science standards to refer to "the theory that life is the result of the purposeful, intelligent design of a Creator," and HB 5005, which would have allowed the teaching of "the design hypothesis as an explanation for the origin and diversity of life" in public school science classes. These bills, as well as HB 5251, were denounced by the Michigan Science Teachers Association. (For background, see *RNCSE* 2005 May–Aug; 25 [3–4]: 15–17.)

There was concern that the bill, if enacted, would encourage a threatened lawsuit against the Gull Lake School District, which in June 2005 instructed two middle school science teachers who were using *Of Pandas and People* and other creationist material in their science classes to desist. (For background, see *RNCSE* 2005 May–Aug; 25 [3–4]: 15–17.) That decision prompted the Thomas More Law Center, which subsequently unsuccessfully represented the defendants in *Kitzmiller v Dover*, to threaten to sue. A lawyer for the school district said that the original version of HB 5251 "essentially would provide a legal basis for [the] Thomas More Center to follow through on the threat to sue for not teaching intelligent design," adding that the bill mirrored the "intelligent design" movement's "teach the controversy" slogan.

**Minnesota, Bemidji:** The Board of Education of School District 31 in Bemidji, Minnesota, considered a proposal to weaken evolution education at its June 19, 2006, meeting. Although the key proponent of "intelligent design" on the school board, Mona Carter, was absent, the board heard testimony from a local lawyer, a local pastor, and a middle-school teacher in support of including ID — or one of its euphemisms, such as "teach the controversy" — in the curriculum. One supporter of ID expressed concern that students who "believed in" ID would be ridiculed if the school district had an evolution-only curriculum. NCSE member Evan Hazard was joined in his rebuttal of the ID proposal by the head of the science department at Bemidji High School. At the end of what Hazard called "a tense evening," the board voted unanimously against adopting the proposal by agreeing to adhere to the Minnesota science education standards. The minutes of the June 19 meeting have not yet been posted on the SD 31 website. [*Thanks to Evan Hazard, both for monitoring the situation and providing NCSE with details of the meeting.*]

**Missouri, Potosi:** On May 8, 2006, a creationist spoke in two public schools in Potosi, a town of about 2700 in southeastern Missouri, despite warnings from Americans United for Separation of Church and State. Mike Riddle, formerly a staffer at the Institute for Creation Research and now a speaker for Answers in Genesis, was invited to speak at Potosi High School, in part because he was also speaking at nearby churches. The *St Louis Post-Dispatch* reported (2006 May 8), "Randy Davis, superintendent for the Potosi R-III School District, said Riddle's background as a trained mathematician and former public high school teacher with a graduate degree in education helped convince the district that he was an appropriate guest for the science classes." Davis also said that after reviewing Riddle's presentation, he concluded, "This is simply a factual discussion of science. ... It is not religion-based."

In a May 5 letter to school officials, Richard Katskee of Americans United wrote, "We write to inform you that the scheduled assembly and classroom presentations cannot lawfully be presented in the public schools and that allowing them to occur would be a substantial constitutional violation. ... Simply put, public schools may not

lawfully seek to debunk evolution for religious ends, nor may they teach religious views of the origins of life. The May 8 assembly and classroom presentations by Answers in Genesis will do both." Riddle was nevertheless allowed to speak both at Potosi High School and John A Evans Middle School. In his presentations — which were closely monitored by teachers, administrators, and concerned citizens — Riddle was careful not to espouse creationism explicitly; the *Post-Dispatch* reported (2006 May 13), "During an hour-long presentation, Riddle never said the words 'Jesus' or 'God' or even 'religion.'"

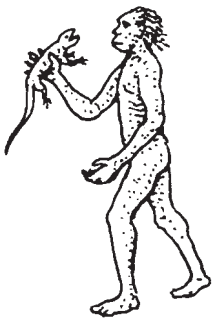
Concerns about Riddle's presentations linger. The *Post-Dispatch* editorially commented (2006 May 9), "Mr Riddle is a doubt-peddler. The whole thrust of his work is to convince the unsophisticated that evolution is a theory in crisis, collapsing under its own weight. ... By allowing Mr Riddle to address science students during science classes, Mr Davis is sending the message that there's something especially untrustworthy about evolutionary theory." NCSE's deputy director Glenn Branch told the newspaper (2006 May 13), "Some kids and their parents probably attended Riddle's presentations the day before at church. ... Then they see him at their school the next morning and the thought process is, 'my school approves of him and so must approve of what he said in church on Sunday.'" And Americans United filed a public records request for all documents involved in the planning of the event.

The good news is that such presentations are apparently infrequent. Riddle told the *Post-Dispatch* (2006 May 8) that it was rare for him to speak in a public school: "We don't get invited in very often." And the *Post-Dispatch* reported later (2006 May 13), "Answers in Genesis said since its founding 12 years ago, it had been invited into a public school only five times."

**Nevada:** The proposed voter initiative to amend the Nevada constitution to require the teaching of the "strengths and weaknesses" of evolution is dead, after its petition failed to garner enough signatures for the initiative to qualify for the 2006 ballot by the June 20, 2006, deadline. The "Truth in Science" initiative called for students to be told that "although most scientists agree that Darwin's theory of evolution is well supported, a small minority of scientists do not agree," and listed five specific "areas of disagreement" to be discussed: the origin of life, the complexity of DNA, the existence of "complex biological systems," the absence of any "transitional specie" (*sic*) in the fossil record, and the origin of sexual reproduction ("or sex drive"). The author of the petition, Las Vegas masonry contractor Steve Brown, told the *Las Vegas Sun* (June 20, 2006) that he did not think that it would have passed even if it had been included on the ballot. For background, see *RNCSE* 2006 Jan–Apr; 26 (1–2): 4–11.

**New York:** When the New York State Assembly's legislative session ended on June 23, 2006, Assembly Bill 8036 died in committee. If enacted, the bill would have required that "all pupils in grades kindergarten through twelve in all public schools in the state ... receive instruction in all aspects of the controversy surrounding evolution and the origins of man." A later provision specified that such instruction would include information about "intelligent design and information effectively challenging the theory of evolution." The bill was never expected to succeed; its sponsor, Assemblyman Daniel L Hooker (R–District 127), was reported as explaining that his intention was more to spark discussion than to pass the bill, and as acknowledging that the bill was "religion-based." Moreover, Hooker is not planning on seeking a third term in the Assembly due to his military commitments: he is expected to be on active duty with the Marine Corps until at least early 2007. For background, see *RNCSE* 2006 Jan–Apr; 26 (1–2): 4–11.

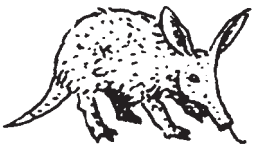
**New York, New York:** In a commencement address at Johns Hopkins School of Medicine in Baltimore on May 25, 2006, New York City's mayor Michael R Bloomberg (R) decried the political manipulation of science to further ideological ends, saying, "Today, we are seeing hundreds of years of scientific discovery being challenged by people who simply disregard facts that don't happen to agree with their agenda. ... Some call it pseudoscience, others call it faith-based science, but when you notice where this negligence tends to take place, you might as well call it 'political science.'" In that context, Bloomberg deplored ongoing controversies over evolution education in Kansas, Mississippi, and elsewhere: "It boggles the mind that nearly two centuries after Darwin, and 80 years after John Scopes was put on trial, the country is still debating the validity of evolution," adding, "This not only devalues science, it cheapens theology. As well as condemning these students to an inferior education, it ultimately hurts their professional opportunities." "Intelligent design," he said, "is really just creationism by another name." NCSE's deputy director Glenn Branch commended Bloomberg for his defense of the teaching of evolution, telling the *New York Sun* (May 26, 2006), "It's not as though he's flying in the face of the established scientific consensus ... Bloomberg's view is at one with the National Academy of Sciences, which is the nation's most prestigious scientific organization. It is also [at] one with the American Association for the Advancement of Science, with the Royal Society of London, and with dozens of other major scientific organizations."



**Oklahoma:** No fewer than four anti-evolution bills were introduced in the Oklahoma legislature in 2006: HB 2107 (encouraging the presentation of "the full range of scientific views" with regard to "biological or chemical origins of life"), HB 2526 (authorizing school districts to teach "intelligent design"), SB 1959 (encouraging the presentation of "the full range of scientific views"), and HCR 1043 (encouraging the state board of education and local school boards to ensure that students are able to "critically evaluate scientific theories including, but not limited to, the theory of evolution" with regard to "biological or chemical origins of life"). Of the four bills,

HB 2107 was the only one to reach a floor vote: it was passed by the House by a vote of 77–10 on March 2, 2006. With the adjournment sine die of the legislature on May 26, 2006, all four are presumably dead. Oklahomans for Excellence in Science (<http://www.biosurvey.ou.edu/oese/> and its allies were instrumental in organizing resistance to these bills. (For background, see *RNCSE* 2006 Jan–Apr; 26 [1–2]: 4–11.)

**South Dakota:** Among the 2006 resolutions of the South Dakota Republican Party (available on-line at <http://www.southdakotagop.com/gopfacts/2006resolutions.htm>) is a resolution that concerns the place of evolution in science education:



> WHEREAS, education on species origin is a vital aspect in the understanding of nature and the purpose of human life; and,
>
> WHEREAS, evolution is a theory that is taught in public schools as fact and at the exclusion of all other theories; and
>
> WHEREAS, the South Dakota Republican Party believes there are other plausible theories, including creationism;
>
> THEREFORE, BE IT RESOLVED, the South Dakota Republican Party supports efforts to expand beyond evolution the knowledge, scope, and debate in public education on the theories of species origin.

The Republican parties of Alaska, Oklahoma, Oregon, and Texas call for teaching creation science and/or "intelligent design" along with evolution; the Republican party of Kansas calls for allowing and encouraging students "to fully discuss and critique all science-based theories for the origin of life in science curricula"; and the Republican parties of Iowa, Minnesota, and Missouri call for referring the decision whether to teach such "alternatives" to local school districts. No state political party, whether Democratic or Republican, specifically endorses evolution education. (For details on Kansas, see above; for details on other states, see *RNCSE* 2004 Nov/Dec; 24 [6]: 4–9.)

**Virginia, Richmond:** A reference to creationism in a biology textbook divided the biology faculty at Virginia Commonwealth University. *Style Weekly* reported (2006 Jun 7) that adjunct professor Jim Sparks was upset by Sylvia S Mader's textbook *Essentials of Biology* (Boston: McGraw-Hill, 2006), adopted by VCU for use in its introductory biology classes, because "it omits critical chapters in evolutionary theory and is biased toward creationism and intelligent design, which argues life is too complex to have evolved over millions of years solely through Darwin's theory of natural selection and must have come at the direction of a supreme being or a supernatural force." Of particular concern to him was its mention in a sidebar of the Institute for Creation Research, described as advocating that "students be taught an 'intelligent-design theory.'" His colleague Jill Reed told *Style Weekly*, "Mader is not trying to slip in creationism ... Jim's basing his ideas on very weak circumstantial evidence that's not adding up to what he's claiming," and Steve Schafersman of Texas Citizens for Science agreed that the book was not promoting creationism, while also agreeing with Sparks that the absence of the Miller-Urey experiment from the book was odd. Subsequently, the *Richmond Times-Dispatch* reported (2006 Jul 6) that VCU would not be employing Sparks in the fall; Sparks suggested, but the dean of VCU's College of Humanities and Sciences denied, that his complaint about *Essentials of Biology* affected the decision not to hire him again. *Style Weekly* reported (2006 Jul 5) that his complaint provoked a review of the textbook; the biology faculty voted unanimously to use it again in the fall.

**Wisconsin, Oshkosh:** If anyone ever doubted the resilience of creationism in the light of major legal setbacks, recent events in Oshkosh, Wisconsin, should resolve any lingering uncertainties. Sandra Gade, a retired professor of physics at the University of Wisconsin, Oshkosh, launched a petition drive in order to "[d]rop a pebble into the sea of discontent with biological evolution and watch the ripples grow into a tsunami which wipe away the just-so stories and replace them with the truth!" On her website (<http://www.tellall.org>), Gade exhorts the citizens of Oshkosh to sign her petition to include this resolution on the November ballot:

> Be it resolved that when evolution is taught in the Oshkosh public schools, it shall not be taught as fact but rather with pro and con evidence and with an analysis of its testability.

The petition touched off a minor flurry of articles and comments in the pages and on the website of the local newspaper, *The Northwestern.* The response from Barb Herzog, assistant superintendent of curriculum for the Oshkosh Area School District was cold comfort: "Our high school biology teachers and middle grade teachers do address evolution as a theory, as just one theory," she told *The Northwestern* (2006 Jul 18).

Reporter Bethany Warner asked for NCSE's help in reporting the story, and with support from NCSE staff and members in Wisconsin, a response to Gade's claims was compiled and hosted temporarily on the newspaper's website. These responses to the specific claims are now available on-line in PDF form at <http://www.uwm.edu/~ajpetto/Oshkosh_Bgosh.pdf>. The *Northwestern*'s website also maintains a link to <http://www.talkorigins.org> for people interested in more detailed answers to the issues that Gade raised.

At this point, no petition has been presented to the school board. It may be a moot point, however. According to Joe Donovan, Communications Officer at the Wisconsin Department of Public Instruction, "There are no provisions in state law for referenda on curricular issues" (*The Northwestern* 2006 Jul 18). Still, NCSE and allies will watch carefully. [*Thanks to Andrew J Petto for his report.*]

# NCSE NEWS

## News from the Membership

*Glenn Branch, NCSE Deputy Director*

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

On May 10, 2006, **Brian Alters** delivered a lecture on "Evolution and education" in the National Institute of Health's Evolution and Medicine lecture series, presented by the National Institute of General Medical Sciences, the Office of Science Education, and the National Human Genome Research Institute. His lecture is now available on-line at <http://videocast.nih.gov/ram/evmed051006.ram> to view in RealPlayer format. (Other lectures in the series included Rudolf Raff speaking on "Evolution and development," Eric Green speaking on "Evolution and genomics," and Robin Bush speaking on "Evolution and infectious diseases.") Alters is the Tomlinson Chair in Science Education, director of the Tomlinson University Science Education Project, and Sir William Dawson Scholar at McGill University. He is the author of several books, including *Defending Evolution*, co-authored with Sandra M Alters, and *Teaching Biological Evolution in Higher Education*. He testified as an expert witness on science education for the plaintiffs in *Kitzmiller v Dover*. Alters was awarded NCSE's "Friend of Darwin" award in 2005, in which year he also became a member of NCSE's board of directors.

**Philip Appleman** contributed "Darwin's example" to the May/June 2006 issue of *The Humanist*, a meditation on death with Darwin as a model: "Death, Darwin knew, is simply a natural part of a natural process. Death is always out there, waiting: only its timing is in doubt. Eventually we will have played our small part in the great system of nature, and have passed on, leaving the system intact. We are a part of nature, just as tigers or termites are." Distinguished Professor Emeritus in the Department of English at Indiana University, Appleman is the editor of the *Norton Critical Edition of Darwin*, now in its third edition (New York: WW Norton, 2000).

NCSE deputy director **Glenn Branch** reviewed Ronald Kidd's young-adult novel *Monkey Town: The Summer of the Scopes Trial* for *Geotimes* (2006 May; 51 [5]: 48–9). "With its lively dialogue, fast-paced plot, and adroit use of historical detail," he wrote, "*Monkey Town* is a welcome contribution and important read — especially in a time where communities across the country still wrestle with the perceived religious consequences of evolution, and the quality of science education suffers as a result." Of interest in the same issue of *Geotimes* are a letter about Darwin's experience of earthquakes in Chile (6) and Michael Roberts's review of Sandra Herbert's *Charles Darwin, Geologist* (49).

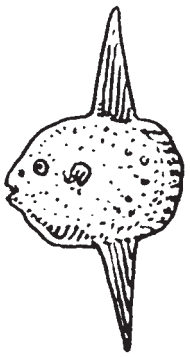
On June 12, 2006, **William T Bridgman** was interviewed by Robert Lippens as part of his "Big Bang and Creationism" podcast forum; the interview is available on-line via <http://lucretius1.blogspot.com/>. Bridgman runs the "Dealing with Creationism in Astronomy" website at <http://homepage.mac.com/cygnusx1/index.html>.

NCSE Supporter **Sean B Carroll**'s book *Endless Forms Most Beautiful* (New York: WW Norton, 2005) was reviewed, along with the second edition of his *From DNA to Diversity* (coauthored with Jennifer K Grenier and Scott Weatherbee; Malden [MA]: Blackwell Scientific, 2005) and Marc W Kirschner and John C Gerhart's *The Plausibility of Life* (New Haven [CT]: Yale University Press, 2005; reviewed by **Andrew J Petto** in *RNCSE* 2005 Sep–Dec; 25 [5–6]: 53–4) in *The New York Review of Books* (2006 May 11; 53 [8]: 12–7) by Israel Rosenfield and Edward Ziff. "We now have a far deeper understanding of evolution than even a decade ago," Rosenfield and Ziff write. "And although our knowledge is still incomplete, our new understanding, as the books under review admirably show, has opened the way toward a comprehensive account of evolution and has supplied solid answers to the critics of evolutionary theory."

**Frederick Crews**'s *Follies of the Wise: Dissenting Essays* (Emeryville [CA]: Shoemaker & Hoard, 2006) was published, containing "The new creationists and their friends" and "Darwin goes to Sunday school" (chapters 14 and 15), which appeared originally in *The New York Review of Books* as "Saving us from Darwin" (2001 Oct 4; 48 [15]: 24–7 and Oct 18; 48 [16]: 51–5). Also included is **Glenn Branch**'s interview of Crews about the reaction to his essay, which appeared originally in *RNCSE* 2002 Nov/Dec; 22 [6]: 27–30. On May 26, 2006, Crews was interviewed about his book by Milt Rosenberg of Chicago's station WGN: the interview is available on-line via <http://wgn radio.com/shows/ex720/audio/index.html#060526>.

Responding to a letter to the editor of the *Lake County Record-Bee* in which churches that support biological evolution were described as evil and immoral, **Robert Derenthal** cited NCSE's Project Steve (now with over 750 Steves) as evidence for the scientific consensus on the standing of evolution. "I am sure that Mr Watkins thinks I am an immoral, evil person," he concluded, "but, shucks, I think I'll still join up with the 'Steves.'" His letter appeared on May 9, 2006.

Following the publication of a profile of Phillip Johnson in the *Sacramento Bee* (2006 May 11), **Chet Dickson** explained in a letter to the editor, "Science doesn't deny the existence of a supernatural; science simply uses verifiable observations of nature as the basis of its explanations." And he noted that in a recent talk by Johnson,



"When asked what Intelligent Design is, Johnson once again failed to provide any scientific evidence. There is none. Instead, he explained that since he feels 'theory S' (for science) is wrong, then 'theory C' (for creator) must be right." Dickson is a science teacher in the Sacramento suburb of Roseville, where he was instrumental in resisting a series of proposals to undermine evolution education.

**John G Hildebrand** received the Outstanding Service Award, presented annually in recognition of individuals' and organizations' noteworthy service to the biological sciences, from the American Institute for Biological Sciences. According to a press release from AIBS dated May 17, 2006, "Hildebrand is Regents Professor and Professor of Neurobiology, Biochemistry & Molecular Biophysics, Entomology, and Molecular & Cellular Biology and Director of the Arizona Research Laboratories Division of Neurobiology at the University of Arizona. He has given service to many professional societies, government agencies, editorial boards, and research laboratory boards, including at the Marine Biological Laboratory in Woods Hole and the Statione Zoologica in Naples. He has received many honors and awards for his energetic and enthusiastic contributions. Most recently, Hildebrand serves as president for the Arizona Arts, Sciences and Technology Academy. This is a new effort to bring the intellectual forces in Arizona together with state leadership, and has already attracted the governor's attention and participation. He is an outstanding teacher and mentor, and is dedicated to producing outstanding research in the neurosciences and behavior while also promoting public understanding of science and its social impacts."

**Mark Isaak**'s *The Counter-Creationism Handbook* is to be published in a paperback edition by the University of California Press in late 2006, thus answering the plea of **Tim Berra**, who in his review of the hardcover edition (*RNCSE* 2005 Sep–Dec; 25 [5–6]: 45–6) wrote, "This is a very good and useful book ... I encourage the publisher to release an inexpensive paperback immediately so teachers and concerned parents can own their own copies and will be willing to present them as gifts to local school members." Also forthcoming from the University of California Press is **Nina G Jablonski**'s *Skin: A Natural History*, which **John Relethford** described as "[a] fascinating and comprehensive account of the biological and cultural aspects of human skin."

*Grand Canyon Yardstick of Geologic Time: A Guide to the Canyon's Geologic History and Origin*, with concept and text by **Allyson Mathis**, was published by and is available from the Grand Canyon Association at 1-800-858-2808 or <http://www.grandcanyon.org>. The GCA writes, "This yardstick places the Grand Canyon's geologic story within the time frame of Earth's history to provide an interesting and informative deep-time perspective. It is designed and written for non-scientists by condensing geologic time into a measurement that is commonly understood. It places the formation of the Grand Canyon into the context of Earth history and explains the five major geologic events that formed the Grand Canyon's three sets of rocks. Printed on durable synthetic stock to withstand heavy use. Folds to a convenient 4.75" x 6.5" so that it can fit easily into a pocket or daypack." The ideal companion to any trip to the Canyon!

NCSE's **Nick Matzke** reviewed NCSE Supporter **Michael Ruse**'s *The Evolution–Creation Struggle* (Cambridge [MA]: Harvard University Press, 2005) for *Free Inquiry* (2006 Jun/Jul; 26 [4]: 59–60). Remarking that "the scientist or science fan who wants to do his intellectual duty and attempt to actually understand where seemingly bizarre phenomena like twenty-first–century creationism come from does not face an easy task," Matzke praised the book for its thorough historical review, although not without chiding Ruse for collaborating with "intelligent design" promoter William Dembski and feuding with **Daniel C Dennett**. He concluded the review by suggesting a future project for Ruse: "looking at other sciences that were once religiously controversial: heliocentrism, atomism, meteorology" and seeing how those controversies were defused.

**Ralph Nielsen** wrote to the editor of the *Lewiston* (Idaho) *Tribune* (2006 Apr 30) to correct a creationist who quoted a "George Wall" from the May 1954 issue of *Scientific American* as saying, "When it comes to the origin of life ... we choose to believe the impossible: that life arose spontaneously by chance." Investigating, Nielsen discovered that "[t]here was no such article. I also looked at the August 1954 issue and found an article by George Wald (not Wall), of Harvard University, who wrote: 'Life, as an orderly natural event on such a planet as ours, was inevitable.'" Nielsen commented, "Fake quotations and outright lies are typical of fanatical creationists. They try to twist biblical stories into scientific facts and pervert scientific research into support for prescientific mythology."

**Kevin Padian**, who serves as the president of NCSE's board of directors as well as a professor of integrative biology at the University of California, Berkeley, and a curator at the University of California Museum of Paleontology, was featured in a recent issue of *Berkeley Science Review* (2006; 10 [1]). The article, "In the matter of Berkeley v Berkeley," focuses on the opposed roles played by Padian, one of the expert scientific witnesses for the plaintiffs in *Kitzmiller v Dover*, and retired Berkeley law professor Phillip Johnson, whose 1991 book *Darwin on Trial* is widely credited with introducing "intelligent design" to the general public. Padian's appearance in the *Kitzmiller* trial is described entertainingly: "Far from being the dry and clinical expert, Padian peppered his day-long testimony with affectionate references to 'critters' and 'guys' and 'Paleozoic roadkill'. All kidding aside, much of Padian's testimony was dedicated to a detailed, point-by-point criticism of *Of Pandas and People*, the intelligent design textbook that was to be made available to Dover students." His frank assessment of the Dover policy was also quoted: "I think it makes people stupid. I

think essentially it makes them ignorant. It confuses them unnecessarily about things that are well understood in science, about which there is no controversy."

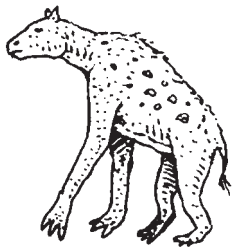
A story about, and photograph of, **Andrew J Petto** appeared on the front page of the *Kenosha News* (2006 Apr 19), after he gave a talk entitled "Teaching evolution: What's not to like?" at Carthage College in Kenosha, Wisconsin, on April 18, 2006. According to the story, Petto's talk somehow "sparked very little religious discussion," perhaps because he said, "Even though there are plenty of scientists out there that I would call evangelical atheists, science has nothing to say about God." Instead, he concentrated on the scientific credibility of evolution — "It is reliable. It works ... It predicts the kind of answers we get" — and the lack of evidence for supposed alternatives such as "intelligent design". Petto, a member of NCSE's board of directors and editor of *Reports of the NCSE*, teaches at the University of Wisconsin, Milwaukee.

**Patricia Princehouse**, a prominent defender of evolution education in Ohio, was among eight people to receive a Hugh M Hefner First Amendment Award from the Playboy Foundation on May 11, 2006. A philosopher of science and evolutionary biologist at Case Western Reserve University, Princehouse was instrumental in founding, organizing, and leading Ohio Citizens for Science, the coalition of scientists, teachers, clergy, and concerned citizens in general that successfully fought to preserve the integrity of science education in Ohio's public schools (see p 7). The award, which includes a $5000 honorarium and a specially designed crystal plaque, honors "individuals who have made significant contributions to protect and enhance First Amendment rights of Americans," according to a Playboy Foundation press release. A transcript of Princehouse's speech "Science and the First Amendment" — delivered as she accepted her award in New York City — was posted on *The Nation*'s website on May 16, 2006 (see <http://www.thenation.com/doc/20060529/princehouse>). In the speech, she asked: "If we allow certain special-interest religious groups to co-opt the public school science classroom, to use it as a vehicle for converting children to religious views their parents don't hold, if we allow them to spout outright lies about the nature and content of science, what do we really have left? If you can lie about science and get away with it, you can lie about anything." And she also offered a forecast of battles to come: "I call it the 'orange is the new pink' strategy; every time the public cottons on to a catch term like 'creation science' or 'intelligent design,' they change to a more neutral-sounding term like 'critical analysis' or 'evidence against.' But defenders of American freedom are learning to stand up and say no, it really is fair to forbid teachers to lie to students, to prohibit school boards from using the power of the state to convert children to other peoples' religions."

NCSE members were prominent in a recent issue of *Skeptic* (12 [2]) featuring a special section on creationism. First, **Jason Rosenhouse** offered a report from the Mega Creation Conference (11–15), commenting, "With the Intelligent Design (ID) proponents sucking up all the anti-evolution oxygen these days, it is easy to forget that the Young-Earth Creationists (YEC) are still around." Second, **Burt Humburg** and **Ed Brayton** described how the trial in *Kitzmiller v Dover* unfolded (44–50), with photographs by NCSE's **Wesley R Elsberry**. Third, **Robert Camp** contributed a piece on the putative comparison of "intelligent design" and the Search for Extra-Terrestrial Intelligence (54–9), concluding that the analogy fails. Also of interest in the same issue of *Skeptic* were a number of letters (16, 21) commenting on previous articles about creationism; Richard Dawkins's essay "The illusion of design" (51–2), reprinted from the November 2005 issue of *Natural History*; David Brin's "The other intelligent design theories" (60–3), arguing that the "intelligent design" movement's appeal to fairness undermines its implicit goal; Tim Callahan's review of Lee Strobel's *The Case for a Creator* (64–6); Charles Lambdin's review of the "intelligent design" film *The Privileged Planet* (71–3); and David Brin's review of Chris Mooney's *The Republican War on Science* (77–9).

**Judy Scotchmoor** received the Education Award from the American Institute for Biological Sciences at the annual gathering of the AIBS Council of Member Societies and Organizations on May 23, 2006. In a press release, AIBS wrote that the Education Award is "presented annually to individuals or groups who have made significant contributions to education in the biological sciences, at any level of formal and informal education." Scotchmoor is Assistant Director for Education and Public Programs at the University of California Museum of Paleontology, Berkeley, where she administers the critically acclaimed Understanding Evolution website (<http://evolution.berkeley.edu>). She is also a director of the California Science Teachers Association and co-chair of the Education Committee of the Society for Vertebrate Paleontology.

NCSE's executive director **Eugenie C Scott** received an honorary degree from Mount Holyoke College on May 28, 2006. Founded in 1837, Mount Holyoke is the nation's oldest continuing institution of higher learning for women. In a letter to Scott, the college's president Joanne V Creighton



## Troll Donates Additional Artwork to NCSE

One of the most charming aspects of *RNCSE* is the artwork donated by Ray Troll that graces the margins and the spaces between articles. Recently, Ray offered to share more of his original work with NCSE, and we were delighted to accept. Look for it in future issues of *RNCSE*! And also look at Ray's website, which features his latest work and schedule of exhibits around the country (<http://www.trollart.com>). One of our favorites is the evolvovision page at <http://trollart.com/evvision.html>.

## "Evolution 101" Podcasts

A good source of short discussions of the basic science behind evolution and its importance both to biology-related fields and to life in general, listen to (or download) topics from this website: <http://www.freethoughtmedia.com/evolution101.ftm>

[*Thanks to Molleen Matsumura and Kim Johnson for alerting NCSE to this resource.*]

wrote, "As science education has been under ideological and political assault in the US, you have defended the separation of church and state and the power of uncompromised scientific inquiry and knowledge. By putting your intellect and passion to work for the greater good, you have exemplified the ideals upon which Mount Holyoke was founded." The honorary degree was Scott's third; she received honorary Doctor of Science degrees from McGill University in 2003 and the Ohio State University in 2005.

NCSE's executive director **Eugenie C Scott**'s "The challenge of intelligent design," originally delivered as the Society of the Study of Evolution's Public Understanding of Evolution lecture at the Evolution 2003 conference held at California State University, Chico, is now available on-line at <http://aics-research.com/lotw/lotw20060508.html>, as the QCShow Author lecture of the week for May 8, 2006. Scott explained, "Proponents of 'intelligent design' have argued that their 'theory' is distinguishable from creation science, yet convergence in philosophy, content, and methodology is apparent," and posed the questions, "Where does the ID movement stand, and what are promoters of good science education to do about it?" The lecture was prepared for its on-line presentation with AICS Research's QCShow Author, an inexpensive authoring tool that translates PowerPoint and Adobe PDF files into high-quality audio and image slideshows at very low bandwidths, which may be displayed with the freely downloadable QCShow Player. Also available in the same format are a number of presentations from the Evolution 2003 and Evolution 2004 conferences (Elizabeth Kellogg, **Susan Epperson**, Michael Sanderson, and Rick Grosberg) and from the Ernst Mayr Centenary event (**Douglas Futuyma**, Andrew Knoll, Axel Meyer, and **Ernst Mayr**): visit <http://aics-research.com/> for details.

NCSE's executive director **Eugenie C Scott**, Georgetown University theologian John F Haught and Michigan State University philosopher **Robert T Pennock** (both of whom testified as expert witnesses for the plaintiffs in *Kitzmiller v Dover*), and philosopher **Michael Ruse**, biologist Joseph Travis, and law professor **Steven Gey**, all from Florida State University, participated in a public forum — "Keeping science and religion separate in schools: The vigil after Dover" — held at Florida State University on May 17, 2006. The Pulitzer-prize–winning science writer Deborah Blum served as the moderator. The event was recorded and is now available on-line at <http://www.research.fsu.edu/dover>. Before the event, Pennock told the *Tallahassee Democrat* (2006 May 15), "The Dover trial really was the test case for intelligent design," and Gey suggested that after *Kitzmiller* policymakers would be less likely to seek to introduce creationism in the classroom: "School boards will be hesitant to go down that road," especially in light of the $1 million bill incurred by the defendants. But Scott warned that even in the absence of explicit anti-evolution policies, "teachers are still very intimidated about teaching evolution," adding, "When parents or school boards look cross-eyed at evolution, the tendency for teachers is just to skip those chapters."

The inaugural issue of the new journal *Museums & Social Issues* (2006; 1 [1]), published by Left Coast Press, was devoted to the topic of museums and the public understanding of evolution, and unsurprisingly NCSE members were represented. **Eugenie C Scott** contributed the introduction (7–8), briefly discussing ways in which museums supplement formal evolution education. **Robert T Pennock** discussed "Scientific integrity and science museums" (9–18), arguing that museums are ethically obliged to regard science itself as a stakeholder in their activities. In "Exhibiting evolution" (21–48), Judy Diamond and **Judy Scotchmoor** discussed the strengths and weaknesses of different approaches to exhibiting evolution in museums. NCSE board member **Robert "Mac" West** reviewed the Explore Evolution exhibit, coordinated by the University of Nebraska, Lincoln, and housed at six museums in the Midwest (120–6), describing it as "well-done, interesting, and temporally extremely important." NCSE Supporter **Richard K Stucky** reviewed **Eugenie C Scott**'s *Evolution vs Creationism* (127–30), praising it as "thorough and provocative ... an excellent sourcebook on the fallacies behind intelligent design and creationism's attempt to pose as a science." And **Gregory Forbes** reviewed *Evolutionary Science and Society: Educating a New Generation*, edited by NCSE Supporter **Joel Cracraft** and **Rodger W Bybee** (131–5): "While *Evolutionary Science and Society* serves as an excellent introduction to the topic of evolution education and evolutionary science," he wrote, "it should also find an appreciative audience in those educators that are knowledgeable about evolution but would like to update their content knowledge base and/or their pedagogical approach to this very important topic." Also of interest in the same issue of *Museums & Social Issues* are Monique Scott and Ellen Giusti's "Designing human evolution exhibitions" (49–68), Amy N Spiegel, E Margaret Evans, Wendy Gram, and Judy Diamond's "Museum visitors' understanding of evolution" (69–86), John Fraser's "Group identity, protest, and evolution exhibits in America" (87–102), Constance Clark's "Ignoring the elephants" (discussing visual images of evolution in the Scopes era; 103–10); Richard Bellon's review of the

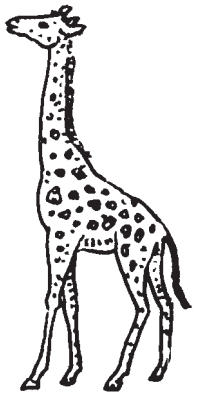
Darwin exhibit at the American Museum of Natural History (111–9); and Johanna Jones's list of "Resources for museums and public understanding of evolution" (137–41).

Prompted by a piece about Islam in the weekly *Toledo City Paper* which quoted several Muslims who rejected evolution, **TO Shanavas** wrote to the editor to remark, "It is important for the community at large to know that Muslim evolutionists exist in Toledo and in its neighboring communities, especially in the context of political maneuvering to teach intelligent design, a camouflaged form of creationism. Personally, I believe that 'intelligent design' or creation stories have no place in science classrooms. If we keep telling our children, whether Muslim or Christian, that the theory of evolution and science are wrong, we are going to raise a generation of Americans who are illiterate in science." His letter appeared in the May 31–June 6, 2006, issue of the paper. Shanavas is the author of *Creation and/or Evolution: An Islamic Perspective* (Philadelphia: Xlibris, 2005).

**Steven D Verhey**'s article "The effect of engaging prior learning on student attitudes toward creationism and evolution" appeared in the November 2005 issue (55 [11]: 2–9) of *BioScience*, published by the American Institute of Biological Sciences. In his article, Verhey reports on a pedagogical experiment in which students in introductory college biology classes were exposed either to literature attacking and defending evolution or (as a control) to literature on the evolution of sex. According to a November 1, 2005, press release from AIBS, "Sixty-one percent of students in the intervention streams reported some change in their beliefs; most of these students were initially sympathetic to creationist explanations and moved toward increased acceptance of evolution." The noted evolution educator **Craig E Nelson** commented in his editorial in the same issue that emulating Verhey's approach "may be difficult in high-school classes in many communities, especially since college science classes have prepared so few of the teachers to do it well, and so few of the parents and politicians to understand and support it. Hence, it would be quite inappropriate to require such comparisons in high school. But it is time for college and university classes to more effectively help future teachers and other leaders understand why there is no contest scientifically between creationism and evolution." A subsequent issue of *BioScience* contained a letter commenting on Verhey's study with a response from Nelson and a correction from Verhey (see *BioScience* 56 [4]: 285–6). Verhey teaches in the Department of Biological Sciences at Central Washington University, and is Steve #289 of NCSE's Project Steve (now with over 750 Steves).

**Jason R Wiles**'s article "The missing link" — detailing the ways in which evolution education is neglected in his home state of Arkansas — appeared as the cover story in the weekly *Arkansas Times* (2006 Mar 23). Relying on both anecdotal and statistical data, Wiles concludes, "evolution is being squeezed out of education systematically and broadly," adding, "The fallout is widespread ignorance of the tools and methods of science for generations to come." Wiles is a PhD candidate in science education at McGill University, where he is also co-manager of the Evolution Education Research Centre. His article originally appeared in *RNCSE* 2005 Jan–Apr; 25 [1–2]; 32–6. Accompanying Wiles's article in the *Arkansas Times* were three letters of support, including one from **Susan Epperson**, the plaintiff in the landmark case *Epperson v Arkansas*. Epperson wrote, "I wanted to say 'thanks' to you for this article about all the difficulty teaching evolution in Arkansas. ... I really feel for these teachers and administrators having to deal with the attitudes of folks who have been taught that scientists are atheists and not to be trusted. A crying shame."

**Wade B Worthen** expounded on "The false choices of intelligent design" in a column he wrote for *The State* (2005 Sep 25), published in Columbia, South Carolina. He wrote, "Proponents of intelligent design have suggested that its exclusion from classrooms is simply another assault on victimized Christians. This is an excellent example of the 'intelligent design' strategy: Use false dichotomies and misinformation to obscure the real issue. Whether it should be taught in public school science curricula should not be about politics or religion. The real issue is this: Is 'intelligent design' a legitimate scientific theory?" His answer, of course, was no: "The premise of 'intelligent design' is that there are natural phenomena that are too complex to explain as a consequence of natural processes. Therefore, a supernatural designer must be invoked to explain these phenomena. True or not, this is not a testable scientific concept, and so deserves no consideration in science class." Worthen, a lifetime member of NCSE, teaches biology at Furman University.



## Dembski on Human Evolution

My focus with evolution tends to be on the molecular side, so with regard to human origins, I'm still sorting out what I believe. I do know, however, what I don't believe, that is, I don't believe that humans evolved from ape-like ancestors by a gradual process of descent with modification. Thus I don't see human consciousness and language ability gradually emerging as an ape-like ancestor gradually becomes more and more human. Thus I see these features of our humanity as well as the physical endowments needed for these features as emerging suddenly.

Posted July 4, 2005, at <http://www.uncommondescent.com/index.php/archives/171#comments>

# The Evolution of Biological Complexity

*Finn Pond, Whitworth College*

## INTRODUCTION

The origin of biological complexity is not yet fully explained, but several plausible naturalistic scenarios have been advanced to account for this complexity. "Intelligent design" (ID) advocates, however, contend that only the actions of an "intelligent agent" can generate the information content and complexity observed in biological systems.

ID proponents believe evolution theory is a failed enterprise that offers no credible explanations for the origins of complexity. They fault evolutionary scenarios for lacking sufficient detail. Furthermore, ID advocates claim to have presented empirical evidence that an "intelligent agent" designed at least some complex biological systems.

In contrast, this paper reviews several scientific models for the origin of biological complexity. I argue that these models offer plausible mechanisms for generating biological complexity and are promising avenues of inquiry. I take issue with ID proponents who dismiss such models for lack of "sufficient causal specificity," arguing that this criticism is unwarranted. Finally, I look briefly at ID's proposed explanation for the origin of biological complexity, and consider William Dembski's "empirical evidence" for the design of bacterial flagella, arguing that his supposed evidence is biologically irrelevant.

## THE PROBLEM OF COMPLEXITY

Biological systems are staggeringly complex. Professional biologists devote their careers to describing those complexities, dissecting those systems by chemical and physical methods, and characterizing their structural components and functional interactions. How can such complex systems evolve? We understand the ways in which the individual components of a complex system can be altered in structure and function by mutation, and the way in which natural selection favors one form over another. Furthermore, in many cases we have traced the family relationships among different nucleic acid and protein variants.

Envisioning ways by which natural selection can construct biochemical and molecular systems that involve dozens of proteins integrated in complex and highly specific ways is much more difficult. How could all the necessary proteins be selected simultaneously with a common endpoint as the goal? Unless each intermediate construct possessed at least partial function, how could natural selection act?

This is the argument put forth by Michael Behe in his book *Darwin's Black Box: The Biochemical Challenge to Evolution* (1996), and championed by ID advocates ever since. Behe contends that the structural and functional complexities found throughout biological systems could not have been established through evolutionary processes. He argues that the bacterial flagellum, for example, is an irreducibly complex system, in which the individual components have no function apart from the whole, and therefore could not have been selected for in nature.

> 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. An irreducibly complex biological system, if there is such a thing, would be a powerful challenge to Darwinian evolution. (Behe 1996: 39)

Biologists recognize that integrated system complexity is a feature of living systems. That is, some biological systems consist of component parts that interact in a coordinated way so that the system as a whole exhibits a specific function. It is questionable, however, whether any such systems are irreducibly complex as Behe claims (see Coyne 1996; Doolittle 1997; Miller 1999; Shanks and Joplin 1999). But even if examples of irreducible complexity are found in living systems, the origins of such systems are not necessarily outside the realm of natural processes (Orr 1996; Miller 1999; Thornhill and Ussery 2000; Catalano 2001). That the function of a highly integrated system may collapse with the removal of a component part does not mean that the system in question cannot be deconstructed to reveal an origin by undirected evolutionary processes.

Behe was not the first to recognize that biological complexity poses a challenge (see for example Cairns-Smith 1986). During the past decade, the discipline of complexity science has blossomed, attracting an interdisciplinary contingent of scientists, including biologists interested in the very question Behe addresses:

*Finn Pond is Professor of Biology at Whitworth College, where he teaches cell and molecular biology.*

*continued on page 27*

# Federation of American Societies for Experimental Biology

## FASEB Opposes Using Science Classes to Teach "Intelligent Design", Creationism, and other Non-Scientific Beliefs

Representing 22 professional societies and 84 000 scientists in disciplines that range from single molecules to public health, the Federation of American Societies for Experimental Biology (FASEB) affirms that instruction in science is an essential component of education. Science education has become increasingly important in driving innovation and discovery, and in enabling citizens to make informed decisions and to compete in the 21st century workplace. For these reasons, it is critical to preserve the integrity of science education by opposing the mandatory teaching in science classes of creationism, "intelligent design", and other concepts not based on sound scientific principles.

Proponents for non-scientific accounts of the development of life, including creationism and "intelligent design", contend that evolution alone should not be taught in science classes. Arguing that evolution is "just a theory," rather than a fact, they insist that "intelligent design" should be offered as an alternative to evolution or given "equal time", and that schools should "teach the controversy" surrounding evolutionary theory.

FASEB does not support these views. We also affirm that these positions seriously undermine science education.

In science, a theory is a coherent explanation of natural phenomena based on direct observation or experimentation. Theories are logical, predictive, and testable. They are open to criticism and when shown to be false, they are modified or dismissed. Using this definition, evolution is categorized with other scientific theories such as gravity or atomic theory, which, like evolution, are universally accepted among scientists.

Evolution is among the most thoroughly tested theories in the biological sciences. It is supported by volumes of scientific evidence in numerous fields, including genetics, biochemistry, developmental biology, comparative anatomy, immunology, geology, and paleontology. Moreover, evolution lays the foundation for much of what we know about genetics, immunology, antibiotic resistance, human origins, and the adaptation of species to a changing environment. Removing evolution from the classroom, or misrepresenting evolution as a flawed theory, deprives students of one of the most important tenets of science and the basis of our understanding of biology and medicine, including pandemic influenza and AIDS.

In contrast to evolution, "intelligent design" and creationism are not science because they fail to meet the essential and necessary requirements: they are not based on direct observation or experimentation nor do they generate testable predictions. Therefore, offering these beliefs as alternatives to evolution or giving them equal time in science classes completely misrepresents the nature of science.

Before information is presented as fact in science textbooks, it is tested, evaluated by experts, published in scientific journals, and considered credible by the broader scientific community. Even alternative ideas should have an evidentiary basis and garner at least limited support by scientists before they are incorporated into textbooks. Allowing "intelligent design" and creationism to circumvent this rigorous process of scientific scrutiny paves the way for other, poorly studied, pseudoscientific ideas to enter science curricula.

Proposals that call for "teaching the controversy" or singling out evolution for criticism are equally objectionable. While there may be some disagreement about the details of evolution, it is not a controversial theory among scientists. Rather, there is overwhelming scientific consensus that evolution is a valid explanation for the development of species. Although students should be encouraged to think critically about all ideas, introducing false controversy into science classes will ultimately impair science education.

**FASEB** considers evolution a critical topic in science education and strongly supports the teaching of evolution.

**FASEB** opposes mandating the introduction of creationism, "intelligent design", and other non-scientific concepts into the curricula of science.

**FASEB** opposes introducing false controversies regarding evolution or other accepted scientific theories into the curricula of science.

**FASEB** calls upon the scientific community and American citizens to defend science education by opposing initiatives to teach "intelligent design", creationism, and other non-scientific beliefs in science class.

*Adopted by the FASEB Board of Directors on December 19, 2005.*
*http//www.faseb.org/opa*
*Reprinted with permission.*

# Small things considered

Life started small. It continues, for the most part, to be small; as Stephen Jay Gould observed, "On any possible, reasonable or fair criterion, bacteria are — and always have been — the dominant forms of life on Earth." The genetic machinery by which life continues is positively tiny. Yet among the biggest — and most exciting — topics in contemporary biology are the character of early life (that is, from its origin to the burst of multicellularity in the Cambrian), the ways and means by which microbial evolution took place over the eons and continues to take place today (including such relatively unfamiliar processes as endosymbiosis and lateral gene transfer), and, of course, genomics (in the news constantly as genome after genome is sequenced). To magnify, as it were, your knowledge of such topics, check out the following books, ranging from the popular to the technical, all of which are now available through the NCSE website: <http://www.ncseweb.org/bookstore.asp> — look in the "In the latest *RNCSE*" section. And remember, every purchase through the website benefits NCSE!

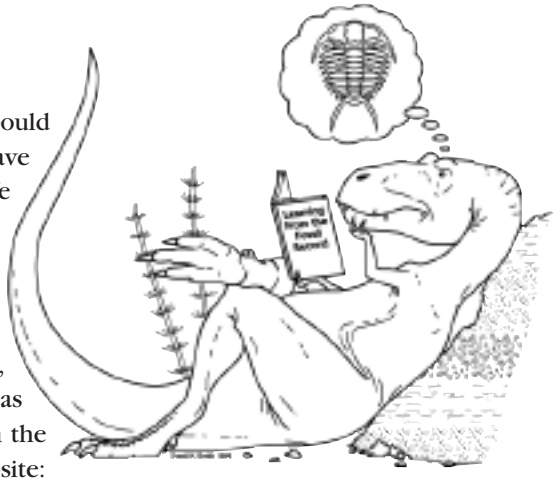


*Illustration by Dave Smith, used with permission of the University of California Museum of Paleontology.*

## Early life

*The Origin and Early Evolution of Life*
by Tom Fenchel
"This book," Tom Fenchel explains, "is about the development of life from its origin and until multicellular plants, fungi, and animals arose — corresponding approximately to the time period from 4 to 0.6 billion years ago." The reviewer for *BioEssays* writes, "The classical, recurrent themes are treated in a clear and interesting style of writing. The scope of the book is broad enough to be useful to advanced undergraduate or graduate students as well as to any reader possessing a college scientific background." A glossary and suggestions for further reading are included.

*Life on a Young Planet*
by Andrew F Knoll
From the origin of life to the Cambrian explosion, Knoll draws not only on paleontology but also on the latest insights from molecular biology, ecology, and the earth sciences to produce a broad understanding of the emergence of biological diversity. Sean Carroll (the author of *Endless Forms Most Beautiful*) writes, "This is a truly great book. It is a remarkably readable synthesis of many diverse ideas selected from a breathtaking array of disciplines. The narrative is engaging and entertaining — a travelogue through time that incorporates amusing and informative anecdotes from Knoll's travels to many far-off places." Knoll is Fisher Professor of Natural History at Harvard University.

*Cradle of Life: The Discovery of Earth's Earliest Fossils*
by J William Schopf
"This book chronicles an amazing breakthrough in biologic and geologic science," Schopf writes, "the discovery of a vast, ancient, missing fossil record that extends life's roots to the most remote reaches of the geologic past. At long last, after a century of unrewarded search, the earliest 85% of the history of life on Earth has been uncovered to forever change our understanding of how evolution works." Writes the reviewer for *Scientific American*, "Schopf ... has a good deal to say about scientists and the way science is done. It all makes for a book that bears out his assertion that 'science is enormously good fun!'"

*The Spark of Life: Darwin and the Primeval Soup*
by Christopher Wills and Jeffrey Bada
"Life as we know it is assertive, demanding, and unstoppable," Wills and Bada write in *The Spark of Life*. But how did it get started? The authors defend the "primeval soup" model against its competitors, extending it with suggestions of their own. The reviewer for *Nature* writes, "They entertain by not only giving a *lively* description of the 'spark of life', but also by conveying the sparkle of its investigators and the nature of the scientific process. These two professors have written a book that reads like a novel, and one would be happy to have them educate one's children."

## Ways and means

*Lateral DNA Transfer: Mechanisms and Consequences*
by Frederic Bushman
Although lateral gene transfer was observed in bacteria almost fifty years ago, only recently are biologists beginning to appreciate its extent and significance. In *Lateral DNA Transfer*, Frederic Bushman provides a helpfully selective introduction to LGT; as the reviewer for *Nature Cell Biology* comments, "Rather than attempting to be an exhaustive resource for researchers in the field, his book aptly samples from the vast literature and takes special efforts to make it palatable and relevant to a



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

wide audience." Bushman discusses LGT in bacteria and archaea, in eukaryotes (including a chapter on LGT and the AIDS epidemic), and even among the domains of life.

*Symbiotic Planet: A New Look at Evolution*
by Lynn Margulis
In *Symbiotic Planet*, a book in the Science Masters series of popularizations, Lynn Margulis argues that symbiosis is crucial to the emergence of evolutionary novelty, from the eukaryotic cell, and somewhat controversially, to the planet itself. ("Gaia is just symbiosis as seen from space," as one of her students offered.) *Kirkus Reviews* writes, "This is vintage Margulis — personal, autobiographical, passionate, argumentative, at times over the top, but full of ideas — at least some of which, in the past, have proved to be right." A Supporter of NCSE, Margulis is Distinguished University Professor in the Department of Geosciences at the University of Massachusetts, Amherst.

*Microbial Evolution: Gene Establishment, Survival, and Exchange*
edited by Robert V Miller and Martin J Day
Published by the American Society for Microbiology in 2004, *Microbial Evolution* is a state-of-the-art compilation on the evolution of bacteria, containing twenty-two essays under four broad rubrics: intracellular mechanisms for generating diversity, intercellular mechanisms for gene movement, mechanisms for gene establishment and survival, and mechanisms for detecting genetic diversity. It is suitable for classroom use, the editors explain: "we have asked the contributors to address questions, identify important evolutionary points, and differentiate what we understand from what we do not." Moreover, the contributors provide scientific and historical references as well as questions for further study, and the editors summarize the themes and highlights of each section of the book.

*Power, Sex, Suicide: Mitochondria and the Meaning of Life*
by Nick Lane
From the publisher: "Power, Sex, Suicide, Complexity, Individuality, Fertility, Prehistory, Ageing, Death. These universal themes are all linked by mitochondria — the tiny structures located inside our cells — miniature powerhouses that use oxygen to generate power. ... Once considered menial slaves, mere workhorses for complex cells with nuclei, their significance is now undergoing a radical revision. Mitochondria are now seen as the key ingredient that made complex life possible at al. ... This is a book full of startling insights into the nature and evolution of life, and should be read by anyone who wants to know why we're here."

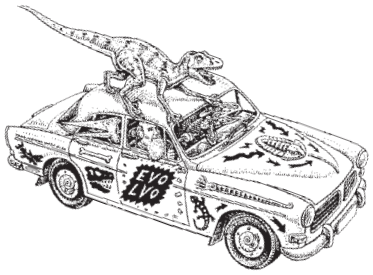
## Investigating Genomes

*Darwin in the Genome: Molecular Strategies in Biological Evolution*
by Lynn Helena Caporale
The title of the prologue to *Darwin in the Genome* encapsulates the thesis of the book nicely: "Chance favors the prepared genome." The publisher writes, "Written by a molecular biologist at the forefront of genomics research, *Darwin in the Genome* is an exciting account of one of the hottest new theories in biology today: evolution by natural selection inevitably leads to strategic mutations. In the struggle for survival, from pathogens to flowers, birds to orangutans, baker's yeast to people, the fittest genomes are those that evolve effective molecular strategies that respond to, and in fact anticipate, challenges and opportunities in their environments."

*Welcome to the Genome: A User's Guide to the Genetic Past, Present, and Future*
by Rob Desalle and Michael Yudell
In their lively and illustrated introduction to genomics, Rob Desalle and Michael Yudell discuss how the genomic revolution came to pass, what it amounts to, and what prospects and perils await. The reviewer for *Natural History* described *Welcome to the Genome* as "engagingly written and illustrated in full-color ... an essential guide for those who want to understand — and participate in — the accelerating promise of the genomic revolution." DeSalle curated the American Museum of Natural History's Genomics Revolution exhibit; Yudell is a professor of public health at Drexel University; and together they edited *The Genomic Revolution: Unveiling the Unity of Life* (Washington DC: Joseph Henry Press, 2002).

*Genome: The Autobiography of a Species in 23 Chapters*
by Matt Ridley
In his preface to *Genome*, Matt Ridley — the zoologist-turned-science-writer who wrote *The Red Queen* and *The Origin of Virtue* — describes the original plan for the book: "Why not try to tell the unfolding story of the human genome, now being discovered in detail for the first time, chromosome by chromosome, by picking a gene from each chromosome to fit the story as it is told?" And that is what precisely he did, in clear, instructive, and lively prose. James Watson praised *Genome* as "[a] lucid and exhilarating romp through our 23 human chromosomes that lets us see how nature and nurture combine to make us human."

*Genomes*
edited by Hillary E Sussman and Maria E Smit
From the publisher, Cold Spring Harbor Laboratory Press: "Hundreds of genomes have been completely sequenced in the past decade, significantly advancing our understanding of genome structure and function. *Genomes* comprises a collection of review articles reprinted from the 10th Anniversary Issue of the journal *Genome Research* that captures the status of genomic research in a selection of model species — from microbes to human. Written by renowned leaders in the field of genomics, each chapter focuses on what has been learned from the genomes of a given kingdom, group, or species and offers a unique perspective on the history, the current status, and the future of genomic research efforts."




# NCSE on the Road

## A Calendar of Special Events, Presentations, and Lectures

| | |
|---|---|
| **Date** | November 16, 2006 |
| **City** | Lawrence KS |
| **Presenter** | Eugenie C Scott |
| **Title** | Faith, Reason, and Assumption in Understanding the Natural World |
| **Time** | 7:30 PM |
| **Event** | Public lecture |
| **Location** | Kansas Union Ballroom |
| **Contact** | Victor Bailey, vbailey@ku.edu |

| | |
|---|---|
| **Date** | December 1, 2006 |
| **City** | Irvine CA |
| **Presenter** | Eugenie C Scott |
| **Title** | Biological Design in the Classroom and Public Arena |
| **Time** | 7:30 PM |
| **Event** | Sackler Colloquium |
| **Location** | Beckman Center |
| **Contact** | John C Avise, javise@uci.edu |

| | |
|---|---|
| **Date** | December 4, 2006 |
| **City** | Philadelphia PA |
| **Presenter** | Eugenie C Scott |
| **Title** | Teaching Evolution in the Public Schools |
| **Time** | 6:30 PM |
| **Event** | Public lecture |
| **Location** | The Academy of Natural Sciences |
| **Contact** | Roland J Wall, rwall@acnatsci.org |

| | |
|---|---|
| **Date** | December 7, 2006 |
| **City** | Salt Lake City UT |
| **Presenter** | Eugenie C Scott |
| **Title** | Teaching Evolution: Cans, Can'ts, and Shoulds |
| **Time** | 9:15 AM |
| **Event** | NSTA Western Regional Conference |
| **Location** | Salt Palace Convention Center |
| **Contact** | Donna Fletcher, dfletcher@nsta.org |

| | |
|---|---|
| **Date** | January 19, 2007 |
| **City** | Las Vegas NV |
| **Presenter** | Eugenie C Scott |
| **Title** | Covering Creationism: The Good, the Bad, and the Irrelevant |
| **Time** | TBA |
| **Event** | The Amazing Meeting 5 |
| **Location** | The Rivera Hotel and Casino |
| **Contact** | Linda Shallenberger, linda@randi.org |

| | |
|---|---|
| **Date** | January 27, 2007 |
| **City** | Boston MA |
| **Presenter** | Eugenie C Scott |
| **Title** | Science, Pseudoscience, and Beliefl |
| **Time** | TBA |
| **Event** | Science + Society: Closing the Gap |
| **Location** | Westin Copley Place Hotel |
| **Contact** | Hyman Field, hfield@aaas.org |

*Check the NCSE web site for updates and details — <http://www.ncseweb.org>.*

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*continued from page 22*

Can natural mechanisms account for the observed complexity of biological systems? (See Adami and others 2000; Strogatz 2001; Adami 2002; Carlson and Doyle 2002; Csete and Doyle 2002.)

## Naturalistic models for the evolution of biological complexity

Several models have been advanced to account for a naturalistic origin of the complexity seen in biological systems. Following are brief descriptions of four models advanced to account for the origin of biological complexity.

### Incremental additions model

The incremental additions model hypothesizes that an initial association of components favorable to some function may become an essential association through time (Lindsay 2000; Orr 1996, 2002). The complexity of the system may increase with the addition of new components. Suppose, for example, that a molecule carries out a particular catalytic function. If an association with another molecule enhances that function — for example, through structural stabilization — then natural selection can favor the association. The second molecule is initially beneficial although not essential. The second molecule may become essential, however, if an inactivating mutation in the first molecule is compensated for by the presence of the second.

There are numerous examples of molecules whose function is enhanced in the presence of another molecule. Consider the activity of RNase P (an RNA-protein complex responsible for processing transfer RNA molecules). The RNA component of the molecule possesses the catalytic activity and has been shown to function without its protein partner, albeit at a very much lower activity (Reich and others 1988; Altman 1989).

Work done with hammerhead ribozymes (RNA molecules capable of cleaving other RNA molecules) has demonstrated that the activity of one of these ribozymes increases 10- to 20-fold *in vitro* in the presence of a non-specific RNA-binding protein (Tsuchihashi and others 1993; Herschlag and others 1994). Furthermore, ribozymes are routinely generated whose activity can be regulated by other molecules (Soukup 1999), and *in vitro* evolution experiments have generated protein-dependent ribozyme ligases (Robertson and Ellington 2001).

Group II self-splicing introns, although capable of independent cleavage of RNA under some conditions, require stabilization by maturase proteins for effective *in vivo* functioning. It is generally accepted that the catalytically active RNA components of spliceosomes are able to function because spliceosome proteins stabilize a functional conformation (Lodish and others 2003). Therefore, one might speculate that a ribozyme could lose independent activity through a mutational event and yet continue to function in association with a protein molecule that promotes or stabilizes a catalytically active ribozyme structure.

### Scaffolding model

Scaffolding is another mechanism whereby irreducible complexity might be established (Lindsay 2000; Shanks and Joplin 2000; Orr 2002). In the incremental additions model, a beneficial association of components becomes an essential association because mutational events compromise the independent activity of one or more component parts. In the scaffolding model, superfluous components are lost, leaving a system in which the remaining components appear tightly matched as if they were specifically designed to fit and function together. The arch is an example of an irreducibly complex structure that requires scaffolding for its construction (Cairns-Smith 1986; Lindsay 2000; Shanks and Joplin 2000; Schneider 2000; Orr 2002). Scaffolding may also be functional in nature.

Many biochemical systems are characterized by "redundant complexity" (Shanks and Joplin 1999, 2000). Biochemical pathways rarely function in isolation; rather, one pathway interconnects with another (see Nelson and Cox 2000). For example, carbon atoms entering the Calvin-Benson cycle within a chloroplast may find their way into any one of many different molecules and be shunted into other pathways. There are also many cases of a redundancy of enzymatic components, or variant isoforms. Gene duplications increase the number of genes in a species, which can then evolve in different ways. This branching pattern in protein evolution is significant. For example, several different yet related hemoglobin molecules are utilized in human development. These variant forms are understood to have arisen from gene duplication, mutation and selection processes (Lodish and others 2003).

An initial loss of redundant components in a biochemical pathway will not destroy function. However, at the point where a system cannot endure further loss of components without losing function, an irreducible system exists. The redundancy of biochemical components in such a scenario serves as scaffolding. Shanks and Joplin (2000) evaluate this model in reference to several of Behe's examples of irreducibly complex biochemical systems. Robinson (1996) has also taken a similar approach by explaining in plausible evolutionary terms the origin of vertebrate blood-clotting cascades.

### Co-option model

Natural selection acts upon an existing set of structures within a particular environmental context. An altered environment demands altered responses from an organism. Consequently, it should not be surprising to find in the fossil record and in comparative anatomical and physiological studies evidence that some structures have been modified through time to serve different functions. In fact, a common theme of biological evolution is that existing structures are often put to new uses, and new structures are created from the old. "Co-option" is the term used to describe the recruitment of existing structures for new tasks. This recruitment can explain evolutionary increases in biological complexity.

Genes co-opted for new functions can give rise to developmental and physiological novelties (Eizinger and others 1999; Ganfornina and Sanchez 1999; Long 2001; True and Carroll 2002). Genes can acquire new functions when protein-coding sequences are altered, when coding sequences are spliced differently during

RNA processing, or when spatiotemporal patterns of gene expression are changed (True and Carroll 2002). Gene duplication followed by differential mutation will give rise to new protein configurations, and the alteration of regulatory controls for gene expression can result in significant developmental and morphological changes.

Many complex biological systems are characterized by a tight integration of component parts. Behe (1996) has argued that it is highly unlikely that such systems could arise through a simultaneous co-evolution of numerous parts or a direct serial evolution of the necessary components. But complex systems, even irreducibly complex ones, need not be assembled this way.

New associations of existing substructures or proteins may give rise to new functions, thus it is not necessary for the system to evolve *in toto*. Many critics of ID have pointed this out (Miller 1999; Thornhill and Ussery 2000; Miller 2003). A particularly instructive example of probable co-option is seen in the evolution of the Krebs (citric acid) cycle. Melendez-Helvia and others (1996) recognized that the Krebs cycle posed a real difficulty to evolutionary biologists because intermediate stages in its evolution would have no functionality. An analysis of the component enzymes and cofactors, however, revealed that the component parts and intermediate stages had functions apart from their role in the Krebs cycle.

Another example is the V(D)J gene splicing mechanism in vertebrate immune systems (Thornhill and Ussery 2000). True and Carroll (2002) also present examples of how multiple genes linked by a gene regulatory system can be co-opted as a unit for a new function; their examples include the evolution of butterfly eyespots, vertebrate limbs, complex leaves in plants, and feathers.

**Emerging complexity model**

Some complexity theorists believe that laws of self-organization exist that play a role in the evolution of biological complexity (Kauffman 1993, 1995; Solé and Goodwin 2000). Theoretical work in this area has expanded rapidly in the past decade (see, for example, Camazine and others 2001). The interaction of various component parts, it is argued, leads inevitably to complex patterns of organization.

One measure of complexity is the information content of a system, and Schneider's "ev" program has demonstrated that new information can indeed emerge spontaneously. The "ev" program was constructed to simulate evolution by mutational and selection events. In the program, certain DNA sequences acted as "recognizer genes", while other sequences were potential binding sites for the recognizer molecules. During simulations, both the recognizer genes and potential binding sequences were allowed to mutate. Selection was based upon successful binding of recognizer molecules and appropriate binding sites. The change in the complexity of the system was evaluated as a change in the information content of the DNA sequences. Specificity between recognition genes and corresponding binding sites increases the information content of the system, which is measured in bits of information according to Shannon information theory. Beginning with a random genome, the "ev" program leads to the evolution of DNA binding sites and a consequent increase in information. Furthermore, in the simulation, binding sites and recognizer genes co-evolved, becoming an irreducibly complex system. The results showed that processes of Darwinian evolution do generate information as well as irreducibly complex systems (Schneider 2000).

**Conceivability vs plausibility: ID's response**

The above models are based upon natural processes that are subject to experimental investigation. Evidence supporting these models is accumulating. These models have been evaluated by ID advocate William Dembski in his book *No Free Lunch* (2002a). Dembski declared each model inadequate, with his most specific criticism directed toward Schneider's "ev" program. He rejected Schneider's claim that information had been generated *de novo* and accused Schneider of smuggling information into the program by specifying the program's conditions for survival of "organisms" (Dembski 2002a). From a population biologist's perspective, the criteria used by Schneider were perfectly reasonable. Nevertheless, Schneider eliminated the special rule that Dembski objected to, retested the program, and found the same results (Schneider 2001a, 2001b).

Arguing more globally, Dembski claimed that the No Free Lunch Theorems make it clear that the program could not do what Schneider claimed. David Wolpert, however, one of the developers of the No Free Lunch Theorems, says that Dembski applies the theorems inappropriately (Wolpert 2003).

Dembski's criticisms of the other models were more general. He and other ID advocates complain that naturalistic models for the evolution of biological complexity lack causal specificity. According to Dembski, "Causal specificity means identifying a cause sufficient to account for the effect in question" (Dembski 2002a: 240). He argues that, until sufficient details are worked out (presumably in terms of the order in which components became associated, the manner by which these assembled components interacted to improve function, and the mutations that led to obligate dependency) there is no way to evaluate naturalistic scenarios. "Lack of causal specificity," he says, "leaves one without the means to judge whether a transformation can or cannot be effected" (Dembski 2002a: 242).

Dembski accuses evolutionists of being satisfied with a very undemanding form of possibility, namely, conceivability (Dembski 2002b). Allen Orr reviewed *No Free Lunch* and took Dembski to task for using biologically irrelevant probabilities and requiring unrealistic details of causal specificity (Orr 2002). In his rebuttal, Dembski said that, for Orr, "Darwinism has the alchemical property of transforming sheer possibilities into real possibilities" (Dembski 2002b). He went on to say that "Orr substitutes a much weaker demand for 'historical narrative,' which in the case of Darwinism degenerates into fictive reconstructions with little, if any, hold on reality."

Dembski positions himself as the critical empiricist, asking only for what all scientists should ask —

details by which to determine the validity of Darwinist claims. Howard Van Till reviewed *No Free Lunch* and commented upon Dembski's demand for causal specificity:

> Many scientific hypotheses regarding the manner in which various transformational processes may have contributed to the actualization of some new biotic structure might fall short of full causal specificity — even though they may be highly plausible applications of mechanisms that are at least partially understood. When that is the case, the ID approach tends to denigrate them as nothing more than "just-so stories" and to remove them from further consideration. (Van Till 2002)

Dembski's demand for greater details is reminiscent of earlier anti-evolutionists' demands for more transitional fossils. Undoubtedly, there will always be gaps in the fossil record, and there will always be room for more details in evolutionary scenarios. The biologist's search for these details is ongoing.

### ID's explanation for the origin of biological complexity

Biologists have proposed a number of models to account for biological complexity. ID proponents have criticized these models for lacking sufficient detail. It is instructive then to examine ID's own explanations for the origin of biological complexity. Dembski (2002a) claims that certain types of biological systems, such as Behe's "irreducibly complex" systems, must have been designed by an intelligent agent, because they possess a characteristic he calls "specified complexity." It is possible, he says, to distinguish objects that were designed from those that arose by natural mechanisms because only designed objects have this characteristic (Dembski 1998, 2002a). ID advocates offer no models to explain the processes by which biological complexity came to be. They argue, nevertheless, that "specified complexity" is empirical evidence that the observed structure or function was intentionally designed.

How can we know that an object possesses "specified complexity"? Dembski says that structures or events that are highly complex will have a low probability of occurring by chance. Therefore a probability assessment must first be made. Because even rare or improbable events might occur by chance if given enough time, Dembski (1998) has set a probability value of $10^{-150}$ as a criterion for design.

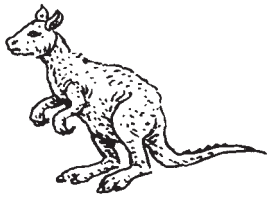
To be specified, an object or event must possess a pattern independent of or detachable from the nature of the object or event in question (Dembski 1998). In the movie *Contact*, for example, SETI researchers interpret a radio signal as a sign of extraterrestrial intelligence because the signal contains the first 100 prime numbers. That particular sequence of numbers is specified because it has no inherent relationship with radio waves and is therefore independent of the radio waves themselves. Finally, a designed object or event, regardless of its complexity or specificity, cannot be the outcome of a deterministic natural law.

ID proponents argue that certain biological systems exhibit specified complexity and therefore must have been intentionally designed. But is specified complexity a reliable indicator of design? The validity of Dembski's approach is questionable at best. Flaws in his argument have been pointed out previously (see for example, Orr 1996, 2002; Miller 1999, 2003; Schneider 2001a; Van Till 2002). But perhaps the best way to evaluate ID's claim is to consider the application of their criteria to a specific example.

### The bacterial flagellum: ID's test case

Dembski (2000) says, "Design theorists are not saying that for a given natural object exhibiting specified complexity, all the natural causal mechanisms so far considered have failed to account for it and therefore it had to be designed. Rather they are saying that the specified complexity exhibited by a natural object can be such that there are compelling reasons to think that no natural causal mechanism is capable of producing it." ID advocates have presented the bacterial flagellum as a biological structure that is clearly the result of design. Dembski's application of his own complexity-specification criterion in the case of the bacterial flagellum, however, fails to demonstrate that the flagellum is either complex or specified (Van Till 2002).

Dembski's calculation of the probability for the origin of the flagellum treats the flagellum as a discrete combinatorial object that self-assembled by pure chance. In other words, all the proteins spontaneously formed by the chance coming together of amino acids in the correct order, then the chance assembling of those proteins in the correct arrangements. This is not an evolutionary scenario ever postulated by biologists (Miller 2003; Van Till 2002). Evolutionists envision a far different scenario. Proteins are not built or assembled with the intent to construct a flagellar system. Protein variants appear through time, forming new interactions and taking on new functions. Protein assemblies that contribute to the reproductive success of the organism are maintained and shaped by natural selection.



Although Dembski (2002a: 19) stated that, in calculating the probability of an event, it is necessary to take into account all the relevant ways an event might occur, he himself failed to do so. By calculating *only* the probability that the flagellum arose by sheer chance, Dembski cannot justify his claim that the flagellum is a product of design (Van Till 2002). Dembski (2003) responded to such criticisms by stating that it was not his intention to "calculate every conceivable probability connected with the stochastic formation of the flagellum ... My point, rather, was to sketch out some probabilistic techniques that could then be applied by biologists to the stochastic formation of the flagellum." Dembski then challenged his critics to calculate their own probabilities using whatever scenario they wish.

> The bacterial flagellum is indeed a discrete combinatorial object, and the self-assembly that I describe is the one we are left with and can compute on the basis of what we know. The only reason biologists would refuse to countenance my description and probabilistic calculations of self-assembly is because they show that

> only an indirect Darwinian pathway could have produced the bacterial flagellum. But precisely because it is indirect, there is, at least for now, no causal specificity and no probability to be calculated. (Dembski 2002c)

There will always be a level of uncertainty in elucidating an evolutionary pathway for the origin of a flagellum or any other biological system. Dembski hides behind this uncertainty, content to continue using a pure chance model regardless of the fact that it bears no relationship whatsoever to our understanding of evolutionary processes.

## Conclusions

ID proponents claim that biologists are engaged in a program of inquiry, which is doomed to fail. According to ID proponents, a naturalistic explanation for the origin of genetic information and complex biological organization is not possible. The ID proponents assert that they have developed rigorous criteria by which design in nature can be detected, but they have yet to demonstrate the validity of their criteria. Furthermore, ID proponents fail to engage fully the naturalistic scenarios of evolutionists to explain the origins of biological complexity.

Certainly much remains to be learned about the evolution of complexity, but there is every reason to believe it happened by natural processes. Consider for example the following case. In 1966, Kwang Jeon observed that his cultures of amoebae were dying as a result of a bacterial infection (Jeon 1991). The bacteria had apparently escaped digestion in a food vacuole and were reproducing within the amoebae. Over a period of time, some of the cultures began to recover. Bacteria were still present in the surviving amoeba, though at a much reduced level. Jeon was able to show that the bacteria had become dependent upon their host cell and the host cell was dependent upon the bacteria. Additional work demonstrated that genetic information lost from the bacterium and amoeba genomes had led to their obligate relationship. A mutually obligate endosymbiosis was established, creating what is essentially a new cell organelle. Two component systems became associated, mutated, and are now irreducibly linked to one another. Perhaps ID proponents will argue that the complexity is not sufficient to have required the action of an intelligent agent, but the point here is that undirected natural causes are all that are needed to explain an observed increase in complexity and generation of an irreducible system.

Biologists have advanced plausible naturalistic scenarios for the origins of biological complexity. These scenarios are based upon an understanding of established natural processes. To dismiss them as merely conceivable stories is unwarranted. To demand a detailed chain of causality for evolutionary scenarios is unrealistic. To insist that design has been detected in the bacterial flagellum by calculating the probability of its assembling by pure chance is simply wrong.

## References


Adami C, Ofria C, Collier TC. 2000. Evolution of biological complexity. *Proceedings of the National Academy of Sciences* (USA) 97: 4463–8.

Adami C. 2002. What is complexity? *BioEssays* 24: 1085–94.

Altman S. 1989. Ribonuclease P: An enzyme with a catalytic RNA subunit. *Advances in Enzymology and Related Areas of Molecular Biology* 62: 1–36.

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

Cairns-Smith AG. 1986. *Seven Clues to the Origin of Life: A Scientific Detective Story.* Cambridge: Cambridge University Press.

Camazine S, Deneubourg J-L, Franks NR, Sneyd J, Theraulaz G, Bonabeau E. 2001. *Self-Organization in Biological Systems*. Princeton (NJ): Princeton University Press.

Carlson JM, Doyle J. 2002. Complexity and robustness. *Proceedings of the National Academy of Sciences* (USA) Supplement 1; 99: 2538–48.

Catalano J. Behe's empty box. 2001. Available on-line at <http://www.simonyi.ox.ac.uk/dawkins/WorldOfDawkins-archive/Catalano/box/behe.shtml>. Last accessed October 1, 2006.

Coyne JA. 1996. God in the details: The biochemical challenge to evolution. *Nature* 383: 2278.

Csete ME, Doyle JC. 2002. Reverse engineering of biological complexity. *Science* 295: 1664–9.

Dembski WA. 1998. *The Design Inference: Eliminating Chance through Small Probabilities*. Cambridge: Cambridge University Press.

Dembski WA. 2000. Intelligent design coming clean. Available on-line at <http://www.designinference.com/documents/2000.11.ID_coming_clean.htm>. Last accessed October 1, 2006.

Dembski WA. 2002a *No Free Lunch: Why Biological Complexity Cannot Be Purchased without Intelligence*. Lanham (MD): Rowman & Littlefield.

Dembski WA. 2002b Sheer vs real possibilities: A response to Allen Orr. *Boston Review.* Available on-line at <http://bostonreview.net/BR27.5/exchange.html>. Last accessed August 7, 2006.

Dembski WA. 2002c. Naturalism's argument from invincible ignorance: A response to Howard Van Till. Available on-line at <http://www.designinference.com/documents/2002.09.Van_Till_Response.htm>. Last accessed August 28, 2006.

Dembski WA. 2003. Still spinning just fine: A response to Ken Miller. Available on-line at <http://www.designinference.com/documents/2003.02.Miller_Response.htm>. Last accessed August 28, 2006.

Doolittle RF. 1997. A delicate balance. *Boston Review*. Available on-line at <http://bostonreview.net/br22.1/doolittle.html>. Last accessed August 7, 2006.

Eizinger A, Jungblut B, Sommer RJ. 1999. Evolutionary change in the functional specificity of genes. *Trends in Genetics* 15: 197–202.

Ganfornina MD, Sanchez D. 1999. Generation of evolutionary novelty by functional shift. *BioEssays* 21: 432–9.

Herschlag D, Khosla M, Tsuchihashi Z, Karpel RL. 1994. An RNA chaperone activity of non-specific RNA binding proteins in hammerhead ribozyme catalysis *European Molecular Biology Organization Journal* 13: 2913–24.

Jeon KW. 1991. Amoeba and x-Bacteria: Symbiont acquisition and possible species change. In: Margulis L, Fester R, editors. *Symbiosis as a Source of Evolutionary Innovation.* Cambridge (MA): The MIT Press. p 118–31.

Kauffman SA. 1993. *The Origins of Order*. New York: Oxford University Press.

Kauffman SA. 1995. *At Home in the Universe: The Search for the Laws of Self-Organization and Complexity*. New York: Oxford University Press.

Lindsay D. 2000. How can evolution cause irreducibly complex systems? Available on-line at <http://www.don-lindsay-archive.org/creation/evolve_irreducible.html>. Last accessed August 28, 2006.

Lodish H, Berk A, Matsudaira P, Kaiser CA, Krieger M, Scott MP, Zipursky SL, Darnell J. 2003. *Molecular Cell Biology*, 5th ed. New York: WH Freeman.

Long M. 2001. Evolution of novel genes. *Current Opinions in Genetics and Development* 11: 673–80.

Melendez-Hevia, E, Wadell TG, Cascante M. 1996. The puzzle of the

## AMERICAN SOCIETY FOR MICROBIOLOGY ON EVOLUTION

The American Society for Microbiology — the world's largest scientific society of individuals interested in the microbiological sciences, with over 43 000 members — recently issued a strong policy statement discussing the scientific basis for evolution:

> Knowledge of the microbial world is essential to understanding the evolution of life on Earth. The characteristics of microorganisms — small size, rapid reproduction, mobility, and facility in exchanging genetic information — allow them to adapt rapidly to environmental influences. In microbiology, the validity of evolutionary principles is supported by [1] readily demonstrated mutation, recombination and selection, which are the fundamental mechanisms of evolution; [2] comparisons based on genomic data that support a common ancestry of life; and [3] observable rates of genetic change and the extent of genomic diversity which indicate that divergence has occurred over a very long scale of geologic time, and testify to the great antiquity of life on Earth. Thus, microorganisms illustrate evolution in action, and microbiologists have been able to make use of the microbes' evolutionary capacity in the development of life-improving and life-saving innovations in medicine, agriculture, and for the environment. By contrast, proposed alternatives to evolution, such as intelligent design and other forms of creationism, are not scientific, in part because they fail to provide a framework for useful, testable predictions. The use of the supposed "irreducible complexity" of the bacterial flagellum as an argument to endow nonscientific concepts with what appears to be legitimacy, is spurious and not based on fact. Evolution is not mere conjecture, but a conclusive discovery supported by a coherent body of integrated evidence. Overwhelmingly, the scientific community, regardless of religious belief, accepts evolution as central to an understanding of life and the life sciences. A fundamental aspect of the practice of science is to separate one's personal beliefs from the pursuit of understanding of the natural world. It is important that society and future generations recognize the legitimacy of testable, verified, fact-based learning about the origins and diversity of life.

[*Originally posted on the ASM's website at <http://www.asm.org/Media/index.asp?bid=45937> and reprinted with permission.*]


Krebs citric acid cycle: Assembling the pieces of chemically feasible reactions, and opportunism in the design of metabolic pathways during evolution. *Journal of Molecular Evolution* 43: 293–303.

Miller KR. 1999. *Finding Darwin's God*. New York: Cliff Street Books.

Miller KR. 2003. The flagellum unspun: The collapse of "irreducible complexity". Available on-line at <http://www.millerandlevine.com/ km/evol/design2/article.html>. Last accessed August 28, 2006.

Nelson DL, Cox MM. 2000. *Lehninger: Principles of Biochemistry*, 3rd ed. New York: Worth.

Orr HA. 1996. Darwin v intelligent design (again): The latest attack on evolution is cleverly argued, biologically informed — and wrong. *Boston Review*. Available on-line at <http://bostonreview.net/br21.6/orr.html>. Last accessed August 7, 2006.

Orr HA. 2002. Review of *No Free Lunch* by William A Dembski. *Boston Review*. Available on-line at <http://bostonreview.net/BR27.3/orr.html>. Last accessed August 7, 2006.

Reich C, Olsen GJ, Pace B, Pace NR. 1988. The role of the protein moiety of ribonuclease P, a catalytic ribonucleoprotein. *Science* 239: 178–81.

Robinson K. 1996. Darwin's black box: Irreducible complexity or irreproducible irreducibility? Available on-line at <http://www.talkorigins.org/faqs/behe/review.html>. Last accessed August 26, 2006.

Robertson MP, Ellington AD. 2001. In vitro selection of nucleoprotein enzymes. *Nature Biotechnology* 19: 650–5.

Schneider TD. 2000. Evolution of biological information. *Nucleic Acids Research* 28: 2794–9.

Schneider TD. 2001a. Rebuttal to William A Dembski's posting and to his book *No Free Lunch.* Available on-line at <http://www.ccrnp.ncifcrf.gov/~toms/paper/ev/dembski/>. Last accessed October 1, 2006.

Schneider TD. 2001b. Effect of ties on the evolution of information by the ev program. 2001b. Available on-line at <http://www.ccrnp.ncifcrf.gov/~toms/paper/ev/dembski/claimtest.html>. Last accessed October 1, 2006.

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

Shanks N, Joplin KH. 2000. Behe, biochemistry, and the invisible hand. *Philo*. Available on-line at <http://www.philoonline.org/library/shanks_4_1.html>. Last accessed August 28, 2006.

Sole R, Goodwin BC. 2000. *Signs of Life: How Complexity Pervades Biology*. New York: Basic Books.

Soukup GA, Breaker RR. 1999. Design of allosteric hammerhead ribozymes activated by ligand-induced structure stabilization. *Structure* 7: 783–91.

Strogatz SH. 2001. Exploring complex networks. *Nature* 410: 268–76.

Thornhill RH, Ussery DW. 2000. A classification of possible routes of Darwinian evolution. *The Journal of Theoretical Biology* 203: 111–6.

True JR, Carroll SB. 2002. Gene co-option in physiological and morphological evolution. *Annual Reviews of Cell and Developmental Biology* 18: 53–80.

Tsuchihashi Z, Khosla M, Herschlag D. 1993. Protein enhancement of hammerhead ribozyme catalysis. *Science* 262: 99–102.

Van Till H. 2002. *E coli* at the No Free Lunchroom: Bacterial flagella and Dembski's case for intelligent design. Available on-line at <http://www.aaas.org/spp/dser/03_Areas/evolution/perspectives/vantillecoli_2002.pdf>. Last accessed October 1, 2006.

Wolpert D. 2003. William Dembski's treatment of the No Free Lunch theorems is written in jello. Available on-line at <http://www.talkreason.org/articles/jello.cfm>. Last accessed August 28, 2006.



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# A Common, Conserved Mechanism for all Polynucleotide Polymerases

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## INTRODUCTION

While constructing new science education standards in 2002, the Ohio Board of Education received a bibliography from the Discovery Institute that listed 44 scientific papers on evolution (Discovery Institute 2004). The National Center for Science Education posted a critique of the bibliography on its website and published this evaluation in *Reports of the NCSE*, (Branch 2002), which elicited a response from the Discovery Institute (Discovery Institute 2002). The Discovery Institute chose to send the Ohio Board of Education these particular articles because they "represent dissenting viewpoints that challenge one or another aspect of neo-Darwinism ... discuss problems that evolutionary theory faces, or suggest important new lines of evidence that biology must consider when explaining origins" (Discovery Institute 2004). The apparent motivation behind sending this bibliography to the Ohio Board of Education was to generate doubts regarding the veracity of biological evolution.

One of the articles listed in the Discovery Institute's bibliography, by Leipe and others (1999), analyzes the various differences observed between DNA replication components in eukaryotes and archaebacteria with those in eubacteria. According to this article, despite impressive "functional parallels among all known cellular systems of DNA replication" and conservation of some core constituents, most of the main components of DNA replication in eubacteria differ significantly from those found in eukaryotes/archaebacteria (Leipe and others 1999: 3389). These distinctions led the authors to hypothesize that "the modern-type system for double-stranded (ds) DNA replication might have evolved independently in the bacterial and archaeal/eukaryotic lineages" (Leipe and others 1999: 3390). Interestingly, they also hypothesized that the last common ancestor of all life possessed a genetic system that consisted of DNA replicated via reverse transcription and RNA. Once the more efficient DNA-dependent DNA polymerases were used to replicate DNA, natural selection favored these more accurate enzymes over the more error-prone reverse transcriptases and, therefore, DNA polymerases replaced the RNA-dependent enzymes in the genetic systems of cells.

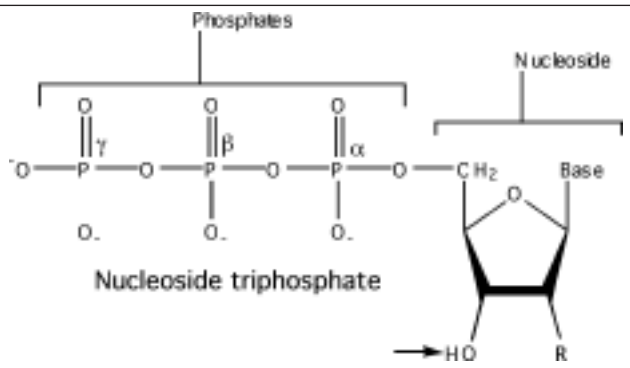


**FIGURE 1.**
*The substrates for DNA polymerases are dNTPs or deoxyribonucleoside triphosphates. dNTPs possess a hydrogen (H) in place of the R group. The substrates for RNA polymerases are rNTPs or ribonucleoside triphosphates, which possess a hydroxyl group ($HO^-$) in place of the R group. The identity of the base is one of four bases, cytosine, adenine, guanine, or thymine. These bases are the same in RNA except that thymine is replaced by uracil. The arrow points to the 3' hydroxyl group that plays a crucial role in the polymerization of nucleic acids by polynucleotide polymerases. Nucleotides contain three parts: a five-carbon sugar, a nitrogenous base, and one or more phosphates. The three phosphate groups are attached to the 5' carbon of the five-carbon sugar and are designated α, β, and γ, with the α phosphate being the closest to the five-carbon sugar, the γ being the furthest from the sugar, and the β phosphate lying in between the α and γ phosphates. A molecule that consists of only the five-carbon sugar and the nitrogenous base is called a nucleoside. The addition of phosphate converts the molecule into a nucleotide or a nucleoside monophosphate.*

Why might such an article cultivate doubt in the minds of education policymakers? In the words of the Discovery Institute, "almost any textbook diagram showing the history of DNA replication depicts a single (monophyletic) origin, in which DNA replication evolves once, and is then inherited by all organisms" (Discovery Institute 2002). Thus the evolutionary scheme proposed by Leipe and others (1999) appears to challenge what is commonly taught in evolutionary biology classes. There is also an implication that the evolution of a complex system is relatively problematic and somewhat unlikely, and that the evolution of two complex systems that perform the same task at roughly the same time is even more improbable, which should make us doubt that DNA replication arose by evolutionary means in the first place.

Unfortunately for this line of argument, it is plain

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from the article that the authors fully accept the common ancestry of all life and even use this unifying theory to mold their hypothesis. Second, although some textbooks might show DNA replication evolving once, that does not mean that such a scenario is a dogmatic assertion. Textbooks change as new knowledge is gained, and it is the nature of science to build upon the knowledge of past workers and modify our perceptions of natural processes or phenomena. Since basic textbooks cover the evolution of DNA in such a cursory fashion, one can hardly hold them up as authoritative summaries of the knowledge in the field. In addition, the failure of the Discovery Institute to cite a single example of a textbook that shows DNA replication evolving only once suggests that its staff has not spent much time looking at what textbooks actually say on the issue. Third, despite dissimilarities between DNA polymerases from archaebacteria/eukaryotes and eubacteria, DNA and RNA polymerases and other polynucleotide polymerases from many distinct organisms operate by means of a very common catalytic mechanism (Steitz 1998, 1999). This common mechanism is even used by RNA molecules that polymerize RNA, which suggests that all polynucleotide polymerases evolved from proteins that co-opted an ancient mechanism of polynucleotide replication that existed during the RNA world.

### The Two-Metal-Ion Mechanism

Originally proposed in 1993, the "two-metal-ion" mechanism of nucleotide polymerization has received extensive confirmation from detailed analyses of crystal structures of a variety of bacterial, viral and eukaryotic DNA and RNA polymerases (Beese and others 1993; Eom and others 1996; Doublié and others 1998; Kiefer and others 1998; Cramer and others 2003; Sosunov and others 2003). This same mechanism is also used by RNA enzymes or ribozymes (Steitz and Steitz 1993; Sontheimer and others 1997; Weinstein and others 1997; Sontheimer and others 1999; Stahley and Strobel 2005), and only requires chemical groups to hold the metal ions, since no other molecules, besides water, participate in the catalytic mechanism. Because the catalytic mechanism utilized by polynucleotide polymerases greatly resembles that used by RNA enzymes, polynucleotide polymerization via the two-metal mechanism could have been a part of the RNA world (Gesteland and others 1999).

The two-metal-ion mechanism of polynucleotide polymerases is very similar to the way the 3'–5' exonuclease of DNA polymerase I works, which degrades polynucleotides (Beese and Steitz 1993; Steitz 1993; Sosunov and others 2003), except that the polymerases work in the opposite direction. The substrate for the polymerase, a nucleoside triphosphate (Figure 1), enters the active site of the enzyme with two magnesium ions bound to its negatively charged phosphates. The magnesium ions encounter 2–3 highly conserved aspartic acid residues that bind the nucleoside triphosphate to the active site and hold it in place (Zhang and others 1999; Cramer and others 2001; Vassylyev and others 2002; Iyer and others 2003). Mutagenesis studies have confirmed that the replacement of these aspartic acid residues in DNA or RNA polymerases with other non-negatively charged residues, or even another negatively-charged amino acid like glutamate, obliterates the activity of these enzymes (Joyce and Steitz 1994; Dieci and others 1995; Woody and others 1996; Zaychikov and others 1996).

The configuration formed between the substrate nucleoside triphosphate and the 3' end of the nucleic acid primer at the active site of the polynucleotide polymerase facilitates the following reaction scheme. First the 3' hydroxyl group is stripped of its hydrogen atom by the nearest magnesium ion (the A metal ion), which creates a negatively-charged, electron-rich oxygen atom. Chemically speaking, electron-rich moieties always go in search of a place to deposit their excess electrons and usually pick atoms that are electron-poor, a process called nucleophilic attack. The nearest, electron-poor atom is the phosphorus atom in the α phosphate group, and the α phosphate of the substrate nucleoside triphosphate experiences nucleophilic attack by the negatively-charged, electron-rich 3' oxygen atom of the last nucleotide in the primer terminus, which is the end of the growing nucleic acid chain (Figure 2). This nucleophilic attack

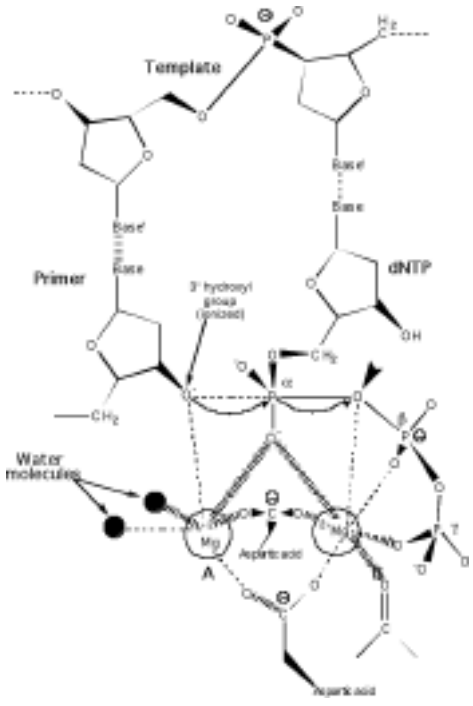


**Figure 2.**
*This represents the two-metal-ion mechanism of polynucleotide polymerases. The two magnesium ions, which are labeled A and B, are actually tightly bound to the enzymes of DNA polymerase I from* Escherichia coli. *The A metal ion helps remove the hydrogen atom from the 3' hydroxyl group of the terminal nucleotide to form the attacking oxygen ion. The B metal ion helps the last two phosphates in the substrate nucleotide leave as a pyrophosphate group after the formation of the new bond between the two nucleotides obliterates the bond between the first (α) and middle (β) phosphates. The two aspartic acid residues required to hold the metal ions in place are highly conserved in polynucleotide polymerases. The curved arrows show the flow of electrons from the electron-rich 3' oxygen to the electron-poor oxygen. The large dark arrow points to the "common oxygen" that binds the phosphorus atom of the α phosphate to the phosphorus atom of the β phosphate group. The reception of those extra electrons allows the common phosphate to break its bond to the phosphorus atom of the α phosphate group, thus allowing the release of the pyrophosphate molecule consisting of the β and γ phosphates. The molecule labeled dNTP is the substrate nucleoside triphosphate. Redrawn from Brautigam and Steitz (1998).*

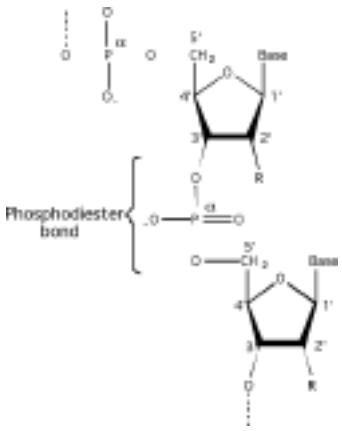


**FIGURE 3.**
*A phosphodiester bond, formed between two nucleotides in a polynucleotide. Note that the phosphates that participate in the phosphodiester bond originate from the α phosphates of the substrate nucleoside triphosphates. Notice that the carbons of the sugar moiety are labeled from 1' to 5'. The 1' carbon is always attached to the nitrogenous base and the 2' carbon is the one to which a hydrogen is attached in the case of DNA and a hydroxyl group in the case of RNA. The 3' carbon participates in the phosphodiester bond with the nucleotide behind it and the 5' carbon participates in a phosphodiester with the nucleotide in front of it. Thus, the 5' end of a nucleotide is like the front of the molecule and the 3' end is like its rear.*

results in the formation of a bond between the oxygen atom of the 3' hydroxyl group and the phosphorus atom of the α phosphate (the phosphate group closest to the five-carbon sugar). This new bond relocates the electrons that help bind the α phosphate group to the β phosphate group via a "common oxygen" atom, which dislodges the bond between this "common oxygen" and the α phosphate group. The new bond created between the substrate and terminal primer nucleotides is called a phosphodiester bond; a special bond found between nucleotides in extant nucleic acids like DNA and RNA (Figure 3). The formation of the phosphodiester bond facilitates the release of the β and γ phosphate groups of the substrate nucleotide as a two-phosphate molecule or pyrophosphate group (Brautigam and Steitz 1998).

### COMMON 3-D STRUCTURE

In addition to this common mechanism, almost all polynucleotide polymerases share common architectural features. The three-dimensional shape of polynucleotide polymerases resembles a right hand, with three domains known as the "thumb", "palm", and "fingers" domains (Steitz 1999). The palm domain houses the site where the reactions form a new phosphodiester bond. The fingers domain interacts with the incoming substrate nucleoside triphosphate and its paired template base, and the thumb domain positions the polynucleotide template and helps move the polymerase along it (Figure 4). Polymerases with very different functions and from divergent organisms show this common spatial structure (Steitz 1993; Sawaya and others 1994; Steitz and others 1994; Wang and others 1997; Hübscher and others 2002). Exceptions to this common structure do exist among polymerases. For example, African Swine Fever Virus (ASFV) encodes a repair DNA polymerase called ASFV pol X that lacks the fingers domain and the hand-like architecture (Oliveros and others 1997; Beard and Wilson 2001; due to differences in nomenclature, others would say that this DNA polymerase lacks the thumb domain; see Steitz and others 1994; Kraynov and others 2000).

Crystal structures of polynucleotide polymerases have also elucidated how these enzymes polymerize nucleic acids with such great accuracy. Particular amino acid side chains of DNA polymerases interact with the newly formed base pairs to determine if the proper nucleotide was attached to the growing end of the polynucleotide primer. In DNA, for example, only four base-pair interactions are normally found: adenine–thymine, thymine–adenine, cytosine–guanine and guanine–cytosine. A variety of chemical interactions between amino acid side chains and all four possible base-pairs confirm to the enzyme that the proper nucleotide was inserted into the growing polynucleotide chain, but abnormal base-pairings (for example, adenine–cytosine or guanine–adenine) fail to interact properly with these amino acid side chains, which activates the exonuclease activity of the enzyme and edits out the errant nucleotide (Jacobo-Molina and others 1993; Eom and others 1996; Doublié and others 1998; Kiefer and others 1998). These same interactions also allow only the proper nucleotide to fit into the active site (Doublié and others 1998). Mutations that change the identity of these particular amino acid side chains greatly decrease polymerase fidelity (Polesky and others 1990; Carroll and others 1991; Polesky and others 1992; Bell and others 1997). In fact, the fingerless ASFV pol X, which is missing some of the amino acid side chains that mediate replication fidelity, binds normal and damaged DNA very tightly but is very prone to errors when repairing DNA. This polymerase seems to generate genetic variability in order for ASFV to evade the host immune response (Beard and Wilson 2001; Maciejewski and others 2001; Showalter and Tsai 2001; Showalter and others 2001). Thus the polymerase protein side chains, while not participating in the catalytic activity of the polymerization reaction, greatly improve the fidelity of the polymerization process (Steitz 1998).

In the case of RNA polymerases, the catalytic sites of all RNA polymerases are formed at the interface of two com-

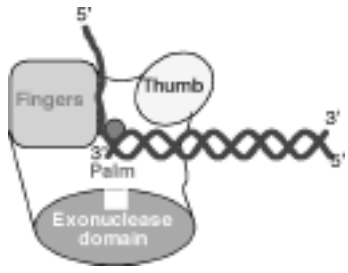


**FIGURE 4.**
*Cartoon representation of the three-dimensional shape of almost all polynucleotide polymerases. All crystallized polynucleotide polymerases to date show the three domains, fingers, thumb, and palm, even though the shapes of these domains differ between the different polymerases. Below the palm domain lies the exonuclease domain, which acts to edit the activities of the polymerase if an incorrect nucleotide is inserted into the growing polynucleotide chain. Redrawn from Steitz (1999).*

mon subunits (β and β' subunits) that share a conserved structural motif called a double-psi, beta-barrel domain (Iyer 2003). The β' subunit contains the metal-binding region common to all RNA polymerases (aspartic acid–basic amino acid–aspartic acid–glycine –aspartic acid) and the β subunit has two conserved lysine residues, which are positively charged and interact with the negatively-charged substrate. Furthermore, the core subunits of RNA polymerases from all organisms contain twenty-two homology regions that cluster around the active site and many other regions share structural similarities without showing amino acid sequence similarities (Cramer 2002).

## Co-option of other 3-D structures to do the job

A few supporting enzymes that assist the main polynucleotide polymerases in the cell also possess polynucleotide polymerization capabilities. Enzymes involved in DNA replication called primases aid the initiation of DNA synthesis by DNA polymerases, since DNA polymerases are incapable of starting DNA synthesis by themselves. Instead, all DNA polymerases need to begin making DNA by attaching the first base to an already-made strand of RNA. Primases are the enzymes that make this short ready-made strand of RNA for DNA polymerases. Primases act as RNA polymerases, except that they show lower fidelity (they make more mistakes) and lower processivity (they are not as good at repetitively continuing their catalytic function without dissociating from their substrate) than classical RNA polymerases. Primases do not show the traditional "hand" structure of classical RNA and DNA polymerases, which probably explains their "quick and dirty" activity. Instead primases from eubacteria possess a TOPRIM fold (Keck and others 2000; Iyer and others 2005) and those from eukaryotes/archaebacteria possess a RNA recognition motif (Augustin and others 2001; Aravind and others 2002; Iyer and others 2005). Despite these distinct structural motifs, they both use the two-metal-ion catalytic mechanism to synthesize their RNA strands (Keck and others 2000; Lipps and others 2004).

These data show that the two-metal-ion catalytic mechanism does not require a specific protein structure in order for proteins to use it. This should not surprise us, since the amino acid side chains merely hold the metal ions, which perform the chemistry that drives the polynucleotide polymerization reaction, in place. Thus several distinct proteins could have been enlisted in the polymerization of nucleic acids, and the data presented in Leipe and others (1999) confirm this prediction.

## Conclusion

The research data show that polynucleotide polymerases found in all cells use a common mechanism of action and possess a common three-dimensional shape. Thus, even though such enzymes from different cells do not often share extensive amino acid sequence similarities, they work through the same means. Furthermore, other proteins that do not share this common 3-D structure play supporting roles in DNA replication, and also use the same mechanism. The two-metal-ion mechanism of catalysis does not use any amino acid side chains for catalytic purposes, but merely uses amino acids to hold the metal ions in place and these metal ions are the catalytically active moieties of the enzyme. Other enzymes, like alkaline phosphatase (Kim and Wyckoll 1991) and tRNA CCA-adding enzymes (Hou and others 2005), use a similar catalytic mechanism, as do RNA-catalyzed reactions (Steitz and Steitz 1993; Sontheimer and others 1999; Stahley and Strobel 2005). The amino-acid side chains of protein-based enzymes confer increased accuracy. Therefore polynucleotide polymerization could have been a part of the RNA world, which suggests that the evolution of DNA replication need not present such an intractable problem. Instead DNA replication was taken over by proteins that catalyzed the polymerization of polynucleotides using the same mechanism as the original ribozymes. These proteins were far more accurate than their RNA precursors and they continued polynucleotide polymerization as the need arose for polynucleotide polymerization mechanisms with greater accuracy. Divergence of these proteins generated the wide variety of other proteins that are also involved in DNA replication and a few others that are not (Iyer and others 2005).

Thus rather than calling evolutionary theory into question, the paper by Leipe and others (1999) enriches our understanding and application of it. Furthermore, this work offers a fine example of how research can complicate and clarify our view of early life. The Discovery Institute's description of this paper as "challenging" evolutionary theory simply underlines its poor understanding of the issues and questions addressed by this work.

## References


Aravind L, Mazumder R, Vasudevan S, Koonin EV. 2002. Trends in protein evolution inferred from sequence and structure analysis. *Current Opinion in Structural Biology* 12 (3): 392–9.

Augustin MA, Huber R, Kaiser JT. 2001. Crystal structure of a DNA-dependent RNA polymerase (DNA primase). *Nature Structural Biology* 8 (1): 57–61.

Beard WA, Wilson SH. 2001. DNA polymerases lose their grip. *Nature Structural Biology* 8 (11): 915–7.

Beese LS, Derbyshire V, Steitz TA. 1993. Structure of DNA polymerase I Klenow fragment bound to DNA. *Science* 260: 352–5.

Beese LS, Steitz TA. 1993. Structural basis for the 3'–5' exonuclease activity of *Escherichia coli* DNA polymerase I: a two-metal ion mechanism. *EMBO Journal* 10 (1): 25–33.

Bell JB, Eckert KA, Joyce CM, Kunkel TA. 1997. Base miscoding and strand misalignment errors by mutator Klenow polymerases with amino acid substitutions at tyrosine 766 in the O helix of the fingers domain. *Journal of Biological Chemistry* 272 (11): 7345–51.

Branch G. 2002. Analysis of the Discovery Institute's "Bibliography of Supplementary Resources for Ohio Science Instruction." *Reports of the National Center for Science Education* 22 (4): 12–8, 23–4. Available on line at <http://www.ncseweb.org/resources/articles/3878_analysis_of_the_discovery_inst_4_5_2002.asp>. Last accessed June 2, 2006.

Brautigam CA, Steitz TA. 1998. Structural and functional insights provided by crystal structures of DNA polymerases and their substrate complexes. *Current Opinion in Structural Biology* 8: 54–63.

Carroll SB, Cowart M, Benkovic SJ. 1991. A mutant of DNA polymerase (Klenow fragment) with reduced fidelity. *Biochemistry* 30 (3): 804–13.

# PALLEN AND MATZKE ON THE BACTERIAL FLAGELLUM

Appearing in the October 2006 issue of *Nature Reviews Microbiology*, one of the leading journals in its field, was "From *The Origin of Species* to the origin of bacterial flagella" (4: 784–90). The article, by Mark J Pallen of the University of Birmingham and Nicholas J Matzke of NCSE, reviews the evidence for the evolution of the bacterial flagellum — which proponents of "intelligent design" (particularly Michael Behe, in *Darwin's Black Box*) notoriously adduce as a clear example of a designed rather than evolved structure. In the words of the abstract:

> In the recent Dover trial, and elsewhere, the "Intelligent Design" movement has championed the bacterial flagellum as an irreducibly complex system that, it is claimed, could not have evolved through natural selection. Here we explore the arguments in favour of viewing bacterial flagella as evolved, rather than designed, entities. We dismiss the need for any great conceptual leaps in creating a model of flagellar evolution and speculate as to how an experimental programme focused on this topic might look.

Pallen and Matzke begin by reminding microbiologists of the way in which their discipline became relevant to the *Kitzmiller v Dover* trial, "where the term 'flagellum' and its cognates appeared 385 times in the transcripts of the 6-week trial." Proponents of "intelligent design" such as Michael Behe and Scott Minnich — both of whom testified for the defense in *Kitzmiller* — have contended that "irreducibly complex" systems such as the bacterial flagellum could not have evolved. At the trial, Kenneth R Miller, testifying for the plaintiffs, effectively dismantled such contentions.

After describing Miller's arguments, Pallen and Matzke note that talk about "the" bacterial flagellum is incorrect: "By even the most conservative estimate, there must therefore be thousands of different bacterial flagellar systems, perhaps even millions. Therefore, there is no point discussing the creation or ID of 'the' bacterial flagellum. Instead, one is faced with two options: either there were thousands or even millions of individual creation events, which strains Occam's razor to breaking point, or one has to accept that all the highly diverse contemporary flagellar systems have evolved from a common ancestor."


Cramer P. 2002. Multisubunit RNA polymerases. *Current Opinion in Structural Biology* 12: 89–97.

Cramer P, Bushnell DA, Kornberg RD. 2001. RNA polymerase II at 2.8-angstrom resolution. *Science* 292: 1863–76.

Dieci G, Hermann-Le DS, Lukhtanov E, Thuriaux P, Werner M, Sentenac A. 1995. A universally conserved region of the largest subunit participates in the active site of RNA polymerase III. *EMBO Journal* 14 (15): 3766–76.

Discovery Institute 2002. Questions and answers about the Discovery Institute's bibliography of supplemental resources for Ohio science instruction. Available on-line at <http://www.discovery.org/articleFiles/PDFs/quesAndAnsNCSECritiqueOfBib.pdf>. Last accessed June 2, 2006.

Discovery Institute 2004. Bibliography of supplementary resources for science instruction. Available on-line at <http://www.discovery.org/scripts/viewDB/index.php?command=view&id=1127>. Last accessed June 2, 2006.

Doublié S, Tabor S, Long AM, Richardson CC, Ellenberger T. 1998. Crystal structure of a bacteriophage T7 DNA replication complex at 2.2-Å resolution. *Nature* 391: 251–8.

Eom SH, Wang J, Steitz TA. 1996. Structure of Taq polymerase with DNA at the polymerase active site. *Nature* 382: 278–81.

Gesteland RF, Cech TR, Atkins JF, editors. 1999. *The RNA World*, 2nd ed. Cold Spring Harbor (NY): Cold Spring Harbor Press.

Hou YM, Gu SQ, Zhou H, Ingerman L. 2005. Metal-ion-dependent catalysis and specificity of CCA-adding enzymes: a comparison of two classes. *Biochemistry* 44 (38): 12849–59.

Hübscher U, Maga G, Spadari S. 2002. Eukaryotic DNA polymerases. *Annual Review of Biochemistry* 71: 133–63.

Iyer LM, Koonin EV, Aravand L. 2003. Evolutionary connection between the catalytic subunits of DNA-dependent RNA polymerases and eukaryotic RNA-dependent RNA polymerases and the origin of RNA polymerases. *BMC Structural Biology* 3 (1): 1–23. Available on line at <http://www.biomedcentral.com/content/pdf/1472-6807-3-1.pdf>.

Iyer LM, Koonin EV, Leipe DD, Aravind L. 2005. Origin and evolution of the archaeo-eukaryotic primase superfamily and related palm-domain proteins: structural insights and new members. *Nucleic Acids Research* 33 (12): 3875–96.

Jacobo-Molina A, Ding J, Nanni RG, Clark AD, Lu X, Tantillo C, Williams RL, Kamer G, and others. 1993. Crystal structure of human immunodeficiency virus type 1 reverse transcriptase complexed with double-stranded DNA at 3.0-Å resolution shows bent DNA. *Proceedings of the National Academy of Sciences* (USA) 90 (13): 6320–4.

Joyce CM, Steitz TA. 1994. Function and structure relationships in DNA polymerases. *Annual Review of Biochemistry* 63: 777–822.

Keck JL, Roche DD, Lynch AS, Berger JM. 2000. Structure of the RNA polymerase domain of *E coli* primase. *Science* 287: 2482–6.

Kiefer JR, Mao C, Braman JC, Beese LS. 1998. Visualizing DNA replication in catalytically active *Bacillus* DNA polymerase crystal. *Nature* 391: 304–7.

Kim EE, Wyckoff HW. 1991. Reaction mechanism of alkaline phosphatase based on crystal structures. Two-metal ion catalysis. *Journal of Molecular Biology* 218 (2): 449–64.

Kraynov VS, Showalter AK, Liu J, Zhing X, Tsai MD. 2000. DNA polymerase beta: contributions of template-positioning and dNTP triphosphate-binding residues to catalysis and fidelity. *Biochemistry* 39(51): 16008–15.

Leipe DD, Aravind L, Koonin EV. 1999. Did DNA replication evolve twice independently? *Nucleic Acids Research* 27 (17): 3389–401.

Lipps G, Weinzierl AO, von Scheven G, Buchen C, Cramer P. 2004. Structure of a bifunctional DNA primase polymerase. *Nature Structural Molecular Biology* 11(2): 157–62.

Maciejewski MW, Shin R, Pan B, Marintchev A, Deninger A, Mullen MA, Chen K, Gryk MR, Mullen GP. 2001. Solution structure of a viral DNA repair polymerase. *Nature Structural Biology* 8(11): 936–41.

Oliveros M, Yáñez RJ, Salas ML, Salas J, Viñuela E, Blanco L. 1997. Characterization of an African Swine Fever Virus 20-kDa DNA polymerase involved in DNA repair. *Journal of Biological Chemistry* 272 (49): 30899–910.

Evidence for the evolution of bacterial flagella includes the existence of vestigial flagella, intermediate forms of flagella, and, importantly, the pattern of similarities among flagella protein sequences. Pallen and Matzke demonstrate that almost all of the core flagellar proteins have known homologies with non-flagellar proteins — contrary to repeated claims from the "intelligent design" movement, such as Minnich's claim in his expert report that "the other thirty proteins in the flagellar motor (that are not present in the type III secretion system) are unique to the motor and are not found in any other living system." In a September 7, 2006, post at The Panda's Thumb blog (<http://www.pandasthumb.org/archives/2006/09/flagellum_evolu.html>), Matzke quotes a number of "intelligent design" proponents as offering estimates of unique proteins in the flagellar motor, summarizing, "All the IDists think that ¾ of the flagellum proteins are 'unique', [that is] do not share homologies with other proteins. All they are aware of is the homologies to T3SS, which they usually mention while rebutting Kenneth Miller. Casey Luskin, a late example, cuts the number to ⅔, probably because he is dimly aware that there are some other homologous proteins out there, perhaps because several of us ID skeptics have been mentioning this point repeatedly for several years."

In fact, as Pallen and Matzke's article shows, there are only two flagellar proteins that are presently thought to be indispensable and for which no homologies are presently known. Matzke comments on the implications in his blog post: "Scott Minnich, the leading flagellum expert in the ID camp, was severely wrong about the most basic data relevant to the origins of the flagellum, the flagship system of the ID movement. ... Minnich promoted his mistaken view in the video *Unlocking the Mystery of Life*, which has been widely promoted by ID advocates across the country, viewed in countless church basements, IDEA club meetings, [and so on]. ... The error propagated further in Minnich's expert report." He concludes, with regard to the bacterial flagellum, "Apparently, everyone in the ID movement just mindlessly copies everyone else's talking points."

In their *Nature Reviews Microbiology* article, Pallen and Matzke offer a call for continued research on flagellar evolution, citing both the need to debunk "the suspicion among members of the public that maybe there is some mystery here, that maybe the ID proponents do have a point" and the prospect of thereby gaining further understanding of bacterial flagella. After sketching a few avenues for future research, they pointedly comment, "Like Darwin, we have found that careful attention to homology, analogy and diversity yields substantial insights into the origin of even the most complex systems."


Polesky AH, Steitz TA, Grindley NDF, Joyce CM. 1990. Identification of residues critical for the polymerase activity of the Klenow fragment of DNA polymerase I of *Escherichia coli*. *Journal of Biological Chemistry* 265 (24): 14579–91.

Polesky AH, Dahlberg ME, Benkovic SJ, Grindley NDF, Joyce CM. 1992. Side chains involved in catalysis of the polymerase reaction of DNA polymerase I of *Escherichia coli. Journal of Biological Chemistry* 267 (12): 8417–28.

Rozenfeld S, Thuriaux P. 2001. A genetic look at the active site of RNA polymerase III. *EMBO Reports* 2 (7): 598–603.

Sawaya MR, Pelletier H, Kumar A, Wilson SH, Kraut T. 1994. Crystal structure of rat DNA polymerase β: Evidence for a common polymerase mechanism. *Science* 264: 1930–5.

Showalter AK, Byeon IL, Su M, Tsai MD. 2001. Solution structure of a viral DNA polymerase X and evidence of a mutagenic function. *Nature Structural Biology* 8 (11): 942–6.

Showalter AK, Tsai MD. 2001. A DNA polymerase with specificity for five base pairs. *Journal of the American Chemical Society* 123: 1776–7.

Sontheimer EJ, Sun S, Piccirilli JA. 1997. Metal ion catalysis during group II intron self-splicing: parallels with the spliceosome. *Nature* 388: 801–5.

Sontheimer EJ, Gordon PM, Piccirilli JA. 1999. Metal ion catalysis during group II intron self-splicing: parallels with the spliceosome. *Genes and Development* 13 (13):1729–41.

Sosunov V, Sosunova E, Mustaev A, Bass I, Nikiforov V, Goldfarb A. 2003. Unified two-metal mechanism of RNA synthesis and degradation by RNA polymerase. *EMBO Journal* 22 (9): 2234–44.

Stahley MR, Strobel, SA. 2005. Structural evidence for a two-metal-ion mechanism of group I intron splicing. *Science* 309: 1587–90.

Steitz TA. 1993. DNA- and RNA-dependent DNA polymerases. *Current Opinion in Structural Biology* 3: 31–8.

Steitz TA, Smerdon SJ, Jager J, Joyce CM. 1994. A unified polymerase mechanism for nonhomologous DNA and RNA polymerases. *Science* 266: 2022–5.

Steitz TA. 1998. A mechanism for all polymerases. *Nature* 391: 231–2.

Steitz TA. 1999. DNA polymerases: Structural diversity and common mechanisms. *Journal of Biological Chemistry* 274 (25): 17395–8.

Steitz TA, Steitz JA. 1993. A general two-metal-ion mechanism for catalytic RNA. *Proceedings of the National Academy of Sciences* USA 90 (14): 6498–502.

Wang J, Sattar AKMA, Wang CC, Karam JD, Konisberg WH, Steitz TA. 1997. Crystal structure of pol α replication DNA polymerase from bacteriophage RB69. *Cell* 89 (7): 1087–9.

Weinstein LB, Jones BCNM, Cosstick R, Cech TR. 1997. A second catalytic metal ion in a large group I ribozyme. *Nature* 388: 805–8.

Woody AYM, Eaton SB, Osumi-Davis PA, Woody R. 1996. Asp537 and Asp812 in Bacteriophage T7 RNA polymerase as metal ion-binding sites studied by ERP, flow-dialysis, and transcription. *Biochemistry* 35: 144–52.

Vassylyev DG, Sekine S, Laptenko O, Lee J, Vassylyeva MN, Borukhov S, Yokoyama S. 2002. Crystal structure of a bacterial RNA polymerase holoenzyme at 2.6 Å resolution. *Nature* 417: 712–9.

Zaychikov E, Martin E, Denissova L, Kozlov M, Markovtsov V, Kashlev M, Heumann H, Nikiforov V, Goldfarb A, Mustaev A. 1996. Mapping of catalytic residues in the RNA polymerase active center. *Science* 273: 107–9.

Zhang G, Campbell EA, Minakhin L, Richter C, Serverinov K, Darst SA. 1999. Crystal structure of *Thermus aquaticus* core RNA polymerase at 3.3-A resolution. *Cell* 98: 811-824.


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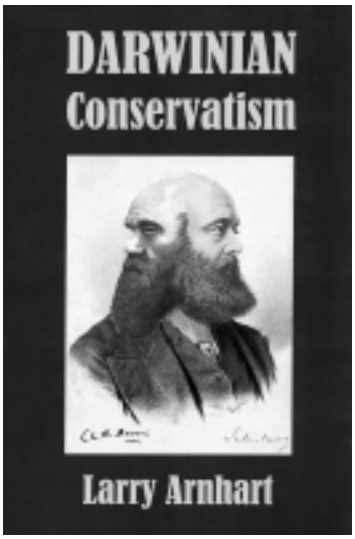
# BOOKREVIEWS




## Darwinian Conservatism

by Larry Arnhart
Exeter (UK): Imprint Academic, 2005. 162 pages

**Reviewed by Timothy Sandefur**

Larry Arnhart's message, stated in the first line of his book, is that "conservatives need Charles Darwin." But *Darwinian Conservatism*, like his earlier book *Darwinian Natural Right* (1998), shows that they need Larry Arnhart just as badly. His new book is an important reform tract: a plea to fellow conservatives not only to see the danger of hitching their wagon to the falling star of "intelligent design", but also to realize that the left has no legitimate claim to the laurels of scientific rationality.

First things first: Arnhart deserves praise for rejecting the notion that science is somehow neutral toward politics or morality. If politics is to solve human problems, then it must be based on an understanding of what humans are, and what they need to survive and to flourish. Unfortunately, many scientists are so eager to keep science strictly separated from messy partisan conflicts that they claim biology has nothing to say about ethics or politics. This is silly. Evolution is the most robust explanation of human nature ever devised, and any political philosophy that hopes to be more than dream talk must ultimately be based on that account. Evolutionary science holds out the possibility of founding politics not on arbitrary value assumptions or cultural relativism, but on humanity's objectively ascertainable qualities and needs. Take property rights, for example. Previous generations thought of property as part of the divine order of the universe. That answer is no longer attractive after Darwin, but neither is the equally contrived answer, common on the left, that property is just a conventional institution that can be altered or revised by wise bureaucrats in the service of noble goals. Like Richard Pipes (1999), Arnhart argues that property rights are a natural need of human beings, rooted in our biological nature, and that they have evolved alongside our physical nature (pages 31, 59–67). He makes the same argument about nineteen other "natural desires" which originate in "a universal human nature," and "motivate [our] moral judgment" (page 26). These desires, he continues, are conservatism's chief concerns, and they are not of supernatural origin, but are the product of evolution. In short, "Natural law is not a 'myth.' It is a rationally observable and scientifically verifiable fact" (Arnhart and others 2000).

It is unfortunate for conservatism that this argument is so unusual. All Arnhart seems to be saying is that conservative values can be grounded in nature, not just myth. Yet conservatism has labored long under the assumption that we need a special magic spark to give us moral significance. Science, according to such conservative mainstays as Russell Kirk (1985: 419), Robert Nisbet (1990), or Richard Weaver (Young 1995: 108–10), leads to a "mechanistic" universe populated by "mere atomistic individuals" who live a graceless life of cost–benefit analysis. But Arnhart argues that there is no need for magic to make us moral creatures. Morality is a function of (evolved) human nature: "Because normal human beings have the human nature that they do, which includes propensities to moral emotions, they predictably react to certain facts with strong feelings of approval or disapproval, and the generalizations of these feelings across a society constitute their moral judgments" (page 44).

But while human nature, and its moral aspects, are not handed down from On High, neither are they arbitrary matters of convention. Throughout the twentieth century, political thinkers on the left have regarded human nature as a function of culture, meaning that it can be changed to serve society's needs. John Dewey, for example, argued that an individual's personality is "something achieved … with the aid and support of conditions, cultural and physical," and that modern liberalism sought the "positive construction of favorable institutions, legal, political and economic" by which individual personality could be formulated, not just liberated (Dewey 1935). In some ways, this Progressive attitude was a consequence of "Darwin's overthrow of essentialism" (Dennett 1995: 39), since it seemed to prove that there was no unique *thing* to differentiate humans from the rest of the universe, and therefore, that there was no such thing as unchanging categories in politics or morality. Right and wrong, justice and injustice, private and public, could be whatever people decided. As Louis Menand puts it, Progressives rejected the idea that "there exists some order, invisible to us, whose logic we transgress at our peril" (Menand 2000: 439), and adopted anything-goes nominalism instead.

But there is an important way in which evolution does *not* overthrow essentialism (Matson 1984:

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24–6). Humans do indeed have a nature, even if biological evolution has molded them from less sophisticated predecessors. The primary error of conservatives like Kirk or Harvey Mansfield, writes Arnhart, is their assumption "that human nature is not a solid ground of moral norms unless it is eternally unchanging" (page 54). Although he does not spend much time in this book on such complicated epistemological arguments, Arnhart has explained in *Darwinian Natural Right* why a much stronger explanation of human nature — and a much stronger foundation for naturalistic ethics and politics — is provided by an "evolutionary account of species [that] is neither strictly essentialist nor strictly nominalist" (Arnhart 1998: 233).

In fact, nominalism should *also* be seen as a rejection of Darwin (see, for example, Menand 2000: 371–2). And yet somehow the idea that natural human conditions like property, inequality, acquisitiveness, or sex roles, have no biological anchor, but can be altered by energetic social planning, has somehow come to be seen as "scientific" by a great many intellectuals (Johnson 1990). This notion really puts leftists in a bind: "On the one hand, Darwinian leftists must accept the Darwinian account of human nature. On the other hand they must assume that human beings are free from the constraints of human nature because they create human history as a cultural artifact" (page 123; see also Johnson 1990: 338–40).

Conservatism overreacted to leftist relativism by searching for eternal, magical solutions; what Daniel Dennett calls "skyhooks" (1995: 74). In fact, some conservatives do not even care whether such solutions really exist, and have argued instead for a "noble lie" whereby "it is the moral and political utility of religious belief that is decisive" (page 91; see also Bailey 1996). But how strong can a political theory be, which *consciously grounds itself* on a lie? The "deepest question," Arnhart writes, is "whether morality necessarily depends on religious belief…or whether a scientific naturalism can support a natural moral sense (as Darwin argued) that does not necessarily require religious belief" (pages 115–6). His defense of the latter is a significant contribution to conservative thought.

In short, Arnhart rejects both the leftist appeal to cultural or moral relativism and the traditional conservative appeal to magic, by grounding politics on "a universal human nature of natural instincts and desires," which allows us to "judge some societies … as satisfying those natural desires more fully than other societies." Understanding this means seeing that "cultural traditions are not the only source of morality, because the natural instincts of human beings provide a natural ground for the moral sense, just as Darwin argued" (page 23). This is correct, but there are two other important issues to be confronted when discussing the relationship of evolution to politics: the concept of spontaneous order, and the conflict of faith against reason.

The Nobel-prize–winning economist Friedrich Hayek coined the term "spontaneous order" while debunking the leftist assumption that social institutions are, or can be, the products of human design. This assumption, alas, remains common among modern liberals; Laurence Tribe, for example, has argued that there is really no such thing as a free market because "'freedom' of contract and property" are really just "expressions of positive governmental intervention," so that there is "no 'natural' economic order to upset or restore" through government regulation (Tribe 1988: 578–9). But as Hayek explained, the market is *not* the product of centralized design, but the outcome of countless unorganized interactions between people, gradually producing stable, useful institutions like property or contract law (see, for example, Hayek 1978–1981). In Arnhart's words, a spontaneous order is "a complex order that arises not as the intended outcome of the intelligent design of any mind or group of minds, but as the unintended outcome of many individual actions to satisfy short-term needs" (page 16). Evolution is the most obvious example of this ordering process, but the free market, and, to a lesser extent, common law legal systems, are also spontaneous orders (see also Nozick 1974: 18–21). Hayek made it clear that not only are government planners unnecessary for solving economic problems, they are often downright harmful, since they ignorantly interfere with better, decentralized problem-solving. For example, when bureaucrats demolish a neighborhood to make way for a new subsidized shopping center, they destroy the spontaneous process of neighborhood-building that gives a town character and a sense of place (Curtis 2006). When they implement technical regulations on a trade, they stifle innovation which might not fit official, preconceived notions of how the market "ought" to work (Postrel 1998: 83–111). Hayek argues that it is usually best to leave markets alone to devise solutions, rather than to impose a single, one-size-fits-all solution invented by politically-influenced bureaucrats in faraway capitol buildings. This argument fits very comfortably with evolution. If design does not require a designer, then there is no need for the state to "design" economic institutions. Multiple decentralized choices will tend toward efficiency.

Ironically, this argument actually *conflicts* with conservative values. While they tend to reject government control over the economy, conservatives are generally eager for government to control *other* relationships, such as sexual relations or marriage. They distrust the free market precisely because its underlying principles allow individuals to make their own choices in these areas of life also (Schumpeter 1962). Richard Weaver, for example, complained that capitalism leads to a "soulless, desiccated middle class which … destroy[s] the concept of nonmaterial value" (Young 1995: 161), and Russell Kirk saw capitalism as expressing a "modern temper" which "ignore[s] the longings of humanity" such as "the comforting assurance that continuity is more probable than change" (1985: 492) Spontaneous order works through vast number of individual choices, but conservatives oppose individual choice in many personal matters because it disrupts tradition (Sandefur 2001). It is libertarian-

ism, not conservatism, that embraces the dynamic character of free markets (Postrel 1998; D'Souza 2000).

Arnhart glosses over this problem by absurdly suggesting that libertarianism is a variety of conservatism, which it emphatically is not (Barnett 2004: 72). In fact, he seems to suffer throughout from a deep confusion as to the difference between conservatism and libertarianism, and he clings to an interpretation of conservatism that many would reject: namely, the notion that liberty is one of its primary values. In fact, liberty has rarely been a conservative value; it was only the chance arrival of Goldwater and Reagan on the Republican Party scene in the 1960s that drew many libertarians into describing themselves as conservative. These people propounded a theory of "fusion" between libertarians and conservatives (Meyer 1996). But recent events have eroded that fusion significantly, and the future of its union seems bleak.

Another troubling omission is Arnhart's failure strongly to confront the philosophical elephant in the room, and that is the interaction of reason and faith in the post-Darwin world. Evolution is not controversial because of its factual conclusions about the origins of species; it is controversial because it shows that our world can be understood in terms of reason alone, without faith. And since so much authoritarian political philosophy — conservatism in particular — has been based on faith, that account has tremendous social consequences. Arnhart's argument that scientific reason can *also* support conservative principles may reassure those whose primary concern is for practical policy matters, but in the end it will make little progress against those whose focus is more fundamental. Without taking a position on the conflict of faith and reason — by, in fact, seeming to appease religion — Arnhart cannot advance far on the battlefield where evolution and conservatism contend.

These two problems actually intertwine. Arnhart's reason-based approach is welcome indeed, and it is true that conservatives need it. But I doubt that that approach can be fairly classified as conservatism itself. In fact, for all his talk of Edmund Burke and family values, Arnhart has much more in common with the secular libertarianism of Ayn Rand or Jacob Bronowski than with such basically theocratic thinkers as Kirk (Rand 1968; Bronowski 1965). It would be nice if conservatives would adopt secular libertarianism, but while a society based on an unceasing demand for evidence and rational demonstration would, indeed, be a society of liberty — it would hardly be conservative.

#### References


Arnhart L. 1998. *Darwinian Natural Right*. Albany (NY): State University of New York Press.

Arnhart L, Behe M, Dembski W. 2000. Conservatives, Darwin & design: An exchange. *First Things* 107: 23–8, 30–1.

Bailey R. 1997. Origin of the specious. *Reason* 29 (3): 22–8.

Barnett RE. 2004. The moral foundation of modern libertarianism. In: Berkowitz P, ed. *Varieties of Conservatism in America*. Stanford (CA): Hoover Institution Press. p 51–74.

Bronowski J. 1965. *Science and Human Values*. New York: Harper Perennial.

Curtis W. 2006. Brand new cities. *The American Scholar* 75 (1): 113–6.

D'Souza D. 2000. *The Virtue of Prosperity*. New York: The Free Press.

Dennett D. 1995. *Darwin's Dangerous Idea*. New York: Simon & Schuster.

Dewey J. 1935. The future of liberalism. *Journal of Philosophy* 22 (9): 225–30.

Hayek F. 1978–1981. *Law, Legislation and Liberty*. 3 volumes. Chicago: University of Chicago Press.

Johnson P. 1990. *Intellectuals*. New York: Harper Perennial.

Kirk R. 1986. *The Conservative Mind: Burke to Eliot*. 7th ed. Washington DC: Regnery Publishing.

Matson W. 1984. Rand on concepts. In: Den Uyl DJ, Rasmussen DB, editors. *The Philosophic Thought of Ayn Rand*. Urbana (IL): University of Illinois Press. p 21–37.

Menand L. 2000. *The Metaphysical Club*. New York: Farrar, Straus and Giroux.

Meyer F. 1996. *In Defense of Freedom and Related Essays*. Indianapolis: Liberty Fund.

Nisbet R. 1990. *The Quest for Community: A Study in the Ethics of Order and Freedom*. Oakland: ICS Press.

Nozick R. 1974. *Anarchy, State, and Utopia*. New York: Basic Books.

Pipes R. 1999. *Property and Freedom*. New York: Knopf.

Postrel V. 1998. *The Future and Its Enemies*. New York: The Free Press.

Rand A. 1968. *Capitalism: The Unknown Ideal*. New York: Signet.

Sandefur T. 2001. Why conservatives oppose progress. Review of *The Virtue of Prosperity* by Dinesh D'Souza. *Liberty* 15 (3). Available on-line at <http://www.geocities.com/sande106/ConservativesProgress.htm>. Last accessed August 8, 2006.

Schumpeter J. 1962. *Capitalism, Socialism, and Democracy*. New York: Harper Perennial.

Tribe LH. 1988. *American Constitutional Law*. 2nd ed. New York: Foundation Press.

Young F. 1995. *Richard M Weaver 1910–1963: A Life of the Mind*. Columbia: University of Missouri Press.



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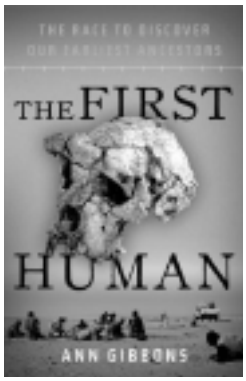


## The First Human: The Race to Discover Our Earliest Ancestors

by Ann Gibbons
New York: Doubleday, 2006.
306 pages

**Reviewed by Pat Shipman, Pennsylvania State University**

Ann Gibbons's fifteen years of writing news stories for *Science* magazine on the subject of human origins shows in this book, and shows well. She has crafted a lively, evocative narrative about the various scientific teams searching


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for the earliest members of the human family — the evolutionary link that will reveal when ape and human lineages diverged — with nary a scientific error or misstep. This is a tremendous accomplishment for any writer and is a testament to Gibbons's intelligence and meticulous reporting, traits which are enhanced by her considerable skill as a storyteller.

The where, when, who, how, and why of human origins has held a great fascination for scientists and laypeople alike for millennia. Even though the fossil record of extinct apes and hominins (ancestors and close relatives of humans) has expanded greatly over the last fifty years, the quest retains its urgency. Nearly all paleoanthropologists agree that the time period when the ape and human lineages diverged from one another was between 5 and 7 million years ago and some would narrow the gap even further. Gibbons takes the reader on recent expeditions that have found fossils from this time period, bones of different extinct species that might — or might not — reveal *who* the first hominin was.

She does an excellent job of capturing the internal drive that propels paleoanthropologists and geologists into the remote and sometimes dangerous places of the world where such fossils might be lurking. She focuses on four teams: one led by Michel Brunet, leader of a French–Chadian team that found a cranium from Chad that is 6 million years old, named *Sahelanthropus*; American Tim White, Ethiopian Yohannes Haile-Selassie, and Japanese Gen Suwa, members of a team that found partial skeletons of two species of *Ardipithecus* dated to between 4.4 and 5.8 million years old in Ethiopia; Frenchwoman Brigitte Senut and her "partner", Briton Martin Pickford, who found leg bones and teeth of 6-million-year–old *Orrorin* in the Tugen Hills of Kenya; and Kenyan Meave Leakey and her team, finders of *Australopithecus anamensis,* a 4.1-million-year–old, upright walking species from Kanapoi, Kenya. (In the interests of full disclosure, I should add that my husband, Alan Walker, was part of the *anamensis* team.)

Gibbons deals first with the claims each set of fossils and their finders have made for "earliest hominin" status. Distinguishing a very early hominin from a very late common ancestor shared with the apes is not a simple business. She shows neatly how the lack of comparable parts causes difficulties — few of the contenders have complete or even largely complete crania to show brain size; those with crania do not always have legs, hips, or feet to show bipedalism or its lack. Another problem is the natural distortion or breakage of fossil bones, which hinders their assessment. If paleoanthropologists had partial skeletons of each of these species, there might be less debate.

Then again, as Gibbons deftly reveals, there might not be less debate with more complete material. Major conflicts and disagreements that come from other sources as well, primarily the issuing of permits. He (or she) who controls the fossils and the finding of fossils controls discovery. That means that who holds the proper permit to a given area, with geologic deposits of the right age, is key. Governments issue permits and governments change, sometimes frequently. In recent years, African nations have also asked to see a return for their fossils, in terms of infrastructure and/or training of their people. This too has created a climate of changing laws allowing the excavation and temporary removal of fossils and other artifacts for scientific study. The result is repeated and often justified charges of claim-jumping by one or the other group of researchers. Nothing is more maddening than spending years putting together a team of experts, obtaining the funding, beginning the survey and excavation — only to find someone else has come in and looted your area. Nothing is more frightening than finding oneself — as one young researcher did in 2003 — confronted by a man waving a gun and claiming one's permits are invalid.

Gibbons not only recounts of all these crucial points but also does a fine job of explaining what criteria are used to judge whether a fossil is a hominin or not and where the gaps in our knowledge lie. I am happy to recommend this book to anyone, specialist or not, who wants an up-to-date account of the "oldest" problem in paleoanthropology.

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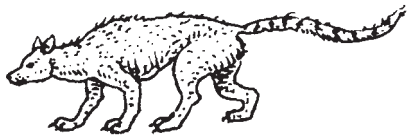

# The Complete Idiot's Guide to Human Prehistory

by Robert J Meier
Alpha/Penguin USA, 2003.
318 pages

**Reviewed by Anne Gilbert**

I stumbled across this book quite accidentally, a month or two ago. I skimmed through it with some interest, as I am continually looking for any material that will introduce this field to those interested in human evolution and prehistory without being too overwhelming. This is one such book. It is part of the *Complete Idiot's Guide* series, which is similar to the *For Dummies* series.

There is a lot of ground to cover: taxonomy, the history of evolution, the discovery of human and prehuman fossils and artifacts, competing models of human evolution, and challenges to the theory of evolution, among others. Meier does a very creditable job of pulling all these things together, describing and explaining them in a simple and straightforward manner. For example, he goes into some detail about the earliest stone tools and how they were made. Then he details how he bonobo Kanzi was taught to make stone tools. The result was that although Kanzi learned the *procedure* for making stone tools, none of them attained the quality that the earliest toolmakers — *Homo habilis* at 2.5 million years ago — attained. The implication is that while we share at least 95% of our

*Anne Gilbert writes "anthropological fiction" with story lines based in human prehistory.*

genetic makeup with chimps and presumably bonobos, there is a definite gulf between the things a chimp can do and the things a human can do. And the development of that gulf is part of our evolutionary story.

This book has another plus: It has little boxes on the sides of many of its pages, defining what the boxes call "anthrolingo" — terms commonly used in discussions of human evolution and prehistory. This could be potentially very useful for students, because terminology is frequently hard to remember. There are also little boxes for interesting "paleofacts" about the people who were players in the human evolutionary discovery story or else about some of the ideas that have been put forward to explain things like bipedalism, and why they did or did not stand the test of time. He does a nice job of this with Raymond Dart's "Osteodontokeratic Theory".

The final section is also interesting, as it deals with the continual challenges the theory of evolution has faced, and the answers to these challenges. Meier goes into some detail so that it is easy to see, after reading this section, why ideas such as "intelligent design" are not good substitutes for evolutionary theory in its modern form. Finally, this book has an extensive bibliography of various sorts of resources, including a number of good websites dealing with aspects of human evolution. I am familiar with most of them, although some of the URLs have changed since Meier started writing the book.

I would recommend this book as a useful resource for anyone interested in, but confused by, the various facets of and problems with the study of human evolution. An interested layperson could look at this book and get a good number of resources for further reading or study. Beginning students of biological anthropology may find this book useful for its definitions and relatively simple but explanatory language. Experts may find faults in some places. For example, Meier made one mistake concerning the discovery of the contents of the famous (or infamous) Feldhofer Cave where the first named Neandertals were found. But compared to the rest of the book, this is relatively minor. All in all, it is worth checking out.

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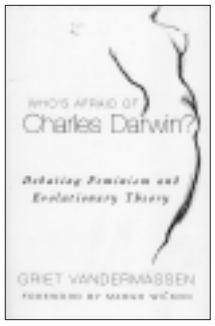


## Who's Afraid of Charles Darwin? Debating Feminism and Evolutionary Theory

by Griet Vandermassen
Latham (MD): Rowman & Littlefield, 2005. 227 pages

**Reviewed by Linda D Wolfe, East Carolina University**

*Who's Afraid of Charles Darwin?* is not the usual evolution-versus-creationism fare found in *RNCSE*. As suggested by the book's subtitle, the concern of this book is the misunderstanding of evolutionary psychology by many feminists. The author hopes to convince feminists of the truth of evolutionary psychology and to help them understand human nature. The title of Vandermassen's book is an apparent spoof on the title of the 1962 play and 1966 movie *Who's Afraid of Virginia Woolf?*, the title of which was perhaps a take-off on the song "Who's afraid of the big bad wolf?" from the 1933 Disney cartoon *Three Little Pigs* and the name of the late British novelist and feminist essayist, Virginia Woolf (1882–1941). *Who's Afraid of Charles Darwin*? concerns feminism and it is, therefore, fitting that the book's title is associated with Virginia Woolf, albeit indirectly.

Over half of Vandermassen's book is devoted to a criticism of feminist theory of the researchers in the social sciences and humanities. For those interested in feminist theory and want their heart rates energized, this is a good read. She is particularly critical of the proponents of "social constructionism", the proposition that male–female differences are the result of differences in learning societal gender roles during childhood. She laments the fact that feminists cannot accept that male–female differences are the result of biological adaptations that evolved during the last two million years.

In the scientific literature, "Darwinism" is used in many different ways and can refer to natural selection, the writings of Charles Darwin, evolution, synthetic theory, evolutionary biology, behavioral ecology, sociobiology and, as found in Vandermassen's book, evolutionary psychology. The author, interestingly, posits that evolutionary psychology has its roots in cognitive psychology and not directly in sociobiology, although sociobiology and evolutionary psychology share ideas. Sociobiology was synthesized independently by Richard Alexander and Edward O Wilson from the published works of such theoreticians as Richard Trivers (parental investment), John Maynard Smith (kin selection), and William Hamilton (inclusive fitness). Sociobiology and evolutionary psychology share the concepts of parental investment, kin selection, and inclusive fitness, and the view that female choice is an important aspect of sexual selection. Sociobiology and evolutionary psychology have at their base the fact of anisogamy — the principle that the female mammal produces the largest gamete and, thereafter, assumes most of the "costs" of bringing offspring to sexual maturity.

From cognitive psychology, evolutionary psychology obtains the idea that mind has specialized devices called modules. These modules, moreover, are adaptations to the problems of survival and

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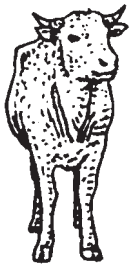

reproduction of *Homo sapiens* during two million years of existence as hunter–gatherers. She provides some examples of modules:

> In humans these content-specific mechanisms (modules) are, among many others, a face-recognition module, a spatial relations module, a fear module, a social-exchange module, an emotion-perception module, a kin-oriented motivation module, an effort-allocation and recalibration module, a child-care module, a sexual-attraction module, a semantic-inference module, a friendship module, and a grammar-acquisition module. (p 134)

It is by way of these modules that men prefer young healthy women, women prefer high ranking men with access to resources, stepfathers are more likely to kill their wife's children than they are the children they have some assurance they have fathered, women will try to cheat if they have a chance to mate with a man with better genes than their husbands, and so forth. Exactly what problems human hunter–gatherer ancestors faced that these modules and the subsequent behaviors were meant to solve is not made explicit. Moreover, two million years is a long time in hominin history, from about *Homo habilis* through *Homo erectus* to *Homo sapiens*. Technology changed over this time period and people lived under many different environmental conditions. There have been changes in human biology during the last 10 000 years, especially with the advent of the domestication of plants and animals, and it is, therefore, difficult to accept that there have been no changes in the neurological structure of the brain, if indeed it is composed of modules as proposed by the evolutionary psychologists. As pointed out by Buller (2005), evolution is a process and not an end game.

I consider myself a feminist and an evolutionist but in the tradition of synthetic theory and the late Stephen Jay Gould. I am also a scientist and, moreover, I accept the research suggesting that at least some differences between boys and girls, and men and women, have a biological basis. I remain unconvinced, however, of the power of evolutionary psychology to explain these differences.

#### References

Buller DJ. 2005 *Adapting Minds: Evolutionary Psychology and the Persistent Quest for Human Nature*. Cambridge (MA):The MIT Press.

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# Monkey Business: The True Story of the Scopes Trial

by Marvin Olasky and John Perry
Nashville: Broadman & Holman, 2005. 344 pages

**Reviewed by George Webb, Tennessee Tech University**

You don't have to be a devoted postmodernist to cringe when you see the words "true story" in a book title. Such tomes are often muddled reports that seek to advance specific agendas, leaving the reader with an inaccurate or, at best, incomplete portrait of the subject under consideration. *Monkey Business* is no exception.

Authors Marvin Olasky and John Perry, journalists whose writings have focused on religious topics, certainly embrace a specific agenda, in this case the advancement of "intelligent design" as an alternative to the teaching of evolution in public schools. The publisher of their book, Broadman & Holman, is best known as one of the largest Bible publishers in the world, but has recently branched out to publish such books as *The ACLU Versus America*. The "truth" the authors present about the Scopes trial must be viewed within this context.

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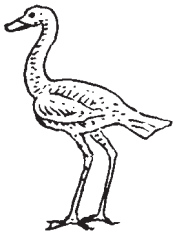
#### The search for the truth

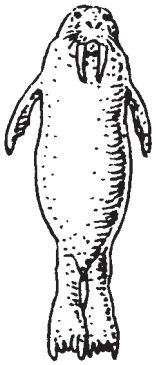
Readers familiar with the anti-evolution, creation science, and "intelligent design" movements will recognize this book's themes and arguments almost at once. "The creation debate is as intense as ever," the authors announce in their introduction, "because it's as important as ever: What we believe about where we came from determines what we believe about everything else." Statements such as this are found throughout the anti-evolution literature of the 20th and 21st centuries.



The authors reprise other arguments as well, some of which emerged as early as the 19th century, concerning supposed scientific shortcomings in evolutionary explanations. They argue that the incomplete fossil record is a serious weakness, forcing the evolutionary establishment to base its acceptance of the theory on "filling in a great many theoretical blanks with hypotheses." Olasky and Perry also opine that both evolutionists and anti-evolutionists base their science on a particular view of God, rather than on a dispassionate view of nature, providing another version of the oft-repeated argument that the acceptance of evolution requires as much faith as any religion.

The authors' search for the "truth" about the Scopes trial leads them down various paths, but they are especially troubled that the public perception of the Scopes trial has been shaped by the myths created by the defense team, the famous reporter HL Mencken, the play and, even more dramatically, the later movie — *Inherit the Wind*. To correct this perspective, Olasky and Perry focus on various "hidden" details of the trial, all of which are well-known to historians.

One "hidden" detail of particular interest to the authors is the American Civil Liberties Union's offer to defend any Tennessee teacher brought to trial for violating the then-recently passed Butler Act, which outlawed the teaching of evolution in the state's schools. The ACLU, as the authors paint it, was a new organization best known for its support of "unions, socialists, and at least initially, Russian communism," and the



Butler Act gave the ACLU an ideal opportunity for publicity.

Equally important to the authors, however, is the "truth" about the defense team, and Olasky and Perry are pleased to expose the lawyers defending John Thomas Scopes as something less than the courageous defenders of free speech described by the media and later dramatists. Clarence Darrow's association with "radical" causes is emphasized, while Dudley Field Malone comes under subtle attack for his law practice. Focusing on one aspect of his career — which included service in the State Department — the authors describe Malone as "a high-society divorce lawyer" who had a long-standing relationship with Darrow. "Darrow worked with Malone," the authors report, "who had an office in Paris, to secure expensive but discreet French divorces for wealthy American clients." Thus they attempt to discredit Darrow by dismissing him as a radical tool and Malone by deriding him as a legal dilettante.

### Darwin, culture, and missing information

After attempting to portray the Scopes trial as something of a fraud publicized by a hostile media, Olasky and Perry dedicate the rest of their volume to a multi-pronged attack on the teaching of evolution and its impact on society and culture.

The status of science remains a troubling aspect of the modern world, according to the authors of *Monkey Business*, for it represents the result of a gradual removal of God from the study of nature and from much of society itself. According to the authors — who are again repeating arguments made for more than a century — with God removed, society has abandoned traditional concepts of morality and standards of behavior. In their chapter entitled "Establishing atheism," the authors contend that the courts have consistently acted during the past half-century to remove God from the nation, just as Darwin and other scientists removed him from nature.

The authors have provided a great deal of information of potential use to those who continue to campaign against the teaching of evolution in the public schools. But their book is plagued by many weaknesses. It is crippled by numerous errors of fact, which suggests a lack of care in the authors' reading of cited sources. For instance, they quote with approval Scopes trial prosecutor Ben McKenzie defending the Butler Act: "Under the law you cannot teach in the common [public] schools the Bible. ... Why should it be improper to provide that you cannot teach this other theory?" And yet, the state of Tennessee in 1915 legislatively *mandated* daily Bible reading. At the very least, McKenzie's statement requires clarification. Furthermore, given the large number of publications about the topics under consideration, it is surprising to find a bibliography of fewer than four pages that includes few standard historical treatments. The authors seem interested only in using these sources selectively to set up various straw men whose destruction might support their evangelical Christian perspective and commitment to "intelligent design".

### Pushing an agenda

Perhaps the most troublesome of all weaknesses, however, is the authors' rejection of expertise. Throughout *Monkey Business* they dismiss those scientists who accept evolutionary explanations as merely another group whose views should not be forced on those who disagree with them.

Instead, Olasky and Perry praise the work of Phillip Johnson, who served as the new and effective leader of the "battle against Darwin" for several years. Johnson's education at the University of Chicago and at Harvard University, as well as his position on the law faculty at the University of California, Berkeley, provide the "outstanding academic pedigree" needed by such a leader, they write. Johnson's lack of scientific background poses no difficulty because his "keen legal mind" reveals that the evolutionary explanation "was fatally flawed and always had been." But Johnson is a lawyer and no matter how "keen" his legal mind, he lacks an adequate understanding of science; he makes numerous blunders of fact and interpretation. This matters not to Olasky and Perry.

*Monkey Business* thus is fatally flawed by clouded logic, an inadequate background in existing historical sources, various factual errors, and a failure to examine alternative interpretations of the controversy. Olasky and Perry have produced a volume that will be of interest only to readers who already embrace the anti-evolution viewpoint.

The search for the "true story" of the Scopes trial will require another team of explorers.

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## Fatal Flaws: What Evolutionists Don't Want You to Know

by Hank Hanegraaff
Nashville: W Publishing Group, 2003. 112 pages

**Reviewed by Michael Buratovich, Spring Arbor University**

Hank Hanegraaff's book *Fatal Flaws* is an abbreviation of his earlier book *The Face that Demonstrates the Farce of Evolution* (Nashville: Word, 1998). For the most part, the book reiterates standard creationist arguments. Previous work by Hanegraaff's Christian Research Institute shows that he and his staff have little tolerance for hucksters and thieves in preachers' clothing (notice their exposés on Benny Hinn), which makes the mistakes and poor research in this book somewhat surprising. There

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is only room to discuss a few of the many errors in this book.

In the introductory chapter of this book, Hanegraaff, who is a very clever designer of mnemonic acronyms, fashions the acronym FARCE to help the reader remember the alleged problems with the theory of evolution. The letters of FARCE represent *F*ossil follies, *A*pe-men fiction, fraud, and fantasy, *R*ecapitulation, *C*hance, and *E*mpirical science.

In his chapter on "fossil follies", Hanegraaff quotes David Raup, the curator of the Field Museum of Natural History in Chicago: "We are now about 120 years after Darwin, and the knowledge of the fossil record has been greatly expanded. We now have a quarter of a million fossil species, but the situation hasn't changed much. ... We have even fewer examples of evolutionary transition than we had in Darwin's time" (p 17). Hanegraaff's reference for this quotation is Paul Taylor's *Illustrated Origins Answer Book*. If he had read Raup's original article ("Conflicts between Darwin and paleontology," *Field Museum of Natural History Bulletin* 1979; 50 [1]: 22–9), he would have discovered what Raup really said on page 25 was this, with the portions quoted by Hanegraaff italicized:

> Well, *we are now about 120 years after Darwin and the knowledge of the fossil record has been greatly expanded. We now have a quarter of a million fossil species but the situation hasn't changed much.* The record of evolution is still surprisingly jerky and, ironically, *we have even fewer examples of evolutionary transitions than we had in Darwin's time.* By this I mean that some of the classic cases of Darwinian change in the fossil record, such as the evolution of the horse in North America, have had to be discarded or modified as a result of more detailed information — what appeared to be a nice simple progression when relatively few data were available now appear to be much more complex and much less gradualistic. So Darwin's problem has not been alleviated in the last 120 years and we still have a record which *does* show change but one that can hardly be looked upon as the most reasonable consequence of natural selection.

In contrast to the impression that Hanegraaff is trying to give, Raup is discussing how — not whether — evolutionary change has occurred. Raup clearly accepts evolution, but he is not convinced that the paleontological record supports Darwinian *gradualism*.

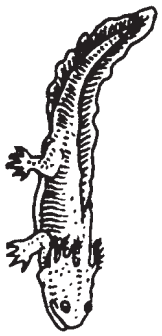
Hanegraaff proceeds to attack *Archaeopteryx* as a "false link between reptiles (such as dinosaurs) and birds" (p 17–8). He dismisses the reptilian features of *Archaeopteryx* with a reference to Duane Gish, who has neither formal training nor any record of serious field experience in paleontology. Unfortunately Hanegraaff's glib attitude toward the reptilian characteristics in the skull, vertebrae, ribs, tail and limbs of *Archaeopteryx* will not make them go away. *Archaeopteryx* also possesses some bird-like features, but these reptilian and bird-like features are found in the same fossil animal. If this does not make *Archaeopteryx* a transitional form linking reptiles and birds, then one is left to wonder what Hanegraaff considers a transitional creature.

Hanegraaff's chapter on human fossils has even more problems. His description of Nebraska Man is riddled with errors. The mistaken identification of the tooth by Henry Fairfield Osborn as an ape tooth was largely due to the similarity of cheek teeth in humans and pigs and the worn condition of the tooth. Furthermore, Osborn never designated *Hesperopithecus* as a human ancestor; there was a healthy skepticism surrounding the validity of Nebraska Man, and the literature of the day makes it clear that Nebraska Man received little backing from other paleoanthropologists.

Hanegraaff does no better with Dubois' discovery of *Pithecanthropus erectus* ("Java Man"; today known as *Homo erectus*). Hanegraaff perpetuates the often-repeated creationist conviction that Dubois suppressed evidence from the Wadjak skulls found nearby that would contradict his interpretation of *Homo erectus* as a potential ancestor to modern humans. However, Dubois did write formal descriptions of these skulls that were published in legitimate journals that were cited by researchers who continued to work on the Wadjak skulls. Furthermore, Trinil, the site where Dubois found *Pithecanthropus*, and Wadjak, where he found the more modern Wadjak skulls, are about 100 miles apart. Clearly these are not "in close proximity" as Hanegraaff would have us believe. In addition, further discoveries of *Homo erectus* skeletons have confirmed the validity of Dubois's *Pithecanthropus erectus* skull cap.

Finally, Hanegraaff's chapter on embryonic recapitulation constructs a straw man. Darwin did not endorse the extreme developmental recapitulationalism of Ernst Haeckel ("ontogeny recapitulates phylogeny") but instead endorsed a modified version of the views of the great German embryologist Karl Ernst von Baer. One of von Baer's famous "laws of development" asserted that the embryo of a higher animal is never like the adult of a lower animal, but does resemble the *embryo* of a lower animal. This principle influenced Darwin during his seminal work on barnacle classification. The common embryological stage shared by other recognized crustaceans and barnacles, the *nauplius* stage, convinced Darwin that barnacles were crustaceans and not mollusks, a taxonomic deduction that holds to this day.

Hanegraaff's book contains a great dependence on secondary sources, which leads to a perpetuation of common errors found in the works of many recent creationists. For a better book from a recent creationist perspective, see Ariel A Roth's *Origins* (Hagerstown [MD]: Review and Herald, 1998).



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