REPORTS OF THE NATIONAL CENTER FOR SCIENCE EDUCATION

Volume 17, Number 4 JULY/AUG, 1997

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REPORTS of the National Center for Science Education

Continues *NCSE Reports* & *Creation/Evolution*

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Cover: Naked Mole-Rats courtesy of Stanton Braude.
(story p 12)

FROM THE EDITOR'S DESK

Reports of the National Center for Science Education just keeps evolving. Of course the punctuation event that produced our redesigned publication format brought *RNCSE* into being—combining the features of both *Creation/Evolution* and *NCSE Reports*. Since then each issue seems to be modified slightly as the journal continues to adjust its new form to the challenges of combatting scientific illiteracy. Each issue helps to clarify the best ways for our new format to reach out and help our members to help NCSE meet our goals in support of science education.

Mail from our readers has suggested a little confusion over the contents of the new format. Some of this has occurred because we have changed the number and names of departments; and some of it certainly is because our combining two different publications has blurred some of the distinctions that readers expected in the items that appeared in each.

Our "News" Department carries reports of events, activities, and other happenings related to the support of evolution. Most of these are short reports sent to us from our members around the country and written up by one of our staff. In the "Features" Department readers will find longer, more detailed items that focus on issues with important national or regional implications or that provide a wider perspective. Finally, the "Resources" Department provides information about books, films, internet resources, and NCSE's books program that our members might find useful for keeping up-to-date and informed. These departments represent the contents of the former *Reports of the NCSE*.

Our "Articles" and "Reviews" Departments represent the contents of the former *Creation/Evolution*. These items tend to be of a technical or scholarly nature, exploring specific issues in scientific method and theory, science teaching and learning, philosophy of science, or other topics related to issues raised by anti-evolutionists in the quest to promote alternative "theories" to evolution. The reviews explore the content and value of books, videotapes, and other media that address the issue of evolution.

In the News

Is there anything new under the sun(belt)? Molleen Matsumura reports that Arizona seems to be following the lead of its neighbor New Mexico in eliminating any mention of evolution from state science education standards. We also report on the situation in New Mexico in "Updates". Statewide struggles about the place of evolution in science education standards also continue in Georgia and Texas, while local "flare-ups" come to us from Pennsylvania, Ohio, and Washington.

On the national scene, the National Association of Biology Teachers has revised its statement on evolution. After serious consideration by the NABT Board of Directors, the association removed two words from the statement that caused confusion about the statement's intent and its characterization of the role of evolution in science education.

Features

In international news, Scott Goodman reports on the final outcome of a long struggle in British Columbia to prevent the adoption of a creation "science" curriculum in Abbortsford. This is a follow-up to a report that Scott filed when the controversy was just heating up a few years ago.

Another ongoing story is the adoption of textbooks in Texas. Ken Miller reports on his appearance before the Texas Education Authority in anticipation of a committee member's challenge of a biology text by Miller and co-author Joseph Levine.

Don't miss NCSE Executive Director Eugenie Scott's state-of-the-theory report on current challenges to evolution. This feature was reprinted with permission from *The Paleontological Society Papers*.

Articles

Can evolutionary theory *predict* nontrivial and nonobvious adaptations? Stanton Braude shows that it can and has. Although we think of "eusociality" as the way of life of bees and other social insects, Braude shows how evolution predicted the conditions that would foster eusociality in vertebrates—long before any eusocial vertebrates were known to exist.

Richard Firenze is back with more reflections from a summer of helping pre-college teachers to improve their understanding of evolutionary theory and to include it in their teaching. The goal is for students to come away from the science classroom with a better grasp of both the content and the nature of science.

You Wrote, We Listened

We have received lots of comments and suggestions about our new format and the items we publish. We recognize that the two most difficult adjustments for a general readership were transgressions we have been committing regularly. First there are the items that are longer than a single page and continue onto one or more additional pages. We resolve to keep our news items and short reports...well, short. Look for items under our "News" heading to be one page or shorter.

The second issue is that some readers are distracted by the tendency of academics to stick citations in parentheses throughout their articles. Our immediate response to that is to move all the parenthetical citations to the ends of sentences, so that the citations will not distract our readers from the author's meaning. We are also reviewing the citation style to evaluation whether other citation and reference styles might be easier for our readers to accommodate.

So, keep those communications coming. We do pay attention to suggestions that you think will make *RNCSE* better and more useful to you.

Anj Petto

NEWS

Arizona: Another Sunbelt State Axes Evolution

Molleen Matsumura
Network Project Director

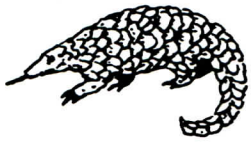
Arizona has adopted science content standards that pointedly omit any mention of evolution. The Academic Standards for Science state that the drafters "relied heavily on the very thoughtful and carefully crafted content standards found in the National Science Education Standards" adding, "These standards should serve as the basis for interpreting and teaching the standards outlined in this document"(Arizona Department of Education 1997). Yet, the Arizona standards' list of "unifying concepts and processes" includes only four of five of the "unifying concepts" listed in the national standards. The other items are repeated word for word, but the phrase "evolution and equilibrium" is missing. The omission was repeated in draft "Performance Objectives" developed in the autumn of 1997.

Observers in Arizona believe that active participation by State Board of Education member Janet Martin probably influenced the decision to omit evolution. Martin's opposition to evolution education is a matter of record. When she was appointed to the board in January 1997, the *Phoenix New Times* reported that FREE (Parents' Foundation for Responsible, Ethical Education), an organization founded by Martin, distributed a pamphlet which urges its members to "protest in court the unfair treatment of Creation as myth and Evolution as the only viable concept....TO SAVE THE CHILD YOU MAY NEED TO REMOVE THE CHILD FROM SCHOOL. THERE ARE GODLY ALTERNATIVES. PRAY!" (*Phoenix New Times* Jan 30, 1997).

NCSE's Arizona members, concerned that teachers will be pressured to avoid teaching evolution if they are not supported by the academic standards, believe it may not be too late to seek a revision, or inclusion of evolution in the performance objectives. Executive Director Eugenie C Scott has written to Arizona's Superintendent of Education, advising her that if evolution is omitted, the state may be faced with costly legal challenges, and science education will suffer. "Just when Arizona State University has been enriched by the addition of the Institute for Human Origins," Scott commented, "Arizona has adopted science standards that will leave students unprepared to take advantage of this resource."

In New Mexico, where evolution was omitted from science standards adopted in 1996, at least one community is considering teaching "creation science". NCSE will monitor developments in Arizona and keep members informed.

[*Readers may view the Arizona Department of Education' academic standards for science" at <http://www.ade.state.az.us/standards>.*]



NABT Statement on Evolution Evolves

Eugenie C Scott
NCSE Executive Director

In 1995 the National Association of Biology Teachers (NABT) issued a "Statement on the Teaching of Evolution" which was reprinted in *Reports of NCSE* (17[1]:31-2). In a list of "tenets of science, evolution and biology education," the first item read:

> The diversity of life on earth is the outcome of evolution: an unsupervised, impersonal, unpredictable and natural process of temporal descent with genetic modification that is affected by natural selection, chance, historical contingencies and changing environments.

After the statement was published, anti-evolutionists criticized the use of the terms "unsupervised" and "impersonal". UC Berkeley lawyer Phillip Johnson (author of *Darwin on Trial*) and other anti-evolutionists have claimed that the NABT statement is "proof" that evolution is inherently an ideological system, rather than simply a well-supported scientific explanation. Criticisms of the statement have appeared in newspaper letters to the editor, in newsletters and other publications. It appears that when most Americans other than scientists hear evolution described in blanket fashion as "unsupervised", they hear, "God had nothing to do with it"—a statement which is outside of what science can tell us.

In September 1997, two distinguished scholars, Alvin Plantinga, John A O'Brien Professor of Philosophy at Notre Dame University, and Huston Smith, Thomas J Watson Professor of Religion at Syracuse University, wrote to NABT Executive Director Wayne W Carley suggesting that the words "impersonal" and "unsupervised" were inappropriate because, "Science presumably doesn't address such theological questions, and isn't equipped to deal with them. How could an empirical inquiry possibly show that God was not guiding and directing evolution?"

The inclusion of those two words, Smith and Plantinga said, "...gives aid and comfort to extremists in the religious right for whom it

provides a legitimate target. And, because of its logical vulnerability, it lowers Americans' respect for scientists and their place in our culture. If the words 'impersonal' and 'unsupervised' were dropped from your opening sentence [*sic*] it would help defuse tensions which, as things stand, are causing unnecessary problems in our collective life."

The NABT annual meeting was held in Minneapolis October 8-11, 1997, and the letter and its request were considered by the Board of Directors on Wednesday, October 8. The board initially voted to retain the original wording, focusing on Plantinga's and Smith's comment that the statement "contradicts the beliefs of the majority of the American people, 90% of whom (according to opinion polls) believe that a *personal* agent—God—*supervised* in some way our arrival on this planet." Board members considered the comment irrelevant because scientific definitions are independent of the percentages of individuals holding opinions on religion. Carley's October 8 statement to the press underscored this view.

Reflecting upon that decision, Executive Director Carley commented, "We were at the end of a 9-hour meeting, we were tired, and we didn't give the subject enough time." During the next few days of the meeting, however, board members consulted with other NABT members and reconsidered the underlying message of the Plantinga-Smith letter. The letter exemplified how describing evolution as "impersonal" and "unsupervised" was being interpreted by individuals outside of science as anti-religious and unscientific.

NABT board members realized that they had a communication problem on their hands; they had not intended the statement on evolution to include theological positions! President-elect Dr Richard Storey, one of the drafters of the statement, and other members of the board called for a reconsideration of the decision, and the board met on Saturday, October 11, the last day of the conference. After a more extensive discussion than had been possible on Wednesday, the board considered that:

1) The extant wording which included "unsupervised" and "impersonal" apparently was miscommunicating both the nature of science and NABT's intent;

2) The deletion of those two words would not affect the statement's accurate characterization of evolution and affirmation of evolution's importance in science education.

The statement still describes evolution as a "natural process" (the only phenomena science can study) and affirms that natural selection "has no specific direction or goal, including survival of a species." The strong position of evolution in biology and other sciences was not compromised by removing two adjectives that miscommunicated NABT's meaning.

As the leading association of biology teachers in the United States, the NABT speaks with authority on issues affecting science teachers. Joseph McInerney, a former NABT president and a drafter of the statement, has said, "teachers are at the front, dealing with direct challenges to their teaching from real students and real parents who have immediate questions and immediate demands." One such question is, "Are you a Christian, or do you believe in evolution?" (*RNCSE*, 17[1]:30).

Plantinga's and Smith's letter underscored a very real problem: Many people perceive that they have to make a choice between their religious beliefs and evolution. As a science education organization, the NABT needs to avoid giving the impression that they are taking sides in theological issues—an impression given by the original text of their statement.

As McInerney pointed out, one of the goals of the NABT's statement on evolution was to "provide support for biology teachers when they are confronted with challenges to the teaching of evolution." By eliminating two nonessential words, the NABT Board of Directors made a statesmanlike decision that better fulfilled this goal by reducing a potential source of conflict in the classroom.

Office Biz

Erik Wheaton
Office Manager

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Pennsylvania—One Step Forward, One Step Back

Molleen Matsumura
Network Project Director

Early in 1993, the Institute for Scientific and Biblical Research (ISBR) began a campaign to set up headquarters in Lancaster County, Pennsylvania, and science teacher Robert Hertzler wrote to NCSE, "I feel that it is only a matter of time until our school board is approached to include 'Creation Science' in our curriculum.... While we live in a very conservative area, our community is very diverse, and I think we could successfully oppose [this] move." By February of this year, Hertzler told NCSE, "[O]ur county science teachers...fear repercussions.... [ISBR has built] a Creation Resource Education Center in Willow Street" [PA], and "the 'movement' has gained new momentum. Several local school boards have elected religious right members and...one of us [will be] targeted for their pressures."

On July 15, Hertzler's predictions came true, according to reports in the *Lancaster Intelligencer Journal* (Aug 14, 1997, p B1), when the Elizabethtown Area School Board voted unanimously to stamp seventh-grade textbooks with a disclaimer that said:

> The theory of evolution includes ideas about the origins and development of life which have not been conclusively proven. Scientists continue to make new discoveries which change their ideas about the theory of evolution.

Board members also voted to write a letter to the textbook publisher protesting the presentation of evolution "as fact".

The board was not unopposed, however. Even before the board's action, 71 area clergy and scientists, including NCSE member Dr Donald Wise, had published an open letter protesting attempts to introduce creationism in public schools (*Lancaster Sunday News* Feb 23, 1997, p A5). A month after the disclaimer was adopted, local citizens protested, commenting "Some of you would like to see creationism taught in science classes," and "Why single out the theory of evolution?"

As happens in many communities where "creation science" is embraced by a "religious right," the disclaimer was one of several decisions that stirred controversy (see similar stories: *NCSE Reports* 1995; 15[3]:3, 1993; 13[1]:1,5). In October 1996, the board had "ignited a wave of anger and bitterness" by passing a "pro-family" resolution (*Lancaster Intelligencer Journal* Jan 22, 1997, p A1).

Finally, on November 4, Hertzler's second prediction came true: successful opposition crystallized, and Elizabethtown's voters voted overwhelmingly for a more moderate school board. While these members have not commented on specific actions they will take, they do agree that change is expected, and the strongest proponents of the disclaimer have been unseated. Still, this step forward may be counteracted; as creationist activity continues in Lancaster County, new crises may occur in other small school districts.

Elsewhere in Pennsylvania, there has been a definite backward step: in the Moon Area School District, near Pittsburgh, "creation science" has been reborn as "intelligent design". In 1994, after students represented by the ACLU filed suit against the teaching of "creation science" at school assemblies attended by ninth- and tenth-grade biology students, the district agreed to stop the practice (*NCSE Reports* 1994; 14[4]:1, 9).

In August of this year, however, the Moon Area school board's education committee scheduled "further discussion on the teaching of creationism" in a revised tenth grade biology curriculum. A story in the *Pittsburgh Post Gazette* reported that the committee chair said creationism will not be taught, but "What we're asking is that evolution be taught within the entire context of science" (Aug 29, 1997, p B1). In a curriculum that would ask students to compare "natural descent" and "intelligent design", the committee has proposed eliminating study of the origin of life, claiming that research is "speculative". As part of the "Human Origins" section of the curriculum, students will watch the videotapes "The Mysterious Origins of Man" and "Darwinism: Science or Naturalistic Philosophy?" "Mysterious Origins", a composite of pseudoscientific claims from contemporaneous human and dinosaur footprints to Atlantis, raised a storm of controversy when it was aired on NBC in 1995 (*NCSE Reports* 1995; 15[4]:1). While school district officials continue to deny any intention to teach biblical creationism, the American Civil Liberties Union has sent a "right to know" letter demanding further details about the new curriculum.

[*NCSE thanks Robert Hertzler, Martin Czigler, Emmanuel Sillman and Donald Wise for contributing information used in this article.*]

NCSE's Pre-Publication Review Project Set to Expand

Molleen Matsumura
Network Project Director

When NCSE's national office was established in 1983, its founders agreed that their purpose was broader than combating "creation science". Although that task was urgent and essential, it is just one way to meet the wider goals of promoting scientific literacy in the press and the public and fostering excellence in science education.

Since accurate textbooks are crucial to good science education, NCSE launched the "Pre-Publication Review Project" (PPRP) which is now administered by Erik Wheaton. Publishers rely on knowledgeable reviewers to comment on textbooks in preparation or under revision. Most publishers have established contacts with teachers who evaluate texts in terms of grade appropriateness, ability to engage students' interest, and similar considerations. However, they need help getting scientists who will review materials for accuracy and currency—that's why NCSE established the Pre-Publication Review Project. Through the PPRP, publishers obtain names and addresses of potential reviewers; once a publisher and reviewer have agreed to work together, they make their own arrangements con-

cerning compensation, work schedule, and so forth. NCSE's Erik Wheaton maintains a database of scientists willing to review drafts of K-12 science textbooks, CD-ROMs, and other instructional materials to assure that they are up-to-date, accurate, and comprehensive.

The PPRP was begun with a grant from the MacArthur Foundation and later supported by the NCSE operating budget. Now, thanks to a welcome grant from Holt, Rinehart, & Winston, Inc, NCSE is able to expand the program. We will use the funds to update the database, locate more reviewers, and inform textbook publishers that this service is available to them.

Here is an opportunity for NCSE members to help achieve our mutual goal of improving science education. Because textbooks are crucial to what is actually taught in science classes, assuring their quality is an important contribution you can make to science education. We invite all members who are scientists to join the Pre-Publication Review Project. Please fill out and return the form [on this page], or email answers to questions on the form to Erik Wheaton at <ncse@natcenscied.org> Feel free to phone or email Erik with any questions about the project, and to give copies of the form to colleagues who might like to be participate.

Pre-Publication Review Project

Name: (first, last): _____

Title: _____

Address1: _____

Address2: _____

Address3: _____

City, State, ZIP: _____

home ph.(optional): _____

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work ph.2: _____

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General topic (please indicate your field of study in its most general form; i.e. biology, geology, etc.): _____

Primary specialization (please indicate your particular area of specialization within the general topic above): _____

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Level:

K-8 ☐ 9-12 ☐ College/Technical ☐

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UPDATES

Georgia: Teacher Hal Banke drew national attention when he protested the Clayton County School Board's decision to have teachers place anti-evolution disclaimers in textbooks (*NCSE Reports* 16[2]:19, and 16[3]:1). He reports that a newly elected school board has dropped the issue. The county curriculum has also been updated to reflect changes in the new statewide curriculum. The county curriculum makes no mention of "theories of life's origin" as described in the disclaimer. Instead, under the specific heading of "Evolution", there are requirements that students will "understand that evolution accounts for the diversity of species, which change and develop through gradual processes over many generations... [and] how natural selection provides a scientific explanation...[and that] the behaviors of organisms have evolved."

Banke was one of many teachers who successfully pressed for explicit mention of evolution in the statewide Quality Core Curriculum (QCC) adopted November 13. A draft given to teachers for comment had referred only to "organic variation", but the final version (available on the World Wide Web at <http://admin.doe.k12.ga.us/gadoe/qcc.nsf >) specifically requires teaching evolution in ninth-grade biology and requires eighth-grade earth-history students to "[d]escribe Earth history,...recognize that change occurs constantly and slowly over time [and]...[i]nterpret the geology of Earth based on the principle of uniformitarianism and the principles of superposition."

While the QCC is a major improvement, it may not spell the end of controversy at the local level. The standards do call for biology students to "compare micro- and macro-

evolution"—a distinction common in anti-evolution literature which was inserted through the efforts of a member of the curriculum team who "raised questions...about Darwinian evolution." The sole critic of the standards speaking at the November 13 public hearing was applauded when he objected to teaching evolution and, according to the *Atlanta Journal-Constitution*, the chairman of the board "responded that his...personal beliefs...were 'not consistent with Mr. Darwin's,' but he does not want to deny to Georgia children exposure to the same ideas that allowed him to make up his own mind" (Nov 11, 1997).

Michigan, Melvindale: On November 10, the school board met to consider a request by local parents, ministers, and the school board president to teach creationism alongside evolution. While the ACLU stated that there would be a challenge if creationism were added to the biology curriculum, and an official of the state Department of Education said that standards adopted in 1996 do not allow teaching creationism, the former chair of the State Board of Education claimed that the guidelines left the door open to "explore" creationism, and the Melvindale Superintendent of Schools stated she doesn't "have enough information to have an opinion" (*Detroit News* 1997 Nov 10: 1A).

More than 250 people attended the meeting, and after hearing from a dozen speakers, the board took no action. However, the president of the school board, a self-described creationist, said that a committee may be formed later this year to study the issue. NCSE members in Michigan expect the Michigan Science Teachers Association, which had supported evolution in statewide curriculum standards, to join the ACLU in opposing pressures to teach "creation science" in Melvindale and other communities.

New Mexico: Statewide curriculum standards are still contested more than a year after the State Board of Education (SBE) voted to eliminate references to evolution and add a requirement for "critical analysis" of multiple "theories of biological origin". The ensuing controversy led to the introduction of state legislation that would have required state science standards to conform with the National Research Council's National Science Education Standards; this legislation passed the Senate, but was tabled in a House committee after the SBE president assured the committee that the board would make necessary improvements. A number of concerned scientists (many of them NCSE members), who had already been working with the SBE, founded the Coalition for Excellence in Science Education (CESE) to involve more citizens concerned about both evolution education and the general quality of science education. CESE continued efforts both to make sure evolution was included in the drafting of performance standards and to bring about appropriate revisions in existing content standards. The Department of Education conducted a survey of public reactions to a detailed list of recommendations published by CESE, and, although responses were overwhelmingly favorable, the SBE made no changes in content standards and benchmarks when they met August 21-22, 1997. CESE President Marshall Berman commented that performance standards which are now being field-tested "have the potential for graduating students who are ignorant of real science and the scientific method." CESE is continuing its efforts to improve science standards; its activities have included formation of a speakers' bureau, appearances on radio talk shows, participation in the drafting of performance standards, and creation of a web-site at <http://www.highfiber.com/~dfbeck/CESE/CESEhome.html>.

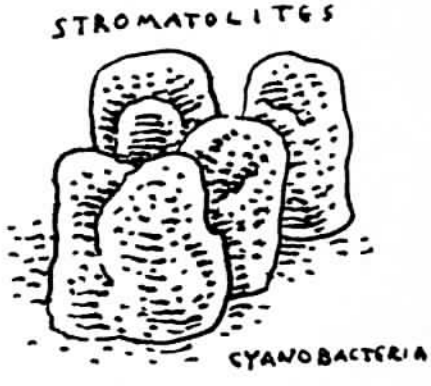
In late October, not long after the SBE's latest refusal to restore evolution to curriculum standards, local citizens pressed the school board of Rio Rancho, the state's fourth largest city, to include "intelligent design" in draft curriculum standards. NCSE members in the community believe that the teachers responsible for developing curriculum will resist this pressure.

Ohio: In Louisville, where there is a long history of attacks on evolution in the curriculum (*NCSE Reports* 13[3]:1; 16[1]:6; 16[1]:18; 16[4]:10; *RNCSE* 17[2]: 9), donated copies of the "intelligent design" textbook *Of Pandas and People* have still, apparently, not been used in the classrooms, and a motion to place a disclaimer in textbooks was defeated on September 9. The disclaimer is the same as that adopted by the Alabama State Board of Education in November, 1995 (*NCSE Reports* 1995 Winter; 15[4]:10), and continues to be considered by local school boards around the country. However, other proposals to bring "creation science" into the curriculum have been referred to a science curriculum committee. NCSE members in the area continue to monitor school board actions and will keep NCSE informed.

Texas: At the State Board of Education's November 6 meeting, board members who had earlier failed to eliminate evolution from the state science curriculum (*RNCSE* 1997 May/Jun; 17[3]: 5) tried to prevent the adoption of textbooks presenting evolution. NCSE Supporter Kenneth Miller, co-author of one of the leading high school biology textbooks, appeared before the board. His report of the meeting and the issues that were discussed there appears on page 32.

Washington, Burlington: A ninth-grade biology teacher has been teaching "intelligent design theory" using hand-outs based on the anti-evolution textbook *Of Pandas and People*. NCSE has written to the district superintendent, explaining that "intelligent design theory" is a euphemism for "creation science" and providing information on the legal, scientific, and educational reasons that it should not be taught.

[*NCSE thanks Carl Bajema, Hal Banke, Marshall Berman, Barbara Forrest, Kim Johnson, Kenneth Miller, John Bannister-Marx, and Jim Walker for contributing information used in these updates.*]



Lamarck vs. Darwin:
Dueling Theories

Richard Firenze

Scientists and science educators are in virtual agreement as to the importance of an understanding of evolutionary principles as the unifying theme for acquisition and internalization of information about the origin, history, and diversity of life on earth. Yet despite this agreement, evidence from a myriad of sources indicates that most students enter and leave our classrooms with great and grave misconceptions of this vital concept. It appears these misconceptions can be divided into two major categories:

1) epistemological misconceptions—those dealing with the nature of science, that is, evolution is only a theory, evolution has never been proven correct, or, because biologists cannot see species evolve, evolution is not a true science, and so on; and
2) content misconceptions—those dealing with the process of evolution, that is, humans evolved from monkeys, through evolution organisms get what they need, organisms progress from "lower" to "higher" forms, and so on.

Although abandoned over 150 years ago, Jean Baptiste de Lamarck's theory of acquired characteristics—the concept that changes acquired during an organism's lifetime are somehow transferred into genetic information and passed on to the offspring—is perhaps more commonly held as the mechanism of how evolution works, than the more scientifically supported Darwinian concept of variation and selection (Deadman and Kelly 1978; Firenze 1997; Greene 1990; Humphreys 1996; and Settlage, 1994). It is easy to see the appeal of this theory since it seems to follow the logic of our everyday experiences where the term "adaptation" is often thought of as a change occurring within the individual organism. After all, most of our students have been repeatedly told that as they mature they will need to "adapt" to a variety of situations they may encounter in the real world (presumably this means the world outside of the educational system). However, it is up to us, as science educators, to help our students discover the scientific flaws in this theory and replace it with a more powerful and accurate explanation for the diversity of life.

Learning About Science

Constructivist learning theory tells us that changing this misconception will only take place if our students' minds have an active cognitive involvement in the processes that allow for the accommodation of new "replacement" knowledge. Mechanisms such as hands-on/minds-on laboratory activities, developing alternative hypotheses, designing evaluative experiments, and arguing about the phenomena under study facilitate this active involvement (Saunders 1992). This is especially true if the work is done in small groups and the students are asked to explain and/or defend their thinking to their peers—who may compare and contrast these ideas with their own constructions. The National Research Council (1996) tells us that teaching science as inquiry is the basic underlying principle of science education as well as the ultimate organizing concept for the selection of student activities. These activities should include: 1) asking appropriate questions, 2) planning and conducting investigations, 3) using appropriate tools and techniques to gather data, 4) thinking critically and logically about the relationships between evidence and explanations, and 5) communicating scientific arguments. Following these recommendations, as well as the 5E cycle (engage, explore, explain, elaborate, and evaluate), this exercise is an attempt to accomplish the

...in order for a misconception to be abandoned, the learner must come to see it as unsatisfactory, while the new conception must be intelligible, plausible, and fruitful.

previously mentioned tasks by allowing the student to discover the inherent flaws in the Lamarckian view, while at the same time encouraging the appropriation of a more Neo-Darwinian concept.

The Conceptual Change Model (CCM), first introduced by Posner (1982) and recently investigated and modified by Demastes (1996) and Jensen and Finley (1996), shows us that in order for a misconception to be abandoned, the learner must come to see it as unsatisfactory, while the new conception must be intelligible, plausible, and fruitful. Here lies our problem: how best to make Lamarck's view the unsatisfactory concept, while showing Darwin to be more intelligible, plausible, and fruitful?

ENGAGE

Here lies our problem: how best to make Lamarck's view the unsatisfactory concept, while showing Darwin to be more intelligible, plausible, and fruitful?

The class should be shown an exciting video of some unusual morphological, physiological, and/or behavioral adaptation. As we all know our students are steeped in a visual world of rapid fire stimuli. The chalkboard or overhead projector stand little chance to excite them. Good examples, that can be found in David Attenborough's The Trials of Life, are:

- the speed and grace of a cheetah in pursuit of a prey species
- blind and/or albino cave-dwelling animals
- the social behavior and morphology of the naked mole rat

EXPLORE

The class should be broken into small groups (4 or 5) and presented with the following questions:

1. Cheetahs can run faster than 60 miles per hour when in pursuit of prey. How would an evolutionary biologist explain how this ability evolved, assuming their ancestors could only run 20 miles per hour?
2. Many cave organisms are blind. In fact, for many, their eyes have become vestigial structures. How would an evolutionary biologist explain how this inability to see evolved from sighted ancestors? (Both questions 1 and 2 have been modified from Bishop and Anderson 1986)
3. Naked mole rats have several morphological as well as behavioral adaptations which allow them to live in a eusocial system within a harsh and unforgiving environment. Make a list of as many of these characteristics as you can. How would an evolutionary biologist explain how these unique characteristics evolved from ancestors which did not possess these traits?

Each group is given ample time to research and discuss the question(s).

EXPLAIN

The groups then present their explanations to the class as a whole to foster comments, critiques, and criticisms of their hypotheses. It should be pointed out here that dissent, argument, and disagreement are all integral components of the scientific process. They are not negative, but rather positive, attributes of science. More than likely, many of the groups will present Lamarckian ideas. Therefore, the important points that need to be illustrated and discussed by the teacher, especially if they do not arise from student discussion, are:

1. Evolution proceeds by the process of variation, a genetically random process, and selection, an environmentally driven non-random process.
2. Organisms do not get what they "need" through "inner wants" or through "use and disuse." Individual intentions do not play a role.
3. Acquired characteristics are not passed on to offspring.
4. Mutations are not directed for the benefit of the individual.
5. Evolution is neither random nor teleological. It is, in fact, driven by both historical contingencies and the non-random, yet non-directed, process of selection.

Elaborate/Evaluate

Feedback on the progress and effectiveness of the learning activity can be used to evaluate its success and to adjust the ongoing process. This "formative evaluation" can be accomplished informally during the preceding stage. More formal assessment of the outcome at the end of the process (summative evaluation) can be performed by offering similar problems for each student to solve on the evaluation tool of one's choice. An example follows:

Many insular species of both plants and animals have lost defense mechanisms that are frequently found on their continental relatives. Several species of birds and insects have become flightless and many plant species have lost defense mechanisms such as thorns

or toxic chemicals. How would an evolutionary biologist explain how these losses came about?

Conclusions

On the surface it seems that to replace the conceptual belief that species change is driven by characteristics acquired during the organism's lifetime with one based on the processes of random variation and non-random selection should be rather an easy task. However, personal experience, as well as most of the research cited, indicates this is not the case. Let's face it, misconceptions concerning evolution are deeply embedded and the concept itself is a lightning rod—one that many of our teachers fear holding in the tempest of today's classroom. As minor as it may seem, the alleviation of any misconception dealing with biology's most important central theme, as well as its most misunderstood concept, is a major step in the right direction for science education. As Bumbry (1979) has pointed out, the acceptance of Lamarckian beliefs, for all intents and purposes, totally blocks the learning of Darwinian principles. Obviously this must be changed. I have found the preceding exercise to be one of the most fruitful in accomplishing this goal.

The term eusocial as defined by Krebs and Davies (1993) includes animals that exhibit: 1) cooperative care of the young; 2) a reproductive division of labor—that is, some castes or classes are less fecund or sterile; 3) an overlap of at least two generations; that is, the offspring assist the parents during some period of their life.

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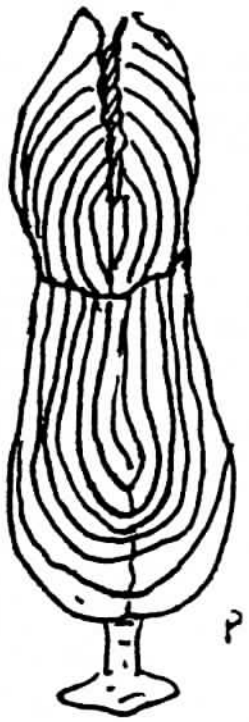

ARTICLE

The Predictive Power of Evolutionary Biology and the Discovery of Eusociality in the Naked Mole-Rat

Stanton Braude

Anti-evolutionists have asserted that evolutionary biology lacks predictive power (Gish 1979; Johnson 1991; Morris 1974, 1989). They still cite Karl Popper's early suggestion that evolutionary theory is untestable because it cannot be used to make predictions, despite the fact that this view has been rejected by philosophers of science and that Popper himself unequivocally reversed this opinion (1978:344-5). Such assertions that evolutionary theory is unpredictive ignore the power of the comparative method in testing both alternative hypotheses and models of evolutionary processes as well as the pervasive implicit tests of evolutionary theory in every aspect of modern biological science. In this paper I will discuss briefly how biologists across disciplines use evolutionary theory as a foundation for understanding biological systems. Next I will give a few examples of how evolutionary biologists test hypotheses about specific modes of selection and evolution. Finally I will discuss, in detail, an example of the extremely successful predictive power of one evolutionary hypothesis.

PERVASIVE USE OF EVOLUTIONARY HYPOTHESES IN BIOLOGY

"Nothing in biology makes sense except in the light of evolution" (Dobzhansky 1973). Accordingly, biochemists, geneticists, ecologists and medical researchers do not choose their hypotheses randomly. A hypothesis must first be logically consistent to be worth testing. An underlying part of the logic in most biological hypotheses is that the system under study is adaptive, selectively neutral or even maladaptive (but maladaptive in ways that we can understand based on conflicting biological demands or novel circumstances). Maladaptive characters are studied in the context of their unusual nature and the surprise they pose in light of an apparently well adapted biological world. When molecular biologists investigate complex biochemical pathways, gene regulators, or carrier proteins, they are working under the paradigms that the molecules in question serve an adaptive function. Biochemists do not test hypotheses about the beauty of a molecule but about its function (Stryer 1995).

The fact that not all biological systems are adaptive can be confusing, and this confusion has misled some scientists to conclude that evolution is, therefore, irrelevant to understanding particular maladaptive systems. However, evolutionary theory is not limited to explaining adaptations. For example, simple adaptive hypotheses cannot explain senescence, but the study of age-related changes in the potential for future reproduction (reproductive value) and of (pleiotropic) genes that produce a number of different traits has given us the clearest understanding of why senescence has evolved differently in different organisms (Alexander 1987; Charlesworth and Hughes 1996; Williams 1957). Cancer is also best understood as the result of selection working at the cellular level and in conflict with competing selective forces at the individual level (Tomlinson and others 1996).

Biologists across disciplines also indirectly test phylogenetic hypotheses and assumptions when choosing test organisms. When medical researchers want to test the effects of a new drug or treatment, they recognize that the phylogenetic relationship between the model experimental organism and humans is relevant to interpreting results and judging either the efficacy or danger to humans. Results based on rodent studies are given less weight than primate studies because of our more distant common ancestry and the greater divergence that has resulted.

DIRECT TESTS IN EVOLUTIONARY BIOLOGY

Direct tests and predictions about the mode of evolution are conducted daily by evolutionary biologists and population geneticists. However, an arbitrary distinction between micro- and macro-evolutionary processes has been used to devalue tests of evolutionary hypotheses in selection experiments or in insect population cages (where insects can hatch, breed and die for hundreds of generations in the course of an experiment). Population geneticists make predictions and test hypotheses about

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the mode of evolution. In population cages, petri dishes or growth media, population geneticists test hypotheses about evolutionary change in controlled populations (for example Carson and others 1994; Goodnight and Stevens 1997; Templeton 1996). In wild populations, population geneticists look at gene frequencies within species or populations in order to test hypotheses about relatively recent evolutionary events (for example Crandall and Templeton 1993; Routman and Templeton 1994; Templeton and others 1993).

Ecologists and conservation biologists use evolutionary theory to interpret the relationships we see in wild communities and to predict how those communities will be affected by changes and environmental pressures (for example Georgiatis and others 1994; Losos and others 1997; Templeton and Read 1994). While much of current ecological theory is complex and multivariate, MacArthur and Wilson (1967) were able to make rather simple and testable predictions about the diversity of species on islands of different sizes and distances from a mainland. In addition, behavioral ecologists make predictive hypotheses about the trends we expect to see across a wide variety of taxa (Alexander and others 1979; Harvey and Pagel 1991; Martins 1996; Ryan 1990).

In the examples cited above, predictions from and tests of evolutionary theory fit into two general categories: how evolution works in specific cases and circumstances, and what evolution has produced in response to particular circumstances. Ecologists, phylogeneticists, and population geneticists are interested in the subtle details of how evolution works. In testing adaptive hypotheses about how their particular biological system works, other biologists are testing predictions of what evolution has produced. The underlying paradigm is that evolution has generally produced adaptive systems and structures.

The uses of evolutionary theory to make these various predictive hypotheses have also been criticized as being *post hoc* since we already know what has evolved but cannot do simple experiments and predict what will evolve. This line of reasoning not only ignores all the population cage experiments in evolutionary biology but, if true, would lead to the classification of astronomy as unscientific as well, since we cannot manipulate the cosmos. The multitude of minute, precise predictions about the locations of known planets and stars in tomorrow night's sky are analogous to the specific predictions that are made in comparative tests by evolutionary biologists.

Occasionally, however, more striking predictions are made. In 1845 John Couch Adams and Urbain Jean Joseph Leverrier both predicted the presence of an unseen planet which affects the orbit of Uranus. It was not until the following year that Neptune was discovered as they had predicted.

Richard D Alexander has made a similarly striking prediction based on first principles of the evolution of social behavior. Although common in social insects, eusociality—the social system with a queen and sterile workers—was unknown in any other taxa. Under the appropriate set of conditions, Alexander predicted, evolution ought to produce a eusocial vertebrate, even though eusociality in the naked mole-rat (or any other vertebrate) was unknown at the time.

A Fertile Use of Inductive and Deductive Logic

The roots of Alexander's prediction go back to questions raised by Darwin over 100 years prior. In his chapter titled "Difficulties with the theory" Darwin addressed the problem that sterile workers in social insect colonies pose for natural selection. How could natural selection cause differences between queen bees and workers if the workers are sterile? Darwin guessed that in these cases selection is acting between families or hives.

In 1964 William Hamilton formalized this idea of kin selection and suggested that eusocial colonies with queens and workers have evolved many times in the ants, bees, and wasps because of their unusual genetic system. In these hymenopteran insects, males have one set of chromosomes (haploid) and females have two sets (diploid); this is called haplodiploidy. As a consequence of this genetic peculiarity, sister workers in these insects are more closely related to each other than they would be to their own offspring. Consequently, they contribute to the propagation of a greater proportion of their genes by helping to rear siblings than by producing offspring themselves.

How could natural selection cause differences between queen bees and workers if the workers are sterile?

In 1974 entomologist and evolutionary theorist Richard Alexander argued that "subsocial" behavior (that is parental care) and the opportunity for parental manipulation were even more powerful factors in the evolution of social behavior in insects (Alexander 1974). Across taxa, parental behavior correlates much more strongly with eusociality than does haplodiploidy (Andersson 1984; Alexander and others 1991). Alexander's critics argued that if parental care is a crucial precursor to eusociality, we should expect eusociality to have also evolved among the highly parental vertebrates: birds and mammals. Alexander could have pointed out that there are far fewer species of birds and mammals than there are species of insects, or that birds and mammals have only existed for 160 million and 250 million years respectively (Eisenberg 1981; Wetly 1979) while insects have existed for 350 million years (Borror and others 1989). Instead he asked himself what characteristics a eusocial vertebrate would have if it had evolved.

Alexander based his answer on his understanding of the selective forces involved in the evolution of insect eusociality and hypothesized a eusocial vertebrate. He created a 12-part model for a eusocial vertebrate, based on this body of theory. He had no idea that a mammal with these characteristics existed.

Alexander predicted that a eusocial vertebrate's

nest should be (1) safe, (2) expandable, and (3) in or near an abundance of food that can (4) be obtained with little risk. These characteristics follow from the general characteristics of primitive termite nests inside logs. The nest must be safe or it will be exploited as a rich food source for predators. It must be expandable so that workers can enhance the value of the nest. It must be supplied with safe abundant food so that large groups can live together with little competition over food or over who must retrieve it.

The limitations of the nest characteristics suggested that the animal would be (5) completely subterranean because few logs or trees are large enough to house large colonies of vertebrates. Being subterranean further suggested that the eusocial vertebrate would be (6) a mammal and even more specifically (7) a rodent since many rodents nest underground. The primary food of the hypothetical vertebrate would be (8) large underground roots and tubers because the small grassy roots and grubs that moles feed on are so scattered that they are better exploited by lone individuals and would inhibit rather than encourage the evolution of eusociality.

...mammalogist Terry Vaughan suggested to Alexander that his hypothetical eusocial rodent was a "perfect description" of the naked mole-rat...

The major predator of the hypothetical vertebrate would have to be (9) able to enter the burrow but be deterred by the heroic acts of one or a few individuals. This would allow for the evolution of divergent life lengths and reproductive value curves between workers and reproductives. Predators fitting this description would include snakes.

The eusocial vertebrate was also expected to (10) live in the wet-dry tropics because plants there are more likely to produce large roots and tubers that store water and nutrients to help them survive the dry periods. The soil would need to be (11) hard clay because otherwise the nest would not be safe from digging predators. These two characteristics further suggested (12) the open woodland or scrub of Africa.

Alexander described this social vertebrate in a series of guest lectures at North Carolina State University, University of Kansas, University of Texas, Colorado State University, Arizona State University, University of Arizona, and Northern Arizona University at Flagstaff in 1975 and 1976. At Flagstaff, mammalogist Terry Vaughan suggested to Alexander that his hypothetical eusocial rodent was a "perfect description" of the naked mole-rat *Heterocephalus glaber*. He further described the burrowing East African mammal and suggested that Alexander contact Jennifer Jarvis, an authority on African mole-rats. Jarvis had studied the ecology and physiology of naked mole-rats but at that time nothing was known about their social system. Subsequent field and laboratory observations have confirmed that they are in fact eusocial, as Alexander's model had predicted, and that the other elements of his model are accurate as well (Braude and Lacey 1992; Jarvis 1981; Sherman and others 1991; Sherman and others 1992). This case demonstrates one type of predictive power in modern evolutionary theory.

Evolutionary biologists are making new discoveries every day. To suggest that evolutionary biology is either untestable or unpredictive ignores their vast body of work including the dramatic discovery of eusociality in the naked mole-rat based on clear understanding of the selective forces leading to the evolution of social behavior.

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THE GALAPAGOS TOUR IS OPEN DUE TO CANCELLATIONS, SEE PAGE 31 FOR DETAILS

ICR Holds "Good Science" Seminar in Pennsylvania

David Caplan

I recently attended an Institute for Creation Research (ICR) "Good Science" seminar in southeastern Pennsylvania. The primary intent of the "Good Science" program is to educate parents about science for home schooling purposes. I do not intend to be critical of the concept of home schooling, since this is an important parental decision. As ICR is aggressively involved with the promotion of creation "science" in the public schools, I must assume that the ICR espouses the same philosophy in its home school program. I believe that under such circumstance, their "Good Science" curriculum should undergo closer scrutiny.

The seminar was located in a country setting with a warm and friendly host. The room was bright and comfortable. The seminar lasted approximately 3 hours with several breaks. Although the setting was ideal, only 6 people attended the seminar (excluding the instructor and host). The host mentioned that 125 children had attended the afternoon class.

The seminar itself consisted of a series of lectures on science education, educational philosophy, and of course, the requisite religious reasonings for the information purveyed. The lectures, largely presented by overhead transparencies and oral explanation, were interspersed with various "experiments" geared to grades kindergarten through the sixth grade. Specific curricula were not presented (although they were on sale in the lobby along with every other book and tape ICR sells), just the basic concepts and approaches ICR promotes. All material was copied and bound in a 3-ring binder supplied by ICR.

Addressing the basic concepts and approach, the instructor explained that ICR professes the "catechetic" method—to teach by having the child observe nature and question observations to come up with answers. Such questions may be why an orange or a peacock feather is designed the way it is. The instructor went on to say that through this method, the parents would not have to be trained in science; they would just facilitate the questions and answers. He further stated that trained science teachers may even hinder this approach, as they would be inclined to tell the child the answer to the questions at hand rather than have the child reason the answer for him or herself.

If the observation, question, and answer approach were the primary method and philosophy taught, it might not be so bad, as these elements are the building blocks in the education of a scientist. However, this was not the case. The ICR people go on to educate the parents about their "Five Fundamentals of Observational and Experimental Science Instruction". The first fundamental, and not surprisingly so, is called "design factors" and describes order, purpose, interdependence, and beauty. The second is "objects and their properties" then "interaction", "introduction of variables", and then finally (also not surprisingly so) "God's attributes". All of these are elicited by the observations that the child made. Therefore, it would not be so important that the parent know any science, just be able to direct the child's answers toward specific design and purpose and that there exists a designer who is, of course, the God of the Bible.

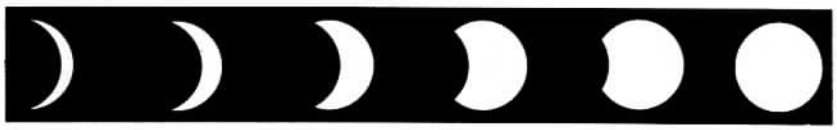
As the seminar was largely based on overhead transparencies, I thought that it might be interesting to count the individual overheads and compare the numbers to what information was presented on each. I then broke the types of information on the overheads into three categories: religious, scientific, and other (largely educational methodology/philosophy). One would expect that a science seminar should largely be based upon scientific information. In the 78 or so transparencies, I found this representation of topics: religious—41%; other—37%; and scientific—22%. It should be noted that the philosophy and methodology overheads were largely based on Christian educational texts. In addition, I counted science overheads as those that made any reference what so ever to accepted scientific thought or information.

As typical of most creationist talks, the class was peppered with the usual evolution-bashing sound bites. The only difference was that they were watered down and over-generalized for the non-technical audience for which the seminar was written. Such examples included the blame of all the worlds' ills (or at least what they consider ills) on evolution; equating "New Age" religions and philosophies with evolution; and the ever-popular bird hatching from a reptile egg as an example of punctuated equilibrium.

Although it did not seem to be part of the creationist curriculum at all, I brought up the idea of safety in the home laboratory. The instructor had named one company he knew of which

supplied chemicals for the experiments performed in the creationist curriculum and would sell such to the home schooler. Such chemicals included bromothymol blue, copper sulfate, and ammonia—none of which should be used by untrained hands. The instructor also stated that this company sold all the same chemicals as a well-known distributor of laboratory supplies which would not supply materials to home schoolers. This he attributed to the potential that the well-known company was "anti-creationist". I asked him if he didn't think the actual reason may be due to safety and liability concerns, the instructor replied that this society is too safety conscious in order to attain perfection as all the New Age religions teach.

In closing, I asked the instructor as to how "intelligent design" and purpose relate to natural things that seemingly have no design, intent, and/or positive use to humans such as viruses and dust bunnies (my personal favorite). He had no answer except to say that creation "scientists" are undoubtedly behind mainstream scientific study—approximately 10 years by his estimate—but he felt confident that, since there are so many creation "science" research programs starting around the world, they would quickly and certainly catch up. I have to agree with his first statement here and say, yes, they are behind. However, I am not so sure I would agree on the catch-up time. I would say the lag would be closer to 150 years, if not greater, given the quality of the "good science" that these "scientists" are learning.



Free Solar Filter and Information for the February 1998 Solar Eclipse

On February 26, 1998, some 20 NCSE members and friends will witness a complete solar eclipse from Isla Pinta in the Galapagos Islands. For those of us left behind in North America, we will be able to witness a *partial* solar eclipse right in our own backyards at the same time. This once-in-a-lifetime experience can be exciting and educational, but it can also be dangerous, if we do not use a safe solar filter to protect our eyes.

A Pennsylvania company is making it easy for NCSE members to understand the solar eclipse and observe it *safely* by offering an Educator's Eclipse Kit, which includes a safe solar filter *plus* information on safe solar eclipse viewing and a guide to photographing solar eclipses. The kits also include a map showing where in the US (and the rest of the world) that the eclipse can be seen.

Single kits ordered by educators or by students of any age are free with a payment of $2 for postage and handling. Orders of 25 or more kits can be sent to a single address for $1.50 per kit. Also available is a low-cost photography kit, which includes a sheet of special optical-grade, safe solar filter material that can be used with a telephoto lens, telescope, or binoculars to produce high-quality photographs and to see fine details of a solar eclipse.

By special arrangement with the supplier, NCSE members who order that Educator's Eclipse Kit for $2.00 will also receive a set of maps showing the path of the final solar eclipse of the millennium on August 11, 1999.

Send orders for the Educator's Eclipse Kit to: ABELexpress, Astronomy Products Division, PO Box 668-SE, CARNEGIE PA 15106.

Creationism Defeated in British Columbia

Scott Goodman

The Spring 1995 issue of *NCSE Reports* carried a progress report of a battle to remove creationism from the school curriculum in Abbotsford, British Columbia (*NSCE Reports* 1995 Spring; 15[1], p 1, 10-11; 18). Readers may have agreed or disagreed with my strategy of taking the battle to creationists and treating the controversy as a political one instead of limiting the response to the defense of proper science education. Indeed, I have received letters expressing strong views both ways. Whatever your opinion on this point, it is hard to argue with success. Therefore, it is with a great sense of accomplishment that I bring you the news that creationism has been specifically banned from the Provincial Curriculum as a legitimate scientific subject in all public schools and level one private schools in British Columbia, Canada. This does not mean, however (as some creationists have claimed), that creationism cannot be discussed in classrooms and examined as an example of a particular epistemology. For instance, creationism can be discussed as an example of one belief among others in a comparative religions course. Another legitimate way to bring creationism into classroom discussions is as an example of propaganda or pseudoscience. However, it is unlikely that this would satisfy the "equal time" ambitions of creationists.

...creationism has been specifically banned from the Provincial Curriculum as a legitimate scientific subject in all public schools and level one private schools in British Columbia

This victory is unambiguous, but somewhat fragile. Nevertheless, in a precedent-setting ruling, the Province's Education Minister at the time, Art Charbonneau, revised three Ministerial Orders-in-Council and had the Biology 11/12 curriculum guidelines changed to make it clear that creationism specifically, along with whatever alias it may assume, as well as any other religious belief system, cannot be taught in its own right in BC's public school science classes or anywhere else in Provincial curricula—either as a serious academic rival to genuine science or as a stand-alone subject elsewhere in the curriculum. The wording of the revised biology curriculum guide goes even further. It mentions creationism and its pseudonyms directly. It states that "the religious belief systems known as creationism, creation science, theory of Divine creation and intelligent design theory may not be taught as science nor in the guise of science" (see text of the Minister's order on p 19). The changes in the Ministerial orders give legal effect to these regulations.

Why, given the above, is this a fragile victory? Because, under the parliamentary system of government in Canada, what one minister puts in place, another may remove—at the stroke of a pen; though I view this possibility as unlikely. Recent case law in the Province of Ontario has set out the basic principles which govern what can and cannot be taught with respect to religious beliefs in public schools. These, together with the Education Minister's tough stand on the issue in this province, will virtually guarantee that creationism will have little or no chance of gaining a secure foothold anywhere in Canada. At least, not for very long. Also, the consciousness of the Civil Liberties Association has been raised on this issue. A close watch will be kept on the activities of creationists throughout BC.

The Setting

Over two years ago I responded to citizens' concerns about creationism in Abbotsford's public school science curriculum. Abbotsford is a notorious fundamentalist Christian enclave located in the semi-rural Fraser Valley in southwestern British Columbia east of Vancouver. Political success has always depended, and still does, on which church a candidate attends. A flyer circulated during the 1990 school board election read "Keep God on the School Board, vote for...." This gives a sense of the sentiments of many in the community.

In response to these concerns we raised the issue publicly, engaged in a six-month running battle in the press with evangelical members of the Abbotsford School Board, threatened a civil-liberties court case, and started a local committee of correspondence. At this point creationism in BC is a dead issue insofar as receiving any serious consideration as an official subject in public schools is concerned. Not only was a definitive ruling on this issue obtained from the Minister of Education, but the financial resources of the creationists have been strained to the limit in useless attempts to foster public support for their cause by inviting high-priced creationist speakers from the US and elsewhere to

Scott Goodman is editor of the OASIS newsletter in Vancouver, British Columbia.

come to BC to reassure the faithful and attack the Minister's ruling. Walter Brown, Duane Gish, David Menton, Larry Vardiman and Donald Chittick have all been through the area on expensive speaking tours in the last year.

My discussions with people in Abbotsford conveyed the sense of an omnipresent and oppressive religiosity in the community that would tolerate no opposition to evangelical Christian views. They told me of retribution against adults and students who questioned creationist assignments in school. Other citizens reported vandalism and anonymous telephone threats. These actions resumed after I became active on behalf of anti-creationists in the community. Clearly, such a situation was not one which was likely to be resolved merely by polite academic debate.

Raising the Issue

In principle, what I did was simple enough; I ambushed the school board. I knew from discussions with people in the community that we could expect a "tooth-and-nail" defense of their Divine creation policy. Several attempts had been made to have it rescinded since its adoption in 1983. All had failed to achieve anything except to instill bitterness between opposing parties. The primary reason for the lack of success had been lack of enforcement of the non-sectarian provisions of the BC School Act on the part of previous conservative Provincial government administrations. Without such support, local efforts were bound to fail. With a more moderate government in office, I felt the time was ripe to deal with the issue.

The first thing that I did was to visit the school board offices and see the policy first hand. Next, I asked for and received press clippings and other materials from local people that they had gathered over the years on the issue. This later proved invaluable since I was able to compile very specific and detailed quotes by current school board members who had been on the board when the issue had erupted on previous occasions which could be used to hold them accountable for their public statements. From these clippings I was also able to get a feeling for the various personalities involved and what I could expect from them when the whole thing blew open. Finally, and most fortunately, I hit on the idea of contacting the school district's central resource office to ask them for a list of resources that had been obtained in support of the policy. This eventually proved to be the Achilles' heel for the school board since everything on the resource list had been obtained from the Institute for Creation Research (ICR). Establishing the sectarian nature of the ICR would be simple, so I was pretty sure of ultimate victory at that point. All that remained was to raise the issue publicly.

In anticipation of my next step, I had begun a letter-writing campaign to the Ministry of Education with two aims in mind. First, I was hoping for a quick ruling on the matter. In this I was (not unexpectedly) disappointed. I got back responses very similar to those received by citizens in Abbotsford earlier. Despite this disappointment, I *was* able to get the Ministry "on the record" with these responses. In return, I warned the officials that I intended to make this a public issue and made them aware of recent case law that would jeopardize their "do-nothing" strategy. These officials responded that such matters were a local concern and that the Provincial government had no responsibility to enforce its own laws! If the local school board would not hear the complaint, I was free to take the matter to court.

Fortunately for us Provincial law requires the government in BC to provide a means for citizens to appeal decisions made by local officials which are autocratic and unfair or which violate Provincial statutes and regulations. The Provincial Ombudsman's Office was established to make sure that the public has an impartial, arm's-length advocate for their concerns. While I put the wheels in

Instructions to Public School Boards in British Columbia

Issued by Art Charbonneau, BC Minister of Education

All School Board Chairs:

Re: Biology 11/12 Curriculum and the Teaching of Evolution

Concerns have been raised by parents, educators and members of the public with respect to the requirements of the Biology curriculum around the teaching of evolution. In particular, issues have arisen around respect for students' religious beliefs, coupled with the need to ensure the integrity of the science curriculum.

While it is important for educators to respect the religious beliefs and viewpoints of their students, it is also important to recognize that religious beliefs are not derived from the discipline of science, and that the science classroom is not the place to provide instruction or require discussions on religious dogma or religious belief systems. Boards may wish to consider offering a locally developed course in comparative religions; however, no religious dogma or belief may be taught under the guise of science nor in any other part of the Provincial curriculum. In addition, I want to clarify that the theories of adaptation and evolution, set out in the Biology 11/12 Curriculum Guide, must be taught as part of the Biology 11 course offered in schools.

In order to clearly set out these expectations, the Biology 11/12 Curriculum Guide has been revised by adding specific course requirements relating to the provision of instruction and the use of learning resources in the classroom, particularly as they relate to the unit on Adaptation and Evolution. As well, three Ministerial orders have been amended to bring the school law [regarding the] Biology curriculum in line with section 95 of the School Act and section 2 of the Canadian Charter of Rights and Freedoms. For ease of reference, you will find copies of the curriculum guide changes and Ministerial Orders attached.

It is my expectation that all school boards will ensure that Biology courses are offered in accordance with the requirements of the revised curriculum guide and the attached Ministerial Orders.

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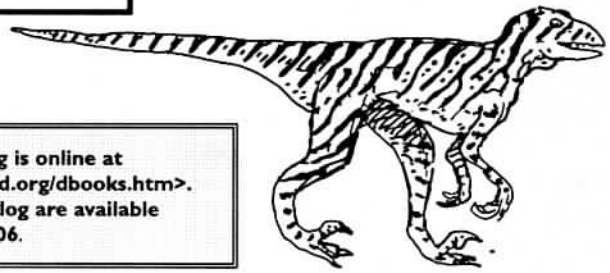

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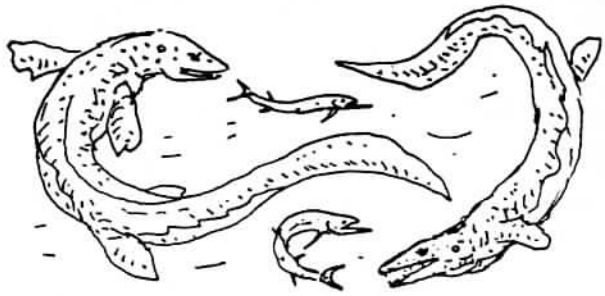

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motion to lay an official complaint, I contacted the BC Civil Liberties Association (BCCLA) for their take on the problem. I was aware from my research that they had a position paper on the matter that strictly opposed any inclusion of creationism in public schools. Through my inquiries, I came to know Dale Beyerstein, a member of the BCCLA and author of the original position paper. He and his brother Barry (president of the BC Skeptics) were to prove key supporters in the controversy .

Engaging the Opposition

During a by-election in autumn 1994, former school board member John Sutherland was re-elected to the board and was subsequently elected chair. During the election campaign, I attended the only all-candidates meeting and asked that each candidate state his position on the subject of teaching creationism in the schools. All except the lone Indo-Canadian candidate declared their support for teaching creationism. At the same time I contacted the Abbotsford School Board offices and requested to appear before them to discuss the matter. With a "new" school board and the Christmas season fast approaching, my request was put over to the February meeting. I also learned that I would not be able to have the twenty minutes that I had asked for, but only five. I sent in a twenty-page set of background information, and the stage was set.

The Biology 11/12 Curriculum Guide...specifically-forbids "the theories of Divine Creation, creation science, and 'intelligent design theory'".

When the appointed evening came I made my five-minute presentation. I spoke about the inappropriateness of teaching sectarian beliefs in a public school and reminded the board that having large numbers of supporters for a particular sectarian view was not a legal basis for overriding the religious rights of others in the community and that, as public servants, they had a duty to protect the rights of all citizens, regardless of their personal beliefs on such matters. I ended with a call to rescind the policy immediately.

For the next twenty minutes, I was questioned, challenged and ultimately, refused. But not before bickering broke out among the board members about the refusal to follow their own policy review procedures and send the policy to committee for a long overdue review. In the end, they postponed the matter to the following week and then tried to drop it. But it was too late, because now the press got involved.

I had made preliminary contact with reporters in all the various media to introduce myself and provide them with background information on the creationism issue and what I was doing about it. No one, for ethical reasons, was prepared to write or go to air about it in advance of my public presentation, but when I went before the board the story broke in the electronic media the next day. Within a few days, a true "media circus" began that never abated until the Minister ruled on the issue nearly 6 months later. Reporters from all over North America contacted me for information. The story was covered by the nationally-distributed *Toronto Globe and Mail* and *Maclean's* magazine. I even convinced the BC Christian newspaper, the *Christian Info News*, to publish an opinion piece of mine entitled "Not All Christians are Creationists". This article proved to be a major annoyance to the creationist members of the Abbotsford School Board.

All of this galvanized several organizations to get involved. The BCCLA waded in by publicly announcing that they would file a lawsuit if the Abbotsford Board didn't rescind the policy. *The Vancouver Sun*, BC's major newspaper, publicly called on the Minister to force the board to comply with the law or fire them. Finally, the Minister acted.

In early summer, the Minister directed the Abbotsford Board either to rescind the policy or replace it with something acceptable to the Ministry. They refused. He then made it clear that they would either comply or be replaced by a Ministry-appointed trustee. Finally, in September 1995 the Abbotsford Board capitulated. Several other boards around BC who had similar policies in place quietly dropped them. We had won.

Beyond Abbotsford

The result of all of this is a precedent-setting ruling here in BC that can be used throughout Canada and beyond to resist the pressures that creationists sometimes put on governments. School boards and departments of education in the US can be informed about this ruling and can use it as the basis of a response to creationists. Textbook publishers can have it sent to them to show them that a bit of backbone can go a long way. These efforts are needed.

As I write this, the Ontario Minister of Education is being petitioned to accept "equal time" for creationism. While I'm sure that this effort will fail, there is no room for complacency. Anti-scientific, anti-enlightenment sentiments are growing throughout the world. From New Age mumbo jumbo to Christian evangelical zeal, science (and knowledge in general) are being attacked and vilified as the root of all of society's ills. A return to ignorance and superstition is being urged that many are heeding. Such sentiments must be opposed at every turn. Gently when confronting followers of these doctrines, uncompromisingly when facing the leaders of such movements.

So that you can use this ruling to advantage in your area, I have included the instructions sent to all of BC's school boards by the Minister of Education at the time, Art Charbonneau. His comments are reflected in the revisions to the Biology 11/12 curriculum guides. Nothing, I submit, could be more clear than that. The Biology 11/12 Curriculum Guide itself leaves even less room for misinterpretation. It specifically forbids "the theories of Divine Creation, creation science and 'intelligent design theory'".

The ICR and the "Bible Code"

Dave Thomas

Even before the best-selling book *The Bible Code* by Michael Drosnin was released by Simon and Schuster in June 1997, Henry M Morris of the Institute for Creation Research (ICR) had endorsed the claims of an Israeli mathematician, Eliyahu Rips, which led to Drosnin's book. Rips published an article with Doron Witztum and Yoav Rosenberg in the August 1994 issue of *Statistical Science* entitled "Equidistant Letter Sequences in the Book of Genesis." In the article, Rips claimed to have found the names of modern-era rabbis hidden in the Hebrew text of Genesis as equidistant sequences—strings of letters formed by repeatedly skipping over a fixed number of letters in the text. For example, the word "generalization" contains the hidden word "NAZI" obtained by starting at the "N" and stepping to every third letter: geNerAliZatIon.

Not only did Rips find the names or titles of famous rabbis, he also found their birth/death dates and found that these were seemingly "linked" when the text of the Torah was wrapped to form "crossword puzzles". Rips and his colleagues contend that these linkages are "beyond chance". Code supporter Jeffrey Satinover is quoted by Morris as saying that the "code" is "the Author's signature... that He is precisely who He had said He is in the astonishing, radical, core document of the Judeo-Christian tradition..." No wonder the creationists are climbing on board!

Australian National University mathematician Brendan McKay has studied the code phenomenon at length and is vigorously pursuing a response to the 1994 *Statistical Science* article. By using the very same rules restricting choices of names, titles and so forth, McKay was able to find an "impossible by chance" result—only in the Hebrew text of *War and Peace*, not the Torah. Full details can be found at <http://cs.anu.edu.au/~bdm/dilugim/torah.html>. McKay has also found numerous hidden messages in books that no one contends were authored by God or other superhuman intelligences, such as *War and Peace* and *Moby Dick*.

I have found numerous hidden messages as well. Several of these were presented in my article in the November/December 1997 issue of *Skeptical Inquirer*. McKay and I have found that almost any message can be "discovered" in any text. What's more, by searching for separate words which can be "linked" in crossword puzzles, truly startling "predictions" can be found, such as this one I found in *War and Peace*: "Guilty Lee Oswald shot Kennedy, both died."

As a warning to creationists and code-followers that the "code" phenomenon is a double-edged sword, I searched the King James version of Genesis for the message "Darwin got it right" and found it!

But these amazing messages are not evidence of divine design; they are simply the luck of the draw.

With the appearance of Drosnin's best-selling book, the Bible code has gained international attention. More recently, a new book written by Jeffrey Satinover has appeared, published by William Morrow. The book, called *Cracking the Bible Code*, also strongly supports the "Code" phenomenon. However, most of the true-blue code promoters despise Drosnin as an incompetent and dangerous rookie (Satinover alludes to him, but won't even mention him by name). Meanwhile, fundamentalist Christians are having a field day looking for "Jesus" (Yeshua) hidden in the Bible. But Drosnin and Satinover have avoided those endeavors for fear it would cause trouble with the founders of the phenomenon—Orthodox Jewish code enthusiasts like Professor Rips.

Watch for the "Code" phenomenon to degenerate to a series of sectarian squabbles. And keep your eyes peeled for the movie version—Time Warner has bought the rights from Drosnin.

[Dave Thomas is president of New Mexicans for Science and Reason.]

Darwin got it Right from Genesis 18:08-20:04 (King James Version). The "puzzle step" used letters separated by 908 characters. "Darwin" was generated using intervals of 909 characters.

Dealing With Anti-Evolutionism

Eugenie C Scott
NCSE Executive Director

In November 1995 the Alabama Department of Education required all biology textbooks used in the state to display a disclaimer informing the young reader that

> This textbook discusses evolution, a controversial theory some scientists present as a scientific explanation for the origin of living things, such as plants, animals and humans. No one was present when life first appeared on earth, therefore, any statement about life's origins should be considered as theory, not fact.

In March 1996 the governor of Alabama sent all biology teachers a copy of an anti-evolution book, *Darwin on Trial*, using his discretionary funds. Shortly thereafter the Tennessee legislature debated and ultimately rejected a requirement that

> No teacher or administrator in a local education agency shall teach the theory of evolution except as a scientific theory. Any teacher or administrator teaching such theory as fact commits insubordination.... (Tennessee HB 2972/SB 3229 1996).

Also during the spring of 1996 Georgia voted down an amendment to an education bill that would "provide that local boards of education may establish optional courses in creationism" and

> As part of any science curriculum wherein students are taught concerning the origins of life and living things, including the origins of humankind, teachers shall have the right to present and critique any and all scientific theories about such origins and all facets thereof, including without limitation scientific theories other than evolutionism.

"Critiques of evolution" or "arguments against evolution" are codephrases for creation science, stimulated by Supreme Court Justice Antonin Scalia's dissent to *Edwards v. Aguillard*, the 1987 case that struck down "equal time for creationism and evolution" laws. Another "arguments against evolution" law was debated by the Senate Education Committee of the Ohio state legislature in May 1996. It was ultimately rejected (by a vote of 12-8). The wording directed that

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

And, as this essay was being written, news arrived to the office of the National Center for Science Education (NCSE) that the Cobb County, Georgia school district had requested MacMillan-McGraw Hill to delete a chapter on the Big Bang and earth's origin in an earth science booklet for fourth graders after parents complained. Newspaper accounts reported that MacMillan would comply.

What's going on here? Clearly, pressure against the teaching of evolution has not abated, and even appears to be on the rise (Gillis 1994; Scott 1994; 1996). What is it about evolution, more than any other scientific theory, that elicits this response? The Alabama disclaimer "no one was present" argument is especially puzzling, as many phenomena studied in modern science are not observed directly. In fact, no one has stood in space and observed the earth making its circuit around the sun through the course of a year, but we do not hear protestations that heliocentrism should be considered just a guess or hunch (the street definition of "theory").

Heliocentrism, as Galileo discovered, was once considered a challenge to religion, because it was thought to conflict with the Bible. The Bible, read literally, assumes the ancient view of the cosmos that the earth is the center of the solar system and the sun revolves around it. Few Americans these days interpret the Bible as a geocentric document, but a healthy percentage still accept a literal reading of Genesis regarding the separate creation of plants and animals as independent "kinds". This belief contrasts starkly with the scientific concept that living species are descended with modification from ancestors that differed from them. Thus evolution, and not theologically-acceptable heliocentrism, is vigorously opposed by an active segment of modern American society.

Anti-evolutionism extends beyond mere biblical literalism, however, as shown by comparing survey data on American religious opinions with survey data on attitudes towards evolution. Polls of adult Americans have consistently shown over the last fifteen years or so that a substantial proportion of us do not think humans evolved (whether other creatures evolved is usually not part of the standard query). In May 1996 the National Science Foundation released results from a telephone survey of 2006 individuals who were asked questions about basic science literacy (Petit 1996). One question was, "Human beings as we know them today, developed from earlier species of animals." Only 44% of Americans answered "True". In 1994 the American Museum of Natural History asked "Human beings evolved from earlier species of animals, true or false" and only 45% agreed—results virtually identical to the NSF study.

Defining religious conservatism is tricky, as there is no uniform agreement on terms. One term for conservative Christians is "evangelical." Evangelicals are Christians who believe the Bible is inerrant, and that salvation is achieved only through Christ (Hunter 1983). According to Marsden (1987), about 20% of Americans are evangelicals, far fewer than the 44% of Americans who reject evolution.

In a nutshell, there is more anti-evolutionism than there are religious conservatives: anti-evolutionism appeals both to evangelicals as well as Americans who adhere to

religiously-moderate faiths. There is an irony here: the "official" theologies of Catholic and mainstream Protestant Christianity are not literalist and have accommodated evolution as the way God created (Scott 1995). NCSE's book, *Voices for Evolution* (Matsumura 1995), includes a collection of statements from the Roman Catholic Pope, the Episcopalians, Methodists, United Church of Christ, Presbyterians, and the Lutheran World Federation (and several Jewish groups) all expressing respect for science and for evolution as part of science. Nonetheless, even if the ministers, priests and rabbis accept evolution, many people on the other side of the pulpit appear largely ignorant of their own theology!

It is important for those of us trying to teach evolution to recognize that many of our fellow citizens find evolution profoundly disturbing. They have been told or have somehow acquired the belief (sometimes from scientists, unfortunately) that evolution "proves" that there is no purpose to life, that life has no meaning, that they must give up their sense of the divine. According to a respected City University of New York poll, 90% of Americans describe themselves as religious (Goldman 1991). If evolution is presented as antithetical to religion (which is precisely how organizations such as the Institute for Creation Research present it), it is no wonder that a high percentage of Americans reject it. Actually, as suggested by the selections in *Voices for Evolution*, mainline Christianity can accommodate evolution, though it is doubtful that Biblical literalism can. As teachers and scientists, we need to leave an opportunity for the religious individual to work out the accommodation according to his or her beliefs, and not slam the door by inserting extra-scientific philosophical statements about purpose and meaning into our discussions of evolution. I will discuss this in greater detail below.

The Importance Of Evolution In The Curriculum

Evolution is a necessary part of the science curriculum. A biology or earth science course taught without the inclusion of evolution is an inferior course. Students who take these courses without being told that evolution unifies the data and concepts of the field are being cruelly short-changed. They will leave the course having been misled that science largely consists of the tedious memorization of lists of facts, rather than a tool we can use to help us understand the world of nature. This episodic, atomistic view of science is particularly regrettable: it turns students away from studying science, and perhaps worse yet, defeats our efforts to produce a scientifically literate society.

Evolution needs to be taught, but some teachers will be doing so in a hostile environment. How can teachers present this topic and avoid the potential minefields? Or, since some of the land mines are unavoidable, how can a teacher defuse them?

Evolution Happened

First, teachers need to be confident that evolution is state of the art science. A common claim made by anti-evolutionists is that evolution is a "theory in crisis," in the words from the title of a popular anti-evolution book (Denton 1985). Many teachers have not studied evolution, feel unconfident about teaching it, and are susceptible to being swayed by "new" information that "evolution is not as well accepted as it used to be". Evolution is presented matter-of-factly at every decent college or university in this country, including Brigham Young, Notre Dame, and Baylor. It is simply untrue that evolution is being widely challenged by scientists themselves. Help your colleagues to understand that scientists do not debate *whether* evolution (change through time, descent with modification) took place, though they vigorously argue how it took place—the processes, mechanisms and details of evolution. The previously-mentioned *Voices for Evolution* contains 33 statements from scientific organizations, all of which reassure teachers that evolution is indeed the reigning paradigm explaining how the universe came to be in its present state. Some statements, such as that from the National Academy of Sciences' booklet *Science and Creationism*, clearly distinguish between evolution as something which should be taught in the science classroom and creation science which should not:

> [T]he Academy states unequivocally that the tenets of "creation science" are not supported by scientific evidence, that creationism has no place in a science curriculum at any level, that its proposed teaching would be impossible in any constructive sense for well-informed and conscientious science teachers, and that its teaching would be contrary to the nation's need for a scientifically literate citizenry and for a large well-informed pool of scientific and technical personnel. (Committee on Science and Creationism 1984, p 7-8).

As scientists agree that evolution is a crucial part of science, so also do educators. The National Science Education Standards, released in February of 1996, present evolution as one of the "Unifying Concepts and Processes," as well as listing it prominently in the Content Standards for grades 9-12. Anticipating a tendency for states and districts to pick and choose among the standards rather than truly revise their curricula, the publication states firmly that, "No standards should be eliminated from a category." Perhaps presciently, the Standards chose evolution as a negative example. "For instance, 'biological evolution' cannot be eliminated from the life science standards." (National Research Council 1996, p 112).

The Alabama disclaimer "no one was present" argument is especially puzzling, as many phenomena studied in modern science are not observed directly.

"Benchmarks for Science Literacy," the 1993 publication by the American Association for the Advancement of Science's *Project 2061: Science for All Americans*, cites evolution as an integral part of the science curriculum. Similarly, the California Science Framework and the curricula of most other states require evolution to be presented. (Some disguise it as "change through time," and confuse ontogeny with phylogeny by referring to evolution as "development"). *Voices for Evolution* includes statements from 30 science education organizations including the National Science Teachers Association, the National Association of Biology Teachers, and the National Science Supervisors Association—all exhorting science educators to teach evolution and not present creation science. If evolution is a "theory in crisis," somehow the entire science and education establishments are unaware of it.

Know What You Are Talking About!

Now, appealing to authority may often be effective with students, but

it is hardly something we wish to encourage! Opponents of evolution rely exceedingly heavily upon (out of context) quotations from authorities like Stephen Jay Gould in their attacks upon evolution. Because "famous scientist X" said something, it supposedly should be accepted. As it happens, when it comes to appeals to authority, the pro-evolution side wins hands down! We have the National Academy of Science, the Nobel laureates, and all the other heavy hitters of big science—but what is more important, we have the science itself. Teachers need to be familiar with the data and theory of evolution, and why this theory has such strong explanatory power. Evolution is accepted by scientists today because it explains more observations than any alternative. Any of a number of basic college level biology and especially evolution textbooks will provide teachers with plenty of evidence for evolution's being the unifying theory explaining observations from biogeography, comparative anatomy, comparative biochemistry, the fossil record, developmental biology, and many other fields.

Evolution isn't just about humans, or even about living things. Astronomers do, after all, study cosmic evolution.

Define Evolution

A colleague in physical anthropology teaching a small college in the Southeast told me she was teaching a class of freshmen college students and found that none of them had ever studied evolution or even knew what evolution was. When they found out, they found the concept exciting and intellectually challenging, and they clamored for a special course on the topic. Their response, in her words, was "Of course species change through time! You mean *that's* evolution?!"

Sometimes finding out what evolution actually is (or more precisely, replacing erroneous ideas about evolution) in itself reduces students' reluctance to learn about it. A proper definition of evolution is important to helping students understand the concept.

It's been my experience (and perhaps yours too) that most non-scientists think evolution means "man evolved from monkeys," which is an exceedingly narrow definition. It is both scientifically accurate as well as strategically wise to embed evolution within the broadest scientific context possible. Evolution isn't just about humans, or even about living things. Astronomers do, after all, study cosmic evolution. Geologists and geophysicists study the evolution of the planet earth, and evolution is the organizing concept of earth science just as it is for the life sciences. Biologists and biochemists study the change through time of living things. Rejection of evolution doesn't mean merely rejection of "man evolved from monkeys," but rejection of principles relevant (and in some cases crucial) to modern science.

The word "evolution" is defined and used in many different ways, some more useful and accurate than others. Embedding evolution in a wide range of sciences requires a broad definition. What unites astronomical, geological, and biological evolution is the concept of *change through time*. But "change through time" can also refer to phenomena like the water cycle, or the rotation of the earth around the sun, or the passage of energy through a food chain, or the metamorphosis of insects. Not all change is evolution, so we must distinguish evolution as being *cumulative* change through time. The evolution of a star from white dwarf to supernova is one such cumulative change.

When we discuss organic evolution, we must be especially precise. Here I part company with many of my colleagues: I do not find the traditional "evolution is changes in gene frequencies through time" to be a useful definition, even if it were modified to be "*cumulative* changes in gene frequencies through time." Especially at the beginning of a course, who knows what a gene frequency is? The genetically-based definition of evolution is useful in understanding the major constituents of evolution (genetic variation, adaptation, reproductive isolation/speciation), but if a teacher waits until students understand all of the related concepts, it will be the end of the semester. If evolution is to be taught as the organizing principle of biology, we shouldn't wait until the end of the semester to let them in on the secret! I find that even college students lose track of the relationship of evolution to biology using this genetically-based definition, and I am sure high-school students will, also.

What do we want students to know about organic evolution? The "Big Idea" is that living things (species) are related to one another through common ancestry from earlier forms that differed from them. Darwin called this "descent with modification," and it is still the best definition of evolution we can use, especially with members of the general public and with young learners. *Descent with modification* makes biology make sense. We can study and understand the workings of evolution using genes, cells, fossils, ecology, taxonomy—you name the biological subfield, and evolution is there.

For example, everyone teaches some taxonomy in high school and junior high. But how many explicitly teach how the concept of descent with modification makes it possible to group organisms into taxa? Horses and donkeys are similar because they shared a common ancestor quite recently, geologically speaking (in fact, they can still interbreed, though the hybrid is sterile). The horse/donkey group can be grouped with zebras because it shared a common ancestor with zebras, and so on up through genera, families, orders, classes, and phyla. Most of the time taxonomy is taught backwards: organisms are classed together because they are similar. Wrong. They are classed together *and they are similar* because they shared a common ancestor.

A good example of a confused understanding of evolution is even found in some textbooks. How many times have you seen the peppered moth or other cases of industrial melanism used as an example of evolution? It is an example of change, but fluctuating change. Remember that the frequencies of melanic genes shifted back to their pre-industrial lows after scrubbers were placed on smokestacks and air pollution was reduced. Industrial melanism is an example of natural selection, not of evolution. A good exercise would be to have the students figure out whether industrial melanism *could* be an example of evolution (as in our definition of "descent with modification.") (Hint: add reproductive isolation and speciation!)

Define "Theory"

Not incidentally, teachers also need to be clear in their minds about what a "theory" is, because (as illustrated in the examples with which I opened this essay) evolution is under attack for being "just" a theory. The problem is that "theory" is used outside of science in a deprecating way as a synonym for guess or hunch. What is a "fact" and what is a

"theory?"

A fact is a confirmed observation. For example, it is a confirmed observation that every tetrapod known has, at some stage of its life, a humerus, a radius and ulna, and a distal cluster of bones corresponding to carpals, metacarpals and phalanges. The general public (and even some scientists) use the word "fact" to imply capital T "Truth": unchanging agreement. In science, facts, like theories, may change: it was once a fact (for about 10 years) that *Homo sapiens* had 48 chromosomes. But other observations were confirmed and explanations found for the erroneous observations, and now we know that there are 46. In general, though, in science we treat facts as statements we don't need to test and question anymore, but rather can use as givens to build more complex understandings.

A theory, in science, is a logical construct of facts and hypotheses that attempts to explain a natural phenomenon. It is an *explanation*, not a guess or hunch that one can casually disregard. Theory formation—explanation—is the goal of science, and nothing we do is more important. A scientist joked that we should applaud the Tennessee law punishing teachers for teaching evolution as a "fact rather than a theory" because "everyone knows that theories are more important than facts!" *Theories explain facts*, but the general public doesn't know that.

Concerning evolution, then, what's a fact and what's a theory? One hears from many scientists, "Evolution is FACT!!!" The meaning here is that evolution, the "what happened," is so well supported that we don't argue about it, any more than we argue about heliocentrism versus geocentrism. We accept that change through time happened, and go on to try to explain how. What we mean and what is heard is often different, however. What the public often hears when scientists say "Evolution is FACT!" is that we treat evolution as unchallengeable dogma, which it isn't.

We must learn to present evolution not as "a fact" in this dogmatic sense, but "matter of factly," as we would present heliocentrism and gravitation. Most people consider heliocentrism and gravitation as "facts", but they are not "facts" in my definition of "confirmed observations." Instead, they are powerful inferences from many observations, which are not in themselves questioned, but used to build more detailed understandings.

From the standpoint of philosophy of science, the "facts of evolution" are things like the anatomical structural homologies such as the tetrapod forelimb, or the biochemical homologies of cross species protein and DNA comparisons, or the biogeographical distribution of plants and animals. The "facts of evolution" are observations, confirmed over and over, such as the presence and/or absence of particular fossils in particular strata of the geological column (one never finds mammals in the Devonian, for example). From these confirmed observations we develop an *explanation*, an inference, that what explains all of these facts is that species have had histories, and that descent with modification has taken place. Evolution is thus a theory, and one of the most powerful theories in science.

We may also speak of "theories" (plural) of evolution, in the sense of the explanations for how descent with modification has taken place. It is conceptually sound to separate evolution as something that did or did not happen from explanations about how, or how fast, or which species are related to which. I'll return to this idea below.

Indeed, teachers have to be sure that students know what theories are and why they are important. Students also must—this is crucial—learn as part of their science instruction that our explanations change with new data or better ways of looking at things. Anti-evolutionists make the statement that "evolution isn't science because you guys are always changing your minds about stuff." This is not a criticism. That's the way a vigorous science works.

Defuse The Religion Issue

People don't oppose evolution because they disagree with the science but because it offends their religious sensibilities. In most communities, at least some students come into a class wary of the "e-word" because somehow they have acquired the idea that acceptance of evolution is incompatible with religious faith. Anti-evolutionists, in fact, make a special point of proclaiming that one is either an evolutionist or a creationist, falsely dichotomizing the issue. Although it is not the job of public school science teachers to teach theology, when students come to class with their fingers stuck into their ears and their eyes closed, it is necessary to figure out a way to get the fingers out and the eyes open.

Most Catholic and mainline Protestant denominations have accepted evolution as the way God brought the world about, and this is also true of the theology of all but the most conservative Jews. Although it would be inappropriate for a teacher to encourage students towards or against any religious view, it is appropriate to inform them, in a comparative sense, of the existence of more than one religious perspective on creation and evolution. Because students are not *tabulae rasae* when they come to class, a constructivist approach is a useful way to help them build their understanding of this important fact.

At least some students come into a class wary of the "e-word" because somehow they have acquired the idea that acceptance of evolution is incompatible with religious faith.

Teachers have told me they have had good results when they begin the year by asking students to brainstorm what they think the words "evolution" and "creationism" mean. As expected, some of the information will be accurate and some will be erroneous. Under "evolution," expect to hear "Man evolved from monkeys" or something similar. Don't be surprised to find some variant of, "You can't believe in God" or some similar statement of supposed incompatibility between religion and evolution. Under "creationism" expect to find more consistency: "God"; "Adam and Eve," "Genesis," etc. The next step in constructing student understanding of concepts is to guide them towards a more accurate view. One goal of this exercise is to help them see the diversity of religious attitudes towards evolution.

After one such initial brainstorming session, one teacher presented students with a short quiz wherein they were asked, "Which statement was made by the Pope?" or "Which statement was made by an Episcopal Bishop?" and given an "a, b, c" multiple choice selection. All the statements from theologians, of course, stressed the compatibility of theology with the science of evolution. This generated discussion about what evolution was versus what students *thought* it was. By making the students aware of the diversity of opinion towards evolution extant in Christian theology, the teacher helped them understand that they didn't have to make a choice

between evolution and religious faith.

A teacher in Minnesota told me that he had good luck sending his students out at the beginning of the semester to interview their pastors and priests about evolution. They came back somewhat astonished, "Hey! Evolution is OK!" Even when there was diversity in opinion, with some religious leaders accepting evolution as compatible with their theology and others rejecting it, it was educational for the students to find out for themselves that there was no single Christian perspective on evolution. The survey-of-ministers approach may not work if the community is religiously homogeneous, especially if that homogeneity is conservative Christian, but it is something that some teachers might consider as a way of getting students' fingers out of their ears.

A less constructivist but not necessarily ineffective approach is to begin by properly separating "evolution" as something that occurred (change through time) from the processes and mechanisms—the causes—of evolution. Define evolution as an issue of the history of the planet: as the way we try to understand change through time. The present is different from the past. Evolution happened, there is no debate within science as to whether it happened, and so on. Then, list (for later discussion) a number of causes or processes which might explain in whole or in part how this change through time might have taken place. Stress that this is where debating takes place. List both currently-debated and also rejected explanations, such as Lamarckism, saltation, Darwinian natural selection, neodarwinism, non-Darwinian evolution, and so on. At the end of the list (and I recommend using a transparency or writing the list on the blackboard), include "Supernatural Causation". Explain that some people think that change through time is caused directly or indirectly by a supernatural being, including God, the Hero Twins (Navajo), or some other supernatural power. At this point you then state *because this is a science class, and science is limited to explaining through natural forces, we cannot discuss supernatural causation here*.

I have used this approach at the college level and seen a remarkable development: the fingers start coming out of the ears. Just by mentioning the fact that some people believe God was responsible for change through time, you are recognizing the view of many Christian and Jewish students, even though you are not going to discuss it further (you're not a theology teacher!) Many religious students have never been exposed to a continuum of religious views, and in a very real sense, you are giving them an opportunity to listen to you and not shut you out. Note that you are not to promote theistic evolution: the schools must be religiously neutral. The purpose of this exercise is to give the student some critically important information so that he or she will be more willing to listen to the scientific information you will present.

Similarly, it is useful to separate "creationism" into two parts. Most Americans define "creationism" as "God created," and when creationism is juxtaposed with evolution, the translation made is that "evolution = God-didn't-create." This is the perspective promoted by anti-evolutionists, of course, but it is an unnecessary dichotomy. As discussed above, mainline Christian and Jewish theology accepts evolution as the way God created. The other type of "creationism" tries to more specifically answer the question, "what happened?" Special creation, the view of biblical literalists, is that everything in the universe was created all at one time, in its present form. From my experience in dealing with the general public on this issue (radio talk shows are very educational...), most Americans are willing to accept that change through time has taken place, but they very much want to retain God as the creator.

Whether God created is of course, not a scientific question, because science is restricted to explaining natural phenomena using only natural processes. But science can tell us a great deal about "what happened," and the evidence powerfully leads us to conclude that change has taken place and not that everything appeared in its present form.

Helping students understand that evolution, like all scientific explanations, deals only with proximate, never ultimate, cause allows them to accommodate their religious views to evolution, if they so choose. Much resistance to evolution is overcome by allowing the religious student to retain his or her faith in God the creator, while still accepting the scientific evidence for descent with modification.

"But I don't believe in evolution"

There will doubtless be students who refuse to accept evolution. That's all right. Remember, the job of you and your colleagues at the K-12 level is to help students understand the consensus view of a discipline, whether it is history, literature, mathematics, or science. No one said a student has to "believe" in a spherical earth, and in fact, a teacher in a small mountain community in Appalachia told me that she had a brother and sister who would walk out of the class when she discussed a heliocentric solar system! It's the job of the teacher to instruct, not to indoctrinate. All you are asking is that the student learn the subject. Whether he agrees with what is being taught is up to him. Although you'd feel silly telling students, "Well, kids, today we're going to discuss the theory of heliocentrism, but you don't have to believe it!," tension is often reduced when you reassure students that all you're expecting of them is to learn the material (they have to pass the test, after all). Whether they accept the modern scientific consensus that evolution occurred is up to them.

Counter The "Equal Time"/"Fairness" Sentiment

School boards in every state have been pressed by citizens to include creationism in the science curriculum because "you already teach evolution, so it's only fair to teach creationism too." The idea of "balancing" evolution with creationism, giving "equal time" out of "fairness" is an approach that resonates with Americans. It is, in fact, the strongest argument creationists have raised—not because of logical soundness, but because Americans value fairness and equality.

Science is not a democratic process

We decide which explanation (theory) is superior based on its power to explain successfully, not on how popular it is. Heliocentrism was not a popular idea 300 years ago—ask Galileo—but it is now the standard explanation for the relationship of the earth to the sun because it explains so many more observations than any other theory. The theories of kin selection and parental investment derived from sociobiology are not "popular" views, but if they continue to explain social behavior successfully, they will be utilized.

If scientists could vote to choose theories, I'd vote for Lamarckism! It's a lot more humane and useful than natural selection! But the world doesn't work that way. The laws of nature work as they will, irrespective of human wish or will. The

Creationists React to "Jurassic Park" Sequel

Molleen Matsumura
Network Project Director

Two leading young-earth creationist organizations, the California-based Institute for Creation Research (ICR) and Kentucky-based Answers In Genesis (AIG), have reacted to the release of the sequel to "Jurassic Park" with criticism and efforts to publicize their own view of dinosaurs as creatures that once lived beside humans, only to be destroyed in Noah's flood.

ICR President John D Morris wrote in the newsletter *Back to Genesis*, "Let me briefly answer some of the movie's themes and place dinosaurs in their proper biblical context. Dinosaur... remains are found in sedimentary rock units hardened...by high energy water currents.... In [chaos theory] life's complexity is attributed to an undiscovered trend in nature which produces order from disorder.... Unfortunately, the observed trend in nature is toward deterioration..." (#103, p d). Morris's purportedly scientific discussion is indeed "biblical" since the mention of "high energy currents" is a reference to Noah's flood, and the "trend toward deterioration" is based on the doctrine of the Fall. Another ICR publication reports that, "Capitalizing on this opportunity [the release of "The Lost World"], ICR produced a two-part, one-hour radio special.... CDs were sent free of charge to hundreds of radio stations" (*Acts & Facts* 1997 Jul; 27[7]:1).

In the Answers In Genesis April newsletter Executive Director Ken Ham described "The Lost World" as "another major attack on Christianity". Rather than attacking the movie's *scientific* premises, Ham criticized "anti-Christian" remarks by some characters. Some examples cited by Ham are, "That's creationism and it's wrong. Just plain wrong.... Now we believe the earth is four billion years old.... We think those beliefs are more scientific and better" and "It's a gift to be alive, to see the sun and breathe the air. And there isn't really anything else." Ham asks, "Do we really want to give the pagans in Hollywood millions of dollars in ticket sales so they can make more anti-God movies?" and urges readers to "Look at the wonderful material now available through Answers in Genesis to enable you to conduct special outreaches in your community that could coincide with this dinosaur extravaganza! Videos, tracts, books...."

In the May issue of the newsletter, Ham praised a man who "called us earlier this year and said that he wanted to purchase at least 1000 of them so that he could stand outside the movie theater and distribute these booklets to theater-goers as they left." In another article in the same issue, Ham calls on readers to "[L]et the 'Lost World' know the TRUTH about God's World and God's Word! Why not run 'Dinosaur Nights' at your home—and special Dinosaur Programs at your church? Use the videos, the books, the magazines."

The reactions of AIG and ICR are a continuing reminder that, though these organizations frequently insist that they are presenting an "alternate *scientific* theory", their real concern is to promote biblical literalism in public schools and all other aspects of public life.

[See the reviews on the April Answers in Genesis pages on the World Wide Web by connecting to <http://www.christiananswers.net:80/aig/aignews/Apr97.htm>.]

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explanations scientists accept are the ones that work, and Lamarckism doesn't work. The special creationism explanation that the universe was created all at one time in its present form doesn't explain nature nearly as well as the evolutionary explanation that the universe has had a history and that change has taken place. Thus, special creation has been discarded as a scientific explanation.

"IT'S ONLY FAIR!"

It is not "fair" to mislead students by pretending that discarded ideas are still viable. We do not present geocentrism and heliocentrism as if they are currently contending theories. We only confuse students by presenting special creation and evolution as if both were equally scientific and as if scientists were still trying to decide between them.

There is another question regarding the "fairness" approach: How should educational curricula be determined? Most of the time, we agree that the consensus scholarship of history, literature, art, or science should be presented to Kindergarten - 12th grade students. We do not teach astrology with astronomy because professional astronomers (and physics teachers) tell us that astrology is not considered good scholarship. Biologists, geologists, astronomers and other scientists tell us that evolution should be taught, and creation "science" should not. The proponents of creationism in the curriculum are a political pressure group outside of the educational and scientific communities. A good defense against the "fairness" argument is to point out that we do not determine scholar-

ship depending on what a political pressure group wants, otherwise we would teach Holocaust revisionism along with standard World War II history, and give equal time in medical school to the ideas that AIDS is caused by viruses and AIDS is a curse sent from God.

"Teach both creationism and evolution to promote critical thinking"

Often teachers are encouraged by parents or others to present creationism with evolution for pedagogical reasons: supposedly, presenting nonscience with science and "letting the children decide" will improve their reasoning skills. It makes more sense to have students practice critical thinking by evaluating ideas that are truly in contention. Few teachers would have students evaluate the "scientific" evidence for flat-earthism (there is some, with emphasis on the quotation marks!) versus spherical-earthism "and let the children decide." Again, the creationists make an issue of *whether* evolution occurred, rather than *how*. The scientific debates concern the latter, not the former.

It is possible to use creationism and evolution as foils in a discussion of the nature of science, but this may well result in a student's taking offense at what may appear to be criticism of his or her religion. It is better to avoid this, for many reasons.

Evaluating the creation science literature requires far more background than students have, or will have—and maybe even than the teacher has. Most teachers would not ask students to evaluate whether balloon angioplasty or bypass surgery should be used to treat heart failure, and that question deals "only" with medicine, one field in biology. Consider that organic evolution (not to mention astronomical and geological evolution) relies on data from biochemistry, comparative anatomy, the fossil record, biogeography, and many other fields. The vast majority of students are not well enough versed in even one of these areas to critically evaluate it. The amount of time devoted to evolution in most classes is pitifully small as it is, although the consensus of science educators and scientists is that it should be the organizing principle of biology and geology, and be referred to regularly throughout the semester. Few teachers who favor teaching the "two models" would be willing to spend enough time teaching about evolution so that students could see why the creationist arguments are faulty.

Summary

Teachers should teach evolution, but in many classrooms they encounter much opposition, mirroring the rejection of evolution by large percentages of the population. There are three approaches discussed here to help teachers deal with anti-evolutionism.

First, be informed about the nature of science, and the science of evolution.

Second, understand the religiously-based opposition to evolution, and consider ways to defuse it. Before students can learn evolution, they must be willing to learn, and many come into class thinking that evolution is incompatible with their religious views. In some cases, this will indeed be the case, and nothing a teacher can say will change it. In this situation, it is best to remind the student that the job of the teacher is to communicate the consensus view of the field, and the job of the student is to learn it. Whether the student accepts what he learns is up to him. For most students, becoming aware of the plurality of religious views towards evolution allows them to accommodate their views to the science you are presenting.

Finally, there is much pressure on teachers to teach creationism along with evolution in the science class because doing so is "fair," or, perhaps, "good pedagogy". Neither is the case: students should learn state of the art science, not outmoded views which have been rejected as science. Also, we do not determine curricula based on the desires of a pressure group, but based on the consensus of scholars in the field.

But teachers themselves need to take the initiative, because ultimately, the buck stops in the classroom, with the teacher. Many teachers teach science without having had training in the subject, or with only inadequate training. Especially at the elementary level, many teachers have "science phobia." These teachers are especially reluctant to teach evolution, for obvious reasons. They need better knowledge of the content of science, but they also need encouragement to teach a controversial issue. There are many knowledgeable teachers who are teaching evolution, and teaching it well. You have a responsibility to mentor those who are not, and I encourage you to do so.

Evolution is the organizing principle of biology and geology, and it needs to be taught if we are to produce new scientists as well as have a scientifically literate society. There is help for teachers willing to teach this "controversial subject," from organizations like the National Association of Biology Teachers, the National Center for Science Education, and also—most importantly—from colleagues.

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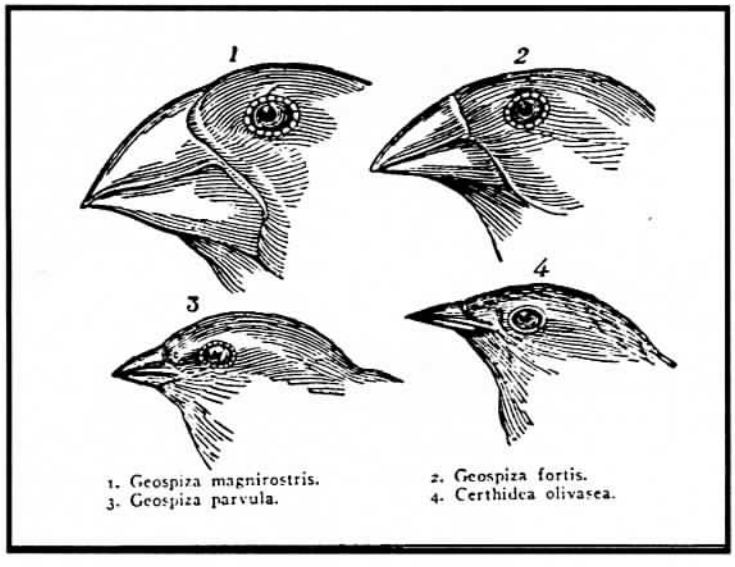
GALAPAGOS

DARWIN'S ENCHANTED ISLANDS

The Galapagos Islands possess an untamed beauty and enchantment giving one the feeling of being on another planet. Due to their geographic isolation, a unique and colorful array of plant and animal life has evolved, representing a "crossroads of evolution." Led by Galapagos naturalist Maxwell (Mickey) Cohen and expert naturalist guides from the Darwin Research Station, you will explore 10 of these mystical islands, creating a tremendous learning experience in natural history. As an added incentive, we've scheduled our Galapagos trip to coincide with the last solar eclipse of the millennium. The best vantage point on the planet will be around Pinta Island in the Galapagos, and although Ecuador does not usually include access to Pinta for tourists, we've received special approval to observe from Pinta! And if a solar eclipse is not spectacular enough, NCSE Executive director, Dr. Eugenie C Scott will be along on this historic trip! You will never forget the aura of "Darwin's Enchanted Islands."

What's Included

- Services of International Expeditions, Inc., our travel agent, for complete predeparture information to help you get the most out of your expedition.
- Round trip international air transportation from Miami to Ecuador and all scheduled transportation in Ecuador and Galapagos, by land, sea and air.
- Land and sea excursions with experienced bilingual guides from Galapagos who are specially trained at the Darwin Research Station.
- All accommodations including hotels and yacht with bedding and linens provided.
- All meals.
- All transfers, porterage, hotel and yacht charges, municipal tax and national park fees.
- In summary—everything except passport fees, tips & gratuities, and items of a personal nature such as laundry, phone calls, beverages, etc.



1. Geospiza magnirostris.
2. Geospiza fortis.
3. Geospiza parvula.
4. Certhidea olivasea.

14 Day Nature Expedition

$4,600 all-inclusive from Miami, departs Sunday, February 22, 1998. Space limited to 10 double cabins.

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SPACE STILL AVAILABLE!!

FEATURE

Showdown at the Austin Corral

Kenneth Miller
Brown University

Public school textbooks in Texas are reviewed and approved by the state through the actions of a state agency known as the Texas Education Authority (TEA). The TEA, unlike most state education agencies, is under direct political control of the Texas Board of Education. The board has 14 members, each elected from a region roughly twice as large as a Congressional district. The board is highly political, and every one of its members ran in the last election with a party affiliation.

One administrator told me that she'd "been waiting for 15 years to see somebody give the board what-for.

Over the years, the board has been involved, directly or indirectly, in many skirmishes on evolution, although during the last statewide biology adoptions (in 1991) it approved all of the books put forward by publishers without so much as a harsh word about their coverage of evolutionary biology. Our publisher, Prentice Hall, had gotten word through the grapevine that this would not be the case this time for the new text that Joseph Levine and I had written, *BIOLOGY — The Living Science*). Several members of the board, they believed, were planning to challenge our book on the basis of its coverage of evolution, so we prepared for the worst.

This should not have been necessary. The public hearings and time for written comment took place in September, and our book had gathered no special criticism. However, the rules that apply to public comment do not apply to criticism from members of the board itself, and we suspected that a few members might try to bring new criticisms into play at the last minute, hoping that the publisher would not be able to respond to them.

I flew into Austin the day before the hearings, bringing with me as much documentation as I could on evolution and the way in which our book presents it to students. The board convened on the morning of November 6th, and spent the better part of 90 minutes wrangling over algebra texts and then turned its attention to the biology "list."

Board member Randy Watson (R-Gorman) introduced an amendment to the motion to approve biology books that would have struck *BIOLOGY-TLS* from the "conforming" list—a move that would have effectively ended the book's chances to compete in the Texas market. The reason, he said, was that the book did not conform to Texas requirements that books provide students with "content necessary to formulate, discuss, critique and review hypotheses, theories, laws, and principles and their strengths and weaknesses." Our book, according to Watson, gave an uncritical accounting of evolution.

"The Darwinian hypothesis," Watson thoughtfully intoned, "is on very shaky ground to begin with." To support his arguments, he quoted extensively from an *American Biology Teacher* (*ABT*) article ("Origin of life and evolution in biology textbooks—A critique" by GC Mills, M Lancaster, and WL Bradley. *American Biology Teacher* 1993; 55: 78-83) that criticized several high school texts, including our 1991 book, *BIOLOGY*.

When Prentice Hall's Texas representative announced to the board that he would ask the author of the book to respond to these charges, Watson was visibly surprised. I don't think he expected any scientist, much less the book's co-author, to be in the audience. I introduced myself and my academic background and then took maximum advantage of the openings that Watson's careless attacks had given me. I pointed out that the *ABT* article was written regarding a *different* book, something that Watson had not been careful to emphasize. This surprised even his supporters on the board.

I answered the criticisms from the article anyway, and noted that Watson had not brought the board's attention to the scientific reaction to this article—a stream of letters in subsequent issues of the same journal pointing out its errors and misrepresentations of fact (incidentally, a hurried phone call to Eugenie Scott at NCSE took only a few hours to produce copies of these letters to back up my claims). Watson had told another board member that our book claimed that human embryos had "gill slits". Our book makes no such claim, and I waited for Watson to agree that his charge was mistaken, which he did, reluctantly. Then I patiently explained the difference between a gill slit and a branchial arch, pointed out the relevance to evolution and explained why embryonic development provides strong evidence even if ontogeny does not precisely recapitulate phylogeny.

I told the board that I would like them to read what my book actually says with respect to evolution and then showed a full page of quotations from the text illustrating how clearly it indicates what aspects of evolutionary theory remain hypothetical and where the most substantial gaps in our understanding of evolutionary change remain. I told the board, which was clearly growing more sympathetic as the errors in Watson's characterization of the

book were pointed out, that Joe Levine and I had been careful to distinguish between the historical *fact* of evolutionary change and the uncertainties of evolutionary *theory* which seeks to understand the mechanism behind that change. The *Dallas Morning News* noted that "Several other criticisms were also rebutted as Watson sat silently."

Watson had concluded his remarks by claiming that our book contained a terrible "mistake," namely the claim that the human appendix is a vestigial organ. Because the appendix does have a function (although Watson didn't seem to be sure what it was), this means that it is not vestigial and is another example of the way in which our book would mislead Texas students. I finished my remarks by defining the word "vestigial", as it is used in biology, to apply to organs that are greatly reduced in size or function compared to identical organs in other animals. The human appendix is indeed just a "vestige" or a trace of its size and importance in other animals, and therefore this term is correctly used in our text. The presence of Peyer's patches, small clusters of immune cells in the appendix, doesn't change this designation—no matter what Watson says, "vestigial" does not mean "functionless". At this point, the publishers, teachers, and administrators in the large (more than 150) audience were visibly enjoying Watson's discomfort as I answered a number of friendly questions from pro-evolution members of the board at the conclusion of my remarks. I also distributed a 3-page statement that Levine and I have prepared to answer parent and community concerns that our coverage of evolution might be somehow anti-religious.

When I sat down after 15 minutes of what the *Houston Chronicle* would characterize as a "mini-lecture on gill slits, branchial arches, vestigial structures, structural homology and other building blocks of evolutionary theory," the mood among publishers in the audience had turned from apprehension to glee. Watson weakly complained that if he had known that "Dr Miller" was coming he could have brought "equally eminent" scientific authorities to rebut me. The board's chair brought Watson back to reality by getting him to admit that, yes, those "eminent" folks would have been welcome during the days of public comment, if Watson had only seen fit to bring them.

Watson's motion to remove our book from the approved list failed, 5 - 9. To no one's surprise, the five Republicans known as "social conservatives" voted against the book. The board's three other Republicans (including its chair, Jack Christie of Houston) and all six Democrats voted in favor of our book.

When the meeting adjourned, I discovered that my 15 minutes in the dock had been a cathartic experience for much of the audience. One administrator told me that she'd "been waiting for 15 years to see somebody give the board what-for." Another said she couldn't wait to get back to her school and tell them about "the look on Randy Watson's face". Publishers' representatives, always present at these hearings in force, were especially thrilled. Rather than watching another instance of a representative politely accepting criticism, they roundly enjoyed the site of a direct confrontation by someone in a position to challenge and refute the assertions of board members on their merits. It was great fun and made me the temporary hero of everyone at the TEA who are used to being lectured by their elected bosses, and delighted in seeing the tables turned for a change.

The bottom line is that everything ended well—high schools in Texas this year will be able to choose from more than a dozen textbooks with excellent treatments of evolution. The board's decision was a clear victory for science, and therefore the news is good. But one thing still puzzles Joe Levine and me. Why was our book singled out for attack? The six or seven major competing books, I'm happy to say, each cover evolution in a thorough, uncompromising way, and each could have been criticized on the exact points used by Watson to try to exclude our book.

We still aren't sure. It could be because the success of our 1991 book, used by nearly half of the schools in Texas, made us a logical and prominent target. Or, it could be that my own writing and debating on behalf of evolution has made anti-evolution forces eager to score a victory against our book in particular. I'm not sure that Joe and I will ever know, but if anyone reading this account has inside information on why we were chosen, please give me a call. I'd love to know the reasons for our sudden notoriety! In the meantime, my special thanks go out to everyone in Texas who supported my efforts to answer these criticisms and especially to the National Center for Science Education, whose crucial support in this little battle and many others has often tipped the balance in favor of scientific integrity.

THE GALAPAGOS TOUR IS OPEN DUE TO CANCELLATIONS, SEE PAGE 31 FOR DETAILS

MEDIA REVIEW

"Creation or Evolution?" review by Braude and Shingleton

"Creation or Evolution?" is the first installment of a forthcoming three part video series, *Science and Religion: Bridging the Gap,* produced by Ambassador Television for The Worldwide Church of God. It differs from other popular creationist efforts in both superficial and substantive ways.

Reviewed by Stanton Braude and Keri Shingleton
Washington University, St. Louis

"Creation or Evolution?" is a very polished video production. Like David Attenborough in a BBC special, the narrator appears in labs and at field sites, and interviews experts. His presence on the family TV screen is friendly and persuasive. In addition, watching a video takes far less effort than reading a book, and this one will keep the attention of the viewer. This video was also advertised in the *Sunday Parade Magazine* (December 8, 1996) and, therefore, has the potential to reach an enormous audience.

The substance of the video also differed from the creationist propaganda with which we are familiar. It starts out defending the evidence for an old Earth and against flood geology in some detail. The narrator specifically contrasts his views with those of biblical literalists. We are told that science helps us answer questions about how and when the world came about, while religion explains who and why. The narrator even goes so far as to declare that it would be an abuse of our "God-given intelligence" to ignore the evidence of science.

It comes as a surprise, therefore, that the video quickly degenerates into familiar rhetoric against an evolutionary explanation for the diversity of life. The narrator uses the false analogy of a deck of cards to argue that there is too little variation for speciation to happen. Then he discusses the "evolution" of Ford motorcars as an analogy to argue for repeated intelligent intervention and creation as an explanation for past extinctions and the fossil record. This diatribe against evolution contradicts the attitude of the first part of the video. Although an old Earth is not threatening, The Worldwide Church of God must consider evolution a dangerous idea because "it will lead to denying God and losing salvation."

Regardless of the religious motives of the producers, this video is intentionally deceptive and cannot be excused as innocent ignorance. Geological data are used to establish the authority and integrity of the narrator, and then biological data are ignored and twisted to persuade the viewer that there are reasons to doubt the fact of evolution. Since The Worldwide Church of God did not skimp on either production or marketing, you should expect this video to appear in newspaper editorials and at school board meetings in the near future.

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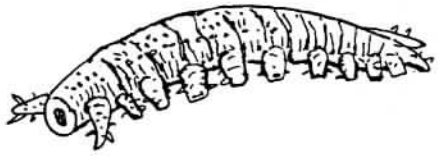
BOOKS OF INTEREST

Bonobo: The Forgotten Ape by Frans de Waal and Frans Lanting, published by University of California Press (Berkeley).
As close or closer to humans than chimps, bonobos are remarkable in their non-hierarchical, cooperative social systems and flamboyant erotic life—they seem to substitute sex for argument and strife common to chimp society. These themes are explored in 8 photo essays.

Operation Adam, by Ivan Petrovich C (pseudonym of a French scientist), published in French by Cerf.
This is a novel about a creationist organization, "Protectors of Adam", which steals virtually all of the world's human fossils at an Arizona conference (they also perpetrated the Piltdown fraud and ditched Peking Man). The somewhat clever premise is wasted on a ludicrous plot line which culminates in an American trial which ends up ruling that the term "scientific creationism" is illegal and ignoring the charges related to the theft of the fossils! Besides, creationists have not been violence-prone, scholars have not been so lax in the security of rare and important fossils, and all fossils would never be in one place, and so on.

[*Contributed by John Cole*]



BOOKREVIEW

Bones of Contention: Controversies in the Search for Human Origins

by Roger Lewin, 2nd ed. 1997, The University of Chicago Press. 366 p.

Reviewed by Danny Yee, Department of Anatomy and Histology, University of Sydney, Australia.

Bones of Contention is an account of some of the chief controversies in paleoanthropology in this century. Lewin doesn't try to narrate the history of the discipline as a whole, but instead concentrates on a few key figures and notable events. Many sciences have their high profile personalities and public disputes, but paleoanthropology has always had more than its share. Lewin begins by exploring why this is so, taking as his starting point a television debate between Richard Leakey and Donald Johanson.

He then goes back to the great paleoanthropologists of the 20s and 30s (people such as Henry Fairfield Osborn and Grafton Elliot Smith), following a study by Misia Landau which analyses their work on human origins as storytelling. Two chapters cover Raymond Dart and the rejection, and later the acceptance, of *Australopithecus* (the Taung Child); they also cover the Piltdown forgery and debates over the relationship between the Neanderthals and modern humans.

There are two chapters on David Pilbeam and Elwyn Simons and the *Ramapithecus* affair, which also consider the initial reaction of paleontologists to the intrusion into their domain of molecular geneticists such as Vincent Sarich and Allan Wilson. Lewin also explores the impact of Louis and Richard Leakey—their contributions to paleoanthropology, their backgrounds as outsiders, and the connections between these.

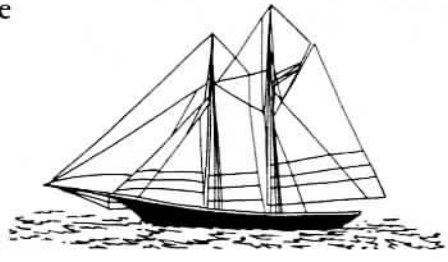
There are two chapters on the controversy over the KBS Tuff dating and its eventual resolution that form a case study in the influence of preconceptions and personal feelings (even with the involvement of so "hard" a science as geochronology). Returning to his starting point, Lewin devotes two chapters to the disputes between Johanson and the Leakeys over the naming and significance of *Australopithecus afarensis*. Finally, this "second edition" (otherwise unchanged from the original 1987 work) contains a fifteen-page afterword covering Mitochondrial Eve and the multiregional versus out-of-Africa debate.

Bones of Contention doesn't assume any prior knowledge of paleoanthropology, but it is only incidentally an introduction to the subject. Lewin is concerned not so much with the scientific details as with the behind-the-scenes workings of the discipline with its human side and its politics. But the stories he tells about paleontologists are as exciting as those they tell about human evolution. For students of the history and philosophy of science *Bones of Contention* will be a practical accompaniment to more theoretical works. And anyone who still holds to a naive belief in the clear-cut objectivity of science and scientists will find it an eye-opener.

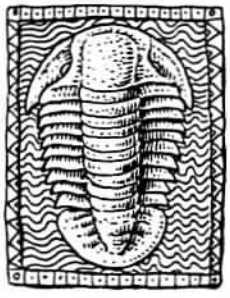
[*This review was originally posted at <http://www.anatomy.su.oz.au/danny/book-reviews/h/Bones_of_ Contention.html> and reprinted with permission.*]

MORE SPACE AVAILABLE ON NCSE GALAPAGOS TRIP

If you were wishing that you *had* booked your cabin for the NCSE trip to the Galapagos Islands, but thought that the opportunity had passed you by, there is good news for you! Past-president and trip coordinator Jack Friedman has informed us that there are a few last-minute openings. Details of the trip are located on page 31.
Jack wrote to remind us that "The eclipse is still on!" Interested readers can e-mail Jack at friedmj@sunynassau.edu or call (516) 921-5522.



RESOURCES



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"In Darwin's Wake" by David Denby appeared in the July 21, 1997 issue of *The New Yorker* on pages 50-61.

Denby writes that he had assumed Darwin was passé as science and literature, but he allowed himself to be dragged along on a Galapagos tour against his better judgment. The tour, led by Mickey Cohen (who will lead the 1998 NCSE Galapagos tour), opened his eyes to the living nature of Darwin's science and his sparkling prose. He emerged from the trip stunned by what he had learned about nature and Darwin. The article is an excellent description of how the Cohen tour won over a skeptic, and it presents aspects of Darwin's work very perceptively; it is not "gee-whiz" in tone or a naïve retelling of the myth of Darwin's having a Galapagos epiphany (the breakthrough came later, back in England, where he realized what his somewhat haphazard collections implied). Denby is very astute, of course, but the "Cohen treatment" is shown to be an outstanding *tour de force*.

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[Resources in the bibliography contributed by Frank Sonleitner, John R Cole, and Jim Foley.]

Resources Available from the AAAS Epic of Evolution Conference

An exciting list of educational resources is being developed from the proceedings of the AAAS Epic of Evolution Conference. Plans include a public television show, an eight-part video series, an edited volume of the proceedings, a secondary school textbook, and a model college course syllabus. These resources will help fill an enormous gap in the science and religion field, in which there is a lot of high-level scholarly discourse but little in the way of introductory material for general adult education and high-school level teaching.

Video Resources
A videotape of the entire conference will provide a record of the entire event and include individual interviews with each presenter. From this material, educational resources will be developed in collaboration with WYCC, the Chicago educational television station. These educational resources are to be aimed at a non-specialist audience including advanced placement high school and college students, and a general adult audience. They will provide an unprecedented educational resource in the evolution and religion area. It is expected that the video production will be completed by June 30, 1998.

An Educational Television Special
The content of the conference will be edited into an educational television special which will be broadcast on WYCC. This special will then be available for use in other educational venues, such as high school biology and social studies classes and local religious educational programs.

An Eight-Part Video Series
The eight sessions of the conference provide the outline for this video series which uses the taped material from the conference including the interviews edited together with other visual materials to form a series of eight 45-minute tapes. These tapes can be used in a variety of educational venues including upper level high school social studies courses, college level science and religion courses and other adult educational settings.

INTERNET LOCATIONS VISITED IN THIS ISSUE

TOPIC:	Quality Core Curriculum (QCC)
LOCATION:	http://admin.doe.k12.ga.us/gadoe/qcc.nsf
OWNER:	Georgia Department of Educatron
LAST VISIT:	Nov 14, 1997
TOPIC:	New Mexico's Science Education Standards
LOCATION:	http://www.highfiber.com/~dfbeck/CESE/CESEhome.html
OWNER:	Coalition for Excellence in Science Education
LAST VISIT:	Nov 97
TOPIC:	Arizona Academic Standards—Science
LOCATION:	http://www.ade.state.az.us/standards
OWNER:	Arizona Department of Education
LAST VISIT:	Nov 1997
TOPIC:	AIG Reaction to "Lost World"
LOCATION:	http://www.christiananswers.net:80/aig/aignews/Apr97.htm
OWNER:	Answers in Genesis
LAST VISIT:	Nov 1997
TOPIC:	Bible Code
LOCATION:	http://cs.anu.edu.au/~bdm/dilugim/torah.html
OWNER:	Brendan McKay
LAST VISIT:	Nov 1997
TOPIC:	*Bones of Contention* Book Review
LOCATION:	http://www.anatomy.su.oz.au/danny/book-reviews/h/Bones_of_Contention.html
OWNER:	Danny Yee
LAST VISIT:	Nov 1997
TOPIC:	AAAS Evolution Conference
LOCATION:	http://www.aaas.org/spp/dspp/dbsr/evol.htm
OWNER:	American Association for the Advancement of Science
LAST VISIT:	Nov 1997

[Ed. Please note that the URL above is correct, but we have experienced difficulty connecting directly. As an alternative, connect to the main AAAS web page <http://www.aaas.org> and click on the Science and Public Policy Link.]

An Edited Volume
The presentations in the conference will provide the basis of an edited text which can accompany the video series as a teacher's resource or can stand alone as an evolution and religion text. The volume is to include a bibliography of additional books in the area of evolution and religion. It is expected that the text will be sent to the publisher by June 30, 1998. Preliminary discussions concerning publication have taken place with Georgetown University Press.

A Secondary School Text
A text for use in secondary schools will be commissioned. The content will be based on the conference presentations in the edited volume but written for a younger audience. The text will be visually engaging and include a glossary and a bibliography. This resource will be widely promoted and also placed on the Dialog Between Science and Religion (DBSR) Evolution Web page <http://www.aaas.org//spp/dspp/dbsr/evol.htm>.

A Model Course
A college course syllabus on "Evolution and Religion" that uses the video and print resources produced by the project will be developed and tested in a model course which will be offered in the 1998 academic year. The syllabus also will be placed on the DBSR Evolution Web page as an educational resource.

INSTRUCTIONS FOR CONTRIBUTORS

Reports of the National Center for Science Education (RNCSE) welcomes contributions from its readers and from anyone interested in issues related to evolution as the foundation for the biological sciences, to the place of evolution in the science curriculum, or to the public perception of scientific method and practice. These contributions may be submitted in one of two forms.

News, commentaries, and features describe events or experiences that we wish to relate to our readers and members. These may include reports of school-board elections or local organizing by parent and teacher groups, political or governmental decisions and policies, first-person accounts of experiences with anti-evolutionist speakers, curriculum, or organizations, other reports of information related to our primary concerns of promoting good science in education and public life, *and*, of course, humor related to creation/evolution issues.

Articles include book reviews, scholarly articles, and formal essays. These may explore specific arguments raised by anti-evolutionist scholars, relate new information that may be helpful in promoting evolution, or original research related to the public understanding of evolution. We also welcome case reports and classroom action research that assess the outcome(s) of strategies for strengthening the understanding of evolution in educational practice.

All articles should be written for a general audience, and authors should provide definitions or descriptions for technical terms and concepts whose meanings might not be evident to the non-specialist. Article manuscripts are submitted to reviewers for comments on the technical content and the suitability for a general audience. Acceptance for publication does not take into account the author's formal academic background or profession. We encourage query letters from any prospective author.

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1. Manuscripts must be typed double-spaced, including inset quotations and references. Margins must be adequate for editorial notation.
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5. Reference sections are alphabetical and should conform to the citation-sequence format in *Scientific Style and Format: The CBE Manual for Authors, Editors, and Publishers*, illustrated in the following example for books and periodicals.

   Chan L. Exciting potential of scholarly electronic journals. *Canadian Association of University Teachers Bulletin* 1996; 43(7):9. <http://www.caut. ca/bull/ejournal.html> Accessed April 17, 1997.

   Kehoe AB. Modern anti-evolutionism: The scientific creationists. In: Godfrey LR, ed. *What Darwin began*. Boston: Allyn and Bacon; 1985. pp 165-85.

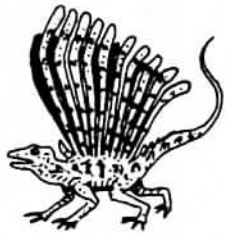
   Kuban GJ. Sea-monster or shark? An analysis of a supposed plesiosaur carcass netted in 1977. 1997; Available from <http://members.aol.com/paluxy2/plesios.htm> Accessed 1997 Mar 28.

   Smith FZ. Geocentrism re-examined. *Journal of Nice Things* 1985; 21(3):19-35.

   Waters IC, Rivers HI, and others. Swept away in a flood of enthusiasm [editorial]. *Reports of the National Center for Science Education* 2995 Jan-Feb; 1015(1):22-9.

   Zubrow E. *Archaeoastronomy*. Orlando, FL: Academic Press, 1985.

   Do not abbreviate names of publications. Include location of book publishers, and use the abbreviation "nd" for undated material. Multiple entries by the same author are listed in the bibliography in chronological order and those in same year are listed as: 1982a, 1982b, and so on.



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