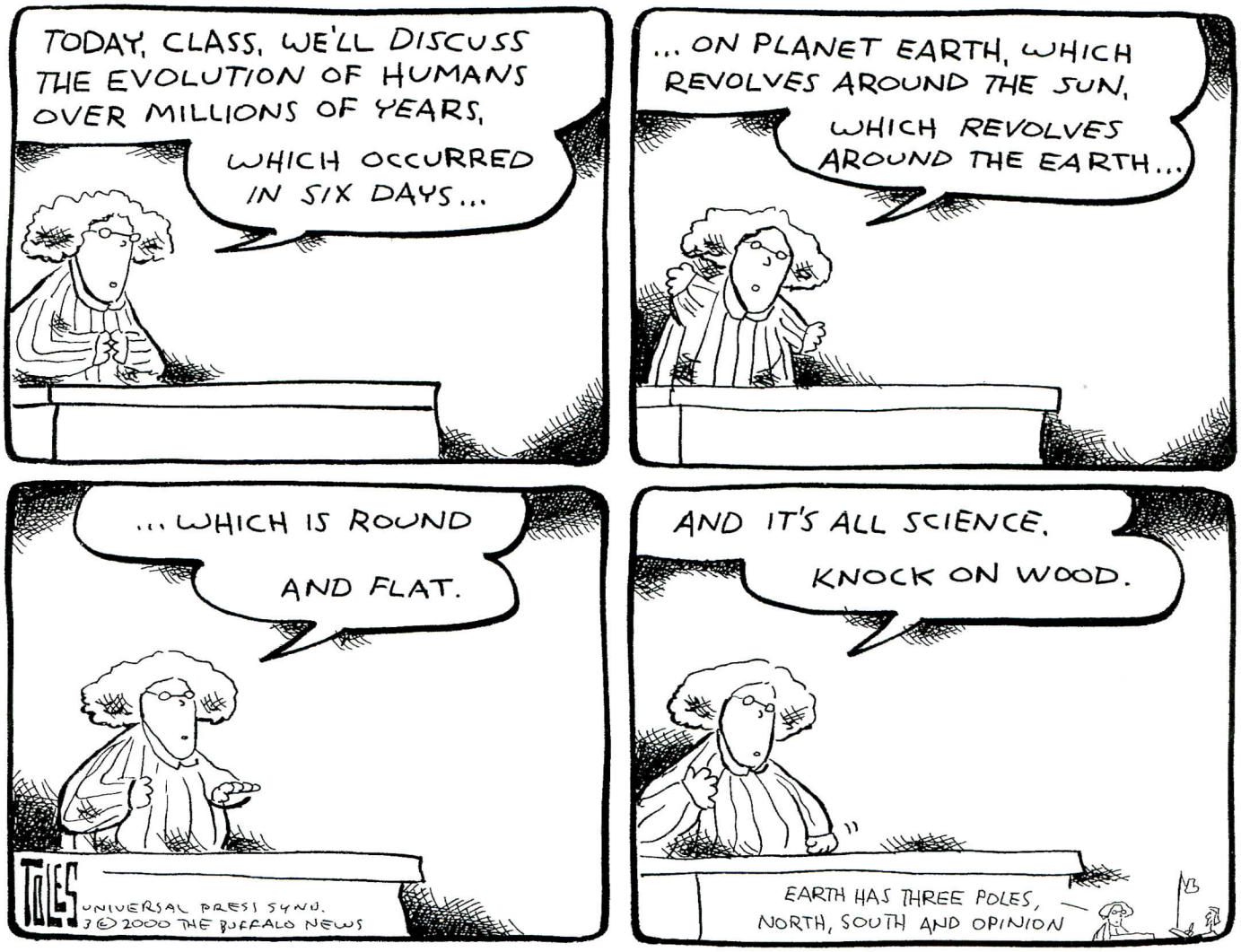
REPORTS OF THE NATIONAL CENTER FOR SCIENCE EDUCATION

DEFENDING THE TEACHING OF EVOLUTION IN THE PUBLIC SCHOOLS

Volume 20, Number 3

MAY/JUN, 2000

CONTINUES *NCSE REPORTS* & *CREATION/EVOLUTION*



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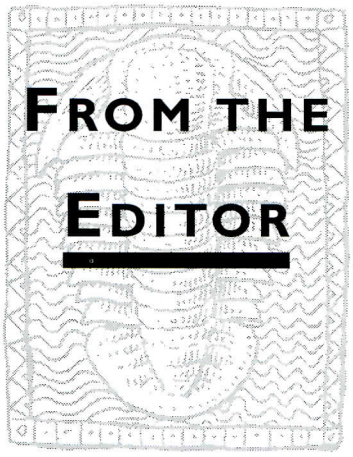
FROM THE EDITOR



The perennial dispute of the age of the earth by anti-evolutionists often focuses on the reliability of scientific methods of determining the dates of geological strata and the materials preserved in them. In this issue we present 3 articles that explain radiometric dating methods — how they are used, how they are interpreted, and why they are reliable. NCSE supporter and geologist G Brent Dalrymple reviews the evidence for consistency and reliability, discussing how radiometric dates are determined in various minerals from various locations around the globe. Then Dalrymple teams up with physicist Derek York to examine creationist claims that the use of a method known as the isochron regression technique is somehow "cooking" the data to make the geological strata appear older than they really are. Finally, we reprint NCSE member Dave Thomas's practical guide to the use of isochrons for determining the age of mineral samples. As usual, most of the "contradictory" dates reported by anti-evolutionists stem from either their misinterpretation of the results or their failure to follow the proper procedures for ensuring the most reliable outcome.

We've Been Reading

And how! We have book reviews that range from serious treatments of evolution by competent scholars to novelized legal drama to the wildest anti-evolutionary speculations.

First, there are 2 recent novels by creationists about — surprise! — the creation/evolution controversy. Glenn Branch reviews *Reaping the Whirlwind*, a murder mystery set in Dayton, Tennessee, in 1925. The reference to *Inherit the Wind* is obvious. There are, Branch tells us, more competent, more entertaining, and shorter treatments of the events. Skip Evans reviews Walter LeRoi Johns's novel *Ride to Glory*, remarking that, besides the obvious anti-evolutionary tone of the novel, the plot, characters, and action are flat and predictable.

Andrew Petto reviews one engineer's idiosyncratic attempt to explain what Douglas Adams memorably called "life, the universe, and everything" in a grand evolutionary synthesis.

Finally, Karen Bartelt reviews the last book published by Colin Patterson — completed by colleagues and published posthumously. Patterson was certainly an important contributor to our knowledge of evolution.

Here and There

What is happening in your part of the world? James Haught responds to a proposal in Kanawha County, West Virginia, to include *Of Pandas and People* as a curriculum resource. He argues that the underlying religious and political motivation of such disclaimers is transparent, since the "scientific" arguments are so distorted. In addition to scientific *accuracy*, Haught maintains, these anti-evolutionists have sacrificed scientific *honesty*.

Liz Craig brings us up to date on events in Kansas. We add comments from people "on the ground" in the Sunflower State and an in-depth look at Scopes Week 2000. Molleen Matsumura follows with a perspective on supporting evolution in an election year.

Ken Miller takes a careful look at the Oklahoma textbook disclaimer and disputes the logic, the scientific basis, and the conclusions of that document.

Keeping Up With NCSE

NCSE is growing and maturing. In this issue, we thank our members who have contributed more than $100 between January and June 2000. We also announce the formation of our legal advisory panel — legal experts who will donate their time, expertise, and services to NCSE in support of evolution and science education.

NCSE is also among the nonprofit organizations eligible to receive financial support from Working Assets. Read about how you can help to increase the contribution that NCSE will receive.

In this issue's members' pages, we reprint a popular and informative article by Mary Lou Mendum on how to write effective letters to the editor — and how to improve your chances of getting them published. Finally, don't forget to check the On the Road listing. NCSE staff members participate in events, panels, and other activities all over the country. The next one could be in your own back yard.

Anj Petto

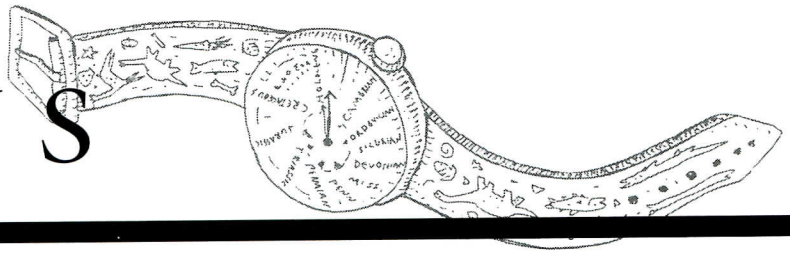
Erratum

In "Supreme Court Rejects Evolution Disclaimer" (RNCSE *2000; 20 [1-2]: 4-5*), the final paragraph of the Tangipahoa School Board's disclaimer was inadvertently omitted. It read:

> It is further recognized by the Board of Education that it is the basic right and privilege of each student to form his/her own opinion or maintain beliefs taught by parents on this very important matter of the origin of life and matter. Students are urged to exercise critical thinking and gather all information possible and closely examine each alternative toward forming an opinion.

RNCSE 20(3) was printed in December 2000.

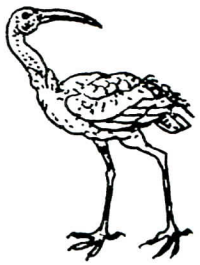
NEWS



Back from the Land of Oz: Moderates Win Republican Primaries in Kansas

Liz Craig

In July 1925, the sleepy little town of Dayton, Tennessee, suddenly found itself blinking in the glare of the national media spotlight. There, in a sweltering courtroom, 2 titans in their respective fields — one a free-thinking defense lawyer, the other a Bible-believing politician — were joined in a battle royal over evolution. In the middle was the unassuming defendant, John Scopes, a teacher accused of breaking Tennessee's anti-evolution law by teaching Darwin's theory in a public school science class.



On August 1, 2000, the nation saw a similar drama unfold in Kansas. On that day, in the state Republican primaries, political moderates faced off at the ballot box with so-called "social conservative" State Board of Education (SBOE) incumbents for 4 seats. The hottest issue in the election was the teaching of evolution in the state's public schools; this issue was so important that in one district, the Democratic candidate said that he hoped the moderate challenger in the Republican primary would win his party's nomination, since their positions were identical. (Kansas voters and political commentators point out that the Republican primaries are decisive, because Democrats rarely win elections and the real struggles in this state are between moderate and "social conservative" Republicans.)

RNCSE readers will remember that, in August 1999, the Kansas SBOE voted 6-4 to adopt creationist-influenced science standards for the state's public schools (*see* RNCSE *1999 July/August; 19 [4]: 7-9, 10-15*). The reaction of the public and media was dramatic, to say the least. Scientific and educational organizations from the national to the local level issued official statements condemning the SBOE's action. Newspapers, magazines, and television networks around the world reacted with shock, amusement, and/or ridicule, portraying the decision as the prelude to a new age of "Endarkenment" in Kansas.

KANSAS:
Where Evolution Has Been Outlawed and the Monkeys are in Charge
KANSAS CITIZENS FOR SCIENCE, http://www.kscfs.org

This bumper sticker expressed the dismay of some Kansans over the SBOE's decision on evolution education.

Back home in Kansas, Governor Graves publicly criticized the SBOE for damaging Kansas's reputation for excellence in education. The deans of all the Kansas state universities signed a joint statement expressing strong disapproval of the creationist-tainted standards. Kansans reeled from the bad publicity and the shame. However, despite nearly universal criticism, the "socially conservative" SBOE members staunchly defended their action. They downplayed the importance of their deletion from the examination requirements of content standards including macroevolution, geological time, the Big Bang, and global warming, and of their undermining of the accepted view that theories are valid and useful scientific frameworks. "What we did with science standards was really minor", was the spin offered by Linda Holloway, chair of the SBOE at the time of the standards vote.

Ever since that fateful vote, members of Kansas Citizens For Science (KCFS; <http://www.kcfs.org>) kept the issue alive in the media by speaking at nearly every public comment session at the SBOE's monthly meetings, by exposing a Missouri creationist organization's authorship of the changes in the standards, by writing letters to the editor and op-ed pieces for Kansas and national publications, and by speaking to various groups around the state. The 75th anniversary of the Scopes trial presented an opportunity for KCFS and other organizations to launch a major public education effort just before the August SBOE primary elections, and national organizations pitched in to help (*see sidebar, p 6*).

Anti-evolutionists added to the pre-election hoopla: Immediately after the Scopes Week festivities, the Seattle-based "Center for Renewal of Science and Culture" held workshops on teaching "intelligent design theory" in Shawnee Mission, a suburb of Kansas City. (Members of KCFS were there, monitoring the presentations and handing out informational literature.) Meanwhile, SBOE President Linda Holloway raised more money than had ever been raised in an SBOE election

Liz Craig is the media contact for Kansas Citizens for Science and is a member of its board. In real life, she works as a senior writer for an interactive advertising agency.

(leading "intelligent design" proponent Phillip Johnson was among the contributors) and her airing of a television advertisement was another first.

When the dust had settled, 3 of the 4 anti-evolution incumbents seeking re-election had lost their party's nomination. The winners' plans to reinstate evolution in the standards when they take office in January 2001 were widely reported.

Incredibly, after 75 years, the evolution controversy behind the Scopes trial is still with us. Events in Kansas were closely watched all over the country, and they contain important lessons for supporters of sound science education:

- Be aware of who is running for local and state boards of education.
- Know their positions on evolution.
- Register to vote, and vote for supporters of science.
- Support public education efforts about science in your community in any way you can.

And by the time the 100th Scopes Anniversary rolls around, let us hope we will have forgotten what all the fuss was about.

Meanwhile, KCFS is keeping in mind another important principle: "Don't rest on your laurels." Opponents of evolution have significant support, and they are still active in many communities. With the primary election over, KCSF continues our work to educate the public about evolution. In September 2000, for example, we brought Victor Stenger, NCSE member and author of *Not by Design: The Origin of the Universe,* to 3 Kansas communities to speak on "Intelligent Design: The New Stealth Creationism". We have many more projects planned: If you want to attend one of our events, or want inspiration for similar projects in your state, visit our web site at <http://www.kcfs.org>.

Not Over Till It's Over: Kansans Vow Continued Vigilance

Steve Lopes, President, Kansas Citizens For Science, Inc:

At the August 1, 2000, primary election, the efforts of many concerned Kansas citizens nominated 3 "moderate" Republican candidates committed to appropriate science standards. All of their Democratic challengers likewise support the KCFS position. With a bit more good fortune in November, a solid majority on the Kansas State Board of Education will be expected to act wisely, restoring quality science standards for all Kansas kids. Nevertheless, KCFS intends to remain vigilant and monitor future board actions. It is obvious that our public, the citizens of Kansas, need a better understanding of science education.

Caroline McKnight, Executive Director, Kansas MAINstream Coalition:

The search for solutions didn't end with the elections. We have to remember that roughly 40% of the population supported the board of education's action at least in part. We most certainly can't teach creationism as science, but we won't succeed in assuring good education in Kansas without making sure that [all citizens] feel [that] their concerns were heard.

Over half of the school districts in Kansas have fewer than 500 students. These districts are centered around small communities where everyone knows everyone else and where it is very hard for a science teacher to teach good science in opposition to community "feelings". In other districts, boards of education have come out openly in support of teaching the best in science. This issue has proven quite divisive, even to the extent of dividing families. While it is very hard to develop data on what is happening, there clearly has been an increase in the number of students in Kansas who do not receive a thorough science education.

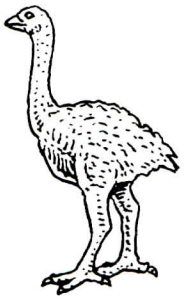
Many good citizens of Kansas were outraged at the actions of the SBOE and our recent primary elections all but guarantee the standards will be "corrected". However, despite the overwhelmingly positive outcome of the primary elections, the results were generated by only 25–35% of the electorate. This issue isn't going away.

Harry McDonald, Kansas science teacher:

Personally, I am more motivated than ever. Most teachers get into education because they want to make a difference, to contribute to the positive direction of the future of this country and its citizens. Many see this as being accomplished solely by their work in the classroom. I hope more teachers will realize that they must remain or become active in their professional organizations and in politics to prevent a recurrence of this farce.

Steven B Case, member of the original science standards writing committee in Kansas:

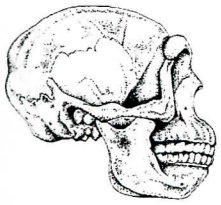
I was at the American Museum of Natural History when I got the election results. I went immediately to the hall of evolution! I would like to address the continuing statements from Linda Holloway [the president of the Kansas SBOE, defeated in the recent primary election] that "people just do not understand we did". I understand very clearly what the SBOE did. As a writer of the rejected standards I know exactly what changes were made. We carefully read their document, did a word-by-word comparison, determined the exact source of their material for the creationist standards. I read everything, many times. What Linda Holloway does not understand is that we are very good teachers, and we were able to share our very clear understanding with the public and the press.... The average Kansan prefers knowledge to an attempt to play on their emotions.



Scopes Week in Kansas

The week of July 9-15, 2000, was the 75th anniversary of the Scopes "Monkey" trial in which a Tennessee teacher was found guilty for violating a state law forbidding the teaching of evolution. For Kansas activists, the timing of the historic event — just weeks before primary elections that included seats on the state board of education — was ideal for educating the public about the issues raised by the board's 1999 decision to eliminate evolution from state science testing standards.

The week's festivities were kicked off on July 9 with simultaneous press conferences in 5 Kansas cities and continued with events across the state featuring local and national notables, including academics, politicians, educators, and other defenders of strong science standards. Distinguished locally sponsored speakers included:



- Dr Eugenie Scott of NCSE;
- Dr Kenneth Miller, Brown University biologist and author of *Finding Darwin's God* as well as co-author of *Biology*, one of the nation's most widely used high school biology texts;
- Michael Shermer, editor of *Skeptic* magazine and author of *Why People Believe Weird Things*, *How We Believe,* and a new book on Holocaust deniers;
- Rob Boston, writer for Americans United for the Separation of Church and State and author of several books, including, most recently, *Close Encounters with the Religious Right*;
- Richard Milner, a senior editor of *Natural History* and author of *The Encyclopedia of Evolution*, who presented a one-man musical about the life and times of Charles Darwin; and
- Douglas Linder, professor at the University of Missouri-Kansas City Law School, an expert on the 1925 Scopes trial (whose speech is now on line at <http://www.law.umkc.edu/faculty/projects/ftrials/scopes/confspeech.html>).

People for the American Way (PFAW) sponsored the centerpiece of the week's activities: a new, original radio drama entitled "Monkey Trial", based on the actual court transcripts from the 1925 Scopes trial. Starring native Kansan Edward Asner, Shirley Knight, and Harold Gould, the live broadcast was carried on public radio from the Lied Center in Lawrence, Kansas. Following the hour-long performance, a moderated panel discussion featured Dr Eugenie C Scott, Leonard "Kris" Krishtalka, Edward J Larson, Tom Willis, and John Calvert.

A broad coalition of organizations helped to bring about Scopes Week. The chief sponsor of the events was the MAINstream Education Foundation — an advocacy group that funds community educational activities. Support was also provided by the MAINstream Coalition, Inc, a nonpartisan group of moderate religious, business, political, and community leaders founded to defend constitutional freedoms; Kansas Citizens for Science, a not-for-profit educational organization supporting excellent science teaching in Kansas public schools; the American Civil Liberties Union of Kansas and Western Missouri; the Heartland Humanists; the National Council of Jewish Women; the Jewish Community Relations Board - American Jewish Committee; the South Central Friends of KCFS; and the People for the American Way Foundation.

Evolution In An Election Year

Molleen Matsumura
Network Project Director

When election dates draw near, NCSE members frequently write or call with questions about how they can make a difference to evolution education. The answers can be complicated, since education policies are decided by elected and appointed officials in many agencies, and advocates of "creation science" can be found in both major parties. Here are some pointers for educating yourself and others on the issues.

Which races matter?

Early in 2000, long before primary elections, candidates for the presidential nomination of both major parties made headlines with their views on evolution-creation controversies. Yet a president has little influence on state and local curricula. Who counts? It depends on the state where you live.

State Supreme Court Justices may be asked to decide lawsuits concerning the teaching of creationism, and before this year's primaries in Idaho, candidates were asked where they stood on the issue (*see* RNCSE *20 [1-2]: 20 — the creationist candidate won*).

Depending on the state, the *governor* may appoint textbook commissioners, board-of-education members, or others who influence the curriculum. Also, in some states the governor is an *ex officio* member of the board of education; for example, then-governor Fob James presided at the meeting during which the Alabama Board of Education adopted its notorious evolution disclaimer (*see* NCSE Reports *1995; 15 [4]: 10, 11*).

In some states, a legislative vote is the final step in curriculum adoptions, and *state legislators* may introduce anti-evolution legislation — recent examples include Arizona, North Carolina,

and Ohio. Finally, members of *state and local boards of education* may periodically adopt curriculum standards, approve textbooks and other curriculum materials, or issue policies that affect the way evolution is taught.

Learning where candidates stand

Such community organizations as the Freedom to Learn Network in Pennsylvania and the Citizens Project in Colorado include questions about creationism in their candidate questionnaires. If you belong to an organization that publishes information about candidates' views or sponsors candidate forums, you can encourage it to ask questions about this issue. Some members have told us that they simply ask such questions themselves, by calling campaign offices or as members of the audience of a campaign debate. Others who know that evolution education has been attacked in their state make a point of finding out how incumbents voted. A North Carolina member wrote, "Since my representative keeps supporting anti-evolution legislation, I'm working for the opponent" (*see sidebar, p 8).*

Reading between the lines

Supporting evolution in an election year requires learning about the issues as well as the candidates. Proposals concerning education may have consequences for evolution education that are not obvious or even intended, but still demand attention. For example, when you study a "parental rights" proposition on your state's ballot, or ask for details of a campaign promise to introduce legislation increasing "parental control" of children's education, you may find evolution included on a list of "objectionable" topics. As another example, proposals meant to encourage innovation can mean — or be misinterpreted as meaning — that experimental schools can ignore constitutional prohibitions on teaching "creation science".

Building coalitions for evolution education

NCSE members who have dealt with evolution-creation issues in state and local elections emphasize that evolution is a "multi-issue issue". One conclusion they have drawn is that it is important to get more than one group of people involved in the process.

Kansas scientists made this point when they responded to an editorial in *Nature* that credited the scientific community with the defeat of anti-evolution candidates in their state's primary elections (*see related stories on pages 4 and 5*). Matthew Buechner and several colleagues sent NCSE a copy of the letter (which *Nature* has agreed to publish) in which they commented:

> We would like to point out, however, that our efforts, and similar efforts of scientists in New Mexico, would have come to naught without the leadership and support of dozens of non-scientists who were willing to devote hundreds of hours to this issue and who were willing to drag us out of the laboratory. The success of groups like Kansas Citizens for Science depends on the combined efforts of people with backgrounds in many fields, including elementary and secondary education, religion, and business....

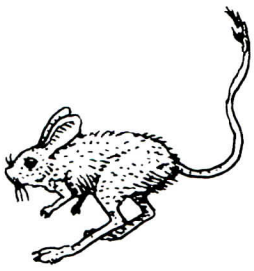
A similar point was made by Caroline McKnight, director of the Kansas MAINstream Coalition, in comments to NCSE about the Kansas primaries: "The solution to this problem was ultimately to be found in Civics 101, not Evolution 101. Scopes Week turned out to be a great way to raise the evolution vs. creation issues and get people thinking about how to bring about change" (*for more about Scopes Week in Kansas, see page 6*).

Keep It Local

A second point activists emphasize is that there is no "one-size-fits-all" message about the importance of teaching evolution. Some voters are more concerned about scientific literacy, others worry about protecting separation of church and state, and still others are most upset by the politicization of educational decisions. Kim Johnson, an NCSE member and the former president of New Mexico's Coalition for Excellence in Science and Math Education (CESE), observes:

> Our successes have come from putting the evolution issue in the context of the general quality of science and math education — after all it's an economic issue and quality of life issue too. People want to know how to tell which technologies are safe, for example. In fact, what I've noticed people all over the country telling their school boards is, "Quit arguing about ideology and figure out how our kids are going to get safer classrooms and better test scores."

Experienced activists also stress the importance of knowing the rules and following them. For example, some of the founders of CESE had already belonged to an educational organization that frequently addressed science curriculum issues. When they decided to become actively involved in political issues, they did not try to bend the rules forbidding educational organizations to advocate partisan positions. Instead, they formed a new organization.



Finally, remember that the need to be active in supporting evolution education does not end on the first Wednesday in November of an even-numbered year. Soon afterward, legislatures and boards of education will begin to meet — and they will need to hear about your support for good education.

[*For advice on writing effective opinion essays and letters to editors, see "Ten Tips for Successful Letter Hacking" on page 21.*]

Where is Evolution a Concern in 2000?

This sampling illustrates the range of issues related to evolution education that arise in election years. Although it is not a comprehensive list of the issues at all levels from federal to local, we hope that it will give readers some questions to ask in their states.

Alabama: Early in 2001, Board of Education members — some of them newly elected or returned to office in November 2000 — will vote on a new "Course of Study: Science" (as this issue of *RNCSE* goes to press, a first draft of these science content standards has just been released for public comment). They will have the opportunity to restore evolution coverage to these standards, and at the same time, or during subsequent adoptions of textbooks, to end the use of the notorious evolution disclaimer that is placed in every biology text used in the state.

Iowa: The platform of this state's Republican party reads, "Education:...9. We believe that Creation, as stated in Genesis, and the theory of creation science should be taught in all government schools equitably with the theory of evolution" <http://www.iowagop.org/about_action.asp?FormMode=Display&ID=4113299656>. NCSE researchers could not find information on the Democratic party's position.

Missouri: The platform of this state's Republican party says, "Restoring Quality Education: ...[E]mpowering local school districts to determine how best to handle the teaching of creationism and the theory of evolution" <http://www.mogop.org/platform.html>. The latest version of the Democratic platform offered on <http://www.missouridems.org/talking/platform.htm#education>, dated 1995, did not contain references to "creation science" or to church-state issues.

Ohio: In late September 2000, the state legislature ended its session without acting on a pending anti-evolution bill. The bill had been introduced for a second time, with additional sponsors, and may be re-introduced in a post-election session.

Oregon: The platform of this state's Republican party says, "Science shall include scientific creationism...." <www.orgop.org/platform.html>. NCSE researchers had difficulty downloading the Democratic party platform from the web site, but received an e-mail stating that the platform includes a plank saying, "Because we are sensitive to the diverse beliefs of our society, we support the historic constitutional separation of church and state."

Texas: The platform of this state's Republican party says "The Party believes that scientific topics, such as the question of universe and life origins and environmental theories, should not be constrained to one opinion or viewpoint. We support the teaching equally of scientific strengths and weaknesses of all scientific theories — as Texas now requires (but has yet to enforce) in public school science course standards. We urge revising all environmental education standards to require this also. We support individual teachers' right to teach creation science in Texas public schools." <http://www.texasgop.org/library/RPTPlatform2000.pdf>. The platform of the Democratic party did not mention "creation science", but said, "We believe in separation of Church and State to preserve the freedom to pursue our beliefs" <http://www.txdemocrats.org/platform.htm>.

[*NCSE thanks Paul Knight for assistance in researching state party platforms.*]

Niles Eldredge Welcomes Biology Honor Students

Andrew J Petto
NCSE Editor

On Friday, March 31, 2000, paleontologist Niles Eldredge of the American Museum of Natural History and an NCSE Supporter gave the keynote address at the 9th annual induction ceremony of the Beta Beta Beta Biological Honor Society at The College of New Jersey in Ewing. He spoke to the 61 newly inducted students and an audience of several hundred from the college and surrounding community. The main themes of the keynote address were the continuing power of evolutionary theory as a foundation for the life sciences and the persistence of anti-evolutionary movements despite their scientific bankruptcy.

Eldredge opened his address by expressing his disappointment that it was necessary to engage anti-evolutionary arguments after all the time and effort that scientists have devoted to debunking them. The basic premises of the continuing opposition to evolution, Eldredge said, were put to rest over 100 years ago in the sciences. The debate today, he argued, remains political, not scientific. Eldredge noted that, while scientists are distracted by the need to reopen long-settled arguments between creationists and scientists, thousands of species are becoming extinct each year. Scientists' efforts *should* be devoted to research into significant biological problems. Perhaps even more disturbing, he added, is that the stewardship of the planet and its species is one area in which the scientific and the religious communities could cooperate to achieve common goals.

Eldredge reviewed long-standing creationist strategies for combating evolution. The main strategy is to give the impression that if any evolutionary hypotheses are

UPDATES

California, Newport-Mesa: On June 17, 2000, the *Daily Pilot* reported that a local school board member criticized the coverage of evolution in textbooks used at Newport Harbor High and requested that "alternative theories" also be taught (pages A1, A11). According to the article, teachers were reluctant to comply. NCSE is monitoring the situation.

California, Ventura County: Board of Education member Ron Matthews's proposal to have creationism taught in county-administered education programs (RNCSE *1999; 19 [6]: 9*) continues to stir controversy. According to the Ventura County *Star*, Matthews plans to put the issue on the board's agenda after the November elections, in which he is running unopposed to keep his seat. The *Star* reports that at least one board member agrees with Matthews "philosophically ... [but is] not willing to step ... out on the limb" and that Matthews has said "he will wait for the results of the board race in ... Camarillo." The County Superintendent of Schools has informed the board that a requirement for teaching creationism could not be implemented because it would be unconstitutional (*see Tom Kisken, "Creation vs evolution: Should both be taught in science class?", Ventura County* Star, *September 6, 2000, <http://www. insidevc.com /news/ 33724.shtml>).*

Colorado, Fort Collins: NCSE members Linda Rosa and Larry Sarner, joined by other concerned parents, continue to press for coverage of human evolution in science classes at Liberty Common School, a charter school that received its charter by promising an enriched science curriculum, and has been directed by the Board of the Poudre School District to revise its curriculum and end a ban on teaching human evolution (RNCSE *1999; 19 [4]: 4, and* RNCSE *1999; 19 [5]: 10*) On August 28, 2000, the *Rocky Mountain News* reported that the school continues to defy the board of education; the dispute has been referred to an administrative law judge (*see <http://www.rockymountainnews.com/news/0828lib5.shtml>*).

Georgia, Lumpkin County: In July, the county Board of Education responded to parental complaints by voting to request an opinion from the state attorney general on whether it would be legal to implement a state curriculum requirement that children be taught "respect for the Creator". The requirement is part of a character curriculum adopted by the legislature in 1997. According to a July 28 report from the Associated Press, State Senator John Marable said that "It allows everybody to look at it through all different theories of creation." In 1996, in response to an inquiry from the Superintendent of Education, the state attorney general then in office wrote that "various theories regarding the origins of humankind may be validly taught *only* if there is a 'clear *secular* intent'" (*see* NCSE Reports *1995; 15 [4]: 8-9*;

false or any questions remain unanswered, then the only available alternative is to embrace creationism. This is the strategy not only of young-earth creationists but also of more recent anti-evolutionary criticisms, such as Phillip Johnson's assault on the windmill of "metaphysical naturalism", most of which are recycled and relabeled to give the appearance of being fresh arguments against evolution.

However, Eldredge pointed out, most of these recycled arguments assume that evolution succeeds or fails only on the evidence from a single study or a single discipline. On the contrary, evolution is continually reinforced by the confluence of research in many fields on many organisms both contemporary and historical. New research and widening knowledge in all these disciplines — from the molecular to the ecological — confirm that evolution has occurred and solidify our understanding of how evolution has produced the diversity of life on earth.

Eldredge's real concern, however, was not restricted to students' understanding and acceptance of evolution. A much more important issue is maintaining the integrity of science education in the US — not for the purpose of producing more scientists, but because the world is becoming more dependent on science and technology. Our citizens need to know what science really does and how it does it, so it is vital to demythologize and increase respect for science. The anti-evolutionary materials circulating as "proof" that evolution is impossible (or a lie, or a conspiracy, and so on) harm scientific literacy not just because they oppose evolution, but also because they distort and misrepresent the nature of science and scientific inquiry.

In the question period that followed his talk, Eldredge encouraged the audience to become active in supporting quality science education in their communities. In particular, he promoted NCSE as a valuable resource for any who must face challenges to evolution education in school curricula, and he urged his listeners to join NCSE. The most important point, Eldredge reminded the audience, is to recognize that the current arguments being used to oppose evolution are really only the old creationist arguments dressed up in new, more neutral-sounding, language. When examined closely, however, it is clear that the "alternative" curriculum is fundamentally the same old "creation science" that has been proposed and rejected numerous times over the last century.

NCSE NEWS

NCSE Forms Legal Advisory Panel

Molleen Matsumura
Network Project Director

The main purpose of the National Center for Science Education, as our name suggests, is to educate the public and the press about evolution and the nature of science, and their importance in public education. Even when defending evolution in evolution-creation controversies, our first step is always to educate the participants about the issues.

However, the question of how evolution will be taught in public schools always has a legal dimension. One reason is that materials that are proposed for teaching "alternatives" to evolution promote sectarian religious views and fall under the First Amendment prohibition of the establishment of religion. Another is that there is a considerable body of law concerning the role of state and local school boards in determining curricula, how much leeway classroom teachers have in presenting prescribed curricula, and related matters.

NCSE has dealt with these legal issues from its earliest days, when it joined a coalition of educators, educational organizations, and scientific societies in signing a Friend of the Court (*amicus curiae*) brief urging the Supreme Court to overturn a Louisiana law requiring the teaching of "creation science" whenever evolution was taught (*see* Creation-Evolution Newsletter *1986; 6 [4]: 8-11*), which was struck down in the famous *Edwards v Aguillard* decision. NCSE has also joined in other briefs concerning church-state separation in public education.

"After the *Edwards* decision in 1987, anti-evolutionists stopped promoting state laws opposing evolution and pursued other strategies", notes NCSE's Executive Director Eugenie C Scott. "In recent years, they have tried state legislation again, but never successfully. Meanwhile, there have been a great number of attacks on evolution in local school districts. These may seem 'low profile', but any one of them can become a test case." Courts have again become a battleground, and NCSE is increasingly called upon to provide legal information and to advise attorneys about scientific issues in evolution-creation controversies.

In 1997, the first step was taken

UPDATES

emphases in the original, including the emphasis added to the quotation from the Supreme Court's decision in *Edwards v Aguillard*).

Indiana, Lafayette: In March, students at Thomas Jefferson High School circulated a petition asking to have "special creation" taught in their biology class. When the petition was presented to the school board, board members, who had been advised by the district's administration, told the students that the topic is not included in the state science curriculum, and therefore would not be added to the local curriculum. NCSE will continue to monitor this situation.

Pennsylvania: Late in the revision process, language requiring students to "[a]nalyze... studies that support or do not support the theory of evolution" has been added to the state's proposed science curriculum standards. Although coverage of evolution is strong in both the life and physical sciences content standards, the revision released in July 2000 contains a number of similar changes that reflect anti-evolutionary catchphrases appearing to soften the support for evolution. Concerned members in Pennsylvania are providing comments to the State Board of Education on the final draft.

Texas, Baylor University: Responding to faculty complaints that they had not been consulted about establishment of the newly-created Michael Polanyi Center and that the Center's promotion of "intelligent design theory" would damage the university's reputation (*see* RNCSE *20 [1-2]: 15-6*), the Baylor University administration assembled a committee of scientists and scholars to assess the Center. The members of the committee include Dr William F Cooper, Professor of Philosophy and former Dean of the College of Arts and Sciences, who is serving as chair of the committee; Dr Cutberto Garza, Professor of Nutritional Science at Cornell University; Dr John A Moore, Professor Emeritus of Biology at the University of California at Riverside; Dr Judith Dilts, Chair of the Biology Department at William Jewell College; Dr Scott K Davis, Vice President for Research at GenomicFX in Austin and former Assistant Professor of Animal Science at Texas A&M University; Dr Ernan McMullin, the John Cardinal O'Hara Professor Emeritus of Philosophy at the University of Notre Dame; Dr Ronald Numbers, Chair and Professor in History of Medicine at the University of Wisconsin-Madison, Dr Elaine Lambert, Clinical Associate Professor of Medicine in Rheumatology at Stanford University; and Dr

toward the establishment of a formal legal program with the addition of attorney Michael McIlwrath to the NCSE Board of Directors (RNCSE *1997; 17 [5]: 4, 5*). Soon after, in a milestone for NCSE, McIlwrath wrote the first *amicus* brief that NCSE submitted independently, which argued that the Fifth Circuit Court of Appeals should uphold a lower court ruling that a school board's evolution disclaimer violated the First Amendment (RNCSE *1997; 17 [5]: 4*).

In February 2000 NCSE reached another milestone with the first meeting of a number of attorneys who had volunteered to serve on a new Legal Advisory Panel. Attorneys with People for the American Way and Americans United for Separation of Church and State took part, and McIlwrath, who chaired the meeting, was pleased that "NCSE has drawn from among the country's leading law firms and civil-liberties organizations to form the Legal Advisory Panel." Later, McIlwrath reported to NCSE's Board of Directors that "The panel already has a number of projects underway and will help to guide NCSE in its efforts to educate and defend the teaching of science in the country's public schools. Our ability to draw on some of the country's top legal talent will add a level of legal sophistication to the NCSE that we have long desired."

The panel is now led by Kevin Wolf, an attorney with the Washington firm of Bryan, Cave LLP. Like McIlwrath, Wolf is a longtime science enthusiast who is excited by the challenges of helping NCSE to defend evolution education. Wolf explained, "Now is the ideal time for NCSE to have formed a legal advisory committee. In the years since the *Edwards* decision, the legal strategies of those opposed to the teaching of evolution have evolved and adapted to each defeat and challenge. The current legal attacks are thus increasingly complex and require ever more sophisticated analysis and response. In light of the diverse backgrounds, tremendous enthusiasm, and high caliber of the attorneys volunteering their time and resources to NCSE, the legal advisory committee is well suited and eager to meet this challenge. It is an honor to lead the group NCSE has assembled."

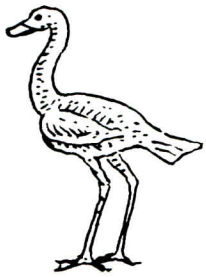
Eugenie Scott added, "Much — probably most — of the panel's work will be an extension of NCSE's educational role, as the members help to clarify the complex legal issues in particular situations. Although the number of legal confrontations has been growing, most cases never reach court, and when they do, they often do not come to trial. Still, in the event that a case needs to be argued in court, NCSE will be in a better position to assure that the outcome is good for science education."

William Abraham, Albert Cook Outler Professor of Wesley Studies at Southern Methodist University's Perkins School of Theology. Committee members met on the weekend of September 9–10, 2000, to assess the center's effectiveness and its appropriateness on Baylor's campus (*Baylor* Lariat, *September 8, 2000, <http://www.baylor.edu/~Lariat/Archives/2000/20000908/art-front01.html>).* The committee's decision was to retain the staff, but to reorganize the program. More in the next issue of *RNCSE.*

Vermont: Before the September 12 Republican primary election, gubernatorial candidate Ruth Dwyer was asked on a radio program whether it is appropriate for public schools to teach creationism. She was quoted in the Burlington *Free Press* as saying that it would be if local people wanted it: "I think schools should do what their communities want them to do." Dwyer won the primary and faces incumbent governor Howard Dean in the November elections. Dean is a former physician and has been a supporter of good science education.

West Virginia, Kanawha County: Following the Board of Education's decision not to purchase copies of the creationist text *Of Pandas and People* (*see* RNCSE *1999; 19 [6]: 12*), the book's strongest proponent on the board has offered to donate copies to school libraries. The decision whether to accept donations must be made by materials evaluation committees at each site, and some local activists are urging these committees either to reject the book or to accept donations of other books that explain evolution more accurately.

[*NCSE thanks Judith Allard, John R Cole, Brent Cullimore, Karl Fezer, and Linda Rosa for information used in this article.*]



Keeping NCSE Up to Date

Many of the news stories reported in *RNCSE* are provided by NCSE members. Such assistance is invaluable to us, because many of these stories are reported only in small local and regional papers. To help NCSE staff report timely and accurate news, please do the following.

When mailing clippings: please include the full name and location of the newspaper. You can simply send in the whole page if it includes this information, or you could attach a note that includes the full date the story ran and the page(s) where it appeared.

When e-mailing stories: please include *both* the text and the URL of the story.

However you get in touch with us, please include your return address so that we may contact you with any questions; if you do *not* wish to be credited for the story, please tell us.

Thank you for your help.

Some of the Stories in Our Next Issue

Criticizing Design

Jeff Otto Reports on the June 2000 Conference: Design and its Critics

Pseudomathematics

Feature Articles on Anti-evolutionists, Mathematical Reasoning, and probability theory

Grading the States

The Fordham Foundation's report on Science Education Standards

Vote for NCSE

NCSE is one of just 60 not-for-profit organizations selected to benefit from Working Assets in 2000 (*see* RNCSE *19 [5]: 12-13*). Whenever Working Assets customers use their credit cards, long distance telephone service, or internet service, part of their payment is added to a donation fund, estimated to be over $4 million for the current year. Customers vote on how the fund is distributed. The amount awarded to each eligible organization is determined by the percentage of votes it receives.

Working Assets distributed a printed ballot to its customers in October 2000, and there is an on-line version at <http://www.workingforchange.com/voting/index>. Or, if you have already bookmarked NCSE's web site, use the link on our home page at <http://www.ncseweb.org>. If you are already a Working Assets customer, be sure to log in and cast your vote for NCSE. If you are not yet a Working Assets customer, you can sign up and then cast your vote for NCSE. And why not encourage any friends who happen to use Working Assets to cast their votes for NCSE as well? Make it easy for them: add a link on your own site to NCSE, or to the Working Assets ballot.

More information about Working Assets is available by calling 1-800-788-8588 or on the World Wide Web at <http://www.workingassets.com>.

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The NCSE Board of Directors and staff would like to acknowledge and extend their warm gratitude to all the individuals, organizations, and firms that donated to NCSE. We also extend a special thanks for their much-appreciated support to the following people who donated $100 or more between January and June 2000 (* indicates an NCSE board member or supporter). Those in the Patrons' Circle (indicated by a +) donated $1000 or more — a level of support that we consider heroic and that allows us a firm foundation for our efforts. Thank you to all donors.

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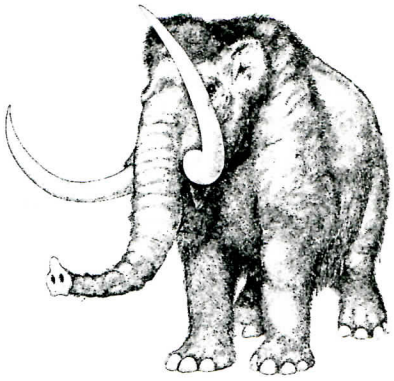


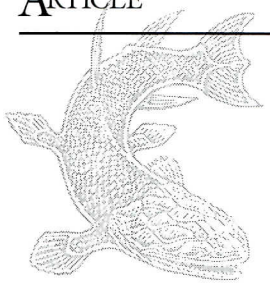
Geneticists Issue Policy Statement on Evolution

The Genetics Society of America (GSA) has approved a policy statement in support of evolution in science education standards and posted it on the organization's web site at <http://www.faseb.org/genetics/gsa/policies/p-gsa-01.htm>.

The resolution reads, in part:

> The GSA supports educating students in genetics, and consequently feels it important to express its views on the teaching of evolution in elementary and secondary schools. The GSA strongly endorses such teaching, as genetics and evolution are two very closely interwoven disciplines. In fact, evolution might be summarized as population genetics over time.
>
> The theory of evolution by natural selection ... developed through the ongoing investigation and understanding of many different areas of biological, chemical, physical and earth science. ... Without evolutionary theory, we would be forced to completely discard much of what we understand about fields such as genetics, botany, zoology, paleontology, and anthropology.

[*Contributed by Jeff Otto.*]



Radiometric Dating Does Work! Some Examples and a Critique of a Failed Creationist Strategy

G Brent Dalrymple
Oregon State University

Radiometric dating of rocks and minerals using naturally occurring, long-lived radioactive isotopes is troublesome for young-earth creationists because the techniques have provided overwhelming evidence of the antiquity of the earth and life. Some so-called creation scientists have attempted to show that radiometric dating does not work on theoretical grounds (for example, Arndts and Overn 1981; Gill 1996) but such attempts invariably have fatal flaws (see Dalrymple 1984; York and Dalrymple 2000). Other creationists have focused on instances in which radiometric dating seems to yield incorrect results. In most instances, these efforts are flawed because the authors have misunderstood or misrepresented the data they attempt to analyze (for example, Woodmorappe 1979; Morris HM 1985; Morris JD 1994). Only rarely does a creationist actually find an incorrect radiometric result (Austin 1996; Rugg and Austin 1998) that has not already been revealed and discussed in the scientific literature.

The creationist approach of focusing on examples where radiometric dating yields incorrect results is a curious one for two reasons. First, it provides no evidence whatsoever to support their claim that the earth is very young. If the earth were only 6000–10 000 years old, then surely there should be some scientific evidence to confirm that hypothesis; yet the creationists have produced not a shred of it so far. Where are the data and age calculations that result in a consistent set of ages for all rocks on earth, as well as those from the moon and the meteorites, no greater than 10 000 years? Glaringly absent, it seems.

Second, it is an approach doomed to failure at the outset. Creationists seem to think that a few examples of incorrect radiometric ages invalidate all of the results of radiometric dating, but such a conclusion is illogical. Even things that work well do not work well all of the time and under all circumstances. Try, for example, wearing a watch that is not waterproof while swimming. It will probably fail, but what would a reasonable person conclude from that? That watches do not work? Hardly.

A few verified examples of incorrect radiometric ages are simply insufficient to prove that radiometric dating is invalid. All they indicate is that the methods are not infallible. Those of us who have developed and used dating techniques to solve scientific problems are well aware that the systems are not perfect; we ourselves have provided numerous examples of instances in which the techniques fail. We often test them under controlled conditions to learn when and why they fail so we will not use them incorrectly. We have even discredited entire techniques. For example, after extensive testing over many years, it was concluded that uranium-helium dating is highly unreliable because the small helium atom diffuses easily out of minerals over geologic time. As a result, this method is not used except in rare and highly specialized applications. Other dating techniques, like K-Ar (potassium-argon and its more recent variant $^{40}Ar/^{39}Ar$), Rb-Sr (rubidium-strontium), Sm-Nd (samarium-neodynium), Lu-Hf (lutetium-hafnium), and U-Pb (uranium-lead and its variant Pb-Pb), have all stood the test of time. These methods provide valuable and valid age data in most instances, although there is a small percentage of cases in which even these generally reliable methods yield incorrect results. Such failures may be due to laboratory errors (mistakes happen), unrecognized geologic factors (nature sometimes fools us), or misapplication of the techniques (no one is perfect). In order to accomplish their goal of discrediting radiometric dating, however, creationists are faced with the daunting task of showing that a *preponderance* of radiometric ages are wrong — that the methods are untrustworthy *most* of the time. Not only that, they have to show the flaws in those dating studies that provide independent corroborative evidence that radiometric methods work. This is a tall order and the creationists have made no progress so far.

It is rare for a study involving radiometric dating to contain a single determination of age. Usually determinations of age are repeated to avoid laboratory errors, are obtained on more than one rock unit or more than one mineral from a rock unit in order

to provide a cross-check, or are evaluated using other geologic information that can be used to test and corroborate the radiometric ages. Scientists who use radiometric dating typically use every means at their disposal to check, recheck, and verify their results, and the more important the results the more they are apt to be checked and rechecked by others. As a result, it is nearly impossible to be completely fooled by a good set of radiometric age data collected as part of a well-designed experiment.

The purpose of this paper is to describe briefly a few typical radiometric dating studies, out of hundreds of possible examples documented in the scientific literature, in which the ages are validated by other available information. I have selected 4 examples from recent literature, mostly studies involving my work and that of a few close colleagues because it was easy to do so. I could have selected many more examples but then this would have turned into a book rather than the intended short paper.

The Manson Meteorite Impact and the Pierre Shale

In the Cretaceous Period, a large meteorite struck the earth at a location near the present town of Manson, Iowa. The heat of the impact melted some of the feldspar crystals in the granitic rocks of the impact zone, thereby resetting their internal radiometric clocks. These melted crystals, and therefore the impact, have been dated by the $^{40}Ar/^{39}Ar$ method at 74.1 Ma (million years; Izett and others 1998), but that is not the whole story by a long shot. The impact also created shocked quartz crystals that were blasted into the air and subsequently fell to the west into the inland sea that occupied much of central North America at that time. Today this shocked quartz is found in South Dakota, Colorado, and Nebraska in a thin layer (the Crow Creek Member) within a thick rock formation known as the Pierre Shale. The Pierre Shale, which is divided into identifiable sedimentary beds called members, also contains abundant fossils of numerous species of ammonites, ancestors of the chambered nautilus. The fossils, when combined with geologic mapping, allow the various exposed sections of the Pierre Shale to be pieced together in their proper relative positions to form a complete composite section (Figure 1). The Pierre Shale also contains volcanic ash that was erupted from volcanoes and then fell into the sea, where it was preserved as thin beds. These ash beds, called bentonites, contain sanidine feldspar and biotite that has been dated using the $^{40}Ar/^{39}Ar$ technique.

The results of the Manson Impact/Pierre Shale dating study (Izett and others 1998) are shown in Figure 1. There are 3 important things to note about these results. First, each age is based on numerous measurements; laboratory errors, had there been any, would be readily apparent. Second, ages were measured on 2 very different minerals, sanidine and

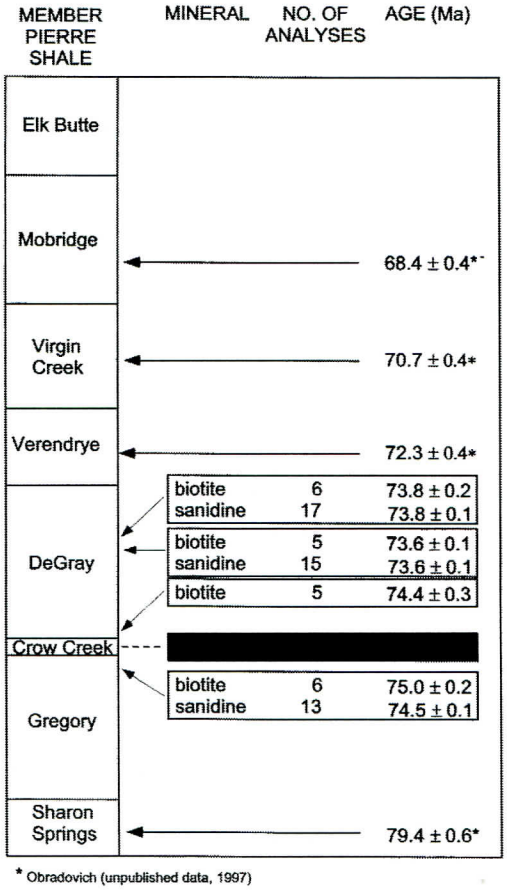


Figure 1. *$^{40}Ar/^{39}Ar$ ages for 8 volcanic ash beds in the Pierre Shale. Sedimentary beds (members) are shown in their known stratigraphic order, youngest at the top. The age data for the Manson impact event (shaded box) is shown in the stratigraphic position of the shocked quartz, which is found in the Crow Creek Member. After Izett and others (1998).*

biotite, from several of the ash beds. The largest age difference between these mineral pairs, in the ash from the Gregory Member, is less than 1%. Third, the radiometric ages agree, within analytical error, with the relative positions of the dated ash beds as determined by the geologic mapping and the fossil assemblages; that is, the ages get older from top to bottom as they should. Finally, the inferred age of the shocked quartz, as determined from the age of the melted feldspar in the Manson impact structure (74.1 ± 0.1 Ma), is in very good agreement with the ages of the ash beds above and below it. How could all of this be so if the $^{40}Ar/^{39}Ar$ dating technique did not work?

The Ages of Meteorites

Meteorites, most of which are fragments of asteroids, are very interesting objects to study because they provide important evidence about the age, composition, and history of the early solar system. There are many types of meteorites. Some are from primitive asteroids the material of which is little

TABLE 1 Radiometric ages for 3 chondrite meteorites.

Meteorite	Method	Age (Ga)	Lab
Allende	$^{40}Ar/^{39}Ar$ age spectrum	4.52 ± 0.02	1
		4.53 ± 0.02	1
		4.48 ± 0.02	1
		4.55 ± 0.03	1
		4.55 ± 0.03	1
		4.57 ± 0.03	1
		4.50 ± 0.02	1
		4.56 ± 0.05	1
	Pb-Pb isochron (27 points)	4.553 ± 0.004	7
Guarena	$^{40}Ar/^{39}Ar$ age spectrum	4.44 ± 0.06	2
	Rb-Sr isochron (13 points)	4.46 ± 0.08	4
St Severin	$^{40}Ar/^{39}Ar$ age spectrum	4.43 ± 0.04	5
		4.38 ± 0.04	6
		4.42 ± 0.04	6
	Rb-Sr isochron (10 points)	4.51 ± 0.15	3
	Sm-Nd isochron (4 points)	4.55 ± 0.33	4
	Pb-Pb isochron (5 points)	4.543 ± 0.019	3

From compilation in Dalrymple (1991). Data from university laboratories in Germany (1), Great Britain (2), France (3), California (4), Minnesota (5), Missouri (6), and the USGS in Denver, Colorado (7).

modified since they formed from the early solar nebula. Others are from larger asteroids that got hot enough to melt and send lava flows to the surface. A few are even from the moon and Mars. The most primitive type of meteorites are called chondrites, because they contain little spheres of olivine crystals known as chondrules. Because of their importance, meteorites have been extensively dated radiometrically; the vast majority appear to be 4.4–4.6 Ga (billion years) old. Some meteorites, because of their mineralogy, can be dated by more than one radiometric dating technique, which provides scientists with a powerful check of the validity of the results. The results from three meteorites are shown in Table 1. Many more, plus a discussion of the different types of meteorites and their origins, can be found in Dalrymple (1991).

There are 3 important things to know about the ages in Table 1. The first is that each meteorite was dated by more than one laboratory — Allende by 2 laboratories, Guarena by 2 laboratories, and St Severin by 4 laboratories. This pretty much eliminates any significant laboratory biases or any major analytical mistakes. The second thing is that some of the results have been repeated using the same technique, which is another check against analytical errors. The third is that all 3 meteorites were dated by more than one method — 2 methods each for Allende and Guarena, and 4 methods for St Severin. This is extremely powerful verification of the validity of both the theory and the practice of radiometric dating. In the case of St Severin, for example, we have 4 different natural clocks (actually 5, for the Pb-Pb method involves 2 different radioactive uranium isotopes), each running at a different rate and each using elements that respond to chemical and physical conditions in much different ways. And yet, they all give the same result to within a few percent. Is this a remarkable coincidence? Scientists have concluded that it is not; it is instead a consequence of the fact that radiometric dating actually works and works quite well. Creationists who want to dispute the conclusion that primitive meteorites, and therefore the solar system, are about 4.5 Ga old certainly have their work cut out for them!

The K-T Tektites

One of the most exciting and important scientific findings in decades was the 1980 discovery that a large asteroid, about 10 kilometers diameter, struck the earth at the end of the Cretaceous Period. The collision threw many tons of debris into the atmosphere and possibly led to the extinction of the dinosaurs and many other life forms. The fallout from this enormous impact, including shocked quartz and high concentrations of the element iridium, has been found in sedimentary rocks at more than 100 locations worldwide at the precise stratigraphic location of the Cretaceous-Tertiary (K-T) boundary (Alvarez and Asaro 1990; Alvarez 1998). We now know that the impact site is located on the Yucatan Peninsula. Measuring the age of this impact event independently of the stratigraphic evidence is an obvious test for radiometric methods, and a number of scientists in laboratories around the world set to work.

In addition to shocked quartz grains and high concentrations of iridium, the K-T impact produced tektites, which are small glass spherules that form from rock that is instantaneously melted by a large impact. The K-T tektites were ejected into the atmosphere and deposited some distance away. Tektites are easily recognizable and form in no other way, so the discovery of a sedimentary bed (the Beloc Formation) in Haiti that contained tektites and that, from fossil evidence, coincided with the K-T boundary provided an obvious candidate for dating. Scientists from the US Geological Survey were the first to obtain radiometric ages for the tektites and laboratories in Berkeley, Stanford, Canada, and France soon followed suit. The results from all of the laboratories were remarkably consistent with the measured ages ranging only from 64.4 to 65.1 Ma (Table 2). Similar tektites were also found in Mexico, and the Berkeley lab found that they were the same age as the Haiti tektites. But the story does not end there.

The K-T boundary is recorded in numerous sedimentary beds around the world. The Z-coal, the Ferris coal, and the Nevis coal in Montana and Saskatchewan all occur immediately above the K-T boundary. Numerous thin beds of volcanic ash occur within these coals just centimeters above the K-T boundary, and some of these ash beds contain minerals that can be dated radiometrically. Ash beds from each of these coals have been dated by $^{40}Ar/^{39}Ar$, K-Ar, Rb-Sr, and U-Pb methods in several laboratories in the US and Canada. Since both the ash

beds and the tektites occur either at or very near the K-T boundary, as determined by diagnostic fossils, the tektites and the ash beds should be very nearly the same age, and they are (Table 2).

There are several important things to note about these results. First, the Cretaceous and Tertiary periods were defined by geologists in the early 1800s. The boundary between these periods (the K-T boundary) is marked by an abrupt change in fossils found in sedimentary rocks worldwide. Its exact location in the stratigraphic column at any locality has nothing to do with radiometric dating — it is located by careful study of the fossils and the rocks that contain them, and nothing more. Second, the radiometric age measurements, 187 of them, were made on 3 different minerals and on glass by 3 distinctly different dating methods (K-Ar and $^{40}Ar/^{39}Ar$ are technical variations that use the same parent-daughter decay scheme), each involving different elements with different half-lives. Furthermore, the dating was done in 6 different laboratories and the materials were collected from 5 different locations in the Western Hemisphere. And yet the results are the same within analytical error. If radiometric dating did not work then such beautifully consistent results would not be possible.

TABLE 2 $^{40}Ar/^{39}Ar$ ages for K-T tektites and related K-T boundary deposits

Location	Material Dated	Method	Number of of Analyses	Age(Ma)
Haiti	tektites	$^{40}Ar/^{39}Ar$ total fusion	52	64.4 ± 0.1
(Beloc		$^{40}Ar/^{39}Ar$ age spectrum	4	64.4 ± 0.4
Formation)		$^{40}Ar/^{39}Ar$ age spectrum	2	64.5 ± 0.2
		$^{40}Ar/^{39}Ar$ age spectrum	4	64.8 ± 0.2
		$^{40}Ar/^{39}Ar$ total fusion	18	64.9 ± 0.1
		$^{40}Ar/^{39}Ar$ total fusion	3	65.1 ± 0.2
		$^{40}Ar/^{39}Ar$ age spectrum	9	65.0 ± 0.2
Mexico	tektites	$^{40}Ar/^{39}Ar$ total fusion	2	65.1 ± 0.5
(Arroyo el Mimbral)				
Hell Creek,	tektites	$^{40}Ar/^{39}Ar$ total fusion	28	64.8 ± 0.1
Montana		$^{40}Ar/^{39}Ar$ age spectrum	1	66.0 ± 0.5
(Z-coal)		$^{40}Ar/^{39}Ar$ age spectrum	1	64.7 ± 0.1
		$^{40}Ar/^{39}Ar$ total fusion	17	64.8 ± 0.2
	biotite, sanidine	K-Ar	12	64.6 ± 1.0
	biotite, sanidine	Rb-Sr isochron (26 data)	1	63.7 ± 0.6
	zircon	U-Pb concordia (16 data)	1	63.9 ± 0.8
Saskatchewan,	sanidine	$^{40}Ar/^{39}Ar$ total fusion	6	64.7 ± 0.1
Canada		$^{40}Ar/^{39}Ar$ Ar age spectrum	1	64.6 ± 0.2
(Ferris coal)	biotite, sanidine	K-Ar	7	65.8 ± 1.2
	various	Rb-Sr isochron (10 data)	1	64.5 ± 0.4
	zircon	U-Pb concordia (16 data)	1	64.4 ± 0.8
Saskatchewan,	sanidine	$^{40}Ar/^{39}Ar$ total fusion	11	64.8 ± 0.2
Canada		$^{40}Ar/^{39}Ar$ age spectrum	1	64.7 ± 0.2
(Nevis coal)	biotite	K-Ar	2	64.8 ± 1.4
	various	Rb-Sr isochron (7 data)	1	63.9 ± 0.6
	zircon	U-Pb concordia (12 data)	1	64.3 ± 0.8

Data from compilation and study by Dalrymple and others (1993). Analyses done by university laboratories in Australia, Canada, France, and California, and at the USGS in Menlo Park, California.

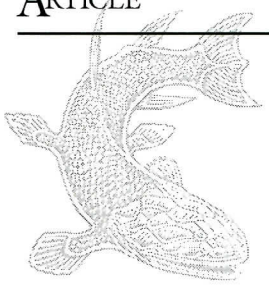
Dating of The Mt Vesuvius Eruption

In the early afternoon of August 24, 79 CE, Mt Vesuvius erupted violently, sending hot ash flows speeding down its flanks. These flows buried and destroyed Pompeii and other nearby Roman cities. We know the exact day of this eruption because Pliny the Younger carefully recorded the event. In 1997 a team of scientists from the Berkeley Geochronology Center and the University of Naples decided to see if the $^{40}Ar/^{39}Ar$ method of radiometric dating could accurately measure the age of this very young (by geological standards) volcanic material. They separated sanidine crystals from a sample of one of the ash flows. Incremental heating experiments on 12 samples of sanidine yielded 46 data points that resulted in an isochron age of 1925 ± 94 years. The actual age of the flow in 1997 was 1918 years. Is this just a coincidence? No — it is the result of extremely careful analyses using a technique that works.

This is not the only dating study to be done on an historic lava flow. Two extensive studies done more than 25 years ago involved analyzing the isotopic composition of argon in such flows to determine if the source of the argon was atmospheric, as must be assumed in K-Ar dating (Dalrymple 1969, 26 flows; Krummenacher 1970, 19 flows). Both studies detected, in a few of the flows, deviations from atmospheric isotopic composition, most often in the form of excess ^{40}Ar. The majority of flows, however, had no detectable excess ^{40}Ar and thus gave correct ages as expected. Of the handful of flows that did contain excess ^{40}Ar, only a few did so in significant amounts. The 122 BCE flow from Mt Etna, for example, gave an erroneous age of 0.25 ± 0.08 Ma. Note, however, that even an error of 0.25 Ma would be insignificant in a 20 Ma flow with equivalent potassium content. Austin (1996) has documented excess ^{40}Ar in the 1986 dacite flow from Mount St Helens, but the amounts are insufficient to produce significant errors in all but the youngest rocks.

The 79 CE Mt Vesuvius flow, the dating of which is described above, also contained excess ^{40}Ar. The $^{40}Ar/^{39}Ar$ isochron method used by the Berkeley scientists, however, does not require any assumptions about the composition of the argon trapped in the rock when it formed — it may be atmospheric or any other composition, for that matter. Thus any potential error due to excess ^{40}Ar was eliminated by the use of this technique, which was not available when the studies by Dalrymple (1969) and Krummenacher (1970) were done.

Thus the large majority of historic lava flows that have been studied either give correct ages, as expected, or have quantities of excess radiogenic ^{40}Ar that would be insignificant in all but the youngest rocks. The $^{40}Ar/^{39}Ar$ technique, which is now used instead of K-Ar methods for most studies, has the capability of automatically detecting, and in many instances correcting for, the presence of excess ^{40}Ar, should it be present.



Comments on a Creationist's Irrelevant Discussion of Isochrons

Derek York, Department of Physics, University of Toronto and
G Brent Dalrymple, College of Oceanic & Atmospheric Sciences, Oregon State University

Radiometric dating of rocks and minerals using long-lived, naturally-occurring radioactive isotopes has provided voluminous and conclusive evidence that the earth is 4.5 billion years old and that life on earth began more than 3 billion years ago (for example, Dalrymple 1991; York 1997). Numerous creationist attempts to show that radiometric dating does not work (for example, Woodmorappe 1979; Arndts and Overn 1981) have invariably fallen far short of the mark and only serve to emphasize that these creation "scientists" do not understand the physical principles on which this valuable scientific tool is based (Dalrymple 1984).

Now there is a new and equally unsuccessful creationist attempt to demonstrate that radiometric dating is somehow flawed. GH Gill has claimed that the isochron regression technique used in rubidium-strontium (Rb-Sr) dating is mathematically invalid (Gill 1996). We show here that Gill's claim is false and results from his misunderstanding of the elementary algebra and isotope relationships that underlie the isochron technique.

Gill correctly notes the obvious fact that if we take data points (x,y) that initially delineate a straight line and divide all pairs of values x and y by a randomly varying quantity, which he calls the confounding variable, the data points will no longer lie on the original line and will exhibit much more scatter about some new line fit to the data. While this is correct, it is also irrelevant; this mathematical truism has nothing to do with the basis of the isochron method.

In reality, geochronologists (the scientists who date rocks) do the exact opposite. They do not begin with data that fit on a straight line and then disturb this situation, as Gill alleges. Instead, they begin with data that do not fit a straight line, then, using high-school algebra, they transform the data from isotopic amounts to isotopic ratios. These new x and y ratio data now fall on a straight line, the slope of which gives the common age of the samples being analyzed.

Revealing Underlying Relationships

The approach of using ratios to reveal important relationships is common throughout science. To understand why this works, let us begin by looking at an example that is somewhat simpler than isotopes in rocks. Suppose we wish to study variations in the female population of selected European countries using 1998 census data. If we plot the number of females in these countries (Figure 1a), the graph shows a large scatter of data. Technically, there is nothing wrong with this graph — it is an entirely accurate representation of the data. We suspect,

Summary

In this short paper I have briefly described 4 examples of radiometric dating studies where there is both internal and independent evidence that the results have yielded valid ages for significant geologic events. It is these studies, and the many more like them documented in the scientific literature, that the creationists need to address before they can discredit radiometric dating. Their odds of success are near zero. Even if against all odds they should succeed, it still would not prove that the earth is young. Only when young-earth creationists produce convincing quantitative, scientific evidence that the earth is young will they be worth listening to on this important scientific matter.

Acknowledgments

I thank Chris Stassen and 2 anonymous reviewers for their thoughtful comments, which led to important improvements in the manuscript.

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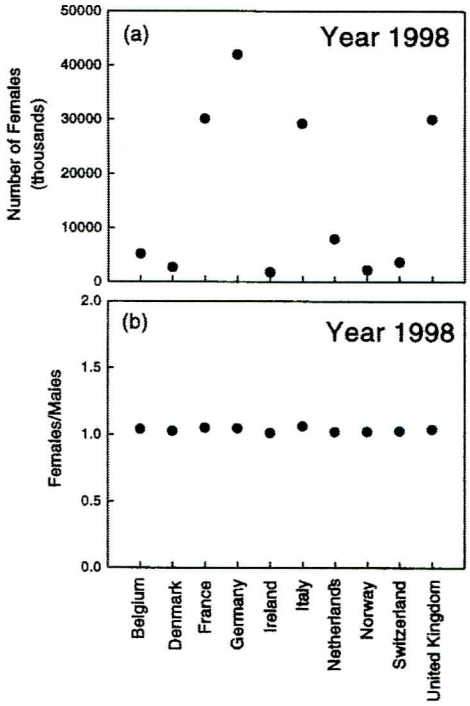

FIGURE 1
Graphs showing (a) the number of females in selected European countries in 1998, and (b) the ratio of females to males in those same countries in 1998. Both graphs are valid, but they each reveal different things about the populations of the countries. Often ratios, as in graph (b), are more revealing than absolute numbers, as in graph (a).

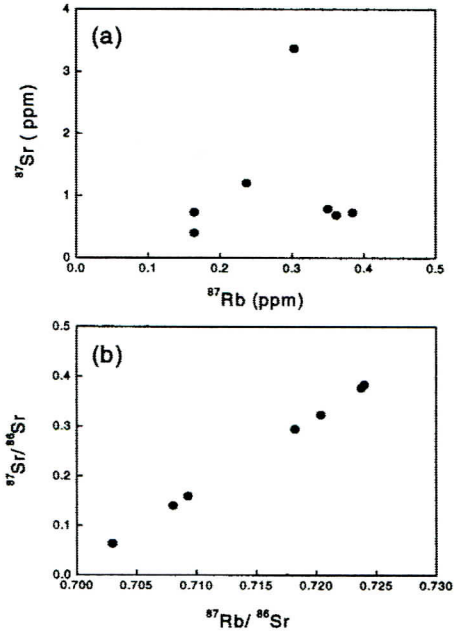

FIGURE 2
Graphs showing (a) the amounts, in parts per million (ppm), of ^{87}Rb and ^{87}Sr in minerals and whole-rock samples of the meteorite Tieschitz, and (b) the isotope ratios for the same meteorite. Graph (a) reveals little information of interest whereas graph (b) shows a linear relationship that not only provides the isochron age of 4.52 ± 0.05 billion years but also demonstrates that the meteorite has not been disturbed significantly since it formed. Data from Minster and Allegre (1979).

however, that the large variation among countries is primarily a function of the population of those countries rather than a function of either the birth or death rates of women.

To test that hypothesis, Figure 1a is not very useful. If we divide the number of females by the number of males and plot the results, however, we get Figure 1b, which shows a clear straight-line relationship. This graph is very useful for our purpose and from it we learn that the fraction of females in the populations of these countries is slightly greater than one-half and that variations from country to country are small. Considering what we wish to know, Figure 1b is much more useful than Figure 1a. This is only one example in which ratios are much more instructive than absolute amounts.

Exactly the same device is used in Rb-Sr isochron dating as well as in other isotopic dating methods. If we plot the *amounts* of ^{87}Rb (the radioactive parent isotope) versus the *amounts* of ^{87}Rb (the daughter isotope produced by radioactive decay of the parent isotope) in various minerals and whole-rock pieces of the meteorite Tieschitz (Figure 2a), we find that the data scatter. If we divide these amounts by the *amount* of ^{86}Sr in the samples and plot those ratios (Figure 2b), however, we get a remarkable transfor-

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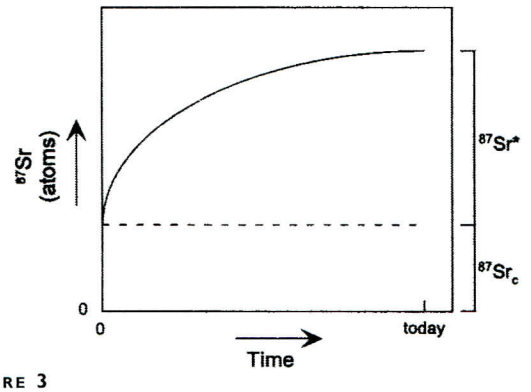

FIGURE 3
Growth of ^{87}Sr* from decay of ^{87}Rb over time. $^{87}Sr_c$ is the amount of *initial* or *common* Sr in a mineral that formed at time = 0. Arrows show direction of increase.

mation — the data fall onto a beautifully delineated straight line. The reason this works is that there is a genuine physical relationship between the isotopes used in the ratio graph. This relationship is hidden in Figure 2a by the huge variation in the amounts of the isotopes. Figure 2a reveals nothing of interest about the meteorite, whereas Figure 2b provides an isochron age of 4.52 ± 0.05 billion years and also tells us that the meteorite has not been substantially disturbed since it formed.

Using Isotope Ratios in Geochronology

Let us explore in more detail the simple logic behind Rb-Sr isochrons and see why isotope ratios in geochronology work the way they do. Gill's criticism of isochrons is mathematical in nature, so in order to refute him the use of some simple algebra is unavoidable. We will keep it as elementary as possible, however, and refer the more mathematically inclined reader to the equations in the Appendix.

All scientists agree that in any undisturbed quantity of rock or mineral sample of age t the number of atoms of ^{87}Sr produced by the radioactive decay of ^{87}Rb since the rock formed — or $^{87}Sr^*$ — can be calculated using the simple exponential decay equation (Appendix, equation 1). The ^{87}Sr*, also known as radiogenic strontium, is not the only ^{87}Sr in the rock. Invariably, when strontium-bearing rocks form, they contain some *common*, or *initial*, strontium, which is a mixture of ^{84}Sr, ^{86}Sr, ^{87}Sr, and ^{88}Sr. So the total amount of ^{87}Sr in the rock sample, $^{87}Sr_S$, is the sum of the amount of the radiogenic strontium, $^{87}Sr^*$, and the amount of the common strontium, $^{87}Sr_c$ (Appendix, equation 2).

By combining these 2 relationships and doing some simple algebraic rearrangement, we get (Appendix, equation 5).

$$^{87}Sr_S = {}^{87}Rb_S\,(e^{\lambda t} - 1) + {}^{87}Sr_C$$

which expresses how the total amount of ^{87}Sr in the sample, $^{87}Sr_s$, grows as a result of radioactive decay over time. The decay constant, λ, represents the probability of decay, is a constant, and can be accurately measured in the laboratory. This growth of $^{87}Sr^*$ in the presence of common strontium is shown graphically in Figure 3.

Those who remember their high school exercises in graphing will recognize that the above equation has the form of the equation of a straight line, commonly expressed as

$$y = mx + b$$

where y (= $^{87}Sr_S$) and x (= $^{87}Rb_S$) are variables and the slope m (= $e^{\lambda t}$ - 1) and the intercept b (= $^{87}Sr_C$) are constants. Thus, the equation for the increase of ^{87}Sr is also the equation for a straight line that expresses the relationship between the quantities of ^{87}Rb and ^{87}Sr in the sample as a function of time, t, which is represented by the slope of the isochron (Figure 4).

The problem with this equation is that while ($e^{\lambda t}$ - 1) is a constant for all rocks and minerals of the same age, $^{87}Sr_C$ is a variable. This is because the 3 variables in the equation are expressed as absolute quantities of the isotopes — in our example as numbers of atoms. The quantities of these isotopes do indeed vary from one sample to another, even if the samples are from the same rock body and formed at the same time. This is because different minerals incorporate varying amounts of rubidium and strontium into their crystal structures when they cool after melting. Indeed, if this were not so, the isochron method would not work, because there would not be enough difference in the data points to form a line. If we measure these 3 quantities ($^{87}Sr_s$, $^{87}Rb_s$, $^{87}Sr_c$) and graph them, therefore, the result will be a scatter of points rather than a straight line, as in Figure 2a. This is a key point that Gill (1996) seems not to appreciate, for he begins his analysis by making the erroneous assumption that there is usually a straight-line relationship between the isotope quantities expressed in this equation.

In order to plot these data on a straight line, we need to find another variable that is perfectly correlated with $^{87}Sr_C$. By "perfectly correlated" we mean

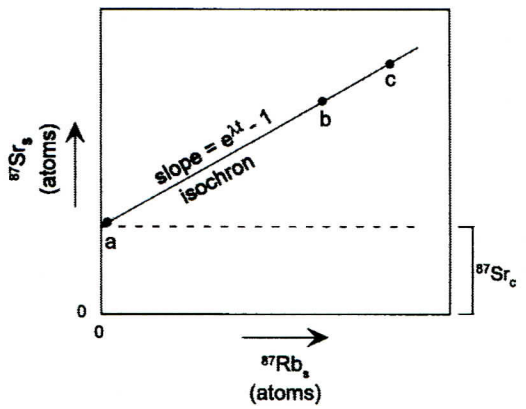

FIGURE 4
Amount of ^{87}Sr as a function of the amount of ^{87}Rb in 3 minerals (A–C) from the same rock after time t. The data from the minerals will plot on a straight line, or isochron, as shown, only if the quantity of $^{87}Sr_c$ in all of the minerals is identical, which is highly unlikely and almost never happens. The most likely situation is that the data will scatter, as in Figure 2a. Arrows show direction of increase.

continued on page 25

Ten Tips for Successful Letter Hacking

Mary Lou Mendum

Although most of the battle against creationism has focused on the political and legal battles over textbooks and curriculum development, it is important to remember that public opinion plays a major role in determining the material actually taught in biology classrooms. One inexpensive and effective way to educate the public on the nature of science in general, and evolution in particular, is through the editorial pages. Letters to the editor are widely read, and fundamentalists have long used letter campaigns to push their agenda. By promptly detailing the scientific errors in creationist letters, NCSE members have the opportunity to expose creationism as the pseudoscience that it is. Here are 10 guidelines to consider when writing rebuttals to creationist letters:

1. Criticize facts, not opinions. Honest statements of belief in creationism as an article of faith are not open to argument, and they serve the useful purpose of revealing its religious basis. Instead, concentrate on exposing misquotes and factual errors. Name-calling is not advisable, but accusations of sloppy scholarship and ignorance, accompanied by proper documentation, can be devastating.

2. Do your homework. If you are criticizing creationists for poor scholarship, you cannot afford to make the same mistake yourself. However, you can greatly increase the impact of *your* letter if you can back up your statements with references to the scientific literature, including complete quotations from the original source used by anti-evolutionists to "prove" their case.

3. Do not cover more than one or two points in each letter. Your goal should be to challenge the credibility of the local creationists, not to give an introductory biology seminar. A lengthy point-by-point discussion of transitional fossils is less effective than a short letter detailing one misquote and one major scientific error. If you try to cover too many topics, the editor is likely to delete half of them.

4. Keep it short and succinct. Letters of one page are much more likely to be published than those of two or more pages. The more concise your letter, the more likely it will appear exactly as you wrote it. Make sure that every word is essential to the overall point of your letter. This is particularly important if you are writing to conservative papers, as they have a tendency to delete all those annoying little facts that make evolution sound more scientific than creationism.

5. Humor is helpful. A funny, entertaining letter is much more memorable to both editor and readers than an angry or sarcastic one.

6. Slant your letter towards the newspaper's style. Do not attack the creationists' right to advocate their beliefs when you write to a liberal paper — you might even want to include a statement that you support their freedoms of speech and religion, when they are exercised outside of the science classroom. Appeals to scientific authority are very effective in letters to conservative papers, while liberal papers prefer more specific references.

7. If you have credentials, mention them. Few creationists writing letters to local newspapers have any scientific training. If you have earned a degree or done research in a relevant scientific field, you are automatically more credible than a person who has not. If you are affiliated with a university, use your departmental address. Most newspapers will print such information under your name, and that is far more impressive to readers than the usual home town.

8. Two letter hacks are more effective than one. Letters editors like to keep lively debates going, but they will seldom print two letters from any one person during an exchange, and if 2 people submit good letters on the same topic at the same time, chances are that only one of them will be published. If you coordinate your efforts with one or more other people, you can be sure that any creationist attacks on your letters will be responded to promptly and effectively.

9. Do not limit your writing to the scientific issues. The anti-evolutionary agenda goes far beyond creationism, and an effective defense of science requires that the constitutional basis for rejecting the teaching of creationism — the First Amendment — remains intact. Upholding strict church-state separation is as important as debunking creationist pseudoscience.

10. Be persistent. It may take 5 or 6 tries before a newspaper publishes one of your letters, especially if it has a large circulation. Do not be discouraged; eventually the letters editor will tire of printing yet more letters on the latest election scandals, and start looking for a little variety.

It is very unlikely that even the best letter-writing campaign will convince hard-core fundamentalists to abandon creationism. However, by writing in to correct their factual errors and dishonest scholarship, it is possible to discourage them from using the letters pages to promote bad science.

[*Adapted from* NCSE Reports *1996; 16 (4): 19-20.*]

Visions of the Scopes Trial

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

It was 75 years ago, in the sweltering July of 1925, that John Thomas Scopes was tried in Dayton, Tennessee, for violating the state's anti-evolution act. Often described as the greatest trial of the century, the case of *State of Tennessee v John T Scopes* sparked hilarity, resentment, confusion, celebration, anger — and, of course, books. Alas, many excellent books about the trial are out of print, such as L Sprague de Camp's *The Great Monkey Trial* (which Sue Hicks, one of the prosecutors, described as the "most accurate overall edition of the published accounts of the trial"), Willard B Gatewood Jr's sourcebook *Controversy in the Twenties: Fundamentalism, Modernism, and Evolution*, and John T Scopes's own *Center of the Storm*. But the following books are available on the NCSE web site: <www.ncseweb.org/bookstore.asp>. And remember, every purchase benefits NCSE!

The Drama

The Great Tennessee Monkey Trial
by Peter Goodchild
(audiocassette)
Unlike *Inherit the Wind*, Goodchild's play is intended to depict the Scopes trial accurately; in fact, it was adapted from the original trial transcripts. The reviewer for the London *Times* raves, "[n]either theatre nor documentary, it succeeds in thrillingly being both." The performance recorded here stars Charles Durning, Tyne Daley, and Ed Asner in a bravura performance as the Boy Orator of the Platte, the Peerless Leader, the Great Commoner — William Jennings Bryan.

The World's Most Famous Court Trial: Tennessee Evolution Case
edited by William Hilleary and Oren Metzger
The very first book on the subject of the Scopes trial contains, in the words of the title page, "[a] word-for-word report of the famous court test of the Tennessee anti-evolution act, at Dayton, July 10 - 21, 1925, including speeches and arguments of attorneys, testimony of noted scientists, and Bryan's last speech." Reprinted with additions from the original 1925 edition, the transcript, although expensive, is invaluable for anyone seriously interested in the Scopes trial.

Inherit the Wind
by Jerome Lawrence and Robert E Lee
Opening on Broadway in 1955, *Inherit the Wind* was intended to indict McCarthy's anticommunism, not Bryan's fundamentalism. Nevertheless, by basing the play loosely on the Scopes trial — Bryan became Brady, Darrow became Drummond, Mencken became Hornbeck, Scopes became Cates, and Dayton became Hillsboro — Lawrence and Lee embedded their vision of the trial in the American popular consciousness. Starring in the 1960 film version — which premiered in Dayton — were Spencer Tracy, Fredric March, and Gene Kelly.

The Players

The Scopes Trial: A Photographic History
introduction by Edward Caudill
photograph captions by Edward J Larson
afterword by Jesse Fox Mayshark
At last, the opportunity to see the persons and places of the greatest trial of the century! The backdrop and the repercussions of the Scopes trial are ably discussed by Edward Caudill and Jesse Fox Mayshark, respectively, but the heart of the book is its wealth of annotated documentary photographs. Slim and elegant, *The Scopes Trial: A Photographic History* is simply irresistible.

The Story of My Life
by Clarence Darrow
introduction by Alan Dershowitz
Straight from the horse's mouth, the story of the most famous — and infamous — attorney of his day contains Darrow's own account of his involvement in the Scopes trial. "To me," Darrow wrote, "it was perfectly clear that the proceedings bore little semblance to a court case, but I realized that there was no limit to the mischief that might be accomplished unless the country was aroused to the evil at hand." Introduction by the Harvard law professor widely considered to be the Darrow of our day.

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Defender of the Faith: William Jennings Bryan, the Last Decade, 1915-1925
by Lawrence W Levine
Although the remarkable public career of the Great Commoner attracted biographers aplenty, Levine's narrow focus on the last decade of Bryan's life makes his 1965 study especially helpful to those fascinated by the Scopes trial. "The Bryan of the 1920s was essentially the Bryan of the 1890s", Levine explains in his introduction: "older in years but no less vigorous, no less optimistic, no less certain."

Attorney for the Damned: Clarence Darrow in the Courtroom
edited by Arthur Weinberg
foreword by William O Douglas
Reprinted from the 1957 edition. "Clarence Darrow [was] perhaps the most effective courtroom opponent of cant, bigotry, and special privilege that our country has produced. All of Darrow's most celebrated pleas are here — in defense of Leopold and Loeb (1924), of Lieutenant Massie (1932), of Big Bill Haywood (1907), of [John] Thomas Scopes (1925), and of himself for attempted bribery", writes the reviewer for *The New Yorker*.

The History

Only Yesterday: An Informal History of the Nineteen-Twenties
by Frederick Lewis Allen
Written by the editor of *Harper's* magazine in 1931, the still-in-print *Only Yesterday* recounts the events of the Roaring Twenties with verve and enthusiasm. "No one", according to the historian Roderick Nash, "has done more to shape the conception of the American 1920s than Frederick Lewis Allen." The Scopes trial, as the major news story of the summer of 1925, receives plenty of attention, although Edward J Larson complains that Allen "presented the trial in cartoon-like simplicity" and "perpetuated various misconceptions about events at Dayton."

When All the Gods Trembled: Darwinism, Scopes, and American Intellectuals
by Paul K Conkin
The author of *American Originals: Homemade Varieties of Christianity* turns his attention to the impact of Darwin's theories on the intellectual scene of the 1920s. The Scopes trial is central, of course, but Conkin also discusses the reactions of intellectuals as diverse as the pastor Harry Emerson Fosdick, the philosopher John Dewey, and the poet John Crowe Ransom. Fellow historian Edward J Larson praises *When All the Gods Trembled* for its "keen insights into the historic fundamentalist-modernist controversy and the ongoing debate over science and religion."

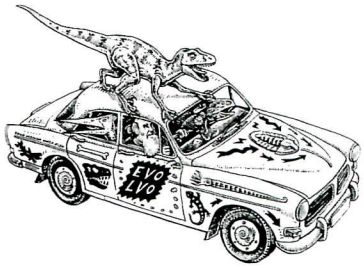
Six Days or Forever? Tennessee v John Scopes
by Ray Ginger
The first authoritative historical treatment of the Scopes trial is still extraordinarily readable. Originally published in 1958, *Six Days or Forever?* is notable for its comparison of Darrow's 1925 interrogation of Bryan and the Senate's 1954 investigation of McCarthy; "if a person holds irrational ideas and insists that others should accept them because of their authoritative source", Ginger writes, "he should never agree to be questioned about them."

Summer for the Gods: The Scopes Trial and America's Continuing Debate Over Science and Religion
by Edward J Larson
Larson, the author of the acclaimed *Trial and Error: The American Controversy Over Evolution*, won the 1998 Pulitzer Prize for history for *Summer for the Gods*. Small wonder: it exhaustively discusses the legal, historical, and social setting of the Scopes trial, all in Larson's characteristically sparkling prose. *Summer for the Gods* is endorsed by such diverse readers as Phillip Johnson, Will Provine, and Ronald L Numbers, who says that it "is, quite simply, the best book ever written on the Scopes trial and its place in American history and myth." Highly recommended.

Darwinism Comes to America
by Ronald L Numbers
In these fascinating essays, distinguished historian of science Ronald L Numbers explores the reception of Darwinism in the US. Eugenie C Scott writes, "Numbers's carefully researched study helps us understand the origin of the wide-ranging attitudes toward creation and evolution found among conservative Christians today. *Darwinism Comes to America* is a worthy successor to *The Creationists*." In the 4th essay in the collection, "The Scopes Trial: History and Legend", Numbers takes "a fresh look at the Scopes trial, focusing specifically on its representation (one is tempted to say *mis*representation) in popular and scholarly works", including, inevitably, *Inherit the Wind*.

And the Children

The Scopes Trial: Defending the Right to Teach
by Arthur Blake
The Scopes Trial was, at bottom, about what children ought to be taught in science class, so it is appropriate that Blake wrote his book specifically for children between 9 and 12, clearly and thoroughly describing the Scopes trial and its enduring significance for religion, education, and society. Contains photographs, bibliography, chronology, and index. Part of the Spotlight on American History series.



NCSE on the Road

A Calendar of Special Events, Presentations, and Lectures

Date January 6, 2001
City Chicago IL
Presenter Eugenie C Scott
Title Creationism: A Panel Discussion
Event Society for Integrative and Comparative Biology Annual Meeting
Time 12 noon
Location Hilton Towers
Contact Daphne Fautin, fautin@ukans.edu

Date January 15, 2001
City Durham NC
Presenter Eugenie C Scott
Title Creationism and Evolution
Event Public Lecture
Time 7:00 PM
Location North Carolina School of Science and Mathematics
Contact Hugh Haskell, hhaskell@mindspring.com

Date January 18, 2001
City Berkeley CA
Presenters Eugenie C Scott and Kevin Padian
Title Tom Jukes, Creationism, and Evolution
Event Memorial Service for Dr Thomas Jukes
Time 4:00 PM -5:00 PM
Location UC Berkeley, Valley Life Sciences Building, room 2040
Contact Kevin Padian, kpadian@socrates.berkeley.edu

Date January 31, 2001
City San Francisco
Presenter Eugenie C Scott
Title Just When You Thought it Was Safe to Teach Evolution
Event The Fromm Institute Wonders of Science Series
Time 10:00 AM
Location University of San Francisco
Contact Jerrold Lowenstein, jlowen@itsa.ucsf.edu

Date February 18, 2001
City San Francisco CA
Presenter Eugenie C Scott
Title Anti-evolution: What's Changed/Unchanged 20 years after *McLean v Arkansas*
Event American Association for the Advancement of Science Annual Meeting
Time 3:00 PM - 6:00 PM
Location San Francisco Hilton
Contact Eugenie C Scott, scott@ncseweb.org
Note Also presenting lectures in the same symposium will be the scientific expert witnesses for the plaintiff's side in *McLean v Arkansas*: geneticist Francisco J Ayala, geologist G Brent Dalrymple, paleontologist Stephen Jay Gould, and biophysicist Harold J Morowitz. The historian Ronald L Numbers, author of *The Creationists* and *Darwinism Comes to America*, will serve as discussant.

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

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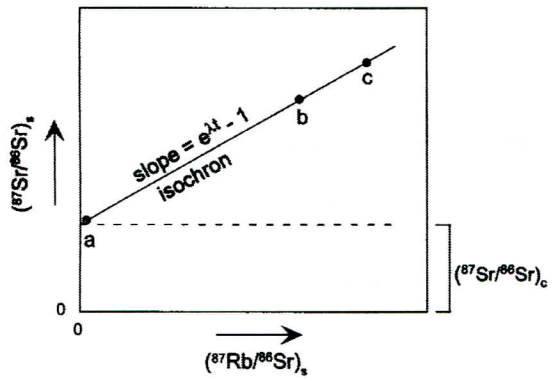


FIGURE 5
$^{87}Sr/^{86}Sr$ as a function of $^{87}Rb/^{86}Sr$ in 3 minerals (A–C) from the same rock after time t. In a rock that has remained undisturbed since formation, the data will always fall on an isochron that indicates the elapsed time since the rock formed. Arrows show direction of increase.

simply that the 2 quantities, $^{87}Sr_C$ and this new variable, increase and decrease precisely together, that is, when the quantity of one goes up or down, the other does likewise by precisely the same percentage. If we can find such a variable, then we can divide $^{87}Sr_C$ by this new variable and the ratio of these 2 variables will be a constant.

But is there another variable that satisfies these requirements? The answer to this question is decidedly yes, and that variable is $^{86}Sr_C$, representing the amount in the sample of another component of common Sr. It has been found by many experiments on rocks from around the world and of different ages that the ratio $^{87}Sr_C/^{86}Sr_C$ is a constant for all samples taken from a single rock body that formed at a single time. This is because natural processes almost never fractionate isotopes of the same element with as little mass difference as there is between the isotopes of Sr. So dividing both sides of our Rb-Sr equation above by $^{86}Sr_C$, and taking into consideration that the common Sr in the rock is the only source of ^{86}Sr, we can rewrite the equation in terms of isotope ratios instead of isotope quantities (Appendix, equation 7):

$$\left(\frac{^{87}Sr}{^{86}Sr}\right)_s = \left(\frac{^{87}Rb}{^{86}Sr}\right)_s (e^{\lambda t} - 1) + \left(\frac{^{87}Sr}{^{86}Sr}\right)_s$$

Thus, for a set of rocks or minerals of equal age, the quantity $(e^{\lambda t} - 1)$ is a constant. For rocks with a uniform common Sr value of $(^{87}Sr/^{86}Sr)_C$, we will obtain a straight line if we plot $(^{87}Sr/^{86}Sr)_S$ against $(^{87}Rb/^{86}Sr)_S$, assuming that the rock samples have all remained closed to changes in the Rb and Sr isotopes other than that due to radioactive decay of the ^{87}Rb. The slope of the line will correctly represent the age of the samples via the quantity $(e^{\lambda t} - 1)$, which can be easily solved for time, t, and the intercept, $(^{87}Sr/^{86}Sr)_C$, will correctly represent the strontium isotopic composition at the time the rock formed. This relationship is shown in Figure 5.

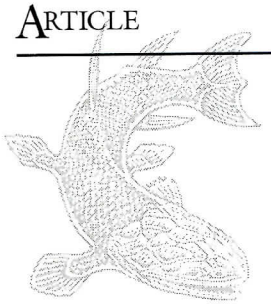
Gill's analysis might be fine, then, if it applied to the dating of rocks, but it clearly does not. We do not start with data defining a straight line then distort this arrangement by dividing the data by a quantity that varies randomly between samples. On the contrary, we begin with isotope concentration data, which do not define a straight line, and then divide the data by a quantity that varies perfectly with one of the variables in our original equation. This logical step reduces our equation to that of a straight line relationship between the isotope ratios, $(^{87}Sr/^{86}Sr)_S$ and $(^{87}Rb/^{86}Sr)_S$, which are plotted on the isochron diagram. We suspect that Gill has been misled by a failure to appreciate the significance of using isotope *ratios*, rather than isotope *amounts*, in dating.

Isochrons Reveal Validity of Sample Ages

There is another important aspect of the isochron diagram worth mentioning. If the sample is not suitable for dating — for example, if it is composed of minerals that formed at different times or if some of the isotopes of interest have been lost due to weathering — then the data will scatter and not form a straight line. Whether or not the data plot on an isochron provides an important test of the validity of the assumptions necessary for a valid radiometric age. In other words, the method is, to a large extent, self-checking.

Because many rocks have been lying in the earth's crust for hundreds of millions of years, it is not surprising that not all of them are easy to date. Their varied experiences during their long existence, such as elevated temperatures during mountain-building episodes, for example, sometimes result in isotope gain or loss, which invalidates the closed-system assumption that is critical for all dating techniques. Many, many rocks and minerals, however, have been successfully dated in the past 40 years using the isochron and other techniques in the Rb-Sr, K-Ar, Sm-Nd, Re-Os, Lu-Hf, and U-Pb systems (see examples in Dalrymple 1991). Much progress has also been made in the dating of rocks that have not remained in closed systems. The result of all of this work by scientists in many countries is that we now know that the earth, the moon, and meteorites are about 4.5 billion years old, microscopic life existed on earth 3.5 billion years ago, upright walking ape-like hominids lived in Africa 3 to 4 million years ago, and modern humans had made their appearance by roughly 100 000 years ago (Dalrymple 1991; York 1997). And these are only a few of the many wonderful discoveries scientists have made about the history of the earth and solar system using radiometric dating methods.

For all of these findings to be wrong, the universally accepted understanding of the radioactive process would also have to be wrong. This, in turn, would require dramatic changes in our understanding of time, and of some of the basic laws of physics. While this is not impossible, there currently is no basis for thinking that it is even remotely worthy of serious consideration.



Nuclear Isochrons

Dave Thomas

Some chemical elements have isotopes that are inherently unstable and undergo radioactive decay. (Isotopes of the same element always have the same number of charged protons in each atomic nucleus, but have different numbers of noncharged neutrons. Isotopes of a single element act the same *chemically*, but often have different properties related to radioactivity or other *nuclear* reactions.) Each radioactive isotope has a remarkably constant decay rate that can be measured quite accurately, and most are constant under a huge range of conditions (temperature, pressure, and so on). The laws of physics do not tell us which atoms of a given isotope (say, uranium-238) will decay at any given time; but they do tell us how long it will take for, say, half of the atoms to decay — this duration is called the "half-life"; it is *independent* of the size of the sample. These laws operate a lot like insurance mortality tables — for a given age group, actuaries cannot predict *which* individuals are good risks, but they can predict things such as the average life expectancy of members of the group and how long it will take for half of the group to succumb to accidents or natural causes.

"Simple" radioactive dating can be visualized as using a kind of atomic hourglass. The radioactive "parent" decays into a "daughter" isotope (often of a different element, since radioactive decays usually involve charged particles). So, if both parent and daughter elements are present, the ratio of parent isotope to daughter isotope can give a clue to the age of the sample. If there is more parent than daughter, the sample is still young (the top of the hourglass is still mostly full). If there is less parent than daughter, the sample is old (most of the sand is at the bottom of the hourglass).

But simple dating techniques can be distorted in several ways. What if there were some of the daughter isotope in the sample *when it was formed*? (Or, by analogy, what if the hourglass had some sand *already in the bottom vessel* when the hourglass was first placed upright?) What if the sample were not a "closed system", and isotopes (either parent or daughter) could enter or leave the system? (What if there were holes in either vessel of the hourglass that could let sand grains in or out?) Such contingencies clearly could affect estimates of how long the "clock" has been running.

To give a concrete example, suppose that we examine 3 different minerals from a rock, labeled A, B, and C, and that isotopic tests revealed the relative amounts of 3 chemical isotopes in these minerals. The parent isotope is rubidium-87 (^{87}Rb for short). It is radioactive, has 37 protons and 50 neutrons (for a

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Appendix
Derivation of the Rb-Sr Isochron Equation

In any undisturbed quantity of rock or mineral sample of age t, the number of atoms of ^{87}Sr produced by the radioactive decay of ^{87}Rb since the rock formed is given by $^{87}Sr^*$, where

$$^{87}Sr^* = {}^{87}Rb_s\,(e^{\lambda t}-1) \qquad (1)$$

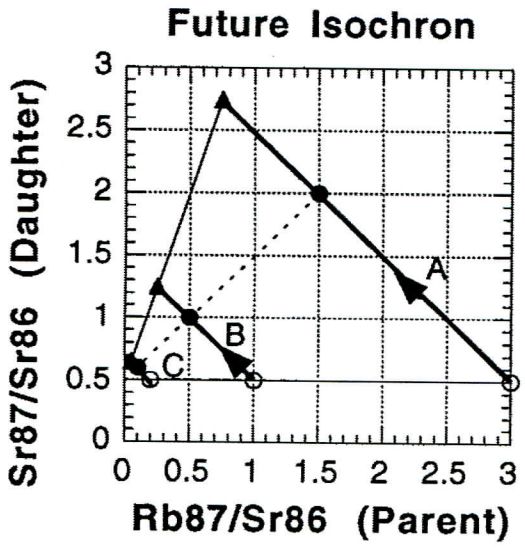
and $^{87}Rb_s$ is the number of atoms of ^{87}Rb in the rock sample today.

total of 87 nucleons), and decays to strontium-87 with a half-life of 49 billion years. The daughter isotope, strontium-87 (^{87}Sr), has 38 protons and 49 neutrons (for a total of 87 nucleons). This is called "beta-decay" because ^{87}Sr is formed when one neutron of a ^{87}Rb atom decays to a proton, ejecting an electron (or "beta ray"). The third isotope in our sample is strontium-86 (^{86}Sr); this is not involved in any radioactive reactions (and thus is "non-radiogenic").

The present-day relative amounts of the isotopes in our fictitious example are:

Mineral	^{87}Rb	^{87}Sr	^{86}Sr
A	60	80	40
B	30	60	60
C	10	60	100

These numbers are purely hypothetical — they were chosen so the explanation would be easy to understand. I decided to make the rock 49 billion years old, one half-life of rubidium. (Yes, that is much older than the universe, but this is merely an example.)



If we were to apply the "simple" dating method to A, B, and C, we would arrive at 3 different ages, assuming that there was no initial daughter isotope (^{87}Sr) when the rock formed. For mineral A, all 80 units of ^{87}Sr would be assumed to have once been ^{87}Rb, so the initial amount of ^{87}Rb would be 60 + 80 = 140. The corresponding age works out to be 1.222 half-lives, or about 60 billion years. [$T = T_{1/2} \times \log_2(($^{87}Rb + $^{87}Sr) / $^{87}Rb) = 49$ BY $\times \log_2(140 / 60)$]. Similarly, mineral B would appear to have an age of 78 BY, and mineral C would appear to have an age of 138 BY. Thus the presence of initial daughter atoms devastates the validity of "simple" dating methods.

Imagine going back in time 49 billion years to observe the rock as it is crystallizing from a melt. [B]oth isotopes of strontium [are] in equal ratios... .

There are 3 important questions to consider when choosing a mineral sample for radiometric dating: (1) Is the rock a good sample for radioactive dating? (2) What was the initial amount of daughter product (^{87}Sr) in the rock at the time it formed out of a melt? (3) How old is the rock? The isochron technique provides a way to answer these questions.

Imagine going back in time 49 billion years to observe the rock as it is crystallizing from a melt. The rock has both isotopes of strontium: the daughter product ^{87}Sr and non-radiogenic ^{86}Sr. Because these all have nearly identical chemical characteristics, they are mixed in equal ratios throughout the melted rock, much as a drop of food coloring stirred into a glass of water quickly diffuses into a uniform hue.

Ratios are the "secret" of the isochron method, and we need just 2 ratios: the ratio of the radioactive parent isotope (^{87}Rb) to the non-radiogenic isotope (^{86}Sr), and the ratio of the daughter isotope (^{87}Rb) to

---

The decay constant, λ, is the probability of decay and can be accurately measured in the laboratory.

Since all strontium-bearing rocks and minerals invariably contain some *common*, or *initial*, strontium, which is a mixture of ^{84}Sr, ^{86}Sr, ^{87}Sr, and ^{88}Sr, the total amount of ^{87}Sr in the sample is

$$^{87}Sr_s = {}^{87}Sr^* + {}^{87}Sr_c \qquad (2)$$

where $^{87}Sr_s$ is the total number of ^{87}Sr atoms in the sample, and $^{87}Sr_c$ is the number of atoms of common ^{87}Sr.

Subtracting $^{87}Sr_c$ from both sides of equation (2), we have

$$^{87}Sr^* = {}^{87}Sr_s - {}^{87}Sr_c \qquad (3)$$

Substituting equation (3) into equation (1) yields

$$^{87}Sr_s - {}^{87}Sr_c = {}^{87}Rb_s(e^{\lambda t}-1) \qquad (4)$$

and adding $^{87}Sr_c$ to both sides we get

$$^{87}Sr_s = {}^{87}Rb_s(e^{\lambda t}-1) + {}^{87}Sr_c \qquad (5)$$

It has been found by many experiments on rocks from around the world and of different ages that the ratio $^{87}Sr_c / {}^{86}Sr_c$ is a constant for all samples taken from a single rock body. Since the common Sr in the rock is the only source of ^{86}Sr, then

$$^{86}Sr_c = {}^{86}Sr_s \qquad (5)$$

We can then write

$$\frac{^{87}Sr_s}{^{86}Sr_s} = \frac{^{87}Rb_s}{^{86}Sr_s}(e^{\lambda t}-1) + \frac{^{87}Sr_c}{^{86}Sr_s} \qquad (6)$$

and finally

$$\left(\frac{^{87}Sr}{^{86}Sr}\right)_s = \left(\frac{^{87}Rb}{^{86}Sr}\right)_s (e^{\lambda t}-1) + \left(\frac{^{87}Sr}{^{86}Sr}\right)_c \qquad (7)$$

which is the equation of a straight line with $(^{87}Sr/^{86}Sr)_s$ as the intercept and $(e^{\lambda t}-1)$ as the slope of the isochron from which the age, t, is found. Both $(^{87}Sr/^{86}Sr)_s$ and $(^{87}Rb/^{86}Sr)_s$ can be precisely measured in the laboratory for any set of rocks from the same rock body or any set of minerals from the same rock.

the same non-radiogenic isotope (^{86}Sr). These are given in the following table for the assumed time of crystallization (49 BY ago).

Isotope Amounts and Ratios 49 Billion Years in the Past

mineral	^{87}Rb	^{87}Sr	^{86}Sr	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$
A	120	20	40	3.0	0.5
B	60	30	60	1.0	0.5
C	20	50	100	0.2	0.5

The rubidium-heavy mineral A has the highest ratio; A's ratio of parent isotope to non-radiogenic isotope is 120:40 = 3.0. In contrast, the rubidium-poor mineral C has the lowest ratio; C's ratio of parent isotope to non-radiogenic isotope is 20:100 = 0.2. Note that *all* of the minerals have the same ratio of *daughter* isotope to non-radiogenic isotope: 0.5, or ½. This is a direct result of the uniform mixing of the melted isotopes.

Now let us return to the present and see what has happened to our rock. The next table shows the present-day amounts and ratios of the isotopes.

Isotope Amounts and Ratios Now

mineral	^{87}Rb	^{87}Sr	^{86}Sr	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$
A	60	80	40	1.5	2.0
B	30	60	60	0.5	1.0
C	10	60	100	0.1	0.6

Because the time elapsed since the rock solidified is one half-life of ^{87}Rb, half of the ancient amount will have decayed by the present. So for mineral A, which started with 120 units of ^{87}Rb, now 60 remain, with the other 60 converted to the daughter isotope (^{87}Sr). Thus, as the ^{87}Rb amount drops from 120 to 60, the ^{87}Sr count goes from 20 (49 BYa) to 80 (now). The story is similar for mineral B, in which ^{87}Rb decreased from 60 to 30, with a corresponding ^{87}Sr increase from 30 to 60. Try the rule out on mineral C to see for yourself how this works. The important thing is that the ratios have changed also — the ^{87}Rb ratios all dropped, and the ^{87}Sr ratios, which used to all be ½, are now quite different (ranging from 0.6 to 2.0).

When applied correctly, the isochron method provides a powerful way to tackle some of the problems encountered with "simple" dating techniques.

So what is an *isochron*, anyway? If the results of the preceding tables are graphed with the parent isotope ratio as the horizontal axis, and the daughter isotope ratio as the vertical axis, then the slope of the isochron — the line connecting the points for the various minerals at the same time (as the etymology of the name "isochron" suggests) — is directly related to the age of the rock. Two such isochrons are shown to the right: the horizontal one labeled 49 BYa, and the slanted one (lower left to upper right) labeled NOW.

The lines with arrows represent the changes in those single minerals over time. For example, A's $^{87}Rb/^{86}Sr$ ratio drops from 3.0 to 1.5, while its $^{87}Sr/^{86}Sr$ ratio rises from 0.5 to 2.0. Compare the plot to the ratios in the preceding tables to see where the isochrons come from.

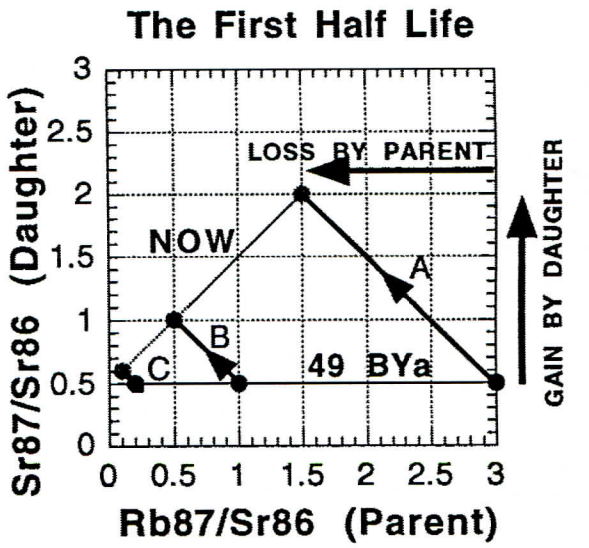
How is the isochron's slope related to the age of the rock? Let us consider one more example — that of the same rock, 49 BY in the future (long after our sun has turned into a smoldering dwarf star).

Isotope Amounts and Ratios 49 Billion Years in the Future

mineral	^{87}Rb	^{87}Sr	^{86}Sr	$^{87}Rb/^{86}Sr$	$^{87}Sr/^{86}Sr$
A	30	110	40	0.75	2.75
B	15	75	60	0.25	1.25
C	5	65	100	0.05	0.65

The slope of the far-future isochron is (2.75 - 0.65) / (0.75 - 0.05) = 2.1 / 0.7 = 3.0. The slope of the isochron is related to the age in half-lives of the ample. Simply add 1 to the slope and express that sum as a power of 2. The exponent is the number of half-lives since the formation of the sample. In this example, the slope is 3, so $3 + 1 = 4 = 2^2$, and the age is 2 half-lives. For a slope of 1 (present-day), $1 + 1 = 2 = 2^1$, so the age is 1 half-life. And for a slope of 0.0 (49 BY ago), $0 + 1 = 1 = 2^0$, so the age is 0. For a slope of 7, slope + 1 = $8 = 2^3$, which means 3 half-lives.

When applied correctly, the isochron method provides a powerful way to tackle some of the problems encountered with "simple" dating techniques. For one thing, if the sample minerals did not solidify at the same time but were mashed together, the points will generally *not* lie on a straight line. And when this scattering is observed, the sample is recognized to be *unusable* for dating with the method. It is like a built-in quality check on the reliability of the result. For another thing, the possibility of having some of the daughter isotope already present in the



rock when it formed can be handled. This initial amount is *revealed* by the isochron method — as the value on the $^{87}Sr/^{86}Sr$ axis where the isochron crosses (0.5 in all the examples). And since the age depends on the isochron slope, the initial amount does not affect the age determination (unlike "simple" dating).

But the method is not infallible. For example cases of non-uniform mixing, or conglomeration of certain types of rocks, can sometimes lead to "false" or "fictitious" isochrons — isochrons that do not represent the true age of the rock. These possible pitfalls are discussed in Bernard-Griffiths (1989) and Faure (1986). There are methods to counteract these problems, such as taking more mineral samples, performing mixture analyses on more than one element, and by checking dates by independent means (such as looking at different parent/daughter pairs). (For more details on this and other methods, see the chapter on dating techniques in Dalrymple [1991] and York and Dalrymple [2000].) When such checks are made, confidence in the results is greatly increased. For example, the St Severin meteorite was dated with 3 different methods (Rb-Sr, Sm-Nd, and Ar-Ar) as being between 4.4 and 4.6 billion years old (Dalrymple 1991: 288).

Creationists love to attack such methods by claiming that we do not really know if radioactive decay rates are constant over time. They point out no human was around back then, so who knows for sure? They also hypothesize that decay rates varied during supernatural events (the Creation, the Flood), but of course they do not test these hypotheses. One interesting point against the creationists is the fact that, if decay rates *did* change over time, the points on an isochron plot would be forced *off* the isochron line and would appear quite scattered. The very fact that isochrons *do* work in many cases is powerful evidence that decay rates have, in fact, remained constant for billions of years.

[*This article originally appeared in* NMSR Reports *1997 May; 3 (5): 5-7. It is reprinted and abridged with permission.*]

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The Carbon-14 Story

The January/February 2000 issue of *American Scientist* has a review article on radiocarbon (14-C) dating. The article, "Fifty Years of Radiocarbon Dating", was written by RE Taylor of the Department of Anthropology at the University of California at Riverside. The *American Scientist* web site has the abstract and some related links at <http://www.amsci.org/amsci/articles/00articles/taylor.html>.

[*Contributed by Rob Pennock.*]

Internet Resources on Radiometric Dating

For interested readers, there are several internet resources on radiometric dating. Connect to one of the following:
<http://www.geocities.com/Tim_J_Thompson/radiometric.html>,
<http://c14.sci.waikato.ac.nz/webinfo/index.html>, or
<http://www.geocities.com/CapeCanaveral/8851/radiometric.html>.

[*Thanks to Tim Thompson and John Lynch for alerting NCSE to these sites.*]

Biochemical "Black Box" on NPR's Science Friday

The July 21, 2000, edition of National Public Radio's *Talk of the Nation - Science Friday* featured historian of science Edward J Larson, Brown University biologist Ken Miller, and Lehigh University biochemist Michael Behe.

A highlight of the program was Miller's challenge to Behe to debate intelligent design in front of an audience of scientists. Miller suggested that this debate be held either at an annual meeting of the American Society for Biochemistry and Molecular Biology (to which Behe belongs) and/or the American Society for Cell Biology (to which Miller belongs). Behe accepted.

Science Friday has posted suggested readings, internet links, and a link to the RealAudio recording of the show on the World Wide Web at <http://www.sciencefriday.com/pages/2000/Jul/hour2_072100.html>.

[*Contributed by Gary L Bennett.*]

Dissecting the Disclaimer

Kenneth R Miller
Brown University

Recently the state of Oklahoma almost adopted a disclaimer to be placed in science textbooks that mention evolution and are used by public schools in the state. (*See* RNCSE *1999; 19 [5]: 7-8, 1999; 19 [6]: 11-2, and 2000; 20 [1-2]: 21.*) *RNCSE* readers will recognize that the wording of the Oklahoma disclaimer is taken directly from the infamous original textbook disclaimer proposed for textbooks in Alabama (*see* NCSE Reports *1995; 15 [4]: 10-1*). Unfortunately, the disclaimer is laden with scientific inaccuracies and distortions that will confuse students about the nature of science and the science of evolution. Such statements place an unwelcome burden on teachers, who must correct this misinformation for their students. They also introduce the dangerous precedent of setting official statements by public officials at odds with scientific accuracy and good educational practice.

What follows is a line-by-line analysis of the scientific accuracy of the disclaimer. The text of the disclaimer is set in boldface type, and my commentary is in plain type.

Message from the [Oklahoma] State Textbook Committee:

This textbook discusses evolution, a controversial theory, which some scientists present as scientific explanation for the origin of living things, such as plants and humans.

This statement is a deliberate attempt to mislead young readers about the scientific standing of evolutionary biology. Within the scientific community, evolution is anything but controversial. Rather, as the National Academy of Sciences states, evolution is "the most important concept in modern biology" (NAS 1998, viii). Saying that "some" scientists present evolution as the explanation for the origin of species is equally misleading. It is like saying that "some" scientists believe that matter is composed of small units they call atoms. That statement would also be true, but would convey a false sense of uncertainty regarding atomic theory. A more accurate statement would tell students that evolution is accepted by the vast majority of life scientists around the world, and by every leading scientific organization in the United States including the National Academy of Sciences, as the best available explanation for the origin of species.

No one was present when life first appeared on earth.

Absolutely correct.

Therefore, any statement about life's origins should be considered as theory, not fact.

This statement manifests a serious misunderstanding of the scientific usage of the terms "theory" and "fact". A *theory* in science is an explanation of a natural phenomenon, and a *fact* is a confirmed observation. An example of a fact would be that there is great consistency in the sequence of fossils in the fossil record, with no major branch of the tree of life being out of order (for example, fossils of mammals are never found in the Devonian Period — a time marked by the diversification of bony fishes and the appearance of the first amphibians and insects). Another fact is that living species tend to be found where their fossil ancestors are also found. We make sense of these and many other confirmed observations, or facts, with the explanation that living things share common ancestors, from which they have diverged. This explanation is the theory of evolution, an extremely strong and well-supported theory. The disclaimer will confuse students about these important elements of science. Theories explain facts, and contrary to the impression given by the disclaimer, this means that theories are more important than facts.

The disclaimer also will confuse students about the nature of science by implying that science concerns only directly observable phenomena. Actually, many scientific discoveries are made about phenomena that are not directly observable, such as those that are too far away (astronomy) or too small (particle physics), as well as those that occurred in the past (geology and evolutionary biology). That "no one was there to see it" does not mean that it cannot be studied scientifically or that we cannot have confidence in our explanations.

Ironically, well-written science

textbooks place even *less* confidence in current ideas about how life may have originated than the disclaimer does. Typically, ideas about the origin of life are regarded as *hypotheses*, placing them a rung lower on the scientific hierarchy of ideas than the textbook committee was willing to do. (A typical example is this: "How then did life begin? ... Although several *hypotheses* have tried to explain how life may have arisen, we may never know the answers" [Miller and Levine 1998, 398].) The disclaimer makes a serious error by elevating current hypotheses about the origin of life to the status of theories (which would mean that they are generally accepted by the scientific community).

The word evolution may refer to many types of change. Evolution describes changes that occur within a species. (White moths, for example, may evolve into gray moths.) This process is microevolution, which can be observed and described as fact.

Evolutionary biologists use "microevolution" to refer to the processes (most of them having to do with genetics) that produce evolutionary changes in populations of species: natural selection, mutation, migration, genetic drift, and other mechanisms. The writers of the disclaimer apparently share this definition, and are correct in noting that we can observe these processes at work.

Evolution may also refer to the change of one living thing into another, such as reptiles into birds. This process, called macroevolution, has never been observed and should be considered a theory.

Here the writers of the disclaimer do not use the scientific meaning of the crucial term. "Macroevolution", for evolutionary biologists, refers to a range of processes having to do with the pattern of evolutionary change: how groups are related to one another above the level of the species, rates of evolutionary change, the behavior of lineages over time, and so forth. But in the disclaimer, the term "macroevolution" means merely the general principle of evolution: that living things have descended with modification from common ancestors. This is not what macroevolution means in science, and to use the term as a synonym for evolution misleads and confuses students.

Clearly, the writers of the disclaimer want students to reject the idea that living things have a common ancestry, and they are in the bind of having to accept well-understood and widely-demonstrated processes of evolutionary change, which, over time, would result in evolution. The reason for this is at bottom a sectarian religious belief known as "special creation": that all living things were created in their present form and did not descend with modification from common ancestors. Special creation is not supported by science — regardless of how the authors of the disclaimer attempt to redefine scientific terms.

Evolution is not rigidly divided into 2 types of change — microevolution and macroevolution — as the disclaimer implies. Macroevolution, for example, may be used to refer to the process of speciation, to major evolutionary transformations, or both. Most importantly, it is commonly accepted among evolutionary biologists that microevolutionary changes (whether caused by natural selection or by genetic drift) can accumulate so as to cause reproductive isolation, hence leading to speciation or macroevolution. Has macroevolution "never been observed"? A recent study (Reznick and others 1997) evaluated the *observed* rates of evolutionary change in populations of guppies (*Poecilia reticulata*) in the wild. The rates of evolutionary change observed were "up to 7 orders of magnitude greater than rates inferred from the paleontological record." In other words, field studies of natural selection show rates of change easily more than large enough to account for the macroevolutionary changes documented in the fossil record. This is just one of many studies that cast serious doubt on the assertion that macroevolution has "never been observed." The researchers also note: "Our work cannot address the efficacy of mechanisms other than natural selection, but it extends our understanding of what is attainable through this process. It is part of a growing body of evidence that the rate and patterns of change attainable through natural selection are sufficient to account for the patterns observed in the fossil record" (Reznick and others 1997: 1936).

Evolution also refers to the unproven belief that random, undirected forces produced a world of living things.

This statement is false on 2 counts. Evolution is not a "random" process, and to characterize it as such seriously misleads students. Natural selection, the most important force driving evolutionary change, is not random at all, but an observable, verifiable process that fine-tunes variation in populations of a species to the demands of the environment in which they live. It is true, of course, that variation in a species arises from sources such as mutation and sexual recombination, which are inherently unpredictable. Therefore evolution, like any historical process, can be *influenced* by random forces.

But a larger problem with this statement is the attribution to evolution of an idea outside of science. Whether evolution is "undirected" or "directed" is a matter for theology or philosophy, not of sci-

ence. Writers of the disclaimer wish for students, most of whom are religious, to believe that acceptance of evolution is incompatible with faith. This is demonstrably false: far too many scientists (and clergy) accept both evolution and a God who creates through evolution. Students should not be taught that evolution equates with atheism, yet, incredibly, that is exactly what this portion of the disclaimer says.

There are many unanswered questions about the origin of life which are not mentioned in your textbook, ...

It is absolutely true that there are "many unanswered questions about the origin of life", and most biology textbooks point this out in far greater (and more accurate) detail than does the disclaimer. Indeed, there are unanswered questions in each and every area of biology, making biology an exciting and vigorous discipline. The disclaimer, however, does not seek to draw student attention to unanswered questions in biochemistry, ecology, or physiology; it singles out evolution for special attention, as if it had special difficulties that other fields do not.

Scientifically, this is not correct, and the next few sentences of the disclaimer show just how badly informed its authors were:

... including: Why did the major groups of animals suddenly appear in the fossil record, known as the Cambrian Explosion?

This question seriously misleads students about the actual natural history of this planet. The term "major group" lacks scientific meaning. Many students, for example, might regard the mammals as a major group. Mammals, however, did not appear during the Cambrian explosion, but rather in the Triassic, nearly 300 million years later. The same can be said of birds, insects, reptiles, and amphibians, each of which is a major group in the ordinary meaning of the term, and none of which appeared in the Cambrian period. Clearly, the authors of the statement could have prevented such confusion by referring only to the animal *phyla* instead of "major groups".

Unfortunately, even if they had done so, the question would still be misleading. Not all animal phyla originated during the Cambrian. Compounding this serious mistake, the authors of the disclaimer seem to be unaware that the first multicellular animals appeared on earth during the Ediacaran Period, and many predate the Cambrian by more than 100 million years.

Why have no new major groups of living things appeared in the fossil record in a long time?

This peculiar question requires students to determine what is meant by a "major group" and also what is meant by "a long time". Neither term, of course, has any scientific meaning. One might regard 100 years as a long time, and it is indeed true that no new phyla have originated in the last 100 years. However, by standards of geologic time, one of the most important "major groups of living things" did indeed originate recently. Flowering plants (the Anthophyta) appeared for the first time in the Cretaceous, roughly 125 million years ago. Flowering plants appeared only in the last 3% of the 4.5 billion years of the planet's geologic history, which certainly qualifies as recent. Therefore, this question, which overlooks the recent evolutionary appearance of flowering plants, makes blatantly wrong presuppositions.

Why do major groups of plants and animals have no transitional forms in the fossil record?

This question also makes blatantly wrong presuppositions. The fossil record is, in fact, replete with splendid examples of transitional forms, as the National Academy of Sciences has taken pains to point out:

> So many intermediate forms have been discovered between fish and amphibians, between amphibians and reptiles, between reptiles and mammals, and along the primate lines of descent that it often is difficult to identify categorically when the transition occurs from one to another particular species. Actually, nearly all fossils can be regarded as intermediates in some sense; they are life forms that come between the forms that preceded them and those that followed (NAS 1999: 21).

How did you and all living things come to possess such a complete and complex set of instructions for building a living body?

This is an excellent question, and students would be well-advised to keep it in mind as they study biology. They may wonder why, for example, the "complex set of instructions" referred to by this sentence includes the genetic remnants of an ancient infection by an HIV-like virus. The interesting fact about these genetic remnants is that they are found not only in humans, but in our closest primate relatives, indicating that these viral DNA sequences entered the genome roughly 30 million years ago. As the investigators who made this discovery pointed out, the existence of identical sequences in closely related species is "very good evidence" that we share a common ancestry with these other primates (Yang and others 1999). As the National Academy of Sciences has written, "compelling lines of evidence demonstrate beyond any reasonable doubt that evolution occurred as a historical process and continues today" (NAS 1998, 16).

Study hard and keep an open mind. Someday you

James A Haught, editor of the Charleston (West Virginia) Gazette, was awarded a Clarion Award by the Association of Women in Communications in the category of editorial opinion in US newspapers under 100 000 circulation. Haught's editorials and columns defended the separation of church and state in a variety of ways, including outspoken opposition to recent attempts of creationists to have the Kanawha County school board advise teachers to teach the supposed evidence against evolution (see Karl D Fezer, "Juicy Fruit or spearmint in West Virginia", RNCSE 2000; 20 [1-2]: 16-9). RNCSE is pleased to reprint one of the columns for which Haught received his well-deserved award.

The Evolution Debate is about Honesty

James Haught, Charleston (WV) Gazette

During a recent evolution showdown, a visiting "creation scientist" from California repeatedly challenged me to debate, because I support the teaching of evolution. A Charleston talk radio host blistered me on the air because I would not come on his show and quarrel with the creationist professor.

But I felt it would be silly for me to argue about his supernatural beliefs. After all, I would not debate a Scientologist who asserts that all human souls are "thetans" from another planet. And I would not quarrel with a Unification Church member's claim that Jesus appeared to Master Moon and told him to convert all people as "Moonies". And I would not dispute a Mormon's belief that Jesus visited prehistoric America. And so on, and so on.

Let them all believe whatever they want. It is pointless to go on radio shows and wrangle over mystical claims. However, such claims must not be imposed on captive children in government-owned schools. That is prohibited by the separation of church and state, a core principle in the First Amendment in America's Bill of Rights.

America's time-tested freedom of religion means that every group may worship however it wishes in its own private church, but it cannot use the power of government to push its beliefs on others. Therefore it was gratifying that the Kanawha County school

may contribute to the theories of how living things appeared on earth.

At last, some excellent advice!

By any standard, this disclaimer fails even an undemanding test of scientific literacy. Twelve statements are included in the disclaimer. Of these, only 5 are free of major errors. Three are seriously misleading, and 4 are downright false. A biology teacher grading this disclaimer based on the proportion of correct answers would calculate a score of no more than 42% — a failing grade.

Our students deserve better.

To be sure, the disclaimer's admonition that students study hard and keep an open mind fits the best traditions of scientific study. But keeping an open mind does not mean that students should intentionally be taught nonsense, nor does it mean that we should pretend to know less than we do about the natural history of this planet and the origins of species, including our own. Healthy skepticism is at the core of a scientific education, but elevating falsehoods and half-truths to the status of scientific theory most definitely is not.

I would argue that any textbook, indeed, any course in the biological sciences should tell students the plain and simple truth, as announced in a single sentence by the National Academy of Sciences: that "[b]iological evolution is the best scientific explanation we have for the enormous range of observations about the living world" (NAS 1999: 28).

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[*"Dissecting the Disclaimer" is also available on the NCSE web site <www.ncseweb.org>.*]

BOOKREVIEWS

Reaping the Whirlwind

By Rosey Dow. Enumclaw (WA): WinePress Publishing, 2000. 408 pages.

Reviewed by Glenn Branch, NCSE, Berkeley CA.

Pity Trent Tyson. Five years ago his wife was accidentally shot to death, leaving him to rear their disabled daughter singlehandedly. Six months ago he was fired from the Chattanooga police force because a criminal he apprehended turned out to be a crony of the police chief. Now, living in a small town, he is in love with his shrewish landlady's daughter, who, however, piously refuses his advances because he is a freethinker. His rakish father is in town, claiming to have been brought to God by an ex-outfielder for the Chicago Cubs. Working as a deputy sheriff, Tyson is disturbed by a spate of mysterious deaths. And it is the summer of 1925, in Dayton, Tennessee, just as the Scopes trial is underway.

What Rosey Dow — an author and missionary in Grenada — offers in *Reaping the Whirlwind* is on one level simply a moderately competent genre novel. A particularly clever touch was Tyson's sweet tooth — I counted over a dozen instances of his gobbling sundaes or guzzling sodas — which provides Dow the excuse to have her detective pop in and out of Robinson's drugstore, the hub of Dayton's movers and shakers (Larson 1997, 88–9). It is also appropriate that his snacks frequently contain strawberries — in the 1920s, Rhea County was a major producer of the fruit (Larson 1997, 88). Yet the exposition is recurrently clumsy, with characters telling each other what they already know, indeed what they already know in their bones. As far as the mystery is concerned, Dow plays fair with the reader, but it is not at all difficult to spot the murderer.

The historical elements of *Reaping the Whirlwind* are at best adequate. Dow provides a bibliography of the sources on which she drew; it is clear that a major source was Edward J Larson's *Summer for the Gods*. She includes many of the more striking incidents of the trial, although often mechanically and sometimes in a way that misses the point. In Dow's humorless version of the arrival of Dudley Field Malone and Arthur Garfield Hays in Dayton, for example, she writes:

> On the edge of the platform Scopes lifted a suitcase from the stack placed there by a porter.
>
> Dr Potter called, "Hey, boy, what are you doing with those suitcases?"

---

board overwhelmingly rejected a proposal to let creationist teachers denounce evolution in class. Educated families owe thanks to 4 brave board members — Pete Thaw, Bill Raglin, Cheryle Hall and John Luoni — who withstood heavy pressure from a throng of fundamentalists.

To me, the whole issue hinges on honesty. Let me explain: Science, from a Latin word meaning knowledge, is simply a search for trustworthy facts. It is human intelligence at work. The process is honest, because every researcher's claim is challenged by other researchers. They test and retest by many methods, until a new idea fails or holds firm. (A researcher who falsifies data is a loathsome criminal in the eyes of fellow scientists.)

While some individual scientists are pig-headed, an entire field cannot be. Science goes where the evidence leads. Science is honest enough to admit mistakes. When new evidence shatters a previous assertion, the old belief is dropped or modified. No such setbacks have hit the theory of evolution.

After 140 years of research, virtually the entire scientific world now agrees that evolution is a fundamental aspect of nature. Complex animals and plants arose from earlier, simpler ones, over hundreds of millions of years. The fossil record shows it. Geological strata show it. Radioactive dating shows it. The incredible diversity of species, with variations in different locales, shows it. The uncanny similarity of organs, bones, fluids, and nerves in many animals shows it.

Evolution was proved when skimpy Indian maize was improved into today's nutritious corn. It was proved when drug-resistant bacteria grew from survivors of antibiotic treatment (survival of the fittest). ... It was proved by the clear fossil record that today's horse grew from a tiny precursor.

College biology books are filled with many more examples. All this is why evolution should be taught in public school classes along with astronomy, physics, chemistry, and other established sciences. However, a fringe of "creation scientists" — rigid religious zealots — contend that evolution never happened, because they think it disagrees with their

> Rappelyea touched the preacher's sleeve. "That's all right, Doc. That's only Scopes" (p 242).

Larson, who understands what a punchline is, writes:

> Charles Francis Potter, who accompanied Malone and Hays on the trip, became alarmed when a young man grabbed their baggage out of the open trunk [of George Rappleyea's car]. "Hey, boy, what are you doing with those suitcases?" Potter shouted. "That's all right, Doc," Rappleyea replied. "That's only Scopes" (Larson 1997, 145).

Where Dow is relying on the sources in her bibliography, she is generally accurate (although in the quotation above she is wrong about the whereabouts of the baggage). Elsewhere, however, she is not so reliable. HL Mencken's first name was not Harry, as Dow thinks, but Henry. The notorious murderess of Falls River was not Lizzie Bordon but Lizzie Borden. And it seems somewhat unlikely that in the 1920s the Chattanooga police department employed a forensic pathologist.

For a genre novel, *Reaping the Whirlwind* is astonishingly didactic — in addition to the bibliography, there are several appendices of materials related to the Scopes trial, an index, and a foreword that vouches that "this book is an enjoyable means of learning about one of the world's great trials" (p xiv). Perhaps — but Larson's Pulitzer-Prize-winning book is about 100 pages shorter, and a better read. Anyhow, the didactic nature of the book serves a sinister purpose, readily apparent from the front matter: the foreword is by Richard Cornelius of Bryan College (who remarks that the book "sounds a warning of the dangerous consequence of scientific theory being accepted as proven fact" [p xiv]); the acknowledgments thank Ken Ham of Answers in Genesis ("for sparking the germ of an idea"— block that metaphor! [p viii]); and the jacket blurbs include praise ("tremendous!") from the irrepressible Kent Hovind.

The creationist message of *Reaping the Whirlwind* is, if understated, present nevertheless. The most prominent spokesman for evolution is the freethinking but kindly old doctor, straight from Central Casting, Adam St Clair—whose name is reminiscent of the Fall: backwards it reveals the *clear sin* of *Adam*. The unstated comparison between Darrow and Bryan is tendentious: although both are friendly and fatherly, Darrow's manner is (Dow informs her readers) merely "a veneer of casual good humor" (p 250). Finally, the murderer (as Tyson explains on the last page) "believed in an evolutionary philosophy called eugenics ... enough to put it into practice" (p 382). Because the murderer is clearly deranged, it would be unfair to reproach Dow herself for the murderer's invalid inference from evolution to eugenics, or for the odd circumstance that several of the victims are past the age of reproduction and therefore should not compel the attention of a eugenicist bent on improving the gene pool, no matter how ruthlessly.

As if all of those creationist elements were not bad enough, the literal reading of the Book of Genesis. These people are not objective about evidence: they reject anything that supports evolution and exaggerate anything that might concur with the Old Testament.

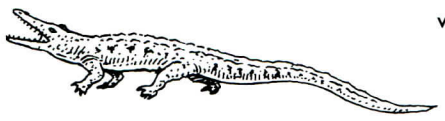
The visitor who challenged me to debate holds a doctorate in physical education and is listed as "an adjunct professor of physiology for the Institute for Creation Research" at Santee, California. He implied that he's motivated only by scientific interest — but his group's Web site <http://www.icr.org> is that of a church. It proclaims:

> We believe God has raised up ICR to spearhead Biblical Christianity's defense against the godless dogma of evolutionary humanism. ... ICR is funded by God's people ... to proclaim God's truth about origins.

The Institute for Creation Research calls itself "a Christ-focused creation ministry". It says humans were made fully developed "in the 6 literal days of the creation week described in Genesis". It says this was a "relatively recent" event, and that fossils were formed during Noah's flood. It says anyone not saved "solely" by Jesus will "be consigned to the everlasting fire prepared for the devil and his angels". In other words, a billion Muslims, a billion Hindus, and hundreds of millions of Buddhists, Jews, Baha'is, Shintoists, and so on are doomed to fry forever, according to the ICR.

Well, all this is standard fundamentalism — but it is not science, and it would be illegal to teach it in public-school science classes, especially in cosmopolitan Charleston schools containing Muslim, Jewish, Hindu, Buddhist, and Baha'i children. Maybe you can see why I chose not to debate this mentality. Incidentally, the visiting professor offered $250 000 to anyone who can prove evolution. If this column wins the reward, I'll donate it to a real science institute.

[*Reprinted from the Charleston* Gazette, *December 21, 1999, by permission.*]



book is thoroughly marred by Appendix B, in which the usual suspects — Piltdown Man, Haeckel's embryos, the dastardly geologists who date rock strata by fossils and fossils by rock strata — are dutifully paraded. Unsurprisingly, the farrago of misinformation is courtesy of Ken Ham's Answers in Genesis.

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Ride to Glory

By Warren LeRoi Johns. Brookeville (MD): General Title Inc, 1999. 416 pages.

Reviewed by Skip Evans

As a matter of principle, I finish any book I start reading. Some books are easy to finish — anything by John Irving, and John Kennedy Toole's masterpiece *A Confederacy of Dunces*, for example. Others are more difficult. No book in recent memory, or distant memory for that matter, challenged this principle more than *Ride to Glory* by Warren LeRoi Johns, a lawyer and novelist wannabe.

Ride to Glory tells the story of one Joshua Chamberlain Ryan, a double PhD candidate in geology and paleontology, who has come to the conclusion, through a careful analysis of the evidence, that the earth is no more than 10 000 years old and that descent with modification is not a valid scientific theory, but rather a collection of "horse-and-buggy myths". Throughout the book Josh continually spouts standard young-earth creationist claptrap, and in fact, many of Johns's source for Josh's diatribes are well-known creationist organizations such as the Institute for Creation Research and anti-evolutionist authors such as Michael Denton.

The plot revolves around a mock trial in which the jury is asked to "render a simple Yes or No verdict to this key issue: '*Is evolution a fact?*'"; the judge adds, "Your responsibility will be to judge Charles Robert Darwin guilty or not guilty of propagating *fact-free science*" (italics in original). The trial is staged by ace Hollywood promoter Pace Terhune. Josh is the star witness, aided by his best friend, law student JT Thomas. JT tosses fluff-ball questions at Josh, whose creationist rhetoric flows in italics, meticulously footnoted by Johns. Traci Kilburn, the new and beautiful love in Josh's life, is responsible for the completely unchallenging cross-examination.

The book fails as literature even more than it fails as science. The dialog is so contrived that it quickly became close to physically painful to read. Josh is described by one of his professors as speaking "the language of the streets". Apparently Johns has not heard any "language of the streets" since "blaxploitation" films were big in the 1970s. Much of the dialog strains at wit and then gets sprinkled with some "bros" to add that hip young attitude: "What's goin' on, Bro? You and the Montgomery County Sheriff are the only people cruisin' the scene at this outrageous hour. You oughta' be in church with the rest of the sinners... [Y]ou could use some of your granddad's preachin' to rid you of those lawyer-like flaws." Who in the world talks like that? Johns must have worn out the apostrophe on his keyboard.

The characters in the book are all completely 2-dimensional, without the slightest bit of the complexity and depth that draws us to literary characters. Joshua Chamberlain Ryan has a 4.0 grade-point average and never a doubt about his convictions or beliefs enters his mind. Traci Kilburn and JT Thomas are unfailingly witty and charming. Dr Karl Striker, "flamboyant campus scientist" and Josh's archnemesis, comes across as gruff, authoritarian and, most importantly, unbending in his religiously dogmatic approach to Darwinism. In fact, the contrast between the supporters of evolution, Striker and his minions, and the upholders of truth, Josh and his buddies, is shallow and obvious to the point of boredom. Two of Striker's underlings turn out to be pathetically nefarious characters, a drug addict and a would-be murderer who attempts to kill Josh.

Josh Ryan appears virtually faultless, which makes him unreal and not the least bit sympathetic. Likewise, Traci and JT are cut from exactly the same mold, always equipped with snappy little comebacks for any situation. When we read about fictional characters, it is often more their faults than their superlative virtues that draw us to them, because we can relate to fallible characters — except for readers who happen to be perfect themselves; but I would imagine that *that* clientele is pretty small.

The plot is so predictable that I began wishing I had taken some speed reading courses. The reader is pummeled, page after page, with tiresome, strained dialog, and such an easily predictable plot that it is possible to anticipate the story line 10, or even 100, pages later. Each plot line proceeds mechanically and unswervingly so that the story wraps up at the end like a television sitcom.

There is not space here to go into the plot in any depth, but I feel pretty sure that after the first 50 pages or so any reader can guess how just about the whole thing will turn out. Traci will accept Josh's proposal of marriage; Josh will be reunited with

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Skip Evans has been active in theater for over 10 years, as actor, director, and playwright. He performed improvisational comedy in Atlanta, Georgia, from 1995 to 1998, and has written 5 full-length plays as well as numerous short stories and essays. His first play, *The Psychopathic Librarian*, was the Best New Play at Eola Theater Company in Orlando, Florida, 1994. He currently lives in San Francisco.

his grandmother, although she dies trying to save his thoroughbred horse from a barn fire set by one of Striker's minions (who then dies in a minivan trying to escape the scene); Josh becomes a star after thoroughly refuting Darwin's theories in "Monkey II"; and JT is promised a spot at a major law firm upon his graduation from law school.

Though subtitled *An American Novel*, from my experience studying the former Soviet Union in depth, I would say that the book reads more like some kind of official propaganda. The absolute demarcation between the guys wearing the white hats and the guys wearing the black hats, and the complete lack of human conflict on any true level, drag the book to such a shallow level that it quickly runs aground; just getting to the end is a real chore.

By now you probably have the idea that I am not going to recommend that you rush right out and buy *Ride to Glory*, but if you do want to check out the story for yourself, I recommend just getting a copy of Jack Chick's notorious anti-evolution tract, *Big Daddy*. It could have easily served as Johns's first draft.

[*An excerpt from chapter 1 of* Ride to Glory *may be found at <http://www.gtibooks.com/sample.htm>.*]

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From the Big Bang to the Human Predicament: Outline of an Ultimate Evolutionary Synthesis

By Nikolai Eberhardt. Raleigh (NC): Pentland Press, 1998. 319 pages.

Reviewed by Andrew J Petto, University of the Arts, Philadelphia PA.

After nearly 30 years I still hear the admonition of Professor George Armelagos to our new class of PhD candidates on the occasion of our first course in research methods: "If the only tool you have is a hammer, then every problem looks like a nail." Eberhardt's book represents a slightly more sophisticated example of this problem — the tendency for us academics to view the entire universe of scientific study through the lens of our own disciplines. Eberhardt's goal is to provide a "unified theory of ourselves" in which the "relevant results of the natural sciences are the building blocks" (p x). A computer scientist trained as an engineer and physicist, he uses neurobiology as the ground on which to unify the natural sciences, the social sciences, and the humanities in an effort to explain "the human predicament" — the need "to understand and explain things as they really are" and not merely as "a fabric of invented stories" (p x). In particular, Eberhardt wishes to understand emotions, the mind, free will, our desire to know, how and why we came to be here, and so on — all of the ultimate questions of our existence.

This book has 3 underlying premises. First, Eberhardt is firmly convinced that finding the answers to these existential questions must begin with and be based on our knowledge of the physical universe. Everything, including the way in which our brains produce emotions and desires, must proceed according to the natural laws that govern the universe. Second, Eberhardt is convinced that intelligence as we experience it is inevitable in the universe. His weak version of the anthropic principle assumes that natural laws must produce the self-conscious intelligence that we possess. Third, Eberhardt proposes that because the human nervous system is the culmination of this inevitable natural process, the answers to life's existential questions will be uncovered in the study of neurobiology.

The book begins with a review of cosmology and focuses on the emergent properties of natural systems which promote self-organization. This discussion is followed by a brief review of natural selection and the role that cognitive abilities may play in adaptation and evolution. These sections are adequate, though brief, but tinged with a progressive view of evolution that pervades the book. For example, he writes that the level of emergence of an evolved life form is measured by "the degree of adaptive modification that can be accomplished by the nervous system" (p 17). Eberhardt does not shy away from the rankings ascribed to organisms in the Great Chain of Being and is not reluctant to label organisms as "higher" and "lower" on the scale; we — *Homo sapiens* — are clearly the "highest" in Eberhardt's scheme.

The greater part of the book is an explanation of the history and state of our knowledge in the cognitive sciences. It mixes information theory with current research on artificial intelligence and Eberhardt's unique view of the inevitable unfolding of the laws of the universe. One of the book's great strengths is its treatment of the physiology of the nervous system and of recent research into self-sustaining and self-organizing artificial neural networks. However, the intermingling of Eberhardt's philosophical views and logical leaps is distracting. The reader has to work hard to reconstruct the pathway from the research results Eberhardt describes to the conclusions he draws; sometimes no amount of work makes this pathway clear. The reader feels like Indiana Jones in search of the Holy Grail, leaping onto an invisible bridge that he must believe is there in order for it to bear his weight.

The scaffolding that underlies Eberhardt's convictions is a variety of progressivism. For Eberhardt, evolution means progress, progress means organismal complexity (read: multicellularity and tissue specialization), and complexity means above all an advanced and highly coordi-

nated neurological mechanism. One can dispute this view in theoretical terms, but in practice the view that less "complex" organisms lack the essential emergent properties of an evolved life form would provoke vigorous disagreement from a wide range of biologists — particularly botanists and those who study protists and protoctists. Eberhardt's progressivist views lead him to deny that organisms can exhibit an advanced degree of adaptive modification through some aspect of organismal physiology other than a complex nervous system.

Ultimately, it is the difficulty in following Eberhardt's unique line of reasoning that undermines the book. Readers can read elsewhere more accessible treatments of the evolution of nervous systems and more lucid discussions of the evolutionary implications of organismal complexity and specialization without all the tenuous connections to an idiosyncratic "ultimate evolutionary synthesis" — and they should.

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Evolution (2nd edition)

by Colin Patterson.
Ithaca (NY): Cornell University Press, 1999. 153 pages.

Reviewed by Karen Bartelt

In 1981, paleontologist Colin Patterson spoke at the American Museum of Natural History. Later he said that in his talk, "I put a case for [the] difficulties and problems with evolution, specifically in the field of systematics. I was too naïve and foolish to guess what might happen: the talk was taped by a creationist who passed the tape to [creationist] Luther Sunderland. ...I was putting a case for discussion, as I thought off the record, and was speaking only about systematics, a specialised field" (Fezer 1984: 5).

Snippets from this unauthorized taping (of which no authorized transcript exists; see Strahler 1987) have been making the rounds of anti-evolutionist publications since Luther Sunderland and Gary Parker's 1982 *Impact* article. They have popped up in many subsequent issues of ICR's *Impact* (for example, Buckna and Laidlaw 1996) and routinely appear in anti-evolutionist articles and web sites (for example, Lenard 2000). Patterson was also featured in a 1996 article in the journal *Origins and Design* (Nelson 1996), a venue devoted to "intelligent design theory", which included 9 of his quotations that supposedly manifest what Nelson calls Patterson's "agnosticism about evolution".

Fast forward to 1999; if ever he was, Patterson is agnostic about evolution no more. All opportunities for anti-evolutionist innuendo and misstatements are put to rest in the second edition of *Evolution*. Sadly, Patterson died 3 days after delivering the manuscript to the publisher; 2 of his colleagues (Peter Forey and James Mallet) made some minor revisions and did the final editing.

The book is a concise, lucid introduction to evolutionary biology for the layperson. Among the valuable resources is a discussion of molecular biology that contains references to 1996 and so is fairly up to date. The drawings and charts make the text easier for a nonspecialist to follow.

I really appreciated the discussion of hemoglobin. Patterson reports that 550 mutations of human hemoglobin have been described (including substitutions, deletions, and additions), and that 1 human in 2000 carries a mutant hemoglobin. The "Tak" and "Saverne" mutations add 10 amino acids each to the beta hemoglobin chain, while the "McKees Rocks" mutation shortens the same chain by 2 amino acids. This is a powerful argument against the anti-evolutionist mantra of "mutations are bad", because, as Patterson notes, "none inhibits development and most produce no detectable physical symptoms" (p 29).

Patterson also focuses on homology at the molecular level, especially as it applies to the evolution of hemoglobin. There is a good discussion of gene duplication, the relationship of the hemoglobin pseudogenes to the active genes, and some nice gene histories showing hemoglobin relationships among primates and other mammals. Patterson finds Motoo Kimura's neutral theory of evolution quite appealing and returns to it frequently. If one is looking for a pithy comment to counter anti-evolutionist claims, try Patterson's conclusion that "[I]n genetic terms we are hardly more distinct from chimpanzees than are subspecies in other groups of animals" (p 113).

Though an interesting introduction to evolutionary biology, the real strengths of this book are in its final chapters and preface, where Patterson explains his ideas about evolution and comments on creationism and (indirectly) on the 1981 taping of his talk. Clarifying his views on evolution in the preface to the second edition, Patterson says:

> The knowledge in my first edition came from education and indoctrination; it was that neo-Darwinism is certainty. The knowledge in this second edition comes more from working things out for myself; it is that evolution is certainty. And part of the ignorance in the first edition concerned the difference between neo-Darwinism and evolution, whereas the ignorance in this edition is of the completeness of neo-Darwinism as an explanation of evolution ... I think that belief [shared ancestry] is now

> confirmed as completely as anything can be in the historical sciences ... [but] ... I am no longer certain that natural selection is the complete explanation... (p vii).

Although Patterson considers the general theory of evolution ("evolution has occurred") to be a historical theory and hence "by some definitions" not a part of science because it deals with unrepeatable events, he acknowledges that it does have rules, does make general predictions, and is open to disproof. Furthermore, evolution has survived a series of severe tests unimaginable to Darwin — including its consistency with genetics, the universality of DNA, and "the evidence from DNA sequences of innumerable 'vestigial organs' at the molecular level" (p 117).

Patterson concludes, "[i]n terms of mechanism ... the neutral theory of molecular evolution is a scientific theory; it can be put into law-like form: changes in DNA that are less likely to be subject to natural selection occur more rapidly. This law is tested every time homologous DNA sequences are compared. ... But neutral theory assumes (or includes) [the] truth of the general theory — common ancestry or Darwin's 'descent with modification' — and 'misprints' shared between species, like the pseudogenes or reversed *Alu* sequences, are (to me) incontrovertible evidence of common descent" (p 119).

Creationism itself receives only a few pages, which include Patterson's response to the taping: "Because creationists lack scientific research to support such theories as a young earth ... a worldwide flood ... or separate ancestry for humans and apes, their common tactic is to attack evolution by hunting out debate or dissent among evolutionary biologists. ... I learned that one should think carefully about candor in argument (in publications, lectures, or correspondence) in case one was furnishing creationist campaigners with ammunition in the form of 'quotable quotes', often taken out of context" (p 122).

Perhaps the best audience for this book would be anti-evolutionists. Not only could they learn about the evidence for evolution at the molecular level, but they might be inspired to correct the inaccuracies about the late Dr Patterson that abound on their web sites.

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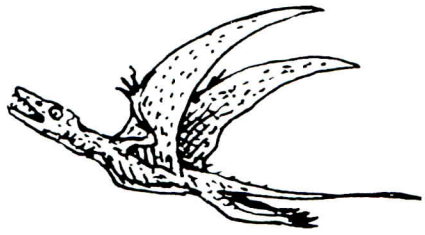

Darwin and the Millennium

Compiled by Glenn Branch

Millennia end neither with bangs nor with whimpers, neither in fire nor in ice, but with lists. Not everyone is quite so enthusiastic about Darwin as is the philosopher Daniel C Dennett, who memorably wrote: "If I were to give an award for the single best idea anyone has ever had, I'd give it to Darwin" (Dennett 1995, 21). Darwin's place in the millennial list-making frenzy is secure nevertheless, as the following lists suggest.

Amazon.com®: Millennium Books *(as voted by customers)*

1. JRR Tolkien, *The Lord of the Rings*
2. Margaret Mitchell, *Gone With the Wind*
3. Harper Lee, *To Kill a Mockingbird*
4. JD Salinger, *The Catcher in the Rye*
5. JK Rowling, *Harry Potter and the Sorcerer's Stone*
6. Stephen King, *The Stand*
7. James Joyce, *Ulysses*
8. Ayn Rand, *Atlas Shrugged*
9. John Steinbeck, *The Grapes of Wrath*
10. George Orwell, *1984*
11. F Scott Fitzgerald, *The Great Gatsby*
12. JRR Tolkien, *The Hobbit*
13. Ayn Rand, *The Virtue of Selfishness*
14. Frank Herbert, *Dune*
15. Jane Austen, *Pride and Prejudice*
16. William Shakespeare, The Complete Works
17. William Shakespeare, *Hamlet*
18. Leo Tolstoy, *War and Peace*
19. Tim F LaHaye and Jerry B Jenkins, *Left Behind*
20. Joseph Heller, *Catch-22*
21. **Charles Darwin, *The Origin of Species***
22. John Irving, *A Prayer for Owen Meany*
23. Frank McCourt, *Angela's Ashes*
24. Ayn Rand, *The Fountainhead*
25. Douglas Adams, *The Hitchhiker's Guide to the Galaxy*

(Source: <http://www.amazon.com/exec/obidos/subst/features/c/century/millennium-books-1-25.html>, last accessed February 26, 2000.)

BBC Online: Who was your choice for the greatest man of the last 1000 years?

1. Mahatma Gandhi
2. Leonardo da Vinci
3. Jesus Christ
4. Nelson Mandela
5. Sir Isaac Newton
6. Albert Einstein
7. Martin Luther King
8. Sir Winston Churchill
9. **Charles Darwin**
10. Karl Marx

(Source: <http://news.bbc.co.uk/hi/english/static/events/millennium/dec/winner.stm>, last accessed February 26, 2000.)

BBC Online: Who was your choice for the greatest thinker of the last 1000 years?

1. Karl Marx
2. Albert Einstein
3. Sir Isaac Newton
4. **Charles Darwin**
5. Thomas Aquinas
6. Stephen Hawking
7. Immanuel Kant
8. René Descartes
9. James Clerk Maxwell
10. Friedrich Nietzsche

(Source: <http://news.bbc.co.uk/hi/english/static/events/millennium/sep/winner.stm>, last accessed February 26, 2000.)

BBC Radio: British Personality of the Millennium

1. William Shakespeare — 11 717 votes
2. Winston Churchill — 10 957 votes
3. William Caxton — 7 109 votes
4. **Charles Darwin** — 6 337 votes
5. Isaac Newton — 4 664 votes
6. Oliver Cromwell — 4 653 votes

(Source: <http://www.sunday-times.co.uk/news/pages/tim/2000/01/01/timnwsnws06005.html?1208683>, last accessed February 26, 2000.)

Biography: Most Influential People of the Past 1000 Years

1. Johann Gutenberg
2. Isaac Newton
3. Martin Luther
4. **Charles Darwin**
5. William Shakespeare
6. Christopher Columbus
7. Karl Marx
8. Albert Einstein
9. Nicolaus Copernicus
10. Galileo Galilei

(Source: <http://www.biography.com/features/millennium/>, last accessed February 26, 2000.)

David Herbert Donald: The Ten Most Significant Events of the Second Millennium

1. Invention of gunpowder (in the West), early 1300s
2. The Black Death devastates Europe, 1347–51
3. Johann Gutenberg uses movable type to print early Bibles, circa 1455
4. Christopher Columbus reaches America, 1492
5. Watt perfects his steam engine, 1775
6. The American Revolution, 1775–1783
7. **Charles Darwin publishes *The Origin of Species*, 1859**
8. Henry Ford begins commercial development of the automobile, 1903
9. The First World War, 1914–1918
10. Dropping of the atomic bomb on Japan, 1945

(Source: *The World Almanac and Book of Facts 2000*, Mahwah (NJ): World Alamanac Books 1999, 35.)

Agnes Hooper Gottlieb, Henry Gottlieb, Barbara Bowers and Brent Bowers: The Men and Women Who Shaped the Millennium

1. Johannes Gutenberg
2. Christopher Columbus
3. Martin Luther
4. Galileo Galilei
5. William Shakespeare
6. Isaac Newton.
7. **Charles Darwin**
8. Thomas Aquinas
9. Leonardo da Vinci
10. Ludwig van Beethoven

(Source: *1000 Years, 1000 People: Ranking the Men and Women Who Shaped the Millennium*, New York: Kodansha America, 1998).

Michael H Hart: The Most Influential 20 Persons in History

1. Muhammad
2. Isaac Newton
3. Jesus Christ
4. Buddha
5. Confucius
6. St Paul
7. Ts'ai Lun
8. Johann Gutenberg
9. Christopher Columbus
10. Albert Einstein
11. Louis Pasteur
12. Galileo Galilei
13. Aristotle
14. Euclid
15. Moses
16. **Charles Darwin**
17. Shih Huang Ti
18. Augustus Caesar
19. Nicolaus Copernicus
20. Antoine Laurent Lavoisier

(Source: *The 100: A Ranking of the Most Influential Persons in History*, rev ed, Citadel Press, 1992.)

Life: Top 100 People of the Millennium

1. Thomas Edison
2. Christopher Columbus
3. Martin Luther
4. Galileo Galilei
5. Leonardo da Vinci
6. Isaac Newton
7. Ferdinand Magellan
8. Louis Pasteur
9. **Charles Darwin**
10. Thomas Jefferson

(Source: <http://www.pathfinder.com/Life/millennium/people/09.html> [for Darwin specifically], last accessed February 26, 2000.)

Life: Top 100 Events of the Millennium

1. Gutenberg's Bible, 1455
2. Columbus reaches the New World, 1492
3. Luther posts the 95 Theses, 1517
4. Watt perfects his steam engine, 1769
5. Galileo discovers the moons of Jupiter, 1610
6. Koch discovers the microbe that causes tuberculosis, 1882
7. Gunpowder weapons are developed in China, circa 1100
8. The Declaration of Independence is adopted, 1776
9. Hitler becomes chancellor of Germany, 1933
10. Compasses are used for navigation in China, 1117
11. Edison builds his laboratory in Menlo Park, 1876
12. The earliest African slaves arrive in the New World, 1509
13. Jenner invents inoculation against smallpox, 1796
14. The first television broadcast, 1928
15. **Darwin publishes *The Origin of Species*, 1859**
16. The bombing of Hiroshima and Nagasaki, 1945
17. Ford unveils the Model T, 1908
18. The First Crusade, 1095
19. The Magna Carta, 1215
20. The first telephone transmission, 1876

(Source: <http://www.pathfinder.com/Life/millennium/events/15.html> [for Darwin specifically],last accessed February 26, 2000.)

Philip and Phylis Morrison: 100 or so Books that shaped a Century of Science

[in the biography section]

1. **Charles Darwin, *Autobiography* (1950)**
2. [G] H Hardy, *A Mathematician's Apology* (1940)
3. James Watson, *The Double Helix* (1968)
4. Freeman Dyson, *Disturbing the Universe* (1979)
5. Richard Feynman, *Surely You're Joking, Mr. Feynman!* (1985)

(Source: <http://www.amsci.org/amsci/bookshelf/centurylist.html>, last accessed February 26, 2000.)

MSNBC: Who are the people, for good or ill, who made us what we are today?

Of 16 895 total votes in the science and technology category:

1. Albert Einstein, 36%
2. Thomas Edison, 18%
3. Isaac Newton, 14%
4. Galileo Galilei, 6%
5. **Charles Darwin, 5%**
6. Louis Pasteur, 3%
7. Nicolaus Copernicus, 3%
8. Jonas Salk, 2%
9. James Watson and Francis Crick, 2%
10. Hippocrates, 2%

(Source:<http://www.msnbc.com/modules/Millennium_People/MillP_ SciTech.asp>, last a ccessed February 26, 2000.)

Arthur Schlesinger, Jr.: The Ten Most Influential People of the Second Millennium

1. William Shakespeare
2. Isaac Newton
3. **Charles Darwin**
4. Nicolaus Copernicus
5. Galileo Galilei
6. Albert Einstein
7. Christopher Columbus
8. Abraham Lincoln
9. Johann Gutenberg
10. William Harvey

(Source: *The World Almanac and Book of Facts 2000*, Mahwah (NJ):World Alamanac Books 1999, 35.)

Glenn T Seaborg: The Ten Greatest Scientists of the Second Millennium

(listed chronologically)

1. Leonardo da Vinci, 1452–1519
2. Isaac Newton, 1642–1727
3. Jöns Jakob Berzelius, 1779–1848
4. **Charles Darwin, 1809–1882**
5. Dmitri Mendeleyev, 1834–1907
6. Ernest Rutherford, 1871–1937
7. Albert Einstein, 1879–1955
8. Niels Bohr, 1885–1962
9. Werner Heisenberg, 1901–1976
10. Enrico Fermi, 1901–1954

(Source: *The World Almanac and Book of Facts 2000*, Mahwah (NJ):World Alamanac Books 1999, 36.)

Tom Siegfried: The Millennium's Brightest Ideas

1. (tie) **Evolution** — Laplace and **Charles Darwin**
1. (tie) Conservation of energy — Julius Mayer, Hermann Helmholtz, James Joule, and others
3. The experimental method — Francis Bacon
4. Antimatter — Paul Dirac
5. Fields — Michael Faraday and James Clerk Maxwell
6. Genes — Gregor Mendel
7. Universal gravitation — Isaac Newton
8. Non-Euclidean geometry — Lobachevsky, Bolyai, Gauss, and Riemann
9. Spacetime — Albert Einstein and Hermann Minkowski
10. Cognitive dissonance — Leon Festinger
11. Boolean logic — George Boole

(Source: Dallas *Morning News*, October 11, 1999.)

The Sunday Times *(London):* Masterworks for the Millennium

1. *Hamlet* — William Shakespeare
2. *David* — Michelangelo
3. *Pietà* — Michelangelo
4. *King Lear* — William Shakespeare
5. Sistine Chapel — Michelangelo
6. ***On the Origin of Species* — Charles Darwin**
7. The King James Bible
8. The Ring Cycle — Richard Wagner
9. The Ninth Symphony — Ludwig van Beethoven
10. The Taj Mahal

(Source: <http://www.sunday-times.co.uk/news/pages/tim/2000/01/01/timnwsnws06005.html?1208683>, accessed February 26, 2000)

The Toronto Globe and Mail: The Millennium 100

1. Albert Einstein
2. Martin Luther
3. Karl Marx (tie)
3. William Shakespeare (tie)
5. Isaac Newton
6. Adolf Hitler
7. Christopher Columbus
8. Johannes Gutenberg
9. **Charles Darwin**
10. Galileo Galilei
11. Mohandas Gandhi

(Source: <http://web.theglobeandmail.com/series/millennium100.html>, last accessed August 18, 2000)

Darwin replaces Dickens on the £10 note

The Bank of England announced that the new £10 banknotes, to be issued in the autumn of 2000, feature the bearded visage of Charles Darwin on the back. A spokeswoman for the bank said that only portraits of "people who are recognised for their contribution to their particular field" are chosen. Pictured on the old £10 banknote was Darwin's contemporary (and fellow member of the Athenaeum club), Charles Dickens.

[*See <www.itn.co.uk/Britain.brit20000517/051714.htm>, last accessed May 18, 2000.*]

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WEB LOCATIONS VISITED IN THIS ISSUE

NEWS ITEMS

TOPIC	Creationism in Colorado Charter School
OWNER	*Rocky Mountain News*
LOCATION	<http://www.rockymountainnews.com/news/0828lib5.shtml>
LAST VISIT	September 29, 2000

TOPIC	Baylor University Committee Assesses Polanyi Center
OWNER	Baylor *Lariat*
LOCATION	<http://www.baylor.edu/~Lariat/Archives/2000/20000908/art-front01.html>
LAST VISIT	September 29, 2000

TOPIC	Scopes Week in Kansas
OWNER	University of Missouri–Kansas City Law School
LOCATION	<http://www.law.umkc.edu/faculty/projects/ftrials/scopes/confspeech.html>
LAST VISIT	October 29, 2000

NCSE NEWS

TOPIC	Vote for NCSE
OWNER	Working Assets
LOCATION	<http://www.workingforchange.com/voting/index>
LAST VISIT	September 29, 2000

RESOURCES AND EVENTS

TOPIC	Geneticists Issue Policy Statement on Evolution
OWNER	Genetics Society of America
LOCATION	<http://www.faseb.org/genetics/gsa/policies/p-gsa-01.htm>
LAST VISIT	September 29, 2000

TOPIC	Retrospective on the Scopes Trial
OWNER	National Public Radio (Talk of the Nation *Science Friday*)
LOCATION	<http://www.sciencefriday.com/pages/2000/Jul/hour2_072100.html>
LAST VISIT	September 29, 2000

INSTRUCTIONS FOR CONTRIBUTORS

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

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

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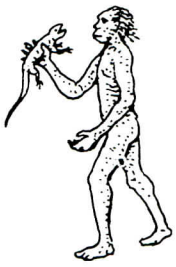

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