December 7, 2003

The Honorable Cheri Pierson Yecke, Ph.D.
Commissioner of Education
Minnesota Department of Education
1500 Highway 36 West
Roseville, Minnesota 55113-4266

Subject: Minnesota Science Standards Minority Report

A Call for Common Ground on Evolution, Not Polarization

Dear Commissioner Yecke,

The signers of this minority report applaud the effort of our fellow science committee members. With the exception of the treatment of evolution, we are confident these new standards will help increase the quality of education for Minnesota students.

However, we remain deeply concerned that the proposed standards fail to require students to learn enough information about evolution to be able to understand the theory's weaknesses as well as its strengths. Unfortunately, this completely one-sided approach to evolution lowers the quality of science education and is more likely to polarize Minnesotans than unify them.

The polarization will get even worse once the public sees the way in which stakeholder input on the evolution issue was largely disregarded during the development of the standards. Contrary to state law, the final draft standards ignore the vast majority of citizen input about evolution submitted during extensive public hearings. The standards also ignore the recommendations of one of the official outside science reviewers who evaluated the first draft of the standards. Finally, they ignore guidance from the U.S. Congress in the No Child Left Behind Act Conference Report, which urged schools to teach "the full range of scientific views that exist" about controversial topics "such as biological evolution."

Because of these problems of both process and content, we urge the legislature to adopt the following improvements in two of the existing benchmarks (new language in bold):

9-12, IV. Life Science, E. Biological Populations Change Over Time, benchmark 4:

> "Students will understand that species change over time and **be able to distinguish how** the term biological evolution is used to describe **changes within existing species (microevolution) as well as the emergence of new species and changes above the species level (macroevolution).**"

9-12, IV. Life Science, E. Biological Populations Change Over Time, benchmark 5:

> "Students will use biological evolution to explain the diversity of species, **and will be able to describe how scientists continue to critically analyze aspects of evolutionary theory.**"

Incorporating these changes will bring Minnesota's standards up to date with current discussions going on in the science community. Students should know what many scientists acknowledge, that a robust debate about the mechanisms of evolution is currently under way within biology. Far from breaking new ground, similar language has already been adopted unanimously by the Ohio State Board of Education, which has required Ohio students to know "how scientists continue to investigate and critically analyze aspects of evolutionary theory."

These proposals are an effort to get beyond the extremes that often dominate the public debates over evolution. On the one hand, some critics of evolution insist that religious accounts be presented in science classes. On the other hand, some evolutionists seem to think that the theory of evolution should be taught like an unquestioned article of faith. We agree with evolutionists that the state should not try to insert religion into biology classes. We are willing to concede as well that the state should not mandate the teaching of scientific alternatives to Darwinian theory. But some evolutionists go too far when they insist that evolution should be taught completely without criticism. There is no valid reason to shield students from scientific criticisms that are being raised about key parts of evolutionary theory in the peer-reviewed science literature. It seems to us that the concerns raised by many Minnesotans during the hearing process can be accommodated by informing students about some of the legitimate *scientific* (rather than religious) debates over evolutionary theory. This modest approach will spark student curiosity, promote critical thinking, and assure the many Minnesotans who have raised concerns that biology classes will engage in education rather than indoctrination.

Adopting these improvements will help teach students of science the skills of analysis and critical deliberation that are central to a quality education and the practice of democratic citizenship. In summary, these changes will allow teachers to cover evolution in an intellectually honest and scientifically accurate manner. Students need to know about the theory of evolution in order to be scientifically literate, but they need to learn about it in a way that promotes continuing inquiry and analysis, not dogmatism.

Supporting Justifications

1. **Concerns raised by the overwhelming majority of parent/citizen testimony on the evolution issue have been ignored.** As proof, compare the evolution standards in Draft #1 to Draft #2. An overwhelming majority of the parents who testified at the 14 public hearings around the state and those who submitted written comments expressed concern with the dogmatic presentation of evolution. These views can not be dismissed as a "fringe group of radicals," as broad public polls show that a majority of people want to see scientific evidence for and against evolution presented to students.
2. **State law requires that the new standards take into account the views of parents: "**Sec. 3. [120B.021] [REQUIRED ACADEMIC STANDARDS.] Subd. 2. [STANDARDS DEVELOPMENT.] (a) The commissioner must consider advice from at least the following stakeholders in developing statewide rigorous core academic standards in ….. science…..: (1) parents of school-age children and members of the public throughout the state…" (emphasis added)
3. **The current draft standards completely ignore the recommendations of the only state solicited science expert who offered specific improvements to the standards' treatment of evolution.** As an expert in the behavior of complex carbon molecules, Dr. Macosko is very qualified in the area of origins and evolution. (See attached letter from University of Minnesota Professor Christopher Macosko.)
4. **Efforts in the writing committee to propose improvements to the evolution standards were blocked because some committee members claimed—wrongly—that previous agreements prevented them from considering changes to the evolution standards.** The only agreement made in the previous large group concerned limiting changes to just one benchmark, and the entire group turned down the opportunity to place any other limitations on the writing committee.
5. **The current draft's treatment of evolution is inconsistent with the "History and Nature of Science" standards contained in the same Draft #2.** For example, one History and Nature of Science benchmark reads: "The student will be able to explain how scientific and technological innovations as well as new evidence can challenge portions of or entire accepted theories and models including but not limited to cell theory, atomic theory, theory of evolution, plate tectonic theory, germ theory of disease, and big bang theory." Yet the current evolution standards do NOT in fact ask for students to learn new evidence that challenges portions of the theory of evolution.
6. **The current evolution standards are out of compliance with the report language of the federal No Child Left Behind Act, which urges the adoption of science curriculum that "help[s] students to understand the full range of scientific views that exist" about controversial subjects "such as biological evolution."**
7. **Special attention is justified for the subject of evolution because it is arguably the most misunderstood and controversial subject in science education.** These

improvements will also help offset the outdated and inaccurate examples still used in biology textbooks. The students of Minnesota deserve to have an accurate, current and thorough education in this important scientific subject.

8. **The current draft standards completely ignore the crucial distinction between microevolution and macroevolution.** Microevolution refers to variation within a species. There is 100% consensus in this "fact of evolution" as we see it everyday in instances like the breeding of dogs and the creation of hybrid corn seed. However, as Gilbert, Opitz, and Raff have stated, "Microevolution looks at adaptations that concern only the survival of the fittest, not the arrival of the fittest." The consensus disappears when discussions turn to macroevolution or the development of new species, new body plans and unique organs. Many scientists now question the mechanism generating the large amount of change required to account for the completely novel organs or body plans that suddenly emerge in the fossil record. Failing to inform students about the distinction between microevolution and macroevolution is poor science education, and our students deserve better.

Respectfully Submitted,

Duane Quam – Chair, Writing Committee
Kathryn Duffield – Member, Writing Committee
Dave Eaton – Member, Writing Committee
Heather McKinley –Member, Writing Committee

For more information, contact Dave Eaton, 952-470-8675, dmeaton@msn.com.

Attachment:

October 6, 2003

The Honorable Cheri Pierson Yecke, Ph.D.
Commissioner of Education
Minnesota Department of Education
1500 Highway 36 West
Roseville, Minnesota 55113-4266

Dear Commissioner Yecke,

Thank you for the work that you are doing to revise the Minnesota Science Standards. This is an excellent opportunity for all of us to evaluate what is being taught to our K-12 students in science. I would like to offer the attached analysis of the Draft Science Standards.

Let me highlight just one of my points here: the controversy surrounding the origin of life (1.e). Most biology texts present the theory for chemical origin of life as fact. This is simply not true and the severe weaknesses, which I outline below, have been known for many years. When I ask students in my freshmen course to read papers which point out these problems many feel that they were severely mislead in their high school biology course. It is excellent practice in critical thinking and good for science for students to learn about the controversy in such an important topic.

Please forward to the science standards committee. I would be glad to elaborate on these points further or speak to the committee in person. I am forwarding this letter and my comments on to other colleagues. I am asking them to drop you a note if they agree with the attached analysis.

Thanks for your attention,

Chris Macosko

Professor, Chemical Engineering and Materials Science
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ANALYSIS OF DRAFT MINNESOTA SCIENCE STANDARDS

Public hearings are now being held around the state of Minnesota for public comment on the first draft of the proposed 9-12 science standards. Minnesotans have an important opportunity to improve and enhance those standards through their comments and testimony. While there are a number of positive features of the draft standards (especially in the area of the "History and Nature of Science"), the proposed benchmarks dealing with the theory of evolution are incomplete, failing to introduce students to the full range of scientific views and evidence on this important topic. Below is an analysis of some positive benchmarks in the initial draft as well as proposals for additional benchmarks that would strengthen how the standards cover evolution.

POSITIVE BENCHMARKS IN THE EXISTING DRAFT

The "History and Nature of Science" section of the initial draft contains many benchmark standards concerning the nature of science that promote good science education. The "Scientific World View" subsection contains a particularly important benchmark:

> Students will be able to explain how scientific innovations and new evidence can challenge accepted theories and models, including cell theory, atomic theory, theory of evolution, plate tectonic theory, germ theory of disease, Big Bang theory.

Another positive benchmark immediately follows the above cited provision:

> Students will know that scientific explanations must meet certain criteria to be considered valid, including that they must be consistent with experimental and observational evidence about nature, logical, respect the rules of evidence, be open to criticism, and report methods and procedures.

Inclusion of these two provisions is important so that students will learn that science is based on critical inquiry rather than dogmatism and that existing scientific theories should always be open to challenges from new evidence.

SUGGESTED BENCHMARK IMPROVEMENTS

Because the theory of evolution is such a central concept in the life sciences, students should be fully informed about it. They should learn not only the best evidence for the modern theory of evolution (known as "neo-Darwinism"), but also about current scientific criticisms of key tenets of the theory. Unfortunately, the draft benchmarks on evolution in the "Life Science" section do not address any scientific weaknesses of modern evolutionary theory, nor do they acquaint students with the full range of scientific views about evolutionary theory. Following are three suggestions for improving the coverage of evolution:

1. Add the following five additional benchmarks to the “Life Science” section to improve the coverage of evolution:

a. Students will be able to distinguish the different meanings of the term evolution, as well as explain the different levels of evidentiary support for each meaning.

b. Students will be able to distinguish between microevolution and macroevolution and explore the controversy over whether microevolution can be extrapolated to explain macroevolution.

c. Students will be able to explain the limits of natural selection and random mutation to explain complexity.

d. Students will be able to critically analyze the evidence for universal common ancestry.

e. Students will be able to explain the controversy surrounding the origin of life.

2. To encourage full discussion and critical thinking relating to evolution, substitute the the phrase "analyze the theory that " for, respectively, "understand," "explain how," "be able to identify," and "describe how," in the following: (a) Sub Strand E in the Life Sciences for Grades 7 through 12; (b) Grade 8, IV Life Science, Strand E, Fifth Benchmark, (c) Grade 9-12, History and Nature of Science, Strand A, Fourth Benchmark; and (d) Grade 9-12, IV Life Science, Strand B, Fourth Benchmark

3. Add the following benchmark to History and Nature of Science, Stand B beginning at an appropriate grade level:

"Students will understand the methods used to test historical hypotheses that can not be confirmed by experiment."

Brief explanations concerning these suggestions:

1.a. Students will be able to distinguish the different meanings of the term evolution, as well as explain the different levels of evidentiary support for each meaning.

“Evolution” is a term that is employed at different times to mean everything from “change over time” to “microevolution” to “universal common ancestry” to the claim that natural selection acting on random mutations has been the primary cause of the major changes that have happened in the history of life. It is important that students learn about these different meanings of the term evolution and understand the difference between empirical support for change over time and microevolution—which can be directly observed—and empirical support for universal common ancestry and the mechanisms responsible for long-term evolutionary change—which cannot be directly observed.

1.b. Students will be able to distinguish between microevolution and macroevolution and explore the controversy over whether microevolution can be extrapolated to explain macroevolution.

Microevolution refers to small intergenerational changes within existing species or gene pools, such as the acquisition of antibiotic resistance in bacteria or a change in average beak size in birds. Macroevolution refers to the process that creates innovations occurring above the species level, such as new complex organs, new body parts, or new body plans.

Natural selection often oscillates with changing conditions from year to year, and it has never actually been observed to produce new species. Furthermore, the genetic mutations that supposedly provide raw materials for selection are almost always harmful, and the rare ones that are beneficial have only been observed to produce minor biochemical changes rather than the major anatomical changes required by evolution. For these and other reasons, the simple extrapolation of microevolution to explain macroevolution is controversial, even among evolutionary biologists. Students should know why the controversy exists.

1.c. Students will be able to explain the limits of natural selection and random mutation to explain complexity.

In neo-Darwinian theory, natural selection improves the function of an existing system gradually, step by step, with no thought for its future utility. According to some biologists, however, "irreducibly complex" systems present a problem for neo-Darwinian theory. An irreducibly complex system is one that functions only when several well-matched parts, all working together, are present; some examples are the human blood clotting cascade, intracellular transport systems, and the bacterial flagellum. Since a partially assembled irreducibly complex system has no function at all, it cannot be improved by natural selection, and thus poses a problem for neo-Darwinian theory.

Students should know the evidence and scientific arguments for and against the sufficiency of neo-Darwinian theory. In particular, they should be encouraged to evaluate critically various claims about the power or limitations of natural selection and genetic mutation.

1.d. Students will be able to analyze critically the evidence for universal common ancestry.

The Darwinian view that living things in all the major kingdoms of life (such as bacteria, fungi, plants and animals) are modified descendants of a common ancestor has been challenged in recent years by a growing number of discrepancies in the molecular evidence previously thought to support that view. Students should know enough about that evidence to understand the controversy over this issue.

Evidence for the common ancestry of all animals has traditionally come from the fossil record, embryology, homology, and molecular studies. Yet the fossil record shows the major groups ("phyla") of animals appearing fully formed in a relatively short time (5-10 million years according to standard geologic dating), a phenomenon known as the "Cambrian explosion." Embryos which Darwin thought were almost identical in their early stages (thus pointing to their common ancestry) are now known to be very different. Neo-Darwinians once thought that homologous features (such as the bones in vertebrate limbs) were produced by similar genes inherited from a common ancestor, but it is now known that there is no simple correlation between genes and homology. Finally, molecular studies have not produced a consistent evolutionary tree for the animal phyla.

Students should understand that common ancestry may be true at some levels (such as the cat family), but may not be true at others (such as the major kingdoms of life). They should know enough about the evidence to be able to evaluate it critically, at least at some representative levels of the biological hierarchy.

1.e. Students will be able to explain the controversy surrounding the origin of life.

While Darwin's theory purported to explain how life could have grown gradually more complex starting from one or a few simple forms, it did not explain, nor did it attempt to explain, how life first originated.

Chemical evolutionary theory has in recent years encountered severe criticisms on many fronts. First, geochemists have failed to find evidence of the "primordial soup" required by the standard model. Second, the remains of single-celled organisms in the very oldest rocks testify that, however life may have emerged, it did so relatively quickly. Third, new geological and geochemical evidence suggests that prebiotic atmospheric conditions did not favor the production of amino acids and other essential building blocks of life. Fourth, molecular biology has revealed such great complexity in living cells that standard origin-of-life scenarios now look quite simplistic.

Even if it could be demonstrated that the building blocks of essential molecules could arise in realistic prebiotic conditions, the problem of assembling those building blocks into functioning proteins or DNA chains would remain. This problem of explaining the specific sequences—and thus the information—in biopolymers lies at the heart of the current controversy over the adequacy of materialistic explanations for the origin of life. Students should at least be aware of the controversy and why it has arisen.

2. To encourage full discussion and critical thinking relating to evolution, substitute the the phrase "analyze the theory that " for, respectively, "understand," "explain how," "be able to identify," and "describe how," in the following: (a) Sub Strand E in the Life Sciences for Grades 7 through 12; (b) Grade 8, IV Life Science, Strand E, Fifth Benchmark, (c) Grade 9-12, History and Nature of Science, Strand A, Fourth Benchmark; and (d) Grade 9-12, IV Life Science, Strand B, Fourth Benchmark

The referenced strands and benchmarks use language that suggests a close minded approach to evolution. The suggested change will encourage critical analysis that will open minds about a controversial subject.

3. Add the following benchmark to History and Nature of Science, Stand B beginning at an appropriate grade level:

"Students will understand the methods used to test historical hypotheses that can not be confirmed by experiment."

According to Ernst Mayr, a highly regarded evolutionary biologist, "Darwin introduced historicity into science. Evolutionary biology, in contrast with physics and chemistry, is a historical science – the evolutionist attempts to explain events and processes that have already taken place. Laws and experiments are inappropriate techniques for the explication of such events and processes. Instead one constructs a historical narrative, consisting of a tentative reconstruction of the particular scenario that led to the events one is trying to explain."[[Ernst Mayr, "*Darwin's Influence on Modern Thought,"* p. 80, (July 2000, Scientific American)]. Other historical sciences include certain aspects of geology, paleontology, anthropology, and archeology.

In the absence of experiment, historical scientists postulate multiple competing hypotheses about the cause of past events and seek to test a given historical hypothesis by collecting evidence that will not only rule in the hypothesis to be tested, but also rule out the reasonable competing hypotheses. [Carol Cleland, *Historical Science, Experimental Science and the Scientific Method,* Vol 29 No. 11, 987-990 (Geology, November 2001)]. According to Kenneth Miller, we "learn about the past by applying good, old-fashioned detective work to the clues that have been left behind." [Kenneth Miller, *Finding Darwin's God,* (Cliff Street Books, 1999), pp. 22-23.] Because the record of past unobserved events is often incomplete with many evidentiary gaps, historical sciences frequently yield only a "best current explanation." This benchmark would complement the second Benchmark in the same sub-strand which requires students to "give examples of how different domains of science use differing bodies of scientific knowledge and employ different methods to investigate questions."