

TESTIMONY BEFORE THE CALIFORNIA ACADEMIC STANDARDS COMMISSION

Bruce Alberts, President
National Academy of Sciences
Washington, DC

6 May 1998
Sacramento, California

1. Introduction

Thank you for the invitation to testify before the California Standards Commission. I am especially pleased to do this because I am a citizen of the state of California, presently being on leave from the University of California, San Francisco (UCSF) while serving as president of the National Academy of Sciences.

As some of you know, for years I have been passionate about improving science education, and I have established education as a dominant theme of my tenure as President of the National Academy of Sciences. This interest forms the foundation for my response and for my concern about the current direction of the California Science Education Standards.

I will base my comments on three experiences that have influenced my professional views of standards and science education. These are my participation in improving elementary school science in San Francisco; my involvement in developing the National Science Education Standards while president of the Academy; and my 20 years of experience in writing biology textbooks for college students.

While I was at UCSF, I worked actively on improving school science programs and teaching practices in the city's elementary schools. Our major project, entitled City Science, is still being supported by the National Science Foundation. As a result of this experience, I learned a great deal about students, schools, and science education. In each of San Francisco's 72 elementary schools, we worked very hard to implement hands-on programs similar to those developed here in California at the Lawrence Hall of Science. We also helped teachers to gain a greater knowledge and deeper appreciation of science. Our work left the children with a science education that went well beyond the memorization of science words and allowed them to develop an understanding and appreciation of scientific ideas and processes. There was also an added benefit to our work that was completely unexpected. This type of science helped students maintain their curiosity and interest in school, and teachers found they could use this interest as the basis for improving their learning to read, to write, and to do mathematics.

A very different experience began when I was elected president of the National Academy of

Sciences and realized that my first major challenge was to guide the development of national standards for science education. I came to understand the complexity of convening and getting input from all the science disciplines, while simultaneously reaching out to science teachers and college science educators. I also learned that scientists, science teachers, and science educators all have valuable contributions to make to the development of such standards. If one group dominates the process and the product, the standards are unlikely to have a useful effect.

2. Comments on the Present Draft Standards

Let me begin my comments about the present draft by addressing an issue that the media has constructed. The quality and importance of science standards is not contingent on which group was responsible for developing them. The propensity of the media to print stories that characterize issues as this group versus that group has done an immense disservice for science standards in California, and I must say the nation.

Despite some claims to the contrary, scientists do not have a unique competence in developing science education standards for the K-12 level. We do, of course, know science well, and our input is critical for discriminating the most fundamental concepts in science from the many facts that are less central to our understanding of the natural world. Scientists are also essential for making sure that teaching materials and standards are scientifically correct. But scientists are almost uniquely unqualified to make certain other judgments that are important when writing science education standards for all students. Scientists are people who have been highly selected for being able to learn science readily from traditional teaching methods. We must therefore rely on expert teachers and on science education researchers, especially those who have carried out well-controlled experiments with students, to tell us what methods of teaching work best for most students -- as well as which concepts are appropriate to teach to children of different ages.

As I review the draft standards for California, I realize how drastically they contrast with my experiences with exemplary science education and the lessons that I have learned over the years. If implemented in a form similar to the current draft, I predict a number of detrimental consequences for science education in California.

The current statements of standards make extensive use of the verb, know, without an explicit reference to student understanding. The unfortunate consequence of this approach is that the standards define very low levels of performance, mostly memorization and recall of knowledge. This approach supports traditional teaching, textbooks, and testing practices -- a major step backwards for the state of California. Students will be asked to recall facts and information. One of many examples is the 5th grade standard in physical science that requires students to know the names and symbols of selected common elements (H, He, C, N, O, Na, Mg, Al, Si, P, S, Cl, K, Ca, Fe, Ni, Cu, Zn, Ag, Sm, I, Pt, Au, Hg, Pd, U).

Many science concepts are presented at grades that are not appropriate for the students. For example, we know from extensive research that students in lower elementary grades cannot comprehend abstract ideas, such as atoms and molecules.

When we teach children about aspects of science that the vast majority of them cannot yet grasp, then we have wasted valuable educational resources and produced nothing of lasting value. Perhaps less obvious, but to me at least as important, is the fact that we take all the enjoyment out of science when we do so. Consider my field, for example. I have spent 30 years of my life working out the mechanisms that allow the DNA in our chromosomes to replicate. The entire DNA story is a beautiful one that should produce aesthetic enjoyment in the student when first learned. I was fortunate enough to have finished my precollege biology education before Watson and Crick unraveled this mystery with their discovery of the DNA double helix in 1953. I can therefore still remember the joy that I felt when I first learned about DNA. Unfortunately, most students today are taught about DNA at such an early age that they are forced to merely memorize the fact that DNA is the material from which genes are made, a chore that brings no enjoyment or understanding whatsoever. Much later, when they do have the background to understand both the structure of the DNA molecule and its explanatory power, I fear that the joy of discovery has been eliminated by their earlier memorization of boring DNA facts. We have spoiled a beautiful story for them, by teaching it at the wrong time.

The standards, when translated into adoption requirements for instructional materials, would preclude adoption of many excellent programs including those developed in California under the leadership of scientists at the Lawrence Hall of Science. There will instead be a regression to traditional textbooks in this state.

Professional development programs for teachers will not help teachers understand science and more actively teach it in classrooms; rather the standards will support more reading about science facts and less understanding of the fundamental concepts and processes of science.

The narrow focus of science topics will preclude students developing any understanding of scientific inquiry, the history and nature of science, or the importance of science for their lives.

In the 1983 report, *A Nation at Risk*, the primary recommendation on science teaching was that The teaching of science in high school should provide graduates with an introduction to: (a) the concepts, laws, and processes of the physical and biological sciences; (b) the methods of scientific inquiry and reasoning; (c) the application of scientific knowledge to everyday life; and (d) the social and environmental implications of scientific and technological development.

The AAAS benchmarks and the Academy's Science Standards emphasize all four of the above aspects; the current draft of the California Standards almost exclusively addresses (a).

Last but not least, the current draft standards make science seem dull and lifeless, a chore that students -- for some unexplained reason -- must be forced to learn. In marked contrast, school science can and should excite students about our understanding of the natural world that surrounds them, and it should give them the confidence that they will need in their adult life to explore this world effectively on their own. If the science standards are well designed, then every year in school could bring new excitement and insights to our students. To quote from Richard Feynman, The world looks so different after learning science, for example, trees are made of air, primarily. When they are burned, they go back to air, and in the flaming heat of the sun is released which was bound in to convert the air into tree... These are beautiful things, and

the content of science is wonderfully full of them.

In summary, the state of California has long provided important national leadership for more and better science learning in schools. I know that this Commission remains interested in making a positive contribution to science education. The proposed California Science Education Standards have the potential of stifling the improvement of student learning in science by sending the wrong message to our teachers, students, and the American public. Along with science teachers, many scientists have worked long and hard on documents such as the National Science Education Standards and Benchmarks for Science Literacy. The California standards should meet or exceed these national standards, and they currently do not.

3. Comments on the Other Reviews That Have Been Received

According to my reading, relatively few of the reviewers would disagree with my own assessment of the current draft standards, as expressed above. Some of those who have commented favorably on the current draft science standards seem to believe in the following argument: We need to have very specific sets of requirements with respect to what students should know at each grade level. Only in this way will the state of California be able to give tests that precisely match the standards at the end of every grade. This view puts the cart before the horse: We must not let the science curriculum be determined by what is easiest to test for in science exams! Instead, we must decide what it is we want children to learn about science in order to become productive adults. Once this is decided, then we must provide whatever resources are needed for the development of tests that examine the performance of students on the tasks that are important for them to learn. Much of the problem with our current mile wide and inch deep science curriculum is that it is designed to teach what is most easy to test: students for on multiple choice and fill-in-the-blanks tests: that is, the recognition of science words. It is precisely this type of science curriculum that has caused most students in today's schools to become disengaged from science learning, and to view science as completely irrelevant to their lives.

In what follows, I list some of the comments made by reviewers that I most strongly agree with:

Many reviewers point out quite correctly that many of the standards listed for grades 9-12 are totally unrealistic for most students -- and that many can be taught effectively only in the college years. This document should be revised to produce a set of grade 9-10 standards for all students, in place of the present text. These fundamental standards for high school could be supplemented, if so desired, by additional material to be learned by those more advanced students who have a particular interest in science.

Many reviewers comment that the Bloom's taxonomy references do not belong in a final draft.

There is strong support for including "overarching statements" of the type present in the AAAS and Academy standards documents, so as to pull out and emphasize the fundamental concepts.

There is strong support for not setting grade-by-grade standards for 6-8 and 9-12. In addition, I would argue for more flexibility in the K-5 years, so as to allow school districts to choose more effectively from among the large menu of excellent elementary science modules developed by the Lawrence Hall of Science, the National Science Resources Center, and others. These curricula are summarized in a book called Resources for Teaching Elementary School Science published by the National Academy Press (the full text is available without cost at www.nap.edu/readingroom/books/rtess/).

There is strong support for the Investigation and Experimentation strand. However, as Mary Price points out, Grade 5 "is the first time that student-developed questions are introduced. Question development is a skill that needs to be introduced at the very beginning and repeated at every grade level."

As many reviewers point out, a major fault in the present draft is the omission of standards that consider science and society issues. I agree that "many of the high school standards are simply irrelevant to most people" (Michael Roa), and that "the 9-12 standards are mostly a parade of facts, many of which are not useful unless the student becomes a science major in college. The implications for students under the current conditions is increased disinterest in science." (Richard Filson).

I strongly support the concise summary four-page review provided by Judi Kusnick. I find it surprising that she could have been a member of the original writing team, since her wisdom appears to have been ignored by whatever process was used to accommodate differences. A similar statement could be made about the review from Art Sussman, who is also listed as a member of this team.

4. My Recommendations on Where to Go from Here

The unambiguous conclusion that I reach, from all of the above, is that the current draft California Science Education Standards are in need of major revision. This is not only my opinion, it is the opinion of most of the reviewers and of those experts whom I most respect: notably James Rutherford from the AAAS, and the staff of one of our nations premier science education organizations -- California's own Lawrence Hall of Science.

It is also clear to me that it would not be productive to continue to use the three official consultants to your committee, since the results from their team process thus far are so discouraging. I have been told that it would be very difficult for you to enlist other paid individuals to help in this task. I therefore strongly recommend that you assign the actual task of revision to a small group of volunteers, directed by the Science Committee, who might be willing to take the next step in this crucial project without monetary compensation. It seems appropriate that individuals from the state of California be recruited for this purpose. The staff of the Lawrence Hall of Science appears to be willing to undertake much of this effort, and I recommend that they be supplemented, if possible, with some of the current reviewers who have

taken a position closely similar to mine with regard to the current draft. These might include original writing team members, Kusnick and Sussman, as well as some of the very thoughtful teacher representatives who have made comparable observations about the current draft..

My recommendation assumes, of course, that your Commission decides to request revisions along the lines that I and the majority of the reviewers have suggested.

Once a further draft has been prepared, I would be willing to recruit a team of outstanding scientists -- including as many Nobel Prize winners as you want (there are 135 Nobel Prize winners in the National Academy of Sciences) -- to check on the accuracy of the scientific concepts that are presented in your document.

I appreciate this important opportunity to testify before the Commission, and I would be pleased to answer any further questions -- either in person or by subsequent correspondence.

