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Guest Editorial

Shaking Things Up

Editor's Note: The following testimony was presented by NABT President-Elect Philip J. McCrea before a Congressional roundtable hearing convened by Congressman Vernon Ehlers of the Science and Education and the Workforce Committees.

Ever since 1957 and Sputnik, science education in the United States has been looked at in a critical way. When our greatest competitor beat us in the race for space, suddenly science and math education got a great boost in funding and attention. It suddenly became important to the general public. Education in general, and math and science education more specifically, improved greatly. American society eventually became complacent once we became the forerunners in a number of scientific accomplishments and I believe that the average American feels that we are far above the rest of the world in math and science. We are not. President Clinton recently said, referring to the results of the TIMSS study, that there is "no excuse for this." It seems that we have our new Sputnik; but we need to look carefully at where we put our efforts to make the best out of the increased awareness that comes with a major perceived crisis. My feelings seem to form a double-edged sword. On one side, I feel that the **perceptions of an inept national education system are far from the truth.** On the other side, I feel it **is time to make some major changes** and the only way to do that is to shake things up.

When California spent $3.7 billion to reduce class size statewide, most educators applauded the effort. Smaller class size seems to make a lot of sense, and it helps create jobs. I don't think they found it was effective at all. Class size is not the issue because there isn't only one issue. In my own experience I have found that large class size is very detrimental to the learning process if the class is of average or below average abilities. Students need more individual attention, especially in laboratory situations. However, in classes of above average abilities, a smaller class size is detrimental to open classroom discussion. The exchange of ideas and the benefit of student questions help everyone in the class. If you run a class where the teacher stands at a podium, lectures and draws on an overhead, then gives a pop quiz, the class size will make no difference whatsoever. Class size, however, becomes very important when you consider laboratory safety. We recently renovated several spaces and created new state-of-the-art laboratories at New Trier High School in Illinois. In doing so, we talked with a number of laboratory and safety experts. It was the consensus that labs should not house more than 24 students just for safety reasons. **Again, we are faced with a double-edged problem: larger class size for discussion and exchange versus smaller class size for safety.**

I have been a longstanding advocate of **multidiscipline projects.** For five years, I taught students in common with an English teacher, a social studies teacher, and a math teacher. Students found that there were many connections between disciplines and started to see education as a shopping mall rather than separate individual stores of information.

I am concerned when government, in the form of a state school board, steps in **and makes one of the keystones of biology optional.** I have every respect for religion. As a devout Roman Catholic myself, I would never expect my church to give equal time to evolution from the pulpit. Nor would I expect any religion to not talk about creation, because some people feel differently about it. I would never expect the social studies standards to make World War II optional because some people contend that the holocaust never happened.

A few years ago, I had the opportunity to sit in for NIH as a reviewer of some of the "Partners in Science" grants. At the time I was very impressed with the millions of dollars being given for worthwhile projects all over the country. Now, however, I look back at that type of funding as ineffective. Instead of spending $40,000 to influence one school and one or two researchers and maybe one hundred students, I would rather see money spent on **Web-based projects** that could influence hundreds of thousands of students all over the world. Funding research projects that could involve students would enhance not only the research world but help spark interest in science as a viable career for students. I can envision researchers allowing students to gather data, or supplying students with real data and having them analyze it for them. The Illinois Department of Transportation is currently working on a project that has students in Mundelein, Illinois gathering data to help make a decision about the rerouting of Route 53 through their area.

A concern that Web-based projects bring to mind is the growing popularity of distance learning and **virtual schools.** I feel that this type of technology will be a major part of the future, but we need to be careful about minimizing a true laboratory experience in science classes. The way that virtual classes are handling the laboratory component is currently inadequate.

An excellent high school teacher in Indiana once relayed an observation that I thought quite poignant. He prepared a new demonstration about mitosis and could hardly wait to share it with his class. As he stood near the door he listened to the students shuffling into his classroom. They were talking about things like the football game coming up, the party last weekend and who had gotten wasted, how Sam got kicked out of his house by his parents and now is living in a shelter. He suddenly came to the realization that those kids were not there for the same reasons that he was. They have their own agenda and mitosis was unlikely to be on it. Students will learn when something is important to them. More relevance than "yes, this will be on the test." That is why I feel **problem-based learning** needs to be supported as much as possible. When looking at the comparative studies of Japan and Germany and the U.S. math classes, I noticed that the Japanese seem to construct their lessons around some common problem. They then learn the tools needed to solve that problem. I believe that the success of the Japanese system is not because they are all lock-stepped throughout the country and that everyone is doing exactly the same problem on the same day. That seems to stifle any creativity in the teaching staff. I see their success more on how they approach a new concept.

A number of people are very concerned about the length of textbooks. When a high school biology text is over 1000 pages, parents and educators balk at the length and question the intent to have a high school freshman read over 1000 pages throughout the year. The length of texts does not concern me at all. The number of pages in a set of encyclopedias doesn't seem to concern anyone. Textbooks should be used as references, not as novels. Teachers need to pick and choose what material out of a text they want to cover, not let the textbook manufacturer control their curriculum. The textbook publishers have no desire to determine any given teacher's curriculum. They want you to buy their book. They put in more than you need; it is the teacher's responsibility to sift through it and choose what they want to cover.

Teachers need to see how other educators use textbooks as references and the best way for them to do this is to attend national conventions and conferences. The greatest problems with attendance at those conventions are funding and release time. The federal government should support teacher enrichment and development by increasing Eisenhower type funds. This funding should have strong guidelines as to how it is to be used and not left open-ended, but it could be the only source for many teachers. Updates and teaching techniques are an excellent way to improve science teaching.

There are a number of factors that we need to be looking at when considering academic change. We tend to get locked into the "what" without re-evaluating the "why." One is the **length of the school year.** Why are we basing all our schooling, both urban and rural, on a schedule set up to allow students to help in the fields at harvest time? In the 1800s we set up a **layer cake sequence** of biology, then chemistry, then physics in school. Now we look for someplace to stick in earth science when we can. This was based on the thought that you don't need math in biology, but you do in chemistry and physics. Students have a much greater math background now when they enter high school. Biology does not help much in teaching chemistry, but a chemistry background would definitely help in teaching biology. Physics doesn't help much in teaching chemistry and hardly at all in teaching biology, but chemistry and biology would help a student's understanding of physics. Why not change the sequence? There is a push in the country for "physics first" but I see chemistry first as a much better alternative.

If we change the sequence, why not think about changing the school year as well. There have been several experiments with **"year round school."** I feel those opportunities should be expanded and the needed research as to their impact studied. **The key is research.** We need to try some alternatives, research them, document them, and use our scientific skills to find out what are some good alternative ways to teach science. Notice I didn't say "the best way" to teach science, because I don't think there is just one way, just as I don't think there is just one solution to educational problems in this country. I feel we need to diversity our efforts, but make them meaningful research studies, collect the data, and draw some conclusions as to what works and what doesn't. We need to use the scientific method to study the method we should use to teach science.

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Letters

Kansas and the State of Mis-Creation

Last summer (August 1999), the Kansas State Board of Education made a decision to effectively devalue, if not eliminate, the teaching of evolution (the Big Bang, geologic time, and plate tectonics were also victims) from public school education. Its decision was based on creationist arguments long rejected by science, arguments that show a basic misrepresentation of not only the nature of evolution, but the nature of science itself. (By the way, I originally used the term "misunderstanding" instead of misrepresentation. But, creationists have been corrected so many times on the following points that it would be disingenuous and inaccurate of me to be so kind.) One of these misrepresentations revolves around the term "theory."

Creationists denigrate evolution by calling it "just a theory." The implication here is that evolution is not a very solid concept, somehow on shaky ground. But in science as well as in any good dictionary, this is not how theory is defined. Theories in science are (as any of my students will tell you, I hope) well-documented, explanatory principles. Thus, theories are supported by abundant, sound evidence. They serve the function of explaining the evidence, and they are the underpinnings of science, guiding research and providing scientists a platform from which to explore the natural world. Every science has its theories. Chemists have the atomic theory, geologists have plate tectonics, and biologists have evolution. None of these "just theories." They are essential constructs for making sense of Nature.

Another misrepresentation has to do with the nature of evidence itself. Creationists say that whatever qualifies as science must be directly observable, and since no one has ever observed evolution, it can't be science. First of all, it is not true that evolution has not been directly observed. Laboratory experiments have demonstrated the evolution of antibiotic resistance of bacteria, pesticide resistance of insects, and speciation in fruit flies. Remarkable field studies in the Galapagos Islands have demonstrated the evolution of finches. However, if we relied on creationist definitions, most of science would dissolve before our eyes because it is the case that most of science is not directly observable.

No one has ever directly observed neutrons and protons inside an atom. Nor, for that matter, has anyone ever directly observed an atom. What we have instead is a mountain of circumstantial evidence that atoms and their constituent parts exist. Thus, we have strong inference that atoms are real, and very few educated people seriously doubt the actual existence of atoms. Here is a short list of other phenomena scientifically accepted but never directly observed: genes coding proteins, the composition of the center of the Earth and sun, plate tectonics, the formation of wood inside a tree, photosynthesis, respiration, digestion, and the orbiting of the Earth around the sun. (Had enough?) Another creationist argument relevant here concerns events that have occurred in the distant past. If no one was around to observe them happening, how can we call them science?

Part, but certainly not all, of evolutionary biology is historical science. In this sense, it is in the same boat as geology, archaeology, and other studies of ancient events. Geologists, for example, can look at rock formations and, using various techniques, give us a good idea of past geological events and make predictions about what is probable in the future. Archaeologists study artifacts and historians study ancient manuscripts to build a picture of past societies. Once again, circumstantial evidence allows us to make inferences about the past. The more evidence we have, the stronger the inferences we can deduce. In this regard, the study of past evolution events is no different from the study of past societies or rock formations.

Fossils and the sediments in which they were formed paint a picture of life's history. Supporting this portrait is evidence from biogeography (distribution of organisms around the world), comparative anatomy and physiology, and the powerful tool of genetic homology (similarity). There is so much evidence to support the theory of life's evolution that it is considered a scientific fact. And here is yet another misrepresented concept. A fact, in science, is a concept shown to be so reliable that to "withhold provisional consent would be perverse." Said another way, facts in science could be wrong. It is a fact that atoms exist and the Earth's plates move about its surface. But in science, everything, including facts, is tentative. We must always keep in the backs of our minds that evidence could present itself that could refute our facts. In some ways, this is not unlike facts in our daily life.

My name is Gerry Barclay. Or is it? It's the name on my driver's license and on my birth certificate. I accept it as a fact. Could I be wrong? Is there any information that could come forward to disprove this "fact?" Of course. However bizarre and strained that information might be, it could be there. Regardless of strange possibilities, I go about my life introducing myself for the fact of who I consider I am. The same holds for scientific facts. Evolution happens and that's a fact.

A popular creationist Web site bears the phrase, "from confusion to certainty." This is not science. Science doesn't deal with absolutes, but rather with probabilities. On a scale of probabilities, evolution ranks very high indeed.

Flying in the face of standards recommended by the National Academy of Sciences that recommend the teaching of elements of evolution as early as the first grade, the School Board of Kansas has decided it knows better. While science stands poised to boldly step into the next millennium, Kansas is taking giant strides backwards to the Dark Ages.

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