PRESIDENTIAL ADDRESS

Scientific Literacy—Brightening a Dim Candle

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In his first presidential address Hilton Ira Jones, the first president of the South Dakota Academy of Science, gave some direction as to the nature and purpose of such presentations, suggesting that they should "…be a learned and serious discussion of some one of the problems of science" (Jones 1917). True to this he chose the lack of appreciation of research in South Dakota, the large distances which isolate its researchers and the role of the Academy in ameliorating these. He envisioned the annual meetings of the Academy as a place where scientists could assemble to share the products of their research. In providing this opportunity, the Academy then would be giving encouragement to its membership (Jones 1917). Indeed, the Academy 90 years later could be the issue that needs some discussion (for its membership has been graying and declining). However, instead of the Academy, I have chosen a larger issue to present, one that includes the nation as a whole. It's the issue of scientific literacy—or rather the seeming lack of it among the general population.

While many definitions of scientific literacy exist, each leading to a different set of expected outcomes, the one put forth by Rutherford and Ahlgren in the AAAS booklet entitled *Science for All Americans* seems appropriate. In this book, they describe a scientifically literate person as one who "…understands key concepts and principles of science; …and uses scientific knowledge and scientific ways of thinking for individual and social purposes" (Rutherford and Ahlgren 1990).

So are we a nation of science literate citizens? We should be. After all, science courses abound in compulsory education in the US. In fact, all teenagers do take science courses; interestingly, most never take any more than their first biology course (National Research Council 1990). At least they have taken some science, and supposedly started that journey of becoming scientifically literate. So the focus of my comments today is to 1) present evidence for the prevalence of scientific illiteracy, 2) suggest some causes, and 3) offer some remediation strategies.

In support of my hypothesis that we live in a country where scientific illiteracy prevails I offer the following: 1) There is a general lack of knowledge about science. According to National Science Foundation's Science & Engineering Indicators 2004, which is a summary of information garnered from surveys and opinion polls, Americans are not very knowledgeable about science. On a test of science facts (like "How long does it take for the Earth to go around the

Sun?" "Did the earliest human live at the same time as the dinosaurs?" And "are electrons larger or smaller than atoms?") administered nationally in 2001, the average grade was only 63% (National Science Board 2004). Support for a lack of science knowledge also comes from American College Testing Service which recently reported that most (88%) of the 2004 test takers were not prepared for college science coursework (American College Testing 2004).

2) There is a general lack of understanding of how science works. Based on the results of an open-ended essay, 2/3 of Americans do not understand the processes of science (National Science Board 2004). As a consequence what may often substitute for using the methods of science is blind faith, a tragic example of which was described by Timothy Ferris, a writer for the *New Yorker Magazine*, in this anecdote: In order to better view the Hale-Bopp comet, several members of the Heaven's Gate commune purchased a rather expensive telescope in order to view an alien spacecraft that they believed followed the comet. According to them, this was the spacecraft that would take them to heaven. Several days after purchasing the telescope, they returned to the store requesting a refund because, while they had seen the comet clearly, they could not find the spacecraft. Their logic for returning the telescope went something like this: We believe that an alien spacecraft is following Hale-Bopp; observations using a high quality telescope reveal no such craft; therefore the telescope is defective (Ferris 1997). As a postscript, it was the members of Heaven's Gate that subsequently committed mass suicide in California, a tragedy that might have been prevented if, instead of questioning a fact, they used the fact to question their supposition.

3) There is a pervasive acceptance of pseudoscience. Again, from the Science & Engineering Indicators 2004, about 50% of the US population believes in ESP, about 40% believe astrology to be at least somewhat scientific, and about 33% believe in lucky numbers (National Science Board 2004). To make matters worse, a recent Gallup poll (Newport & Strausberg 2001) found a significant increase in belief in pseudoscience from 1990 to 2001. But, on a positive note, belief in pseudoscience has been shown to decrease with amount of education (National Science Board 2004).

4) There is a reinvigorated challenge to teaching evolution in the public school classroom. In the past 12 months there have been numerous attempts across the country by recently emboldened conservative Christians and others to remove evolution from the public school science curriculum or to insert the ideology of intelligent design. Nearly every state has experienced proposed legislation or school board challenges to the teaching of evolution. Although South Dakota has been spared, two red flags should be inserted in this state—one for the lack in the South Dakota Administrative Rules, laws that governs the content of teacher education programs, of language requiring that biology programs include evolution (South Dakota Legislature 2000). This omission stands in spite of a resolution by the Academy several years ago requiring evolution in the preparation of high school biology teachers (Teacher Education 1998). That resolution was sent to the SD Board of Education, entered into its minutes, but not enacted. The second red flag comes in the words of our recently elected junior senator, John Thune, who favors intelligent design (Ross 2004).

A recent Gallup poll has shown that the majority of Americans does not accept evolution as the explanation for the origin and diversity of life but instead hold to other non-scientific beliefs. To wit, only 33% of Americans believe there is sufficient evidence to support evolution, while about 50% believe that humans were created about 10,000 years ago (Newport 2004).

One recent example of antievolution activity that has played prominently in the news media occurred in suburban Atlanta. There, in 2002, the Cobb County school board passed a resolution to insert the following disclaimer into the inside cover of their recently adopted high school biology textbooks: "Evolution is a theory, not a fact, regarding the origin of living things. This material should be approached with an open mind, studied carefully, and critically considered" (MacDonald 2002). Fortunately, this resolution was recently ruled unconstitutional in Federal court. While most enlightened citizens have been opposed to this disclaimer, you might agree with Steve Mirsky, who writes for *Scientific American*, that the first sentence about evolution as a theory be deleted, and that the second sentence be retained. Then, instead of requiring this label on the inside front cover of biology textbooks, it be placed on the outside of all textbooks (Mirsky 2005).

Paralleling the challenges to evolution in the classroom is the report that some Imax theaters and science museums will not show material that deals with evolution (Dean 2005).

If, as this evidence suggests, scientific literacy in the US is being eroded and undermined, what, then, are the causes? Rutherford and Ahlgren (1990), who lay part of the blame at the doorstep of education, list the following four factors: 1) "Few elementary school teachers have even a rudimentary education in science…." This may be the case in South Dakota, where elementary education majors are required to take a minimum of three courses in science for certification. 2) Many science teachers have "crushing teaching loads." In a 1996 survey of its members, the National Association of Biology Teachers found that almost half of the teachers claimed the lack of time to be the greatest obstacle to doing more laboratory investigations (Merrill 1996). In smaller school districts one science teacher may be the entire science department, expected to teach physical science, biology & chemistry and perhaps physics. In addition teachers suffer from two other humiliations: low salary and low prestige. In fact, in a recent issue of *Popular Science Magazine*, public school science teacher was listed as one of the worst jobs in science because of "no budget, no equipment, no lab…." (Speed Weed 2004). 3) Science textbooks hinder science literacy. Evaluations of these have found four general faults: a) they contain too many new and unnecessary vocabulary words; b) they offer "too little clear exposition of fundamental concepts," (National Research Council 1990); c) they are often "either misleading or incorrect" (National Research Council 1990), and d) they are reader unfriendly. Unfortunately, in many science classrooms, the textbook is the course (National Research Council 1990). Compounding this are studies reporting that most science teachers are satisfied with their textbooks (National Research Council 1990). 4) Present science curricula suffer from too much breadth and not enough depth. This problem exists because for science textbooks to appeal to the broadest market, publishers feel that they must cover the whole of the dis-

cipline. In doing this, they sacrifice depth of treatment, which, I believe, would facilitate understanding.

What can be done to ameliorate this lack of scientific literacy? Because I do not have solutions to all of these problems, let me focus on just the first and last of these.

Suggestion 1. For the problem of elementary school teachers who are under prepared in science: How about a science specialty elementary ed teacher? One who has fewer courses in language, music, art, social studies, reading, etc. and more courses in science. It would be their responsibility to plan and implement the science lessons for the elementary grades in a district and/ or to train their colleagues. Alternatively, or in addition, provide more incentives for teachers at both elementary and secondary levels to take summer science workshops and/or to pursue the next higher degree in science or science education.

Suggestion 2. To counter pseudoscience and antievolution beliefs, begin all science courses with a deep, rich set of experiences that exemplify the scientific enterprise so that students understand how science invents new knowledge. Then every time a new concept is introduced, show how scientists arrived at this piece of knowledge. Hopefully, when students leave such a course, they will have a firm grounding in what constitutes science, how it works and what its limits are. Perhaps if they knew how to recognize science from non-science, there would be fewer battles over evolution in public school biology classes and less reliance on pseudoscience to explain natural phenomena.

Suggestions 3. Center the science curriculum about those concepts, theories and principles which are the big ideas in and are fundamental to the discipline. In biology that would be the theory of evolution by natural selection, DNA theory, cell theory, germ theory of disease, etc. National science standards nicely cover these (National Resource Council 1996).

At this point I wish I could say that all of these suggestion are new and novel. They are not—sadly, they have been around for decades, printed and reprinted (McComas 2004). Now they need to be implemented. But where do we start with all this? Where else but our teacher education programs. These should include larger doses of the philosophy and methods of science—visited and revisited in all of their science courses. This also should be the main focus of the content tests that determine entry into the profession.

I hope that I have come close to meeting Dr. Jones' purpose for a presidential address. My challenge, as I close, comes from the late Carl Sagan, who did much to bring science to the general public. In *The Demon-haunted World*, he wrote keep lit the "candle in the dark" (Sagan 1996). I say--make it glow even brighter.

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