# 2009: THE YEAR OF SCIENCE: PUBLIC UNDERSTANDING OF SCIENCE

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ABSTRACT

The South Dakota Academy of Science is a member of The Coalition for the Public Understanding of Science. As Coalition members celebrate 2009 as the Year of Science, their goal is to promote public understanding of the process and nature of science. Research indicates that the public admires science and scientists but the public's poor understanding of the nature of science may lead to skepticism or indifference. The objective of my review is to suggest reasons for skepticism that, when understood, might improve science communication with the public. Poor understanding and skepticism may stem from inadequate science education or unrealistic expectations of what science can offer. I have categorized major reasons for public skepticsm into "bottom up" problems with the nature of science and scientists, and "top down" problems with public expectations of science, media coverage of science, and public confusion because of religion, political interference, or manufactured doubt. The Year of Science offers a three-part solution: 1) the Coalition's activities through regional and thematic hubs build networks among scientists, 2) the "centerpiece" Year of Science nationwide event and web site calls public attention to science, and 3) novel information for educators on the Understanding Science web site might improve education and public understanding of science.

Keywords

Education, media, public, religion, science, Year of Science

The Year of Science 2009 was a nationwide effort to engage the American public in activities that will stimulate their interest in the process of science. The overall goal of this celebration was to focus on "how we know what we know," and to help connect the public to the science that is contributing so much to our lives. This goal is similar to mission of the South Dakota Academy of Science.

The South Dakota Academy of Science undertakes activities (Table 1) to develop interest in science, to strengthen the bonds of fellowship between scientists, those interested in science, and students of science, to preserve information of scientific value, and to stimulate research in areas that relate to the natural resources of the state. The Academy and 19 other institutions (Table 2) in South Dakota joined the Coalition for the Public Understanding of Science (www.

***Table 1. Activities of the South Dakota Academy of Science.***

- promote research and publication in the various scientific disciplines;
- strengthen the teaching of science at all levels;
- provide a forum for the scientific community so that the interpretation and dissemination of scientific information will result in a better public understanding of science
- hold annual meetings that includes a program of scientific papers;
- publish The Proceedings of the South Dakota Academy of Science;
- provide awards to regional science fair winners.
- be active in science by work of standing and special committees.
- affiliation with the American Association for the Advancement of Science

***Table 2. South Dakota members of the Coalition for the Public Understanding of Science, 2009.***

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| Science Vision Center |
| Dakota Chapter of the American Fisheries Society |
| South Dakota School of Mines and Technology |
| South Dakota Science Teachers Association |
| Oak Lake Field Station |
| South Dakota Academy of Science |
| South Dakota Discovery Center |
| Sanford Underground Science and Engineering Laboratory |
| Augustana College |
| Dakota State University |
| The Outdoor Campus - SD Game, Fish and Parks |
| Woodfield Center School |
| Northern State University |
| Museum of Geology, South Dakota School of Mines and Technology |
| Black Hills State University |
| University Center |
| South Dakota Wildlife Federation |
| South Dakota Science Education Network |
| comPADRE: The Physics Front Digital Library |
| South Dakota State University |

copusproject.org) in 2009. Members of the Coalition shined a spotlight on science to improve public understanding about how science works, why it matters in South Dakota, and who South Dakota scientists are.

A simple definition of science is "a body of knowledge and a process of understanding." Science in South Dakota includes the natural sciences (e.g., ecology, biology, medicine, physics, chemistry) *and* social sciences (e.g., sociology, political science, consumer science). Year of Science events in South Dakota included the intersection of science in art, journalism, religion, philosophy, politics and policy. The Academy adopted the Year of Science as a theme for the annual meeting and held a special session on Science in South Dakota (see symposium abstracts included in these Proceedings).

*Justification for the Year of Science*—Public opinion surveys indicate that the public has a poor understanding of the nature of science (Weigold 2001) even though Americans like science (Shapin 2008, Pew Research Center 2009). The public is often unsure about the process of scientific research and sometimes even skeptical of its motives. Research indicates that students and teachers at all levels have a poor understanding of the nature of science (Culliton 1989, Ezrailson 2009). This is bad news at a time when science means so much to our lives. South Dakota needs a scientifically literate public to support the State's commitment to opening frontiers of knowledge about physics, health, energy, and the environment. A public that understands the process of science is a public that is able to make informed decisions about quality of life factors, is able to distinguish science from non-science, and can recognize attempts of special interest groups to drive public perceptions with biased science and biased information.

The goal of this report is to link the information presented at the Academy's Year of Science Symposium with factors that influence public understanding of science. Public misconceptions, distrust, and skepticism of science may develop because of "bottom up" problems with the nature of science and scientists, or "top down" problems with public expectations of science, or public confusion because of pseudoscience, religious issues, anti-intellectualism, political interference, or manufactured doubt (Figure 1). *The Journal of Public Understanding of Science* deals empirically with these issues (Bauer 2009).

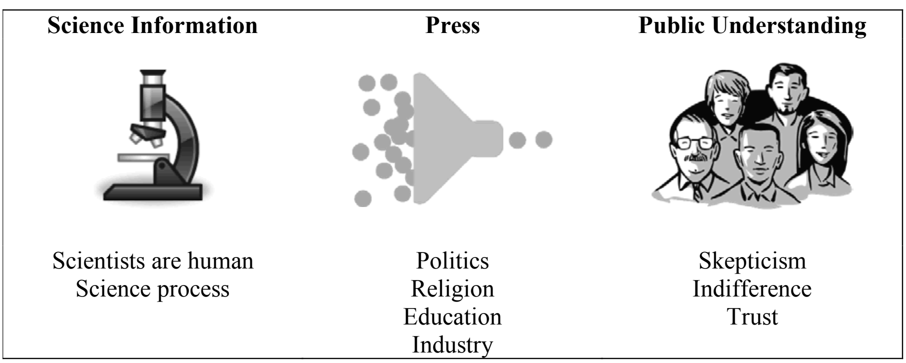


***Figure 1. Information flow from the scientific community to the public is influenced by the public's opinion of science and scientists. Scientific information is understood relative to the information media and the public's attitude is formed by four great institutions: education, religion, industry, and politics.***

***Bottom up problems***—The scientific enterprise is built on a foundation of trust (NAS 2009). Society trusts that scientific research results are an honest and accurate reflection of a researcher's work. When professional standards are violated and that trust is undermined, the relation between science and society deteriorates. Most science is done responsibly but the public and media often focus on the errors.

Errors in science occur because scientists are human. When such errors are discovered, they are acknowledged in the same journal in which the mistaken information is published in a section titled "Corregium," which means retraction. Another type of error is the type that researchers sometimes manufacture through sloppy citations of hedged conclusions (Horn 2001). In these cases, uncertainty becomes fact.

Of all the violations of the ethos of science, fraud is the gravest. Instances of scientific fraud have received a great deal of public attention in recent years. The cases are a tiny fraction of the output from science, but again, they are remembered by the public and sometimes lead to skepticism and disengagement (NAS 2009). Fraud is always discovered. Science is a cumulative process in which investigators test and build on the work of their predecessors, so fraudulent observations and hypotheses tend eventually to be uncovered. However, the public is likely to remember the fraud and not the correction. One example that is often cited in today's discussions of evolution is the fraudulent finding of a primitive human—Nebraska man (Gregory 1927).

Human values cannot be eliminated from science, and the values can subtly influence scientific investigations and conclusions (Shapin 2008). This is called "normative science," or science that is done with a preference for a particular policy (Lackey 2004, Scott et al. 1990). Lackey (2004) says that because of normative science, the public views science as "just another advocacy group."

Scientists sometimes avoid helping the public understand science, or avoid the science writer who might help the public understand. Science and technology have become such integral parts of society that scientists can no longer abstract themselves from societal concerns. Dealing with the public is a fundamental responsibility for the scientific community if scientists are to retain the public's trust (Menninger and Gropp 2009, NAS 2009).

Scientists and science are sometimes for sale. Science is for sale when commercial enterprises influence scientific results. The commercial values and funding may contaminate academia in subtle ways. But even when academic science is conducted freely, the public may be skeptical of the university reports because of the funding sources (Greenberg 2007, but see Davies 2009). A worse case is when a company creates science in a disinformation campaign (Robinson 2007). An example is tobacco industry reports about smoking, but other companies may be practicing similar tactics (Robinson 2007).

The public may have unrealistic expectations of science. Science cannot tell the public what to do, even though the public often is waiting for some answer. This misconception leads to frustration and science is often demeaned. However, "the answer" depends on politics, economics, policy, and human desires and culture. Scientists try to supply the facts and should be "honest brokers" (Pielke 2007) of those facts.

Scientific debate is essential to the scientific process, but the public often misunderstands the debate and dismisses scientists for "always arguing and not finding the truth." Improving the public understanding of the science debate is one of the key goals of the Year of Science program.

The peer review process is thought to be the "stamp of quality" on a scientific report. In peer review, experts evaluate a manuscript to assist editors in deciding if a submitted manuscript is worthy of publication (DeVries et al. 2009). However, peer review usually improves the readability of articles but sometimes fails to detect errors (reviewed by DeVries et al. 2009). For example, when errors have been intentionally introduced to test the peer review process, most errors were not detected (e.g., Godlee et al. 1998, Sokal 2008). The public sometimes hears of these problems and finds another reason to lose trust in science.

The above issues are at most aberrations of science, but the incidences leave some in the public wondering if science is the best "way of knowing." However, the world of science has grown in size and power and overall the scientific process has gained reliable knowledge. Because the scientific process (way of knowing) has developed a body of reliable knowledge, the link between the two sides of our definition of science is strong, It is strong because of the ethical conduct of the great majority of scientists, because of peer review that occurs during the steps in the process, and because of the professional scrutiny after findings are published in science journals. However, the public usually receives science information from the press, and they "hear" the message through filters inherent in the press and in their own lives (Figure 1).

***Top down influences***—Mass media can play a huge role in communicating science to the public. The communication begins between the scientist and the science writer. Scientists can insure that their message is understood by learning basic rules for communicating with the media (Menninger and Gropp 2008). Science writers can get the story wrong, or worse, assume a rhetorical role and adopt a passionate and sensationalistic approach (Boyle 1993, Brossard 2009). A frequent complaint about the media is their desire to provide "balance" with an opposing view, even if that view is a small minority or worse, is intended to sow public confusion (Stocking and Holstein 2009). Moreover, science journalism is in decline as print media gives way to blogging (Brumfiel 2009), which has no controls.

Thomas Berry (1999) thought that there were four great influences on man—religion, industry, government and education. These four institutions are also top down influences on how the science message is received. They influence what we read, hear, believe and understand.

Is science compatible with religion? This question has been discussed by many scholars (Kurtz 2003). Wanous (2009) said that the two "ways of knowing" are compatible as he reviewed historical figures who were both scientific and religious. He reinforced the idea that religion and science are two different ways of knowing (Wanous 2007), and used the quotation attributed to Galileo, "The bible tells us how to get to heaven, not how the heavens go." However, some people view science as a threat to religion, especially when discussing subjects such as evolution, stem cell research, and age of the earth.

Industry interacts with the public in complex ways through research, technology and advertising (Greenberg 2007, Crotwell 2009, Davies 2009). Crotwell and Davies, speaking at the Year of Science Symposium, represented research in the health industry in South Dakota, and described successful partnerships between industry and academia, and benefits to medicine from knowledge of human evolution.

Regarding industry's influence on public understanding of science, the current (2009) discussions usually highlight controversies about energy, environment, and human health. Just as the public recalls the few instances of scientists' misconduct, the scientific community recalls the few instances of industry misconduct. An example often recounted is the tobacco industry's memo saying, "doubt is our product since it is the best means of competing with the "body of fact" that exists in the minds of the general public" (see UCS 2007, but also see Kueter 2007). Industry has a vast influence for the benefit or detriment to public understanding of science. Its huge influence on politics is another issue.

Government influences public understanding of science in many positive ways. Billions of dollars are allocated each year for science education. Several government programs have goals similar to those of the Coalition for Public Understanding of Science. For example, see www.GLOBE.gov, which is a 10-year old international program co-sponsored by several Federal agencies. Government funded science is a huge enterprise for the good of the nation, but the rare political influences can confuse the public about the quality of government science and scientists.

Stakeholders' evaluation of scientists is sometimes explained by their political beliefs (Weible 2007, Pew Research Center 2009). And, government officials can corrupt science in many ways (Orr 2004, Bowen 2008), thus affecting public understanding of science. The corruption happens when there is a clash between two value systems—1) the political value system that places loyalty over all other values, and 2) the scientific value system that places intellectual honesty and integrity above all other values (Yankelovich 2004). The public begins to distrust government scientists and science in general when political and government leaders denigrate government science reports, make changes in the conclusions, and otherwise belittle science to promote a political agenda.

Political influence on science and scientists is often reported at the national level but is unusual at state and local levels. Hansen (2009) discussed science in South Dakota's political arena and presented case histories about how fish and wildlife conservation were openly presented to the Governor through cabinet secretaries.

The quality of education received by the public certainly influences its understanding of science. Koppang (2009) discussed the role of higher education in science literacy in South Dakota. Based on his informal survey of the value of general science education requirements of South Dakota universities, he concluded that "general ed was not created to make science literacy…because it is a mile wide and an inch deep."

One shortcoming in science education is the traditional way of teaching the process of science as a linear 4-step method: observation, hypothesis, experimentation, interpretation (e.g., Smith 1984). Another fault is emphasizing factual

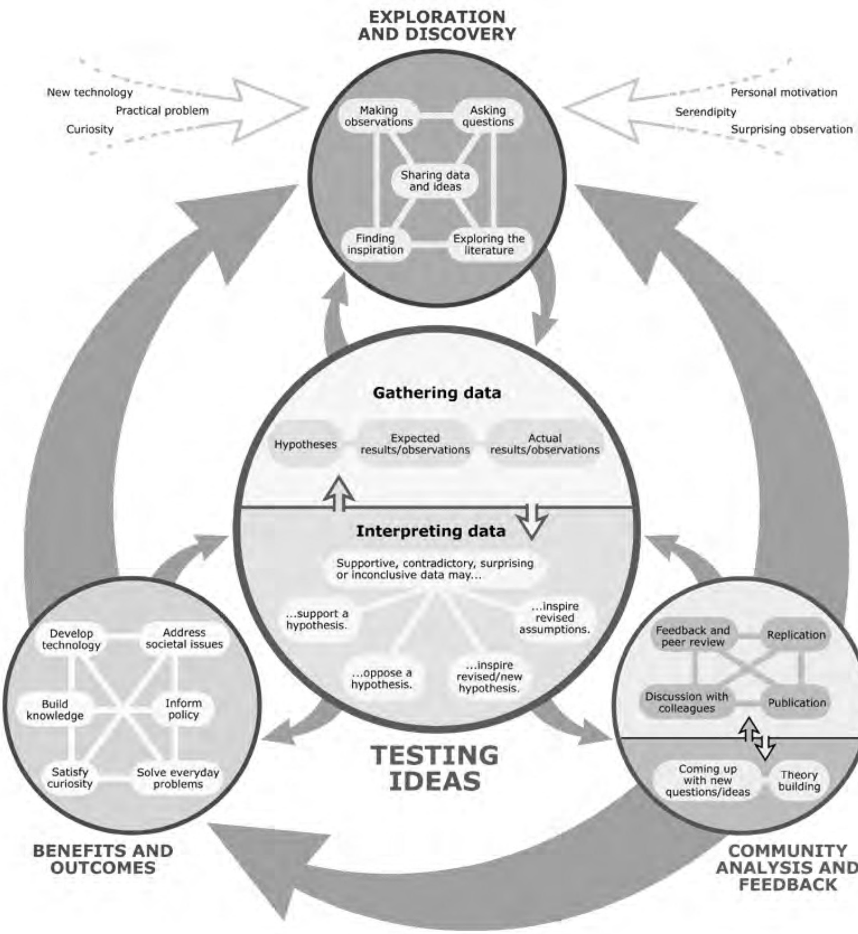


***Figure 2. How science works, a flowchart that shows the real process of scientific inquiry. The flowchart and information to help teachers and students understand science are available at www.understandingscience.org.***

memory over critical thinking skills. Consequently, students think of science as learning facts, and think the science process is an unexciting cookbook. The Year of Science program offers a much more realistic and exciting view of science.

A novel view of science (Figure 2) features circles and loops and curving arrows that suggest that the process of science is dynamic and anything but linear. The process relies on interactions between scientists and between scientists and the public. This model and the supporting information (www.understanding-science.org) was created by scientists, teachers and web experts and supported by the National Science Foundation. The material was designed to improve teacher understanding of the scientific enterprise and provide materials and tools that enable K-16 teachers to incorporate the true nature and process of science throughout their teaching.

***In summary***—The Year of Science 2009 provided the scientific community with the opportunity to assess reasons for the lack of public engagement in scientific endeavours, and presented information and an education program about science. The South Dakota Academy and 19 other South Dakota institutions developed opportunities for engaging the public in science and emphasizing the significance of science in our lives. The Year of Science was also an opportunity to focus on some of the issues (bottom up problems) in the science enterprise that might cause public skepticism. When designing programs to improve the public understanding of science, science writers should be aware of the top down and bottom up problems with science communication.

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