

MODES DE LA CONNAISSANCE | FORMAS DE CONOCIMIENTO
WAYS OF KNOWING

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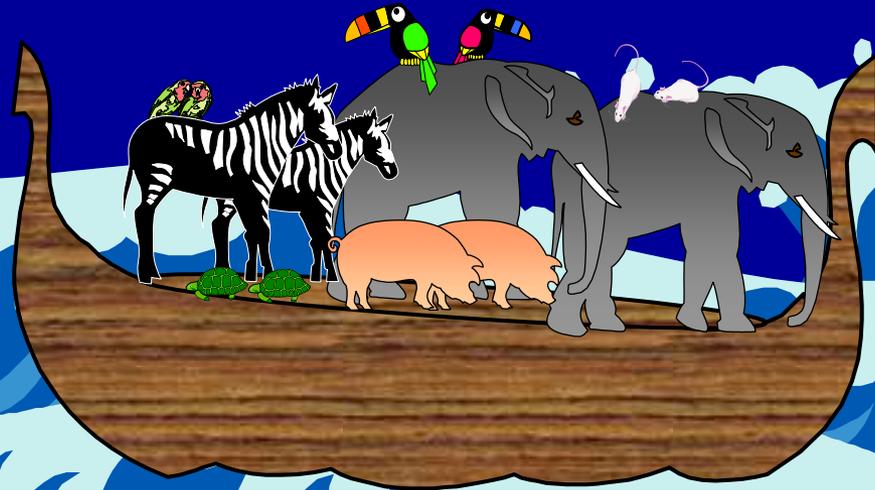
Science as a Way of Knowing

Alan I. Leshner

CEO, American Association for the Advancement of Science

Executive Publisher, *Science*

*Never Talk About Floods
With Noah In the Audience*





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EDUCATING AMERICANS FOR THE 21st CENTURY:

*A plan of action for improving
mathematics, science and
technology education for all
American elementary and
secondary students so that
their achievement is the best in
the world by 1995*

A REPORT TO THE AMERICAN PEOPLE
AND THE NATIONAL SCIENCE BOARD

THE NATIONAL SCIENCE BOARD COMMISSION ON PRECOLLEGE
EDUCATION IN MATHEMATICS, SCIENCE AND TECHNOLOGY



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My goal is to stimulate some discussion

- More questions than answers
- Speak about the context in which education occurs



Over-arching science education questions

- Who needs to know about science and technology?
- What do they need to know?
- How should we teach them?



Who needs to know about science and technology?

- Everybody
 - Does everyone need to know the same things?
 - Not really



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Science and technology are imbedded in every aspect of modern life

- Environmentally sustainable development
- Need for renewable energy sources
- Information and communications technology
- Universal access to education
- Poverty and economic opportunity
- Technology-based manufacturing and jobs
- Intellectual property rights
- Terrorism
- International security
- Natural disasters
- Science and technology capacity building
- Vaccines and medical therapies against infectious diseases
- Quality and accessibility of health care



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Science and technology are imbedded in every aspect of modern life

- To be a modern citizen, one needs familiarity with science
 - Does that mean “to be comfortable with” or “know the details of” science?
 - At least “be comfortable with”
 - At least know about science
 - Details may be less important for “all people”



To be a part of the modern workforce

- Need comfort and familiarity with science and technology
 - Ability to use and adapt to technologies
 - How much detail of S&T do future workers need?



Many countries are recognizing the science-economy (jobs) imperative

- US
- China
- India
- European Union
- Israel
- Japan
- Australia
- Belgium
- Sweden



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**Even if they don't work in STEM fields,
every person has a STEM-related life**



Science and technology are imbedded in every aspect of modern society

- To be a modern citizen, one needs some kind of relationship (familiarity?) with science
 - Confront science and technology every day
 - Regularly make science-related decisions
 - Consumer decisions
 - Health decisions



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So, what do they need to know?



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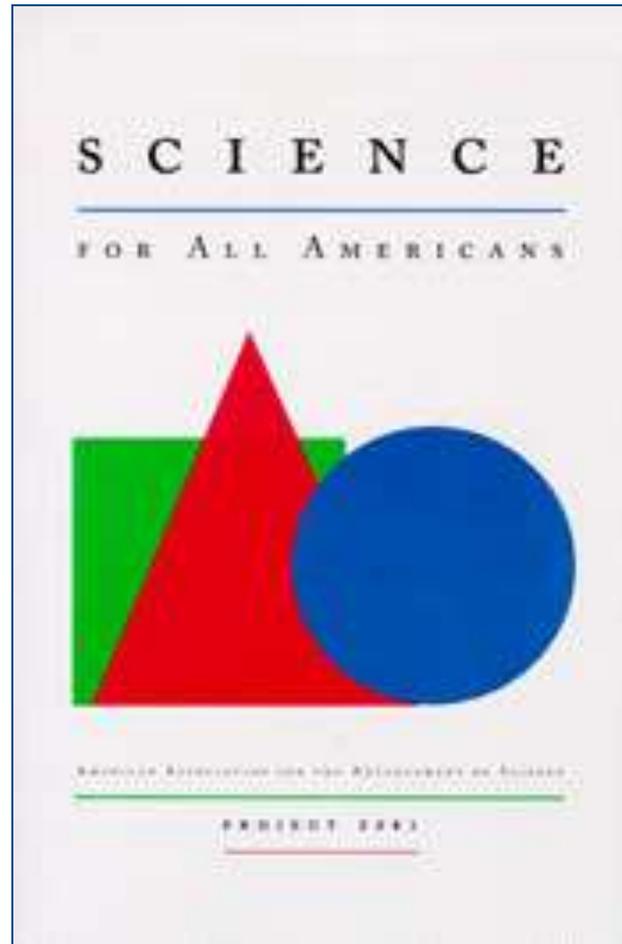
There are, at least, two ways to think about science education content

- Education in science
- Education about science



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AAAS has been involved in “what should be taught/learned” since before 1990





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Some AAAS over-arching guiding principles

- Science literacy is important for **all** students, not only those electing science careers.
- “Science” includes natural science, social science, mathematics, and technology.
- Reform must be structured around powerful, meaningful goals.
- Curriculum should cover less material but at greater depth.



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What is science literacy?

- Familiarity with the nature of science as an enterprise and how it operates
- Awareness of important ways in which mathematics, technology, and the sciences depend upon one another
- Key concepts and principles of science
- Capacity for scientific ways of thinking
- Knowing that science, mathematics, and technology are human enterprises and what that implies about their strengths and limitations
- Ability to use scientific knowledge and ways of thinking for personal and social purposes



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Is detailed content the most important issue in the modern era?

- Most information is accessible with a click



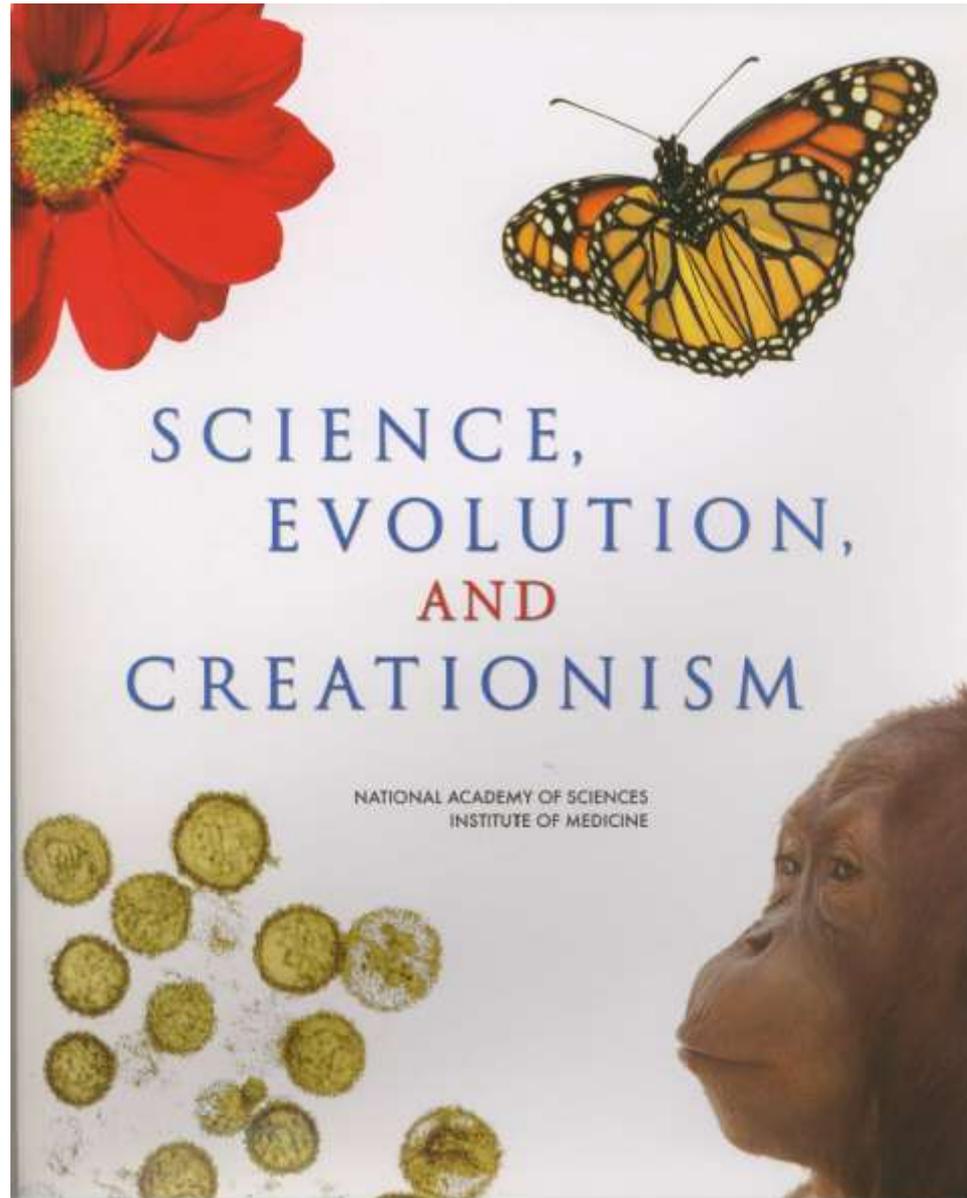
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Education about science

- Science the enterprise



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NAP 2008



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The purpose of science is to tell us about the nature of the natural world

- Science can tell us much
 - But has its limits



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Science depends on reliable and reproducible observations

- Most of the time
 - There can be “one-time events”
 - Neutrinos
 - Higgs bosons



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Most scientists would flunk the “what is the scientific method” question, but...

- The idea of systematically testing hypotheses is critical
 - Hypotheses are not just guesses
- Theories are not “guesses” or “personal beliefs”



Science the enterprise

- What is science?
 - What's the goal of science?
 - What are the criteria for science?
 - What isn't science?
- What are the limits and potentials of science?
 - Observable
 - Reproducible (usually)



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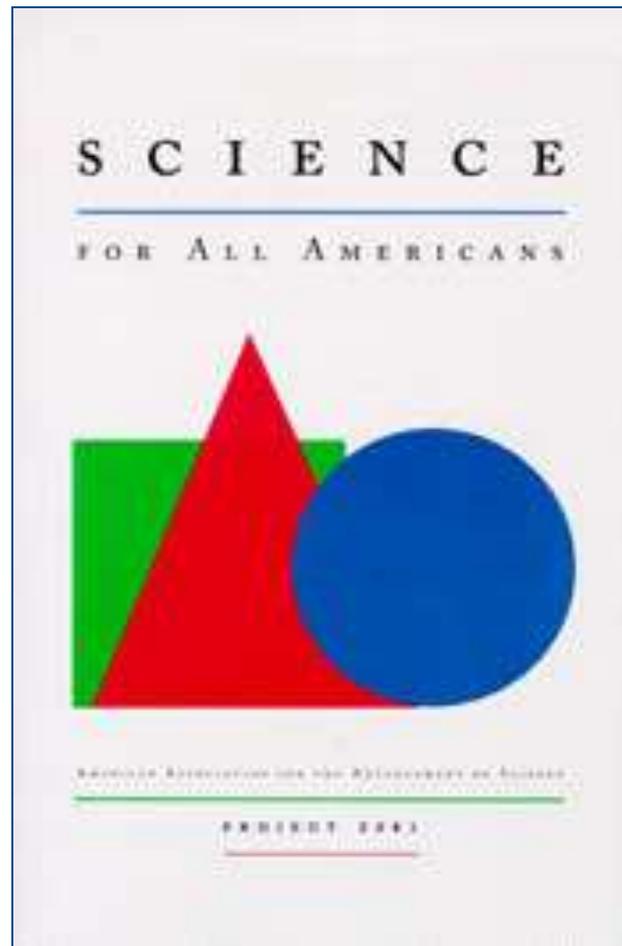
Most attention has been devoted to education in science

- Learning objectives
- Standards



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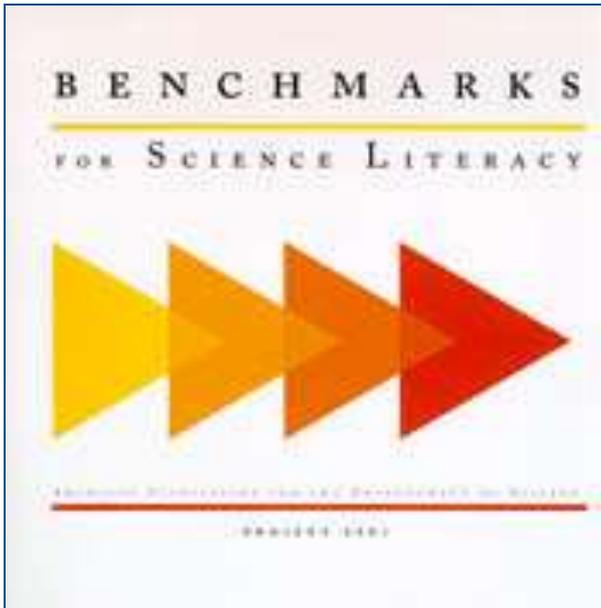
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Benchmarks for Science Literacy



- Released in 1993, *Benchmarks* provides a set of learning goals for the ends of grades 2, 5, 8, and 12



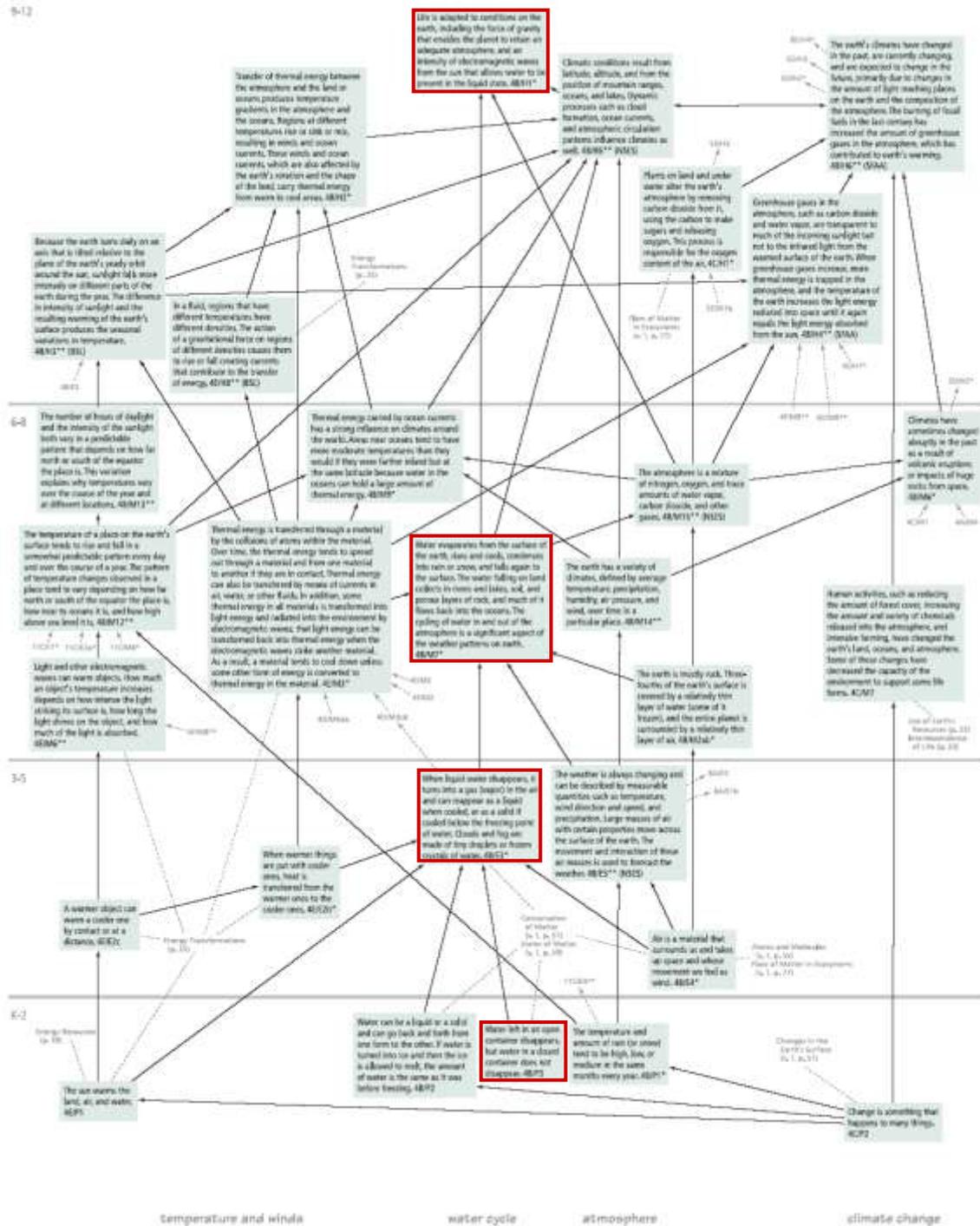
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Atlas of Science Literacy (2001)



- Illustrates the relationships between individual learning goals and shows the growth-of-understanding of ideas

Weather and Climate

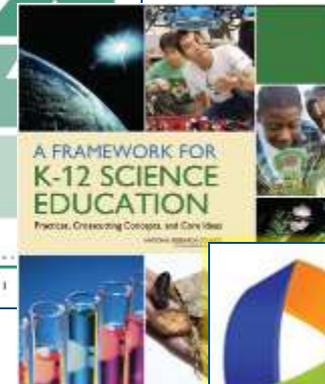
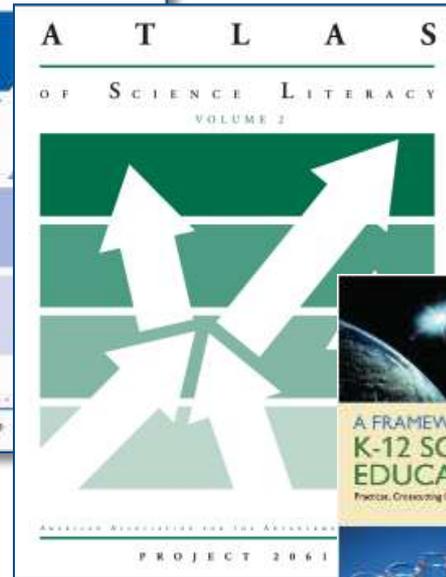
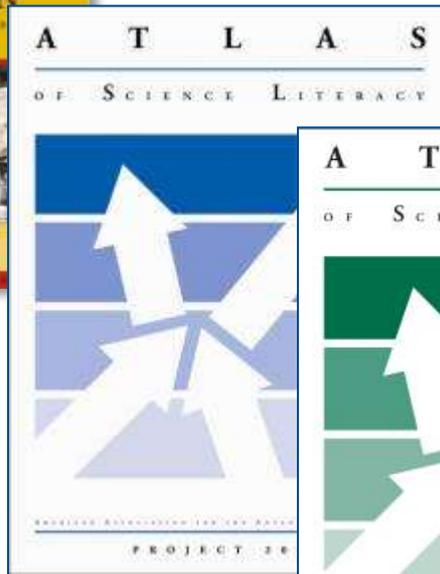
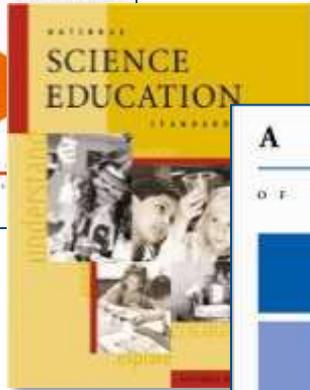
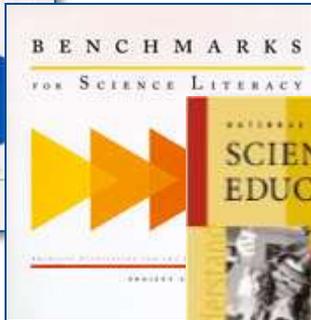
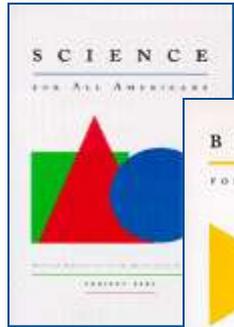




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Standards Documents

1989



2013



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Common educational standards enable cooperation and consistency without too much coordination



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This all sounds good and straightforward

- But science education is one of the more contentious issues at the intersection of science and the rest of society



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Arguments abound

- What should be taught?
- What can be taught?
 - And where



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Controversy around science education is part of a broader set of tensions between science and the rest of society



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The science-public relationship is experiencing some significant turbulence



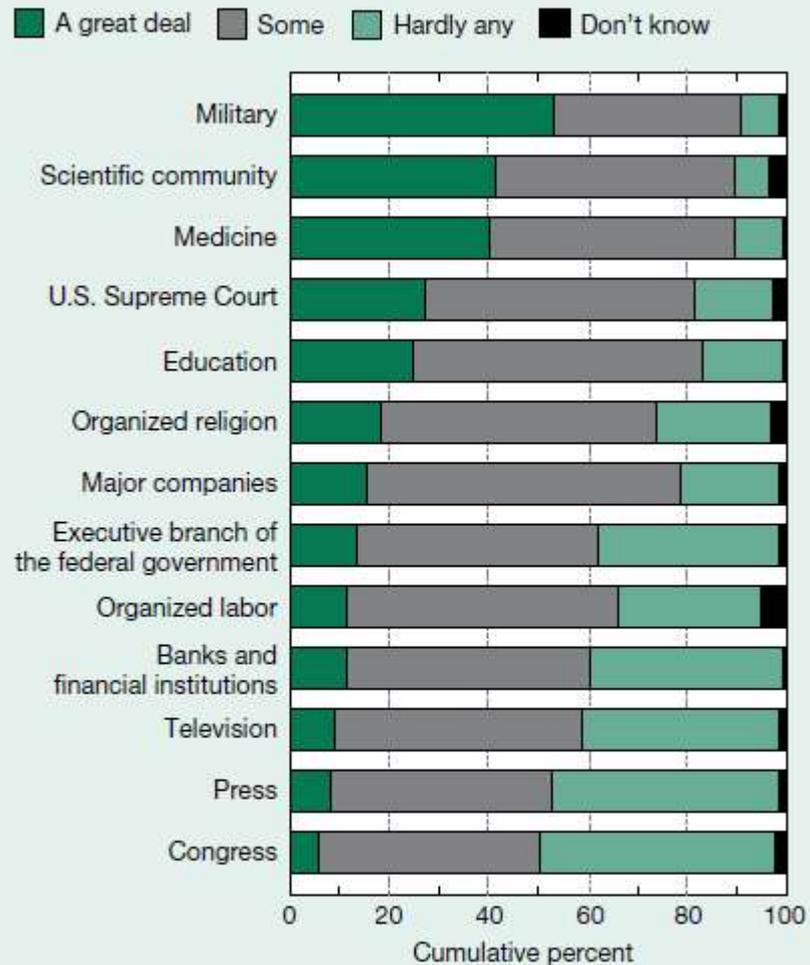


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**People generally still respect
science and technology....**



Figure 7-15
Public confidence in institutional leaders, by type of institution: 2012



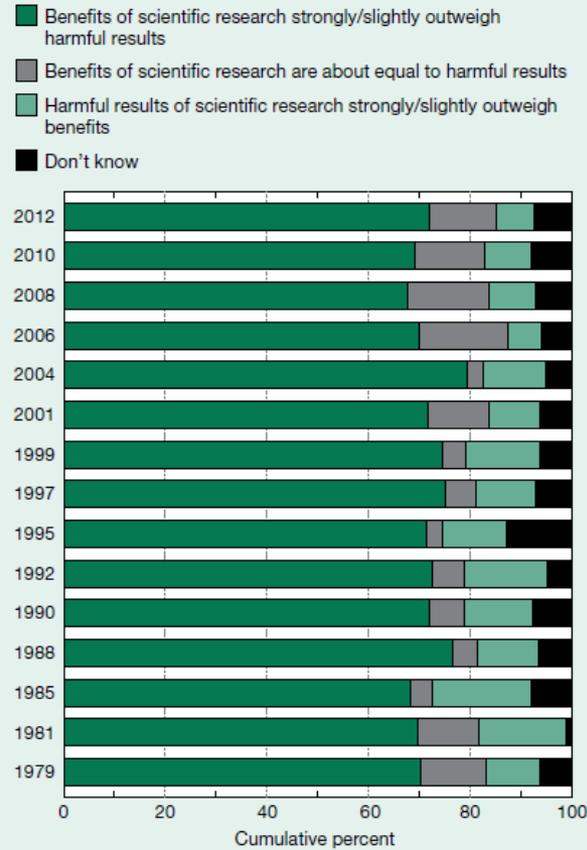
NOTE: Responses to *As far as the people running these institutions are concerned, would you say that you have a great deal of confidence, only some confidence, or hardly any confidence at all in them?*

SOURCE: University of Chicago, National Opinion Research Center, General Social Survey (2012). See appendix table 7-25.



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Figure 7-10
Public assessment of scientific research: 2012-1979



NOTES: Responses to *People have frequently noted that scientific research has produced benefits and harmful results. Would you say that, on balance, the benefits of scientific research have outweighed the harmful results, or have the harmful results of scientific research been greater than its benefits?* In this figure, "Benefits...outweigh harmful results" and "Harmful results...outweigh benefits" each combine responses of "strongly outweigh" and "slightly outweigh." Figure includes all years for which data were collected. Percentages may not add to 100% because of rounding.

SOURCES: National Science Foundation, National Center for Science and Engineering Statistics, Survey of Public Attitudes Toward and Understanding of Science and Technology (1979-2001); University of Michigan, Survey of Consumer Attitudes (2004); University of Chicago, National Opinion Research Center, General Social Survey (2006-12). See appendix table 7-16.



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They have little understanding of what is and is not science

- 60% of Americans believe in extrasensory perception
- 47% still do not answer “*true*” to the statement: “Human beings developed from earlier species of animals”
- 41% think astrology is somewhat scientific



Science-society tension can also result from

- Tarnished image of science
- Widespread misunderstanding
 - Vaccines and autism
 - GMO's
- Political or economic inconvenience
 - Climate change
- Conflict with peer group beliefs
- Conflict with core human values



Current scientific issues that abut against core values

- Embryonic stem cell research
- Studying “personal” topics
 - Sex
 - Genetics of behavior
- Teaching “Intelligent Design” versus evolution in science classrooms
- Origins of the universe
- Synthetic biology
- Neuroscience – mind/body issues



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This science-society tension has consequences

- Science is less able to serve societal needs
- Public support of science is undermined
- Society wants to exert influence on what science is (or is not) done
- The receptors for science input into policy are less receptive



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Science education is significantly affected by these tensions

- What is taught?
- Where?
- How?



The latest attempt to bring religion into the science classroom



Ed Stein
Rocky Mountain News
United Media



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Evolution on the Front Line:

An Abbreviated Guide for Teaching Evolution,
from Project 2061 at AAAS





*We've learned a
lesson here!*





Never pit science against religion!

- They ask different questions in different domains
- “Keep religion out of science classrooms”
 - Whether you talk about it elsewhere is not our business!



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What does all this say about formal education?



1. We need to make sure all young people learn about science

- As well as learning science content



“Taking Science to School” **Framework for Science Proficiency (K-8)**

- Know, use and interpret scientific explanations of the natural world
- Generate and evaluate scientific evidence and explanations
- Understand nature and development of scientific knowledge
- Participate productively in scientific practices and discourse



2. Students need to get enough science and technology to thrive in the modern world

- Comfort/familiarity with science
- Ability to use and adapt to technologies
- Have all career options open to them



In case you haven't guessed...

- I favor national standards
- I favor national assessment tools



Over-arching science education questions

- Who needs to know about science and technology?
- What do they need to know?
- How should we teach them?



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Science

You can't start young enough

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