Reforming Science Education

The History and Current State of Science Education Reform in the United States

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Introduction to Project 2061

- Project 2061 is a science education reform initiative of the American Association for the Advancement of Science (AAAS).
- Project 2061 began in 1985 when Halley's Comet was visible from earth.
- 2061 is the year that Halley's Comet will again be visible from earth. We use the 76-year period of the comet as a metaphor for long-term reform.
- (www.project2061.org)

Project 2061: Student Assessment

2061

1985

1910

1835

1759

1682

The themes of today's talk

- Background
- A brief history of science education reform in the US
- The influence of Project 2061
- Prospects for the future

I. Background

- The US has a decentralized educational system.
- Current federal education legislation (No Child Left Behind Act of 2001) requires all states to have content standards in math and reading and to assess students' with respect to those standards each year in grades 3-8 and once in high school.
- In 2007, for the first time states also have to assess students in science—once in elementary school, once in middle school, and once in high school.

Adequate Yearly Progress

- The states are required to establish year-to-year progress goals for students so that all students will be proficient in reading and mathematics by 2014.
- States are judged by whether they meet the goal of having more and more students proficient in math and reading (adequate yearly progress or AYP).
- If schools do not meet the goals of AYP, they must make improvements or there are penalties. They first receive technical assistance and are required to allow students to transfer schools. As the time period of failure to meet AYP lengthens, the sanctions become progressively more severe, and can result ultimately in the state taking over the school.

The Place of Science in the No Child Left Behind Act of 2001

- Overall, the No Child Left Behind Act has had the effect of focusing attention on reading and mathematics at the expense of other subjects like science.
- Starting in 2007, students have been tested in science, but their scores do not count in determining if a school is making adequate yearly progress (AYP).
- This may have some effect of increasing the attention paid to science.

No National Content Standards and No National Curriculum in Science

- What gets taught in science in each state is determined by the legislature of each state. It is not determined by the federal government. There is no common national curriculum and no national test that everyone takes in science.
- As long as individual schools and teachers prepare students for the state exams, they have a lot of freedom to decide exactly what to teach and how to teach it.
- In some states, there is a textbook adoption committee that decides which textbooks teachers can choose from. Almost half of the states have textbook adoption committees.

A Wide Variety of Textbooks to Choose From

- The textbook industry is a private market-driven enterprise.
- Textbook publishers try to satisfy a variety of interests by including a include a wide range of content. The content is not explicitly aligned to either *Benchmarks* or the *National Science Education Standards*.
- Large states, such as Florida, Texas, and California, which have textbook adoption committees, have a significant impact on what gets covered in the textbooks.

Teacher Certification Varies from State to State

- Individual states establish requirements and guidelines for teacher certification, and individual colleges and universities create programs to meet those requirements and guidelines.

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National Assessment of Educational Progress (The Nation's Report Card)

- Although there is not a national test that all students must take, the National Assessment of Educational Progress is a national test given to a sample of students to determine how well the country is doing in various subjects.
- The program began in 1969.
- Under current federal legislation, all states must participate in the math and reading tests, but the science test is voluntary.
- In 2005, 44 of 50 states volunteered to have their students take the science test.
- The science test is given every 4 years; the math and reading tests are given every two years.

The Role of Project 2061

- Project 2061 is a national organization, but it is not a federal agency. It is not part of the US government.
- It can influence national opinion and practice, but it has no authority over it.
- Our challenge is to produce ideas and products that are of high quality, that are integrated and coherent, and that can be implemented with reasonable effort and money, and that can help produce desired learning outcomes.
- We build tools and resources and hope they will be useful to educators.

Channels of Influence

- State Content Standards
- Curriculum Materials
- Assessment
- Teacher Certification

II. A Brief History of Reform

- In 1983, the US Department of Education released a report of the National Commission on Excellence in Education entitled *A Nation at Risk*. The report challenged the federal government, states, and local school districts to raise the level of competence of American students in all academic areas, but especially in science and mathematics and to set measurable standards in those areas.
- Two years later, in 1985, Project 2061 began its work, and in 1989 published *Science for All Americans*, a comprehensive statement of what all students should know and be able to do in science.

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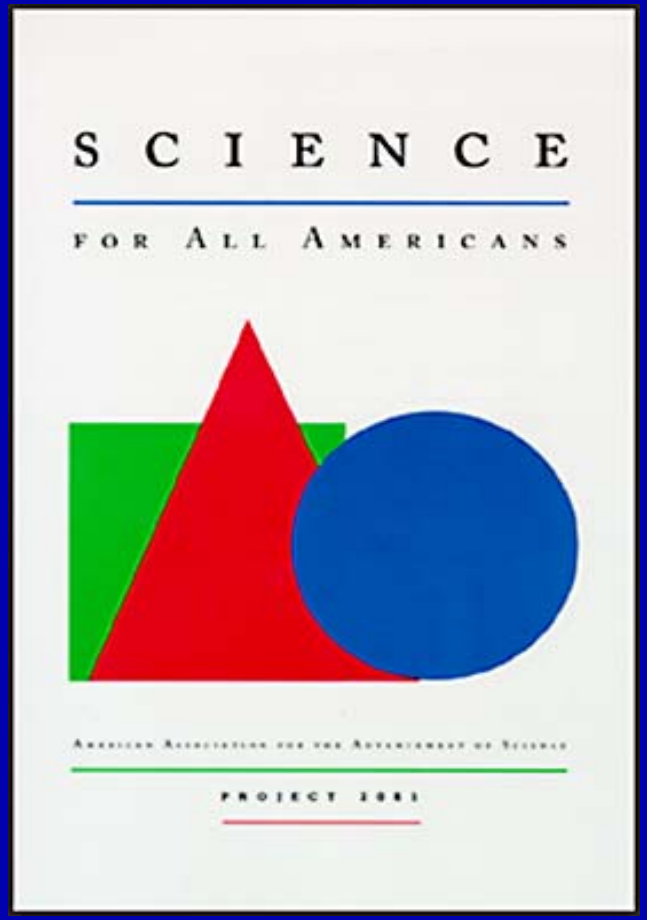

Science for All Americans (1989)

A narrative account of ideas in science, social science, mathematics, and technology that all adults should know to be science literate.

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Content Areas in *Science for All Americans*

- The Nature of Science
- The Nature of Mathematics
- The Nature of Technology
- The Physical Setting
- The Living Environment
- The Human Organism
- Human Society
- The Designed World
- The Mathematical World
- Historical Perspectives
- Common Themes (e.g., systems, models, change, scale)
- Habits of Mind (e.g., communication, critical-response skills)

Project 2061's View of Science Literacy

- Education has no higher purpose than preparing people to lead personally fulfilling and responsible lives. Science education should help students to develop the understanding and habits of mind they need to become compassionate human beings able to think for themselves. It should equip them to participate thoughtfully with fellow citizens in building and protecting a society that is open, decent, and vital (*Science for All Americans*, p. xiii).

How Should Science be Taught?

- Young people learn most readily about things that are tangible and directly accessible to their senses—visual, auditory, tactile, and kinesthetic. Students need to be acquainted with the things around them—including devices, organisms, materials, shapes, and numbers—and to observe them, collect them, handle them, describe them, become puzzled by them, ask questions about them, argue about them, and then to try to find answers to their questions (*Science for All Americans*, p. 199-201).

The Teaching of Science Should be Consistent with the Nature of Science

- Science teaching should encourage students to raise questions about what they are studying, should help them frame their questions clearly enough so they can begin to look for answers to those questions, and should support the creative use of imagination. It should promote the idea that evidence, logic, and claims should always be questioned, and experiments should be subjected to replication. Students should be encouraged to ask: How do we know? What is the evidence? Are there other explanations for what we observe? (*Science for All Americans*, p. 203-204).

Establishing National Goals

- In 1989, President George H.W. Bush and the state governors agreed to establish clear national performance goals for education.
- They agreed on two main points:
  - There should be public accountability that focused on how well students met the performance goals.
  - There should be decentralized authority and decision-making at the local level. Local authorities would determine exactly how the goals would be met.

National Standards

- In 1991, President Bush declared in his *America 2000* report that standards "will be developed…for each of the five core subjects," and he explicitly mentioned the work that had been done so far by AAAS.
- By 1993, Project 2061 completed work on *Benchmarks for Science Literacy*, which recommends what students should know and be able to do by the end of grades 2, 5, 8, and 12 to be science literate.
- Although they were not officially designed to be the national standards in science, *Benchmarks* was the first effort to lay out what all students should know and be able to do in science at various grade levels and were treated as national standards by many.

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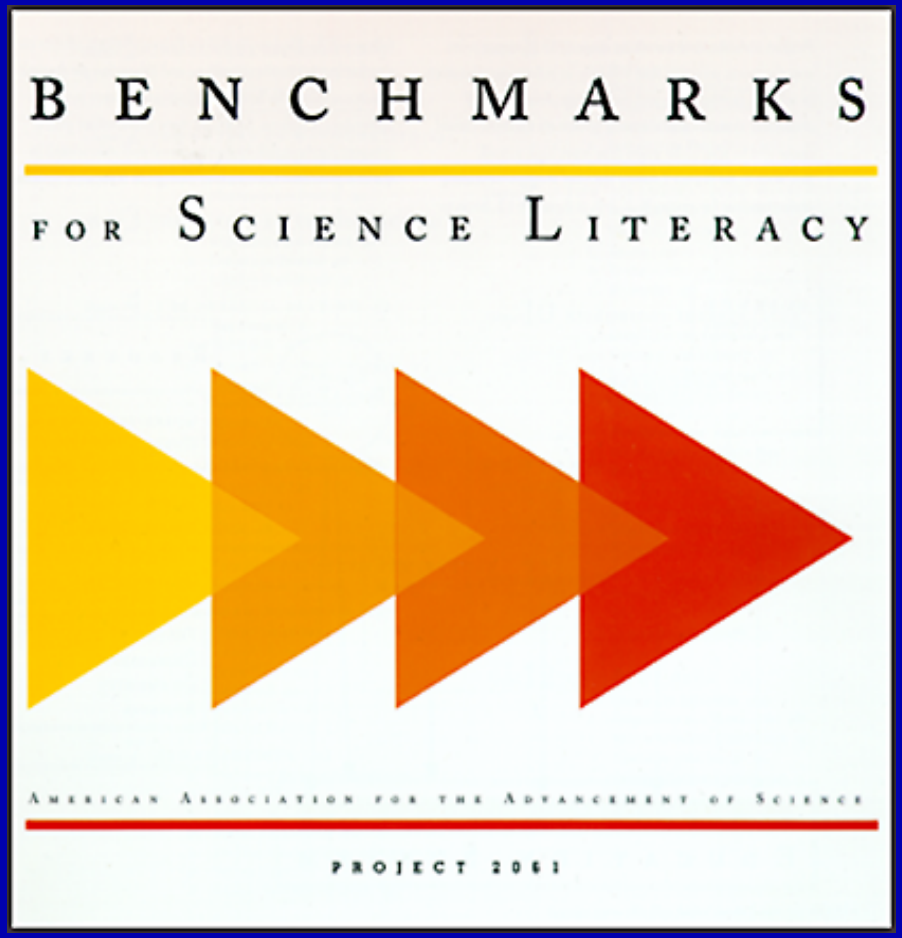

Benchmarks for Science Literacy (1993)

Learning goals to be met by the end of each of four grade bands (K-2, 3-5, 6-8, 9-12) to achieve the goal of science literacy for all.

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Principles of Science Education Reform in *Benchmarks*

- The science ideas students learn should help them live interesting, responsible, and productive lives.
- The science ideas students learn should lead to knowledge that remains throughout adulthood.
- The concepts students are taught should include just the most important ideas so there is enough time to teach them well.
- The most important thing is student understanding of broad science concepts, not isolated facts and definitions.
- The teaching of science should integrate ideas from various disciplines.

Example of a Benchmark Statement

Thermal energy, carried by ocean currents has a strong influence on climates around the world. Areas near oceans tend to have more moderate temperatures than they would if they were farther inland but at the same latitude because water in the oceans can hold a large amount of thermal energy. 4B/M9*

National Science Education Standards

- In 1996, the *National Science Education Standards* were published by the National Academy's National Research Council, with significant input by the staff of Project 2061 as they were being developed.
- By then, Congress had lost interest in having a common set of standards that everyone in the country would be held accountable for. *Benchmarks* and *Standards* were used by states to develop their own content standards, but there would not be common national standards that all students would be held accountable for.

Atlas of Science Literacy (2001, 2007)

- *The Atlas of Science Literacy* is a two-volume collection of nearly 100 conceptual stand maps that show how the ideas and skills in *Benchmarks* could be organized from kindergarten through 12th grade and how students' understanding of those ideas might develop.
- The maps help educators make vertical and horizontal connections among science ideas, including the prior ideas that later ideas build on, and the connections across topics.
- Maps help educators appreciate the progression of understanding that develops from grade to grade, and to decide what ideas to teach at what grade levels.

Making Connections Between Science Ideas

Strand maps show the connections among science ideas. Maps are used to facilitate coherence in instruction and assessment (2001, 2007).

Articulation from K-12

THE PHYSICAL SETTING

WEATHER AND CLIMATE (4B)

The earth has a variety of climatic patterns, which consist of different conditions of temperature, precipitation, humidity, wind, air pressure, and other atmospheric phenomena. These result from a variety of factors. Climate and changes in climate have influenced in the past and will continue to influence what kinds of life forms are able to exist. Understanding the basic principles that contribute to maintaining and causing changes in weather and climate increases our ability to forecast and moderate the effects of weather and to make informed decisions about human activities that may contribute to climate change.

The map is organized around four strands—*temperature and winds, water cycle, atmosphere,* and *climate change*. The progression of understanding begins in the elementary grades with observations about heat transfer, changes in water from one state to another, and changes in weather over the course of a day and over the course of seasons. By middle school, the focus is on the water cycle, patterns of change in temperature, and the notion of climate change. In high school, seasons and winds and the water cycle are related to gravity and the earth's rotation, and climate change is related to natural causes and human activities.

Benchmarks in this map about temperature and winds draw on ideas about heat transfer and transformation in the **ENERGY TRANSFORMATIONS** map. Benchmarks in the *climate change* strand are also related to the **SCIENCE AND SOCIETY** map. The widespread use of climate models to improve our understanding of the earth's climate system and climate change suggests a connection to benchmarks in the **MODELS** map as well.

NOTES

The left-hand side of the *temperature and winds* strand presents a progression of understanding of seasons. The explanation of the seasons in terms of the tilt of the earth requires students to engage in fairly complex spatial reasoning. For this reason, although the idea is introduced at the 6-8 grade level in *Benchmarks*, the map places it (4B/H3) at the 9-12 level.

Benchmarks related to the heating of materials and the transfer of thermal energy lay the conceptual groundwork for understanding solar heating, global circulation, seasonal weather patterns and climate, and the effect of greenhouse gases. To understand how thermal energy moves in both oceanic and atmospheric systems, students need to know that convective currents are an essential mechanism that aids in that movement. In middle school, understanding of convection currents is linked to experiences with relevant phenomena. Understanding convection in terms of gravity, buoyant forces, and pressure is not expected until high school. It is not necessary for students to have a molecular comprehension of thermal energy to be able to understand atmospheric and oceanic circulation patterns and their role in climate.

Several lines of conceptual development converge in the new 9-12 benchmark that begins "Climatic conditions result from…." These include an understanding of temperature patterns over the earth, atmospheric and oceanic circulation patterns, and the water cycle. A double-headed arrow between this benchmark and another new benchmark (4B/H6) on climate change indicates that they are closely related but that neither is conceptually dependent on the other.

RESEARCH IN *BENCHMARKS*

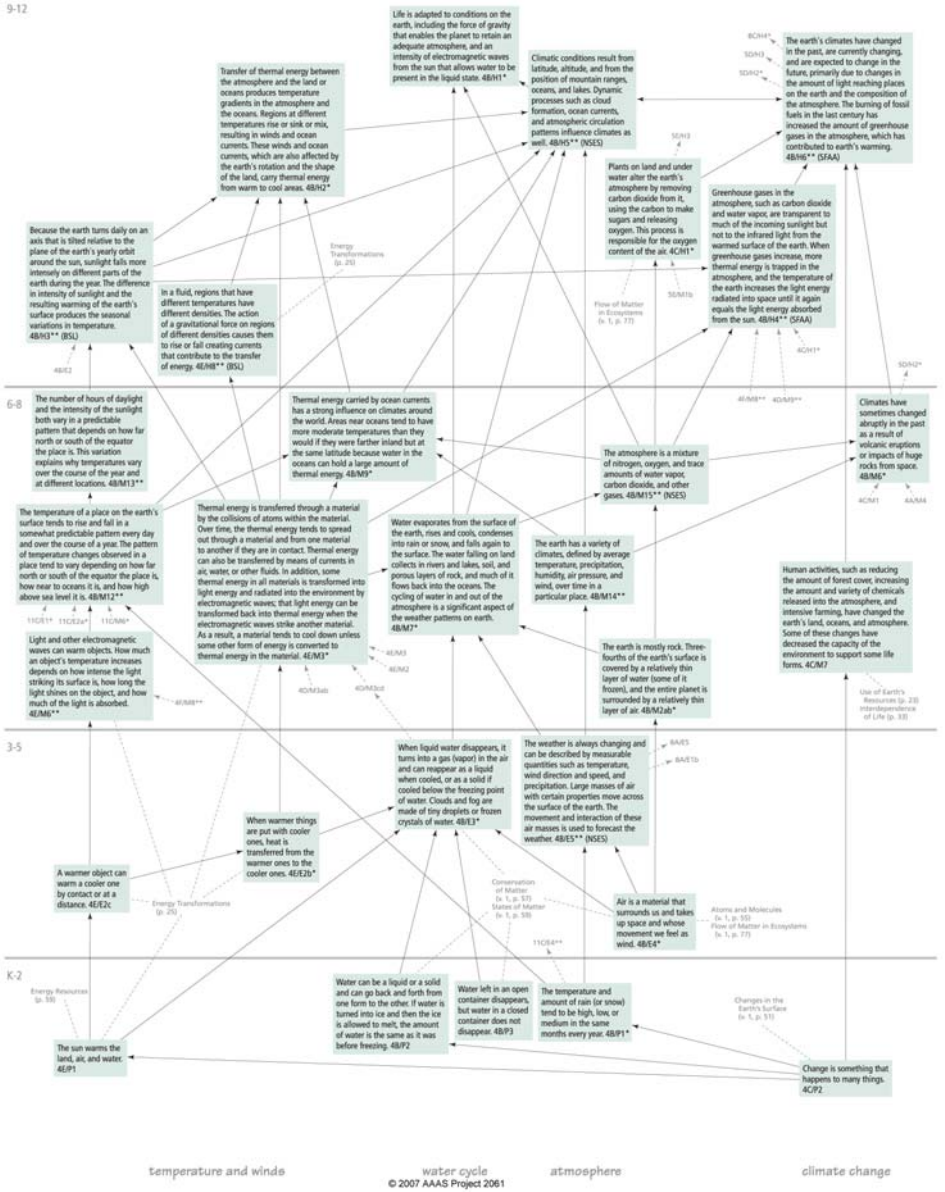
Students of all ages (including college students and adults) have difficulty understanding what causes the seasons. Students may not be able to understand explanations of the seasons before they reasonably understand the relative size, motion, and distance of the sun and the earth (Sadler, 1987; Vosniadou, 1991). Many students before and after instruction in earth science think that winter is colder than summer because the earth is farther from the sun in winter (Atwood & Atwood, 1996; Dove, 1998; Philips, 1991; Sadler, 1998). This idea is often related to the belief that the earth orbits the sun in an elongated elliptical path (Galili & Lavrik, 1998; Sadler, 1998). Other students, especially after instruction, think that the distance between the northern hemisphere and the sun changes because the earth leans toward the sun in the summer and away from the sun in winter (Galili & Lavrik, 1998; Sadler, 1998). Students' ideas about how light travels and about the earth-sun relationship, including the shape of the earth's orbit, the period of the earth's revolution around the sun, and the period of the earth's rotation around its axis, may interfere with students' understanding of the seasons (Galili & Lavrik, 1998; Salierno, Edelson, & Sherin, 2005). For example, some students believe that the side of the sun not facing the earth experiences winter, indicating a confusion between the daily rotation of the earth and its yearly revolution around the sun (Salierno, Edelson, & Sherin, 2005).

Although upper elementary students may identify air as existing even in static situations and recognize that it takes space, recognizing that air has weight may be challenging even for high-school students (Sere, 1985; Driver et al., 1994a; Krnel, Watson, & Glazar, 1998). Students of all ages (including college students) may believe that air exerts force or pressure only when it is moving and only downwards (Driver et al., 1994a; Sere, 1985; Henriques, 2002; Nelson, Aron, & Francek, 1992). Only a few middle-school students use the idea of pressure differences between regions of the atmosphere to account for wind; instead, they may account for winds in terms of visible moving objects or the movement of the earth (Driver et al., 1994a).

Before students understand that water is converted to an invisible form, they may initially believe that when water evaporates it ceases to exist, or that it changes location but remains a liquid, or that it is transformed into some other perceptible form (fog, steam, droplets, etc.) (Bar, 1989; Russell, Harlen, & Watt, 1989; Russell & Watt, 1990; Krnel, Watson, & Glazar, 1998). With special instruction, some students in 5th grade may be able to identify the air as the final location of evaporating water (Russell & Watt, 1990), but they must first accept air as a permanent substance (Bar, 1989). For many students, difficulty understanding the existence of water vapor in the atmosphere persists in middle school years (Lee et al., 1993; Johnson, 1998). Students can understand rainfall in terms of gravity once they attribute weight to little drops of water (typically in upper elementary grades), but the mechanism through which condensation occurs may not be understood until high school (Bar, 1989).

Students of all ages may confuse the ozone layer with the greenhouse effect, and may have a tendency to imagine that all environmentally friendly actions help to solve all environmental problems (for example, that the use of unleaded petrol reduces the risk of global warming) (Andersson & Wallin, 2000; Koulaidis & Christidou, 1998; Meadows & Wiesenmayer, 1999; Rye, Rubba, & Wiesenmayer, 1997). Students have difficulty linking relevant elements of knowledge when explaining the greenhouse effect and may confuse the natural greenhouse effect with the enhancement of that effect (Andersson & Wallin, 2000).

See **ENERGY RESOURCES** and **ENERGY TRANSFORMATIONS** for additional research.



III. The Current State of Science Education Reform in the US and the Role of Project 2061

Project 2061: Student Assessment

Content Standards

- *Science for All Americans* was the first attempt to specify in detail the science content that was most worth knowing. *Benchmarks* showed how those ideas could be learned throughout from K-12.
- The ideas in *Benchmarks* were used in the writing of the *National Science Education Standards* and most state standards document.
- Some states have used the Benchmarks as their own state standards (Delaware, Georgia, Indiana, Rhode Island).
- Many states and local districts continue to use the *Benchmarks* along with the *Atlas* as they revise their standards and determine what content to teach in which grade bands (33,000 copies of *Atlas* 1 and 14,000 copies of *Atlas* 2 sold).

Textbooks and Classroom Instruction

- Textbook publishers have been slow to embrace the vision of reform in *Benchmarks* and the *National Science Education Standards*
- There is still too much content in the textbooks and too much technical terminology
- Too little pedagogical support is given in the textbooks, especially with misconceptions that students may have or helping students in making sense of the science ideas.
- The problems with textbooks are also reflected in teaching.
- Project 2061 has reviewed textbooks and published the results. And we have worked with several NSF-funded curriculum development projects to improve the curriculum materials that are used in classrooms.

Assessment

- All students now have to be tested under the No Child Left Behind Act to determine if they have met their state's content standards in science—once in elementary school, once in middle school, and once in high school, and students are given many practice tests to help them improve their scores on the state tests.
- Most states do not have tests that adequately test students' conceptual understanding of science. Many of the test items ask students about facts and terminology that do not lead to a conceptual understanding of science.
- Project 2061 has a major grant from the National Science Foundation to develop science items to test student understanding of ideas in *Benchmarks* and the *National Science Education Standards*.

Examples of Test Items that do not Test Conceptual Understanding

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Which is an example of an annelid?

A. Earthworm

B. Octopus

C. Slug

D. Snail

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Which of the following arthropods is an arachnid?

A. Butterfly

B. Tick

C. Centipede

D. Lobster

Project 2061: Student Assessment

A scientist combines oxygen and hydrogen to form water. This combination illustrates that water is

A. An atom
B. An element
C. A mixture
D. A compound

Project 2061: Student Assessment

Which is the thickest layer of the earth?

A. Crust
B. Inner Core
C. Mantle
D. Outer Core

Project 2061: Student Assessment

What kingdom contains organisms that are multicellular, have no chlorophyll, and absorb nutrients from decaying tissue?

A. Fungi
B. Plantae
C. Proista
D. Animalia

Project 2061: Student Assessment

Blood from the lungs enters the heart at the

A. Left ventricle
B. Left atrium
C. Right atrium
D. Right ventricle

Project 2061's Current Work on Assessment

- We are creating a bank of middle school science assessment items that are precisely aligned with Benchmarks and the National Science Education Standards.
- Sets of test items are used to measure students' conceptual understanding in science.

Clarification Statements:

- We begin our work by separating each benchmark into key ideas. We then clarify those key ideas to further specify and place boundaries around what students should know and be able to do.
- We write sets of test items to assess student understanding of the larger concept.

Project 2061: Student Assessment

- **Idea A: A pure substance has characteristic properties, such as density, a boiling point, and solubility, all of which are independent of the amount of the substance and can be used to identify it. (NSES 5-8B:A1a edited or 4D/M10**)**

Clarification Statement

- Students should know that every substance has a set of characteristic properties that are always the same for that substance, regardless of time, location, shape, or size (Students are not expected to know that the properties of substance can be different at the nanoscale.). Furthermore, students should know that characteristic properties are consistent throughout a sample of a substance. Characteristic properties with which students should be familiar are boiling point, melting and freezing point, solubility (i.e. how much of the substance can dissolve in water), flammability (i.e. the ease with which a substance will catch on fire), odor, color, and density (i.e., that equal volumes of different substances have different masses), but not the formula (density = mass/volume). Students should know that weight, mass (Students are not expected to know that the atomic mass of a substance is a characteristic property), volume, shape, length/width, texture, and temperature are not characteristic properties of substances and may change.

What middle School Students Know

- Boiling point can be used to identify a substance
- Melting point can be used to identify a substance
- Density can be used to identify a substance
- Substances with different melting points are different substances
- Liquids with different density, boiling point, and color are different substances

What Middle School Students are not Sure of

- If odor can be used to identify a substance
- If mass can be used to identify a substance
- If volume can be used to identify a substance

Project 2061: Student Assessment

- **Idea C: Many substances react chemically in predictable ways with other substances to form new substances with different characteristic properties. (NSES 5-8B:A2a edited or 4D/M11**)**

Project 2061: Student Assessment

- Students should know that when substances react chemically one or more new substances are formed. They should know that if a new substance does not appear, a chemical reaction did not occur. They should know that the products of a chemical reaction can be identified as new substances because each product has different characteristic properties from the original substances under the same conditions. They should know that liquids, solids, or gases can be reactants or products in chemical reactions. Students should also know that it is possible for a single substance to undergo a chemical reaction, such as when the substance is heated or an electrical current flows through the substance. They should also know that it is not true that all chemical reactions are irreversible.
- Students are not expected to know that chemical reactions involve the rearrangement of atoms into new molecules. This idea is addressed in a later idea (Idea D). Students are also not expected to know that nuclear reactions are not chemical reactions nor why nuclear reactions are not chemical reactions. Nuclear reactions are addressed in later ideas (4E/H6* and 4G/H6*).
- NOTE: By "predictable ways," we mean that the same products will be formed when the same reactants are combined regardless of location and experimental set-up. We do not expect the students to predict what the products of a reaction will be.

What Middle School Students Know

- The product of a chemical reaction can be a solid, liquid, or a gas
- A solid that forms when two liquids are mixed is an example of a chemical reaction
- Bubbles forming when a liquid and solid are combined is an indication that a chemical reaction is taking place

Misconceptions Middle School Students Have

- The products of a chemical reaction can never be turned back into the starting materials
- Chemical reactions require starting with at least two substances
- Dissolving is a chemical reaction

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- **Idea G: Whenever substances interact with one another, regardless of how they combine or break apart, the total mass remains the same. (BSL 4D/M7a edited)**

Project 2061: Student Assessment

- Students should know that when substances mix, undergo chemical reactions, change state, or dissolve, or when objects are cut or broken into smaller pieces, the total mass of all the matter will always remain the same. They should also know that regardless of the form that the products of these processes may take (for example, when a sugar cube dissolves in water or a chemical reaction produces a gas), the mass will always stay the same. Students should know that if it appears that the mass has changed, it is because some material has not been accounted for. Students should know that since light is not matter, its presence or absence does not affect the mass of the matter. Students are not expected to know that mass is not conserved in energy-mass conversions such as nuclear reactions or other subatomic interactions.
- Note: The words “weight,” “weigh,” and “mass” are used appropriately in the assessment items. The students are not expected to know the difference between “weight” and “mass.”

What Middle School Students Know

- Mass is conserved when butter is cut into pieces

Misconceptions Middle School Students Have

- When mold grows in a closed bag, the bag weighs more than before the mold grew.
- When a liquid is heated in a closed system, the mass of the liquid increases.
- The mass of a plant-jar closed system decreases when the plant dies.
- Atoms become lighter when a gas forms in a reaction in which two liquids react together.

What Middle School Students are not Sure of

- If total weight stays the same after a substance dissolves.
- If total mass stays the same after a chemical reaction.

Benchmark 4D/M3ab

- Atoms and molecules are perpetually in motion. Increased temperature means greater average energy of motion, so most substances expand when heated.

Key Idea 1: Atoms and molecules are perpetually in motion.

- Students should know that atoms and molecules of *all* matter are *always* moving. They are expected to know that this is true for atoms or molecules of solids, liquids, and gases. They are expected to know that, even when objects appear not to be moving, the atoms and molecules that make up those objects are themselves in constant motion…

Assessment

- We then write assessment items to test what students know about the key ideas.

IV. Future Prospects for Reform of Science Education

Where are we now?

- The No Child Left Behind Act is now scheduled for reauthorization. If it is not reauthorized, the bill can just be allowed to die and a new education bill written to take its place, or it can be extended as it is for up to five years.
- There are some members of Congress who would like science to have a more prominent place in the education law, and there are some who would like to finally move toward national standards and a national test in science.
- There are a number of proposals pending at this time.

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America COMPETES Act was signed into law August 9, 2007

- Focuses on three areas for maintaining and improving US innovation in the 21st century
  - Increasing research investment
  - Strengthening educational opportunities in science, technology, mathematics, and engineering
  - Developing an innovation infrastructure

Strengthening Educational Opportunities

- Grants to states to better align elementary and secondary education with post secondary education and workforce needs
- Improved training of math and science teachers through summer institutes
- Additional funding to train math and science teachers in high need schools
- No mention of national standards or national assessment. All of these programs would be introduced at the state level.
- This is an authorization bill; no money has been appropriated to fund the new programs

Project 2061: Student Assessment

National Action Plan for Science, Technology, Engineering, and Mathematics (STEM) Education

- A report of the National Science Board, the governing body of the National Science Foundation, released October 3, 2007
- Recommends the creation of a non-federal National Council for STEM education to facilitate STEM programs and initiatives throughout the Nation
- Recommends that states work with the national council to coordinate STEM education among the states including defining national STEM content guidelines that would outline essential knowledge and skills needed at each grade level
- Develop measures to assess student performance that are aligned with national content guidelines

Project 2061: Student Assessment

The SPEAK Act (Standards to Provide Educational Achievement for Kids

- Introduced by Rep. Vernon Ehlers (R-MI) and Sen. Chris Dodd (D-CT) January 9, 2008
- Creates voluntary national standards in math and science
- Standards would be aligned with post secondary and workforce needs, and would be comparable to the best standards in the world
- Standards would be reviewed every 10 years
- Provides incentives for states to adopt these standards through competitive grants
- Adds science to the biennial NAEP assessments to place it on par with reading and math
- Aligns teacher preparation programs to the standards

Enhancing Science, Technology, Engineering, and Mathematics Education (eSTEM) Act of 2008

- Introduced May 21, 2008 in the Senate by Barack Obama (D-IL) and in the House of Representatives by Rep. Mike Honda (D-CA)
- Introduced, in part, as a response to the National Science Board's National Action Plan
- Goal is to provide for the coordination of the Nation's STEM initiatives
  - Encourage the development of common science standards across states that would address the workforce needs of an increasingly global world
  - Develop a model STEM curriculum that emphasizes integration with other subject areas
  - Improve and align STEM teacher education programs among the member states

Some Thoughts about How to Improve Science Education

What we can do to improve science education:

1. Focus on the most important and teachable ideas in science. We can't teach everything. Content standards can point the way.
2. Use assessment for diagnostic purposes. Assessment is not just about accountability.
3. Connect science ideas to real-world phenomena. Phenomena alone and abstract principles alone are not effective in achieving the goal of science literacy.

Thank You!