The Return of Halley's Comet as a Metaphor for Long-term Reform

2061

1985

1910

1834

1758

1682

A 17th century scientist, Jan Baptiste Von Helmont put a 5 lb. willow tree in 200 lbs of soil and watered it for five years. After five years, Von Helmont found that the tree had gained nearly 165 lbs.

What percentage of the tree's mass came from minerals in the soil?

(a) 50% (b) 10% (c) 5% (d) .1%

Where did most of the rest of the tree's mass come from?

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What do these 4th graders know about where the mass of a tree comes from?

Which of the following ideas about plants do you think the 4th graders know?

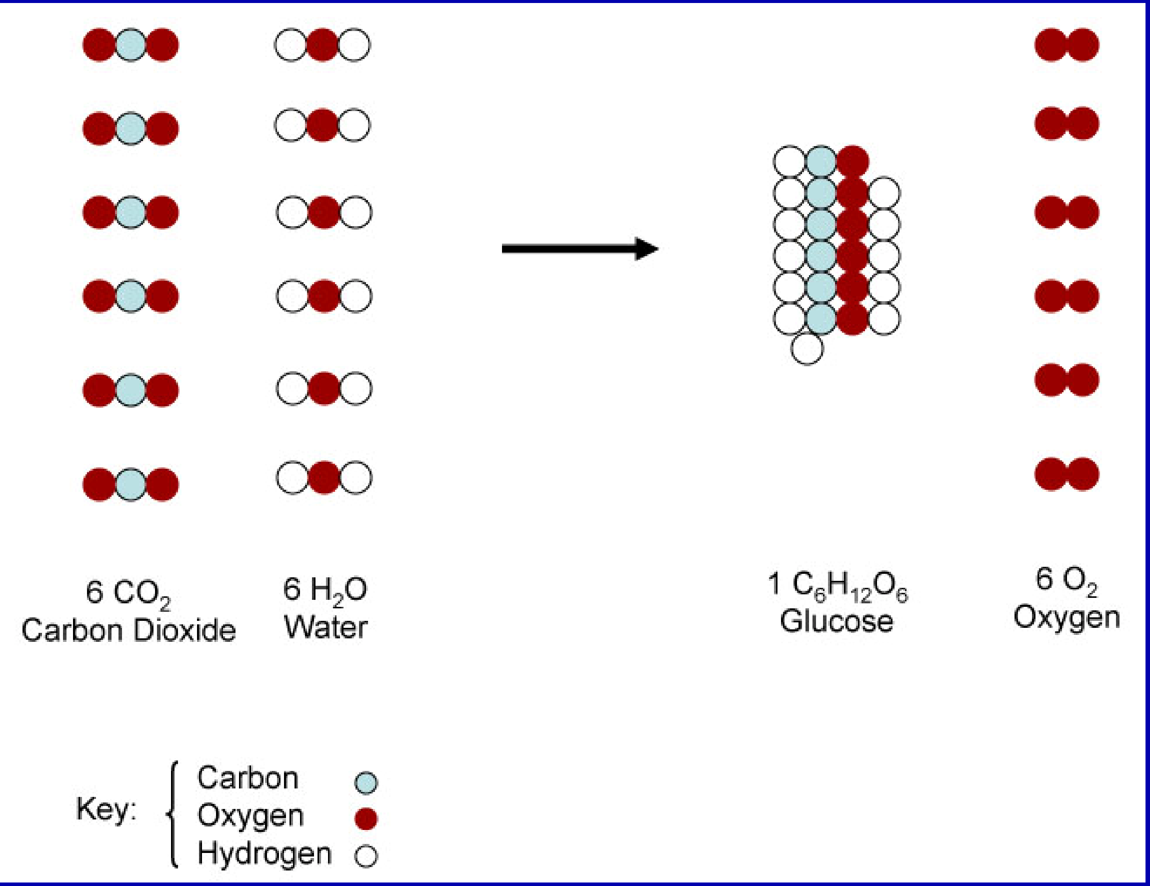
1. Most plants and animals need to take in both water and air. In addition, animals need to take in food and plants need light.
2. From food, people and other organisms obtain fuel and materials for body repair and growth.
3. All organisms need food as a source of carbon-containing molecules that provide chemical energy and building materials.
4. Plants make their own food in the form of sugar molecules from carbon dioxide and water molecules.
5. Plants use sugar molecules to make more complex molecules that become part of their body structures.
6. If not used immediately as fuel or as building material, sugars and other carbon-containing molecules are stored for later use.

For students to understand where the tree's mass comes from they need to have a "Lego" model of matter:

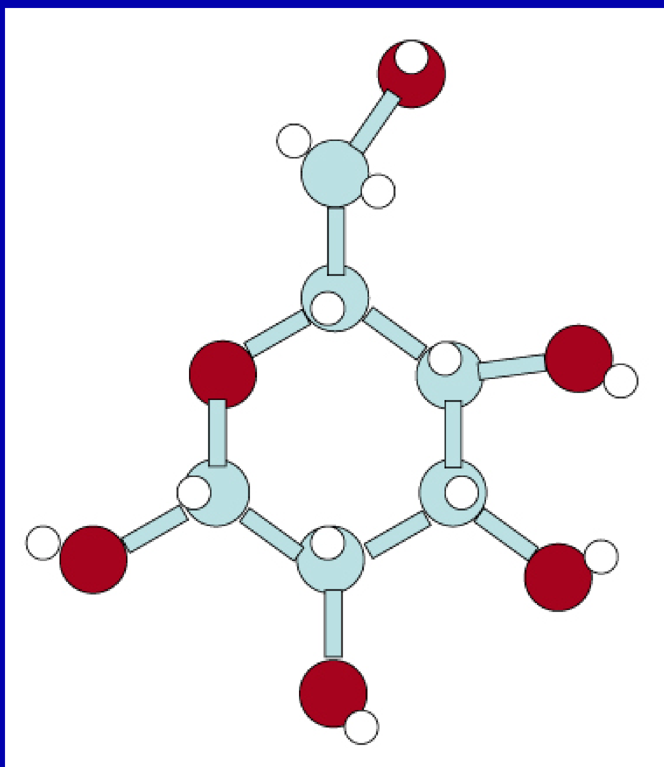
- Substances react chemically in characteristic ways with other substances to form new substances with different characteristic properties.
- All matter is made up of atoms, which are far too small to see directly through a microscope.
- Atoms may link together in well-defined molecules…Different arrangements of atoms into groups compose all substances and determine their characteristic properties.
- The idea of atoms explains chemical reactions: When substances interact to form new substances, the atoms that make up the molecules of the original substances combine in new ways.

and be able to apply it to living systems.

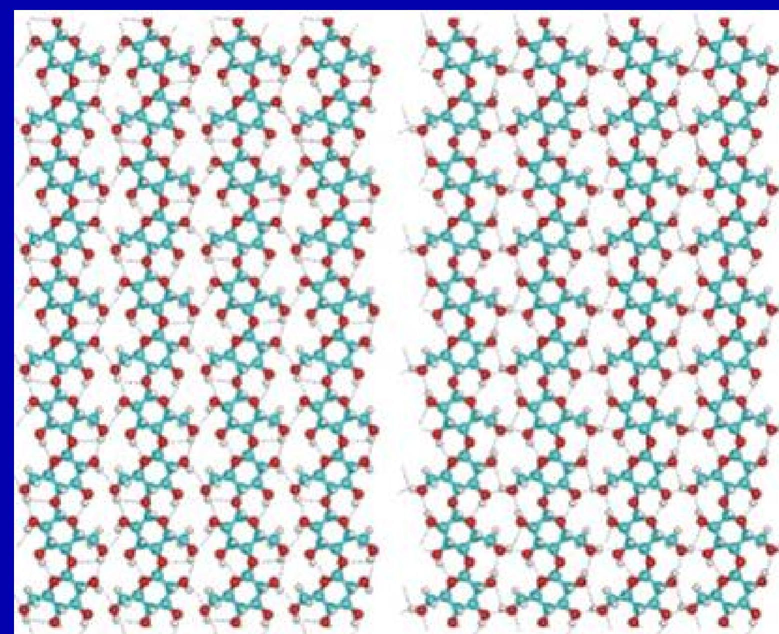
In the leaves, carbon dioxide and water molecules react to form glucose and oxygen molecules.



Throughout the tree, glucose molecules are linked together to form cellulose.

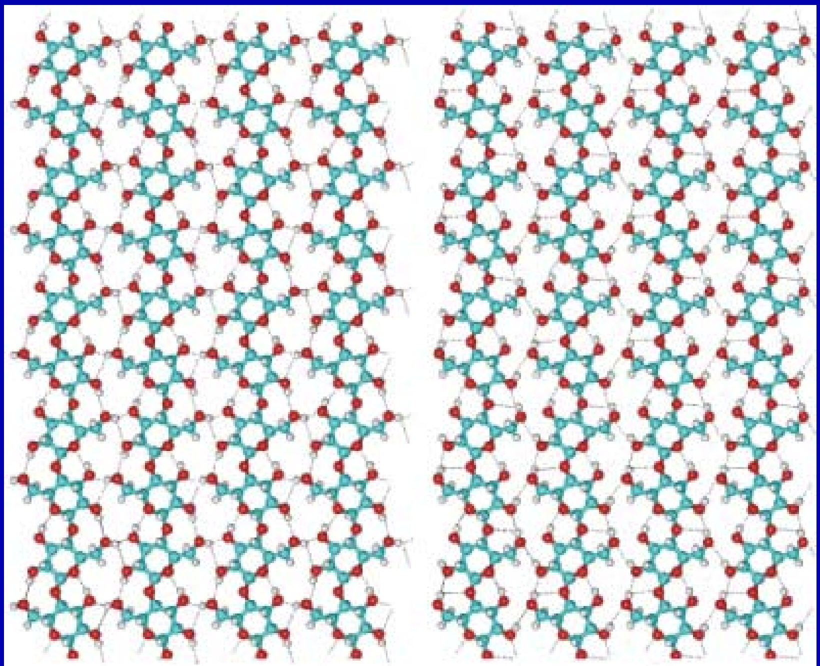


Glucose

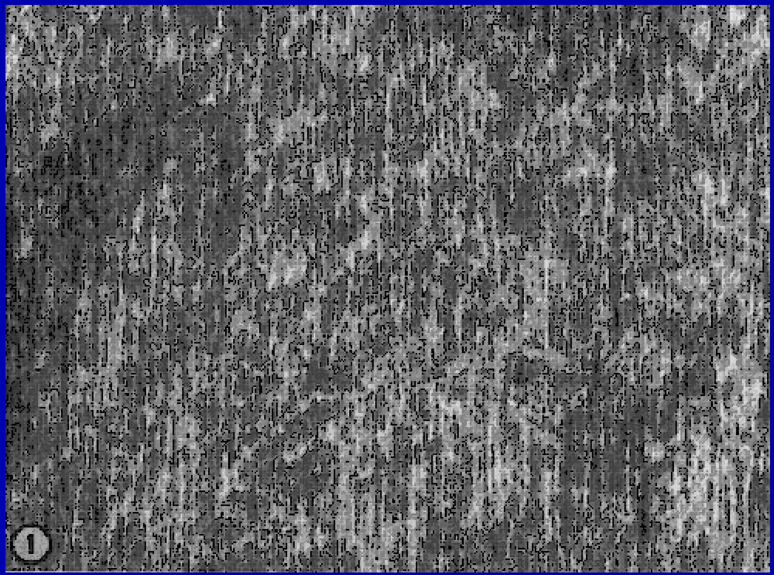


Cellulose

Cellulose molecules form fibers

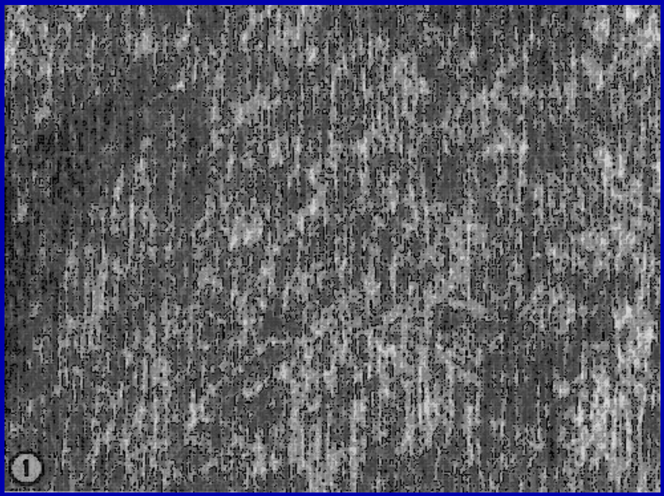


Cellulose



Fibers

Fibers form the parts of the tree



Why is it important for 8th grade students to understand and apply these ideas?

Contributes to understanding basic human body functions

- To burn food for the release of energy stored in it, oxygen must be supplied to cells, and carbon dioxide removed. Lungs take in oxygen for the combustion of food and eliminate the carbon dioxide produced…

Contributes to understanding how plants affect the environment

- Plants alter the earth's atmosphere by removing carbon dioxide from it, using the carbon to make sugars and releasing oxygen. This process is responsible for the oxygen content of the air.

Contributes to understanding climate change

- The burning of fossil fuels in the last century has increased the amount of greenhouse gases in the atmosphere, which has contributed to earth's warming.

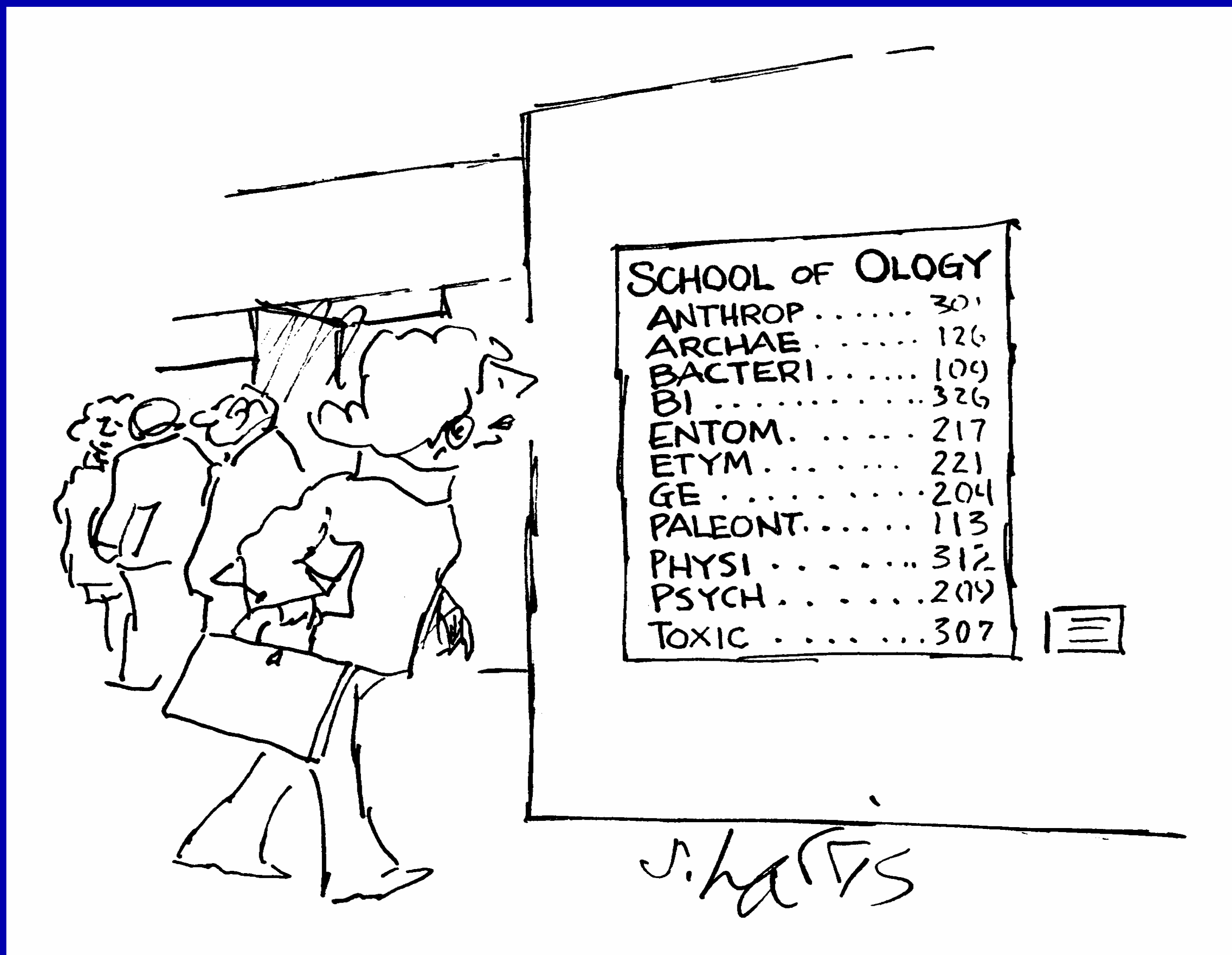
Why is it important for all adults to understand and apply these ideas?

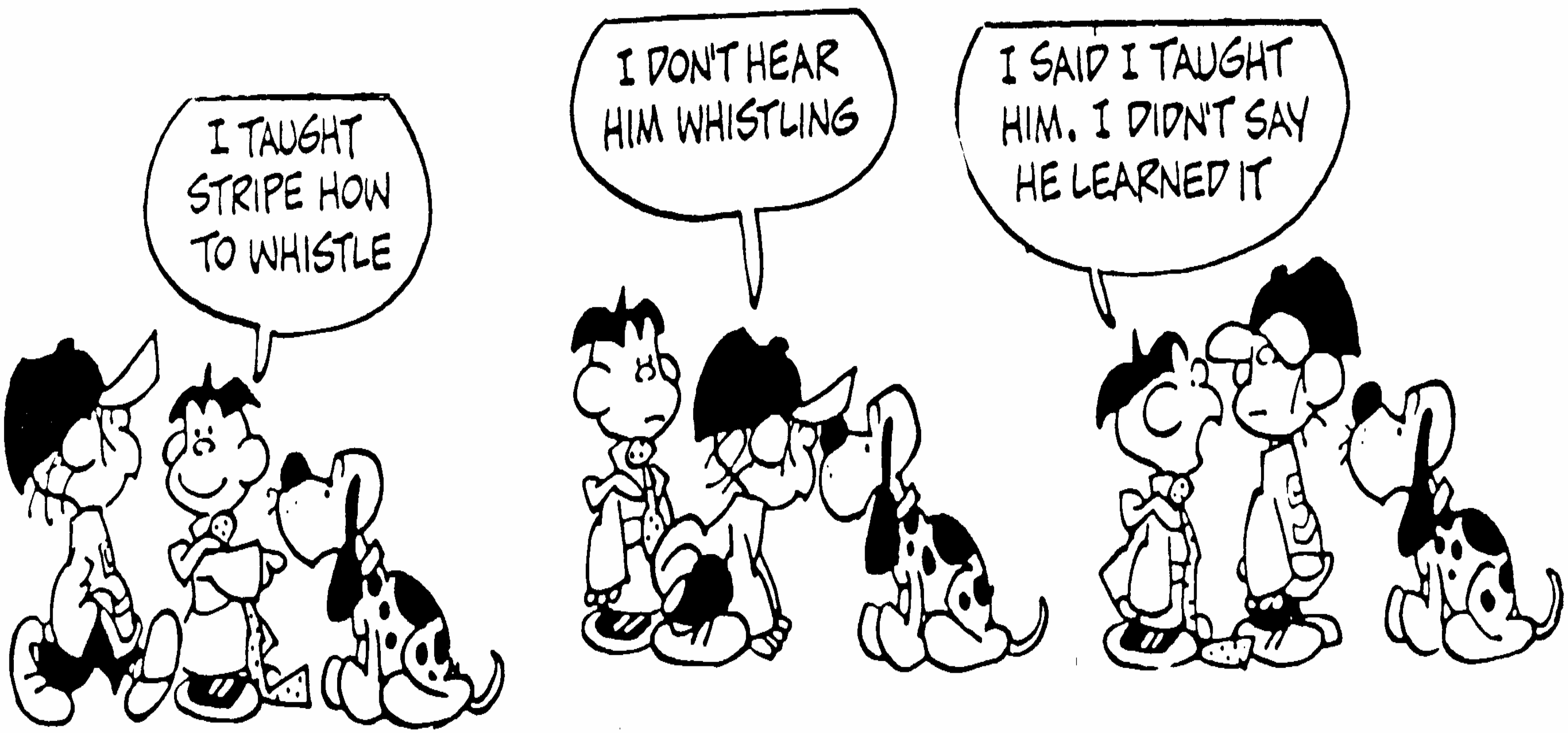
"Many of the big problems facing humanity are biological in nature, or are susceptible to biological influence…Climate change, too, is intimately bound up with biology since it is the result of carbon dioxide going into the air faster than plants can remove it."

The Economist June 16th 2007, p. 13

How well do US college graduates understand these important science ideas?

1. A seed grows into a large tree. Where did the mass of the tree come from?
2. What if I told you that the mass comes mainly from the carbon dioxide in the air?


SCHOOL OF OLOGY
ANTHROP 301
ARCHAE 126
BACTERI 109
BI 326
ENTOM 217
ETYM 221
GE 204
PALEONT 113
PHYSI 312
PSYCH 209
TOXIC 307
S. Harris


I TAUGHT STRIPE HOW TO WHISTLE
I DON'T HEAR HIM WHISTLING
I SAID I TAUGHT HIM. I DIDN'T SAY HE LEARNED IT

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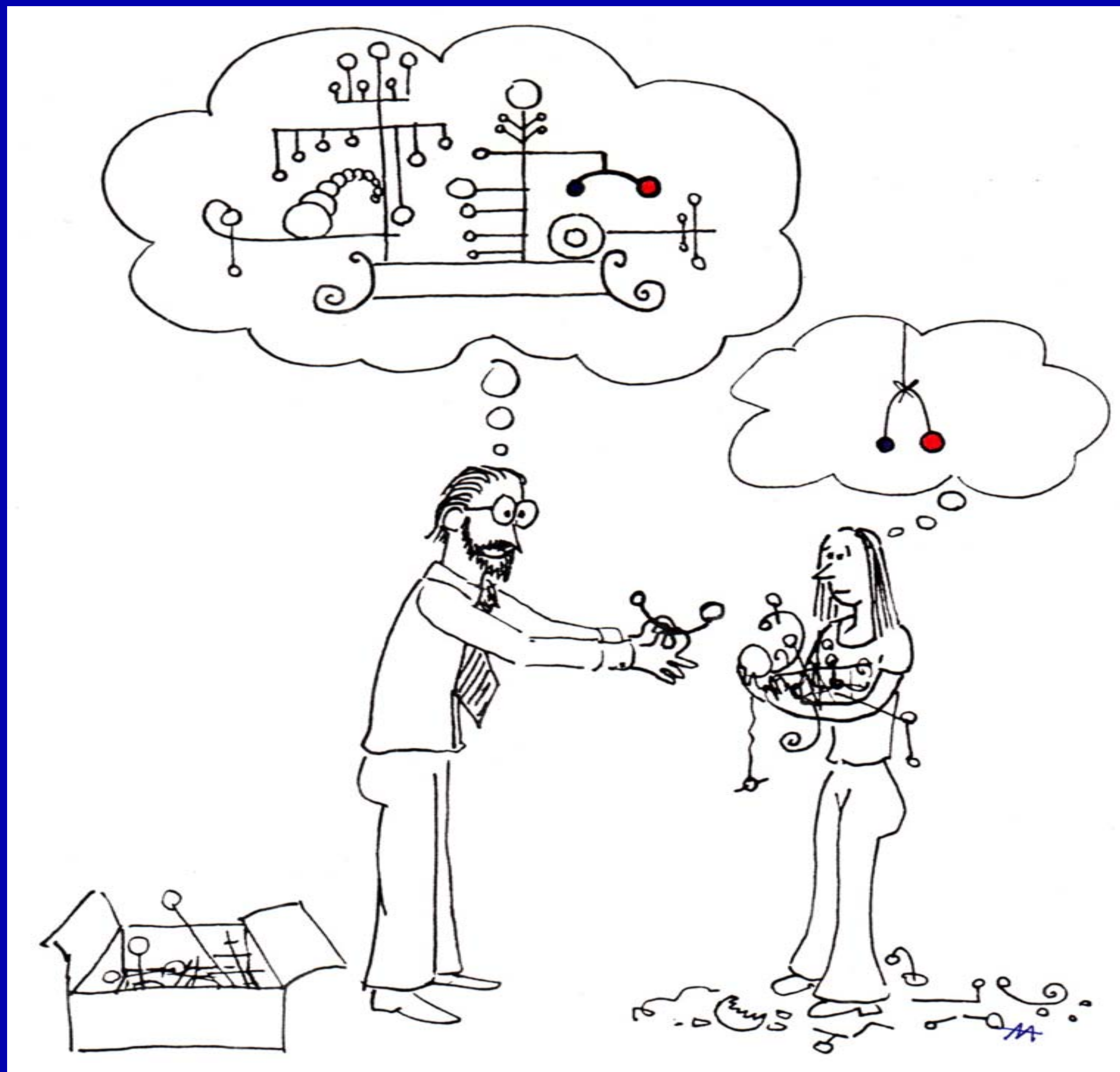


FRANK & ERNEST BOB THAVES
HERE'S WHERE THE MAGIC OF EDITING COMES IN.
THAVES
6-29

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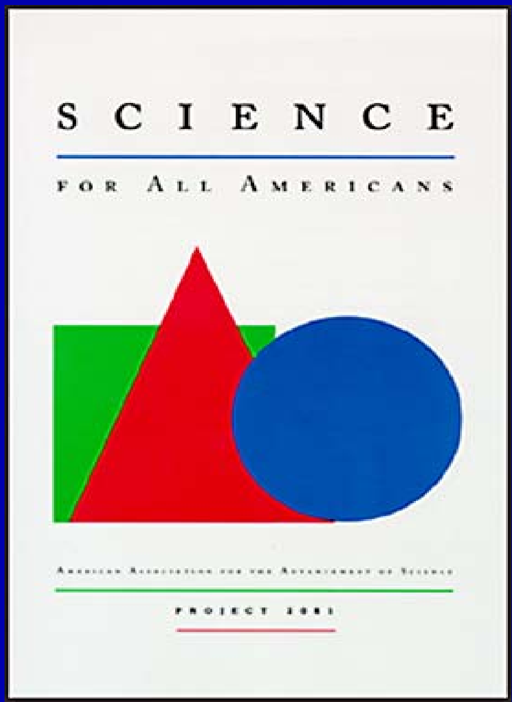
Characterizing Adult Literacy in Science Mathematics, and Technology



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
HABITS OF MIND

from **The Scientific World View**

Scientific Ideas are Subject to Change

Science is a process for producing knowledge. The process depends both on making careful observations of phenomena and on inventing theories for making sense out of those observations. Change in knowledge is inevitable because new observations may challenge prevailing theories. No matter how well one theory explains a set of observations, it is possible that another theory may fit just as well or better, or may fit a still wider range of observations. In science, the testing and improving and occasional discarding of theories, whether new or old, go on all the time. Scientists assume that even if there is no way to secure complete and absolute truth, increasingly accurate approximations can be made to account for the world and how it works.

from **The Earth**

The cycling of water in and out of the atmosphere plays an important part in determining climatic patterns--evaporating from the surface, rising and cooling, condensing into clouds and then into snow or rain, and falling again to the surface, where it collects in rivers, lakes, and porous layers of rock. There are also large areas on the earth's surface covered by thick ice (such as Antarctica), which interacts with the atmosphere and oceans in affecting worldwide variations in climate.

The earth's climates have changed radically and they are expected to continue changing, owing mostly to the effects of geological shifts such as the advance or retreat of glaciers over centuries of time or a series of huge volcanic eruptions in a short time. But even some relatively minor changes of atmospheric content or of ocean temperature, if sustained long enough, can have widespread effects on climate.

Chapter 5: THE LIVING ENVIRONMENT

from Flow of Matter and Energy

However complex the workings of living organisms, they share with all other natural systems the same physical principles of the conservation and transformation of matter and energy. Over long spans of time, matter and energy are transformed among living things, and between them and the physical environment. In these grand-scale cycles, the total amount of matter and energy remains constant, even though their form and location undergo continual change.

Almost all life on earth is ultimately maintained by transformations of energy from the sun. Plants capture the sun's energy and use it to synthesize complex, energy-rich molecules (chiefly sugars) from molecules of carbon dioxide and water…

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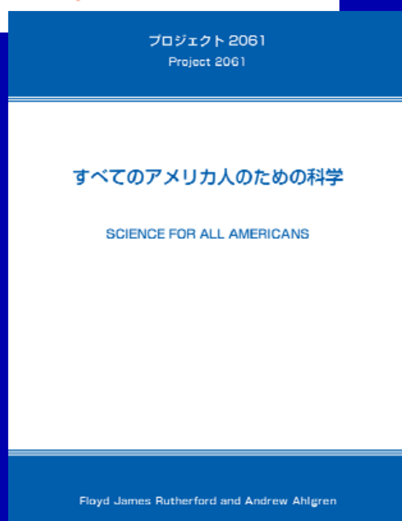

Essential Elements of K-12 Education Reform

- High-quality science standards
- Effective student assessments
- High-quality textbooks and other curriculum materials
- Well-prepared teachers
- Policies and strategies to support needed changes

High-Quality K-12 Science Standards

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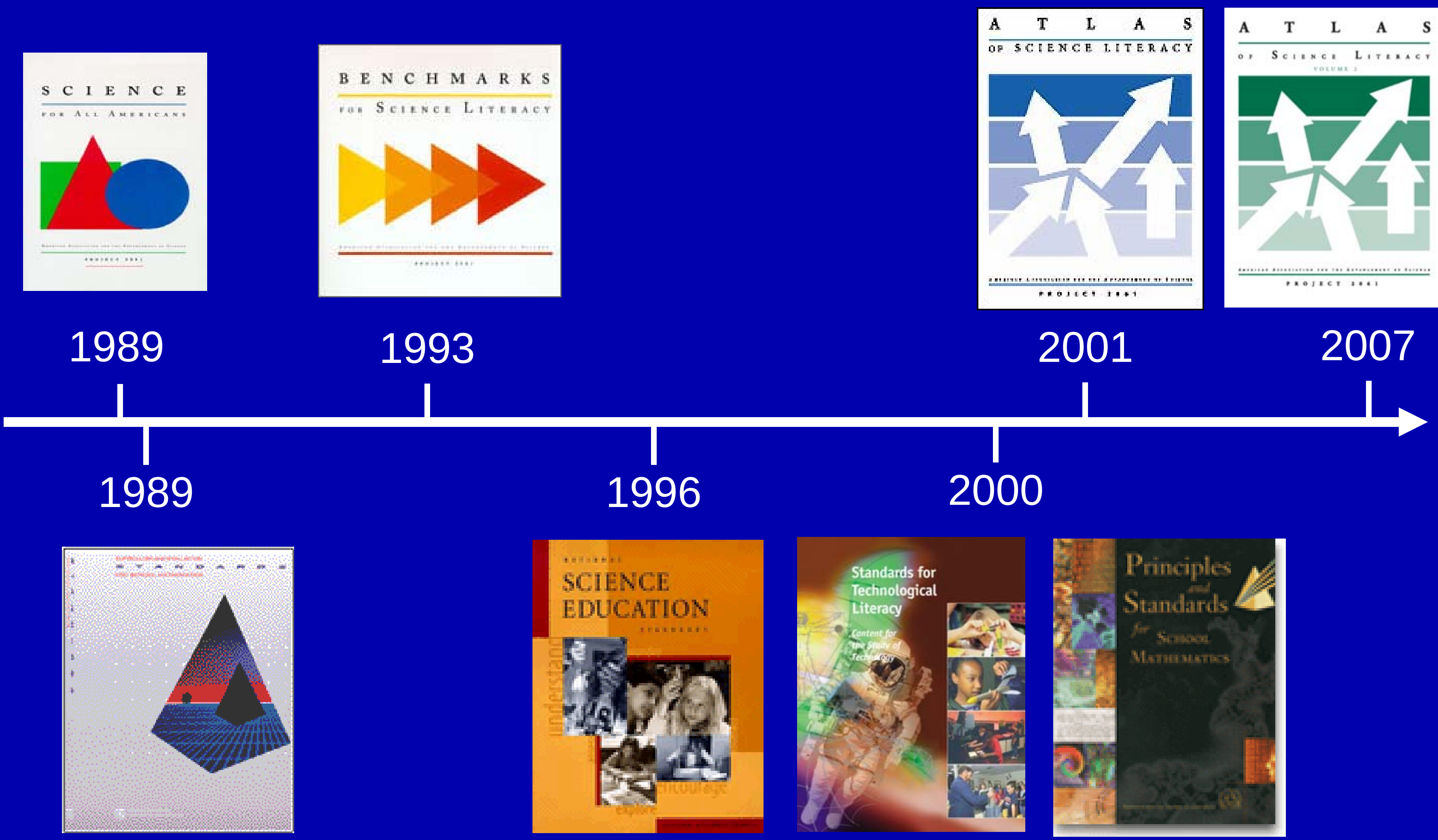
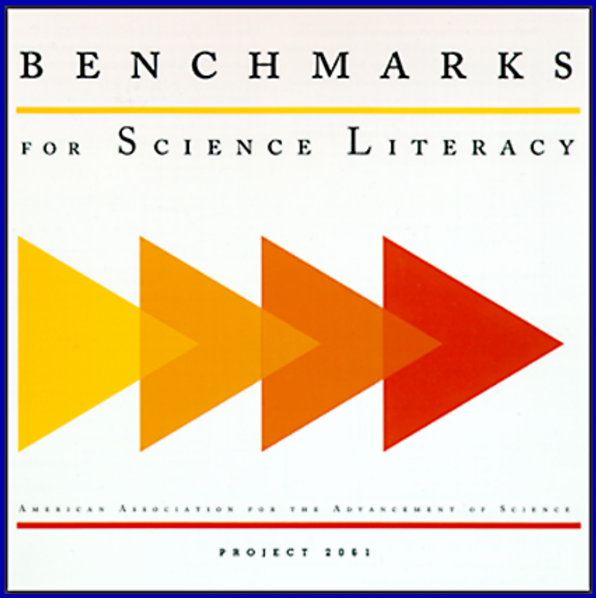
National Standards Documents



K-12 steps toward science literacy



THE NATURE OF SCIENCE
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HUMAN SOCIETY
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THE MATHEMATICAL WORLD
HISTORICAL PERSPECTIVES
COMMON THEMES
HABITS OF MIND

Chapter 5: THE LIVING ENVIRONMENT

from Flow of Matter and Energy

K-2: Most plants and animals need to take in both water and air. In addition, animals need to take in food and plants need light.

3-5: From food, people and other organisms obtain fuel and building materials for body repair and growth.

6-8: All organisms need food as a source of molecules that provide chemical energy and building material. Plants use energy in light to make sugars out of carbon dioxide and water. Plants and other organisms use sugar molecules to make more complex molecules that become part of their body structures. If not used as fuel or building materials, these molecules may be stored for later use.

9-12: The chemical elements that make up the molecules of living things pass through food webs and are combined and recombined in different ways. At each link in a food web, some energy is stored in newly made structures but much is dissipated into the environment as heat. Continual input of energy from sunlight keeps the process going.

K-12 Connections among steps

THE NATURE OF SCIENCE
THE NATURE OF MATHEMATICS
THE NATURE OF TECHNOLOGY
THE PHYSICAL SETTING
THE LIVING ENVIRONMENT
THE HUMAN ORGANISM
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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*

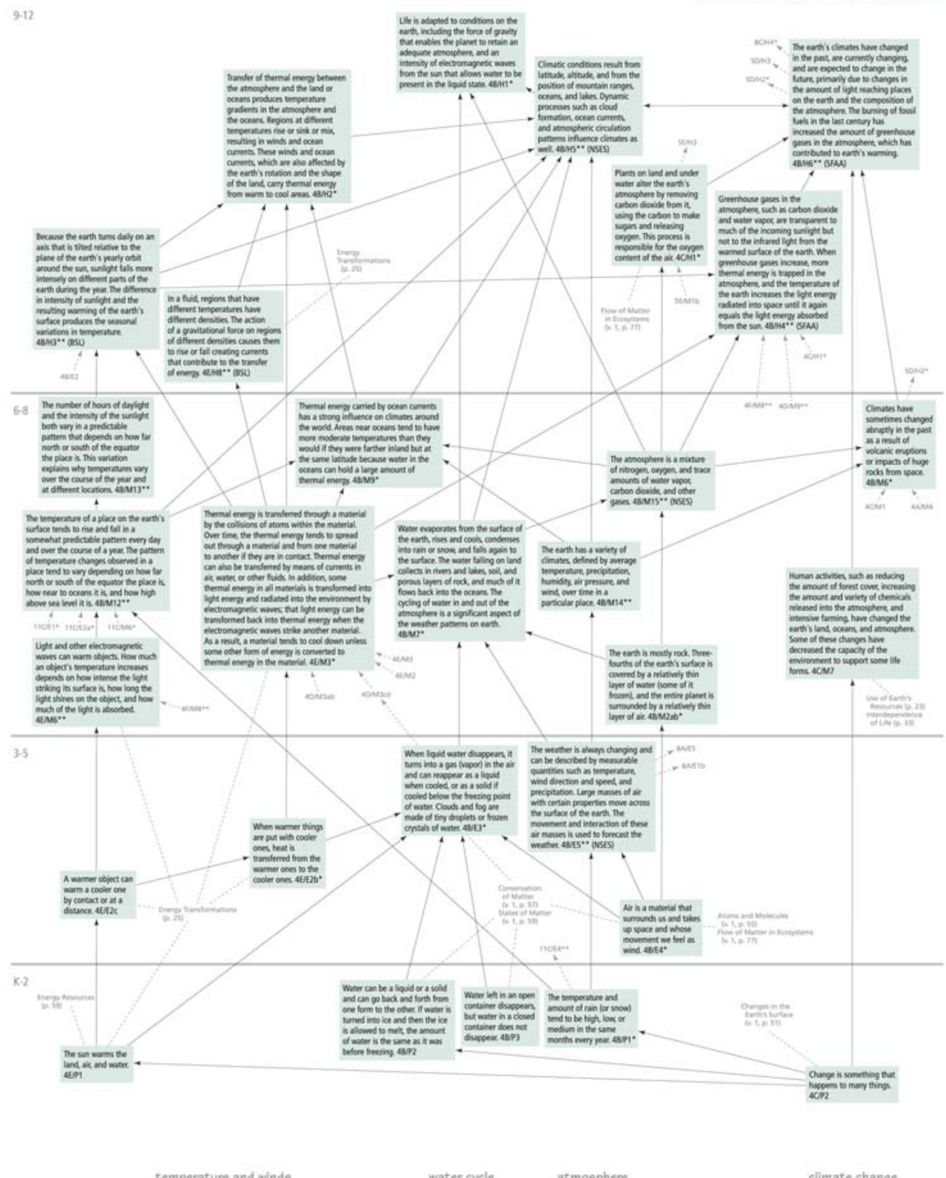
Students of all ages (including college students and adults) have difficulty understanding what causes the seasons. Students may not be able to understand explanations of the seasons before they reasonably understand the relative size, motion, and distance of the sun and the earth (Sadler, 1987; Vosniadou, 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).

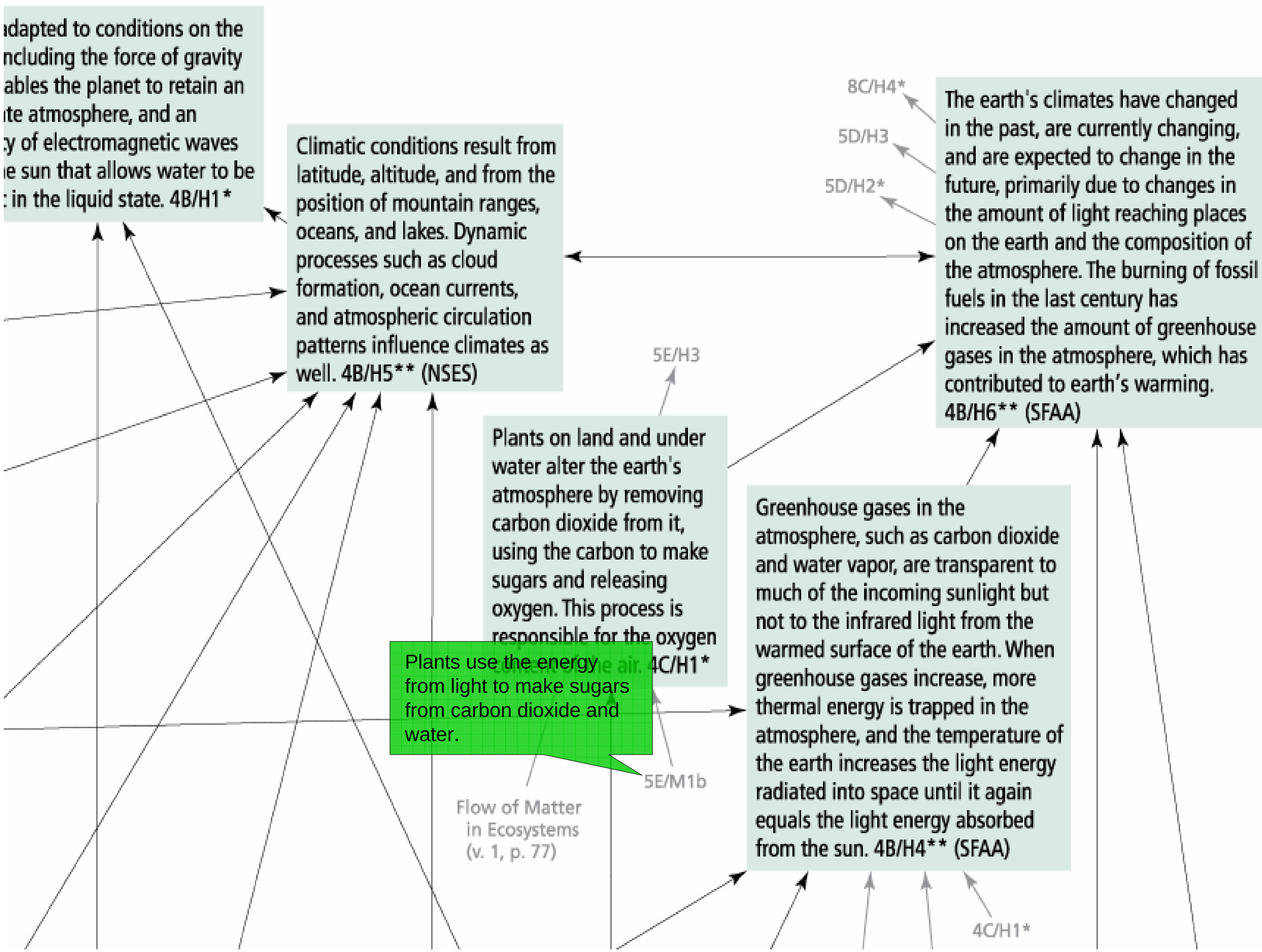
Although upper elementary students may identify air as existing even in static situations and recognize that it takes space, recognizing that air has weight may be challenging even for high-school students (Sere, 1985; Driver et al., 1994a; Krnel, Watson, & Glazar, 1998). Students of all ages (including 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.




adapted to conditions on the
ncluding the force of gravity
ables the planet to retain an
te atmosphere, and an
y of electromagnetic waves
e sun that allows water to be
in the liquid state. 4B/H1*
Climatic conditions result from latitude, altitude, and from the position of mountain ranges, oceans, and lakes. Dynamic processes such as cloud formation, ocean currents, and atmospheric circulation patterns influence climates as well. 4B/H5** (NSES)
8C/H4*
5D/H3
5D/H2*
The earth's climates have changed in the past, are currently changing, and are expected to change in the future, primarily due to changes in the amount of light reaching places on the earth and the composition of the atmosphere. The burning of fossil fuels in the last century has increased the amount of greenhouse gases in the atmosphere, which has contributed to earth's warming. 4B/H6** (SFAA)
5E/H3
Plants on land and under water alter the earth's atmosphere by removing carbon dioxide from it, using the carbon to make sugars and releasing oxygen. This process is responsible for the oxygen content of the air. 4C/H1*
Plants use the energy from light to make sugars from carbon dioxide and water.
Greenhouse gases in the atmosphere, such as carbon dioxide and water vapor, are transparent to much of the incoming sunlight but not to the infrared light from the warmed surface of the earth. When greenhouse gases increase, more thermal energy is trapped in the atmosphere, and the temperature of the earth increases the light energy radiated into space until it again equals the light energy absorbed from the sun. 4B/H4** (SFAA)
5E/M1b
Flow of Matter in Ecosystems (v. 1, p. 77)
4C/H1*

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—Jim Westrick, CEO, WestJam Enterprises, Inc.

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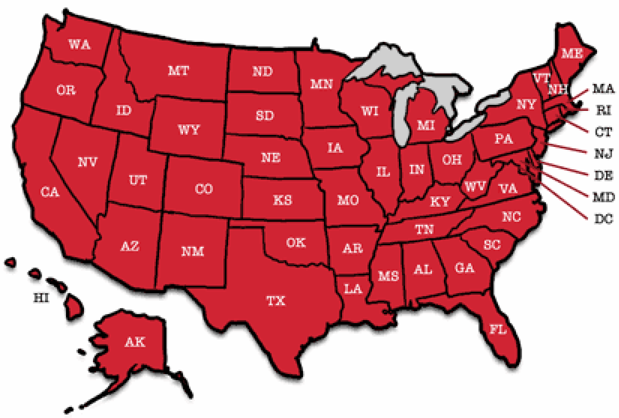
Browse by State: (click on a state below to get started)



Alabama	Kentucky	North Dakota
Alaska	Louisiana	Ohio
Arizona	Maine	Oklahoma
Arkansas	Maryland	Oregon
California	Massachusetts	Pennsylvania
Colorado	Michigan	Rhode Island
Connecticut	Minnesota	South Carolina
Delaware	Mississippi	South Dakota
District of Columbia	Missouri	Tennessee
Florida	Montana	Texas
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Hawaii	Nevada	Vermont
Idaho	New Hampshire	Virginia
Illinois	New Jersey	Washington
Indiana	New Mexico	West Virginia
Iowa	New York	Wisconsin
Kansas	North Carolina	Wyoming

Done | Now: Mostly Cloudy, 70° F | Thu: 85° F | Fri: 66° F | Sat: 62° F | Sun: 64° F

Comparing Science Standards

	Benchmarks	California Standards
K-2	Most plants and animals need to take in both water and air. In addition, animals need to take in food and plants need light.	Know that both plants and animals need water, animals need food, and plants need light.
3-5	From food, people and other organisms obtain fuel and building materials for body repair and growth.	Know that plants use carbon dioxide (CO_2) and energy from sunlight to build molecules of sugar and release oxygen.
6-8	All organisms need food as a source of molecules that provide chemical energy and building material. Plants use energy in light to make sugars out of carbon dioxide and water. Plants and other organisms use sugar molecules to make more complex molecules that become part of their body structures. If not used as fuel or building materials, these molecules may be stored for later use.	Know that carbon, because of its ability to combine in many ways, has a central role in living organisms.
9-12	The chemical elements that make up the molecules of living things pass through food webs and are combined and recombined in different ways. At each link in a food web, some energy is stored in newly made structures but	Know that usable energy is captured from sunlight by chloroplasts and is stored through the synthesis of sugar from carbon dioxide.

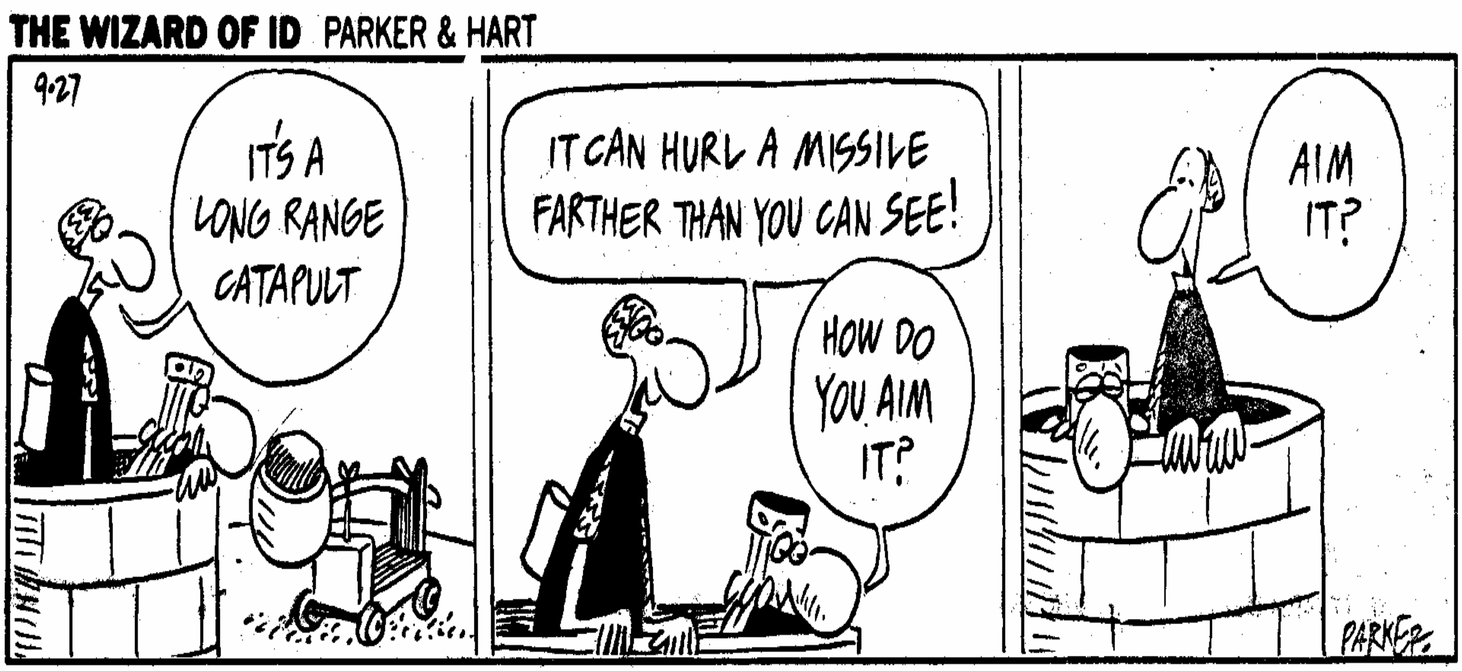
Comparing Science Standards

	Benchmarks	Arkansas
K-2	Most plants and animals need to take in both water and air. In addition, animals need to take in food and plants need light.	Identify basic needs of plants and animals: food, water, light, air, space.
3-5	From food, people and other organisms obtain fuel and building materials for body repair and growth.	Identify the role of chlorophyll in the process of photosynthesis. Explain photosynthesis.
6-8	All organisms need food as a source of molecules that provide chemical energy and building material. Plants use energy in light to make sugars out of carbon dioxide and water. Plants and other organisms use sugar molecules to make more complex molecules that become part of their body structures. If not used as fuel or building materials, these molecules may be stored for later use.	Identify ways plants use organic and inorganic components in the soil.
9-12	The chemical elements that make up the molecules of living things pass through food webs and are combined and recombined in different ways. At each link in a food web, some energy is stored in newly made structures but much is dissipated into the environment as heat. Continual input of energy from	Describe and model the conversion of light energy to chemical energy by photosynthetic organisms: light dependent reactions, light independent reactions.

Characteristics of High Quality Standards

- Importance: Do they focus on the most important science ideas?
- Clarity: Are they clear and specific enough to guide the design of curriculum, instruction, and assessment?
- Coherence: Are they logically connected as a set?
- Age-appropriateness: Are expectations for the different grade levels appropriate?

Taking Standards Seriously: Aligning Curriculum, Instruction, and Assessment with Learning Goals

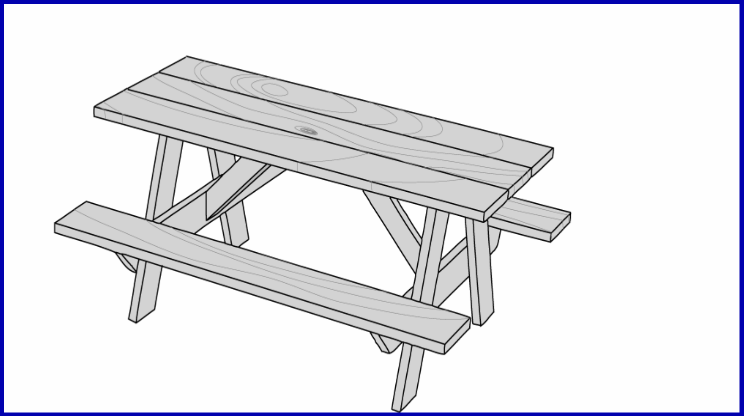


The Assessment Scene

- **NCLB now requires science testing in elementary, middle, and high school**
- **2009 NAEP Science Assessment is based on national standards (*Benchmarks* and *NSES*)**
- **Project 2061 is currently developing standards-based middle-school assessments on 20 science topics**

Sample 2061 Item Recently Field Tested

A table is made from wood that is cut from a tree. Where did most of the material that makes up the table originally come from?



A. From minerals in the soil

B. From sunlight

C. From oxygen in the air

*D. From carbon dioxide in the air

Sample Item from State Test

Use the information at the right and your knowledge of science to answer questions 1-2. The first equation represents photosynthesis. Plants use energy from sunlight to produce sugar and oxygen from carbon dioxide and water. The second equation represents aerobic respiration. Plants and animals release stored energy in a reaction between sugar molecules and oxygen. This reaction produces carbon dioxide and water.

Photosynthesis

$$6CO_2 + 6H_2O \xrightarrow{\text{light energy}} C_6H_{12}O_6 + 6O_2$$

Respiration

$$C_6H_{12}O_6 + 6O_2 \rightarrow \text{energy} + 6CO_2 + 6H_2O$$

1. Oxygen (O_2) is an example of :

A) an alloy B) a molecule C) a salt D) a mixture

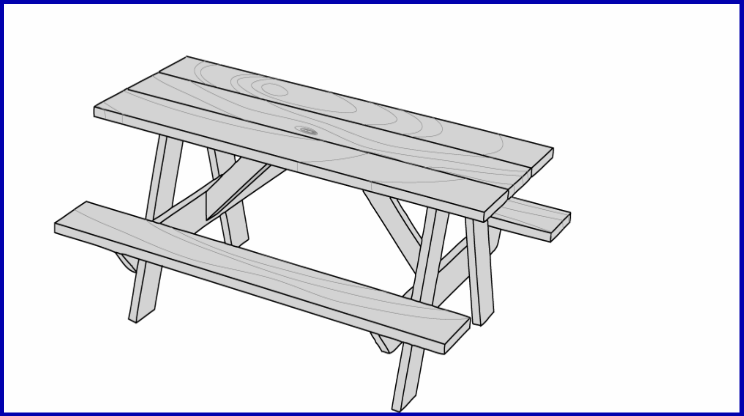
2. To produce 4 molecules of sugar, a plant needs:

A) 6 molecules of hydrogen B) 12 molecules of ATP

C) 18 molecules of water D) 24 molecules of carbon dioxide

Sample 2061 Item Recently Field Tested

A table is made from wood that is cut from a tree. Where did most of the material that makes up the table originally come from?



A. From minerals in the soil (53.6%, 53%)

B. From sunlight (19.4%, 15%)

C. From oxygen in the air (10.6%, 6%)

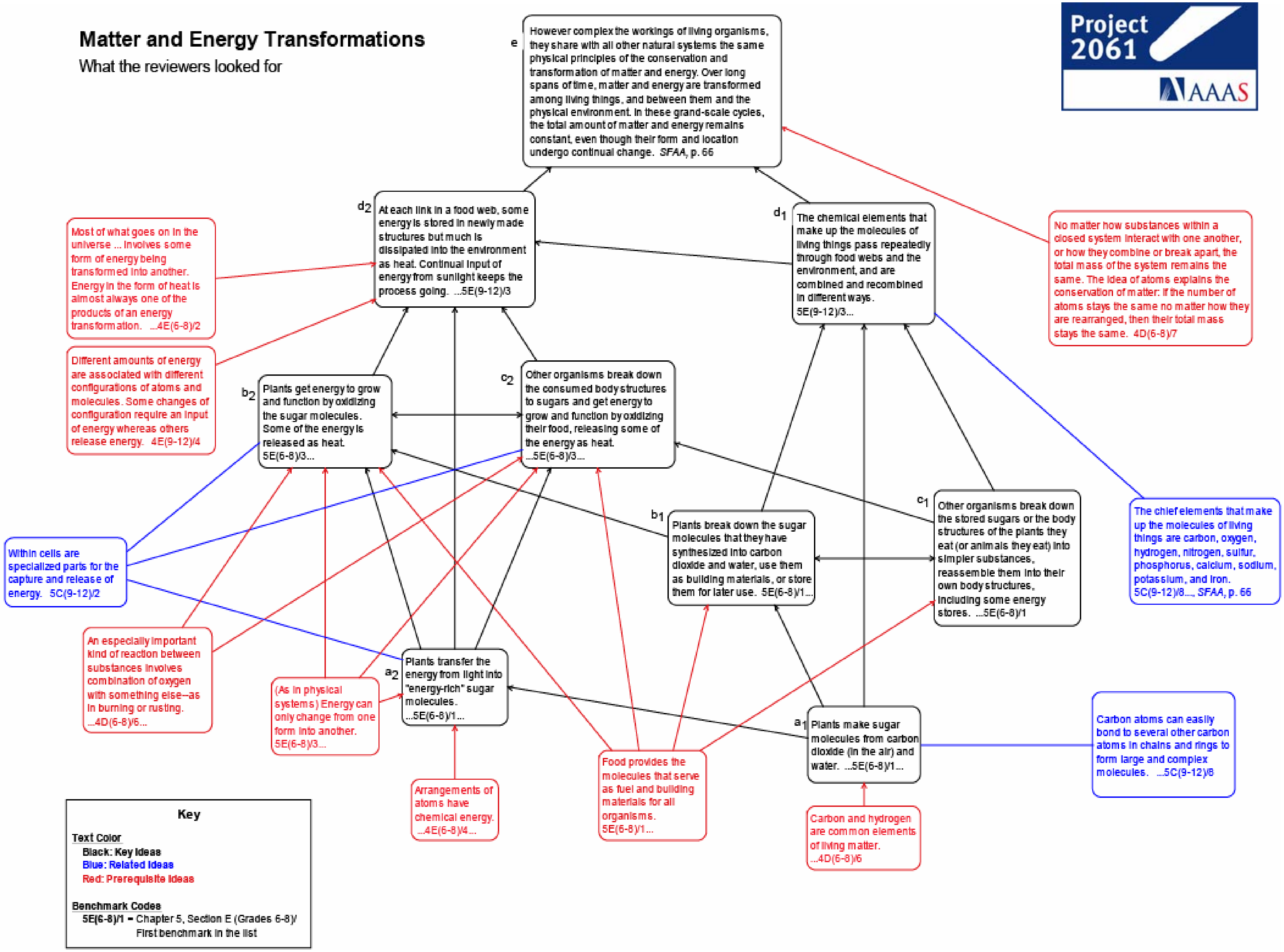
*D. From carbon dioxide in the air (16.5%, 27%)

We Need Textbooks That

- Present the set of key ideas coherently
- Attend to student ideas that interfere with learning
- Include representations that effectively clarify the key science ideas
- Engage students with natural phenomena to make the key science ideas real
- Help students interpret their experiences with the natural world and relate them to the scientific ideas

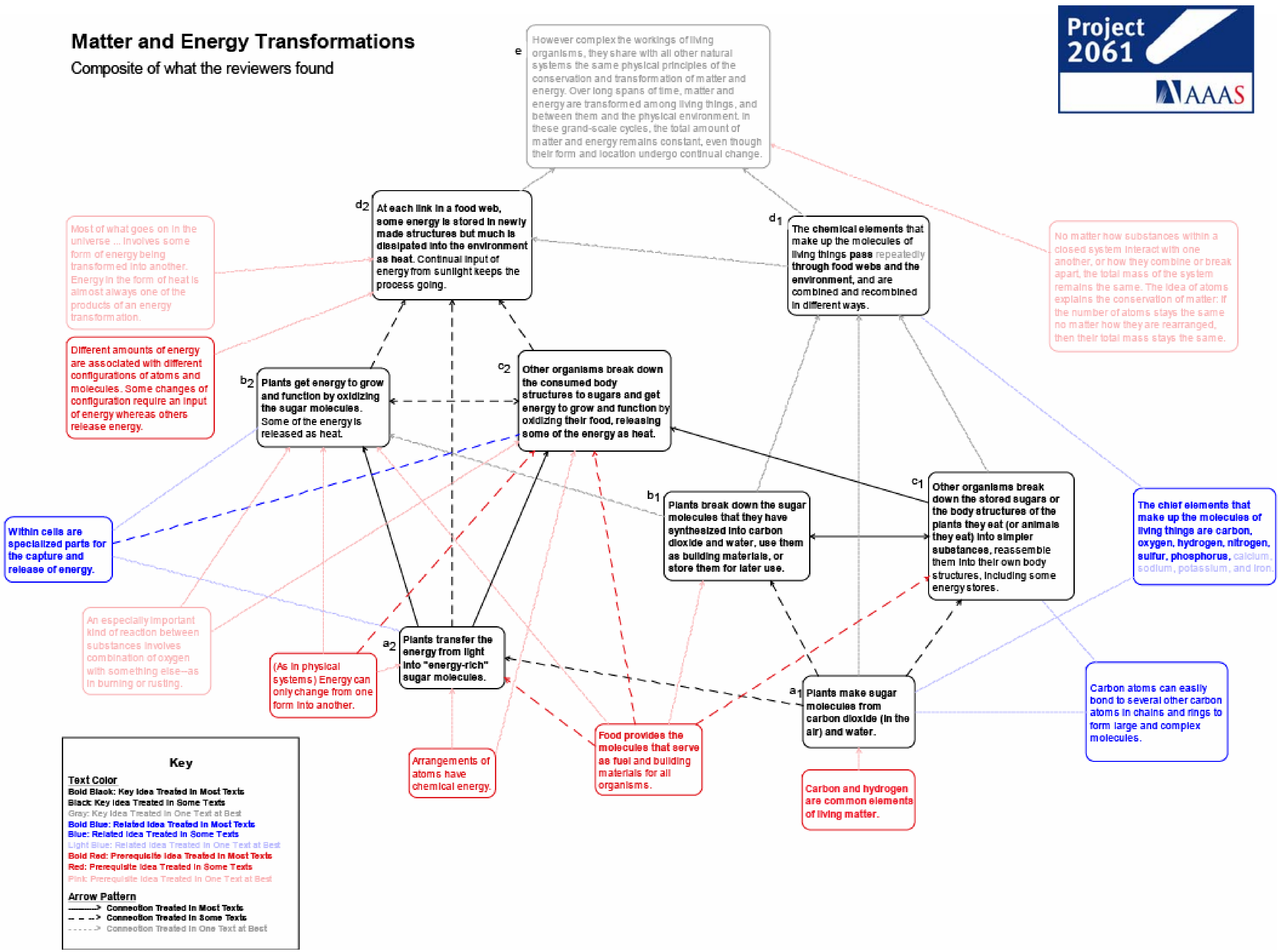
Matter and Energy Transformations

What the reviewers looked for



Matter and Energy Transformations

Composite of what the reviewers found



Topic: Matter and energy transformations

Project 2061 Instructional Analysis of Biology Textbooks

Project 2061 AAAS

Instructional Categories	Biology (Miller · Levine, Prentice Hall)	Biology: A Community Context (South-Western Educational Publishing)	Biology: Principles & Explorations (Holt, Rinehart and Winston)	Biology: The Dynamics of Life (Glencoe, McGraw-Hill)	Biology: Visualizing Life (Holt, Rinehart and Winston)	BSCS Biology: A Human Approach (Kendall Hunt)	BSCS Biology: An Ecological Approach (Kendall Hunt)	Heath Biology (D.C. Heath and Company)	Insights in Biology (Kendall Hunt)	Modern Biology (Holt, Rinehart and Winston)
I. PROVIDING A SENSE OF PURPOSE										
Conveying unit purpose	Fair	Good	Poor	Poor	Poor	Excellent	Fair	Poor	Fair	Poor
Conveying lesson purpose	Poor	Fair	Poor	Poor	Poor	Satisfactory	Poor	Poor	Satisfactory	Poor
Justifying lesson sequence	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair
II. TAKING ACCOUNT OF STUDENT IDEAS										
Attending to prerequisite knowledge and skills	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor
Alerting teacher to commonly held student ideas	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor
Assisting teacher in identifying own students' ideas	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Fair	Poor
Addressing commonly held ideas	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor
III. ENGAGING STUDENTS WITH RELEVANT PHENOMENA										
Providing variety of phenomena	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor
Providing vivid experiences	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor
IV. DEVELOPING AND USING SCIENTIFIC IDEAS										
Introducing terms meaningfully	Poor	Poor	Poor	Poor	Poor	Poor	Fair	Poor	Satisfactory	Poor
Representing ideas effectively	Poor	Poor	Poor	Poor	Poor	Fair	Poor	Poor	Poor	Fair
Demonstrating use of knowledge	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor
Providing practice	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor
V. PROMOTING STUDENT THINKING ABOUT PHENOMENA, EXPERIENCES, AND KNOWLEDGE										
Encouraging students to explain their ideas	Poor	Poor	Poor	Poor	Poor	Fair	Poor	Poor	Fair	Poor
Guiding student interpretation and reasoning	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Fair	Poor
Encouraging students to reflect on their own learning	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor
VI. ASSESSING PROGRESS										
Aligning assessment to goals	Poor	Poor	Poor	Poor	Poor	Satisfactory	Fair	N/A	Poor	Poor
Testing for understanding	Poor	Poor	Poor	Poor	Poor	Satisfactory	Fair	N/A	Poor	Poor
Using assessment to inform instruction	Poor	Poor	Poor	Poor	Poor	Poor	Poor	N/A	Poor	Poor

= Excellent (3); = Good (2.5-2.9); = Satisfactory (2-2.4); = Fair (1.5-1.9); = Poor (0-1.4)

Existing textbooks provide little help

THE NATION'S NEWSPAPER

USA TODAY

NO. 1 IN THE USA . . . FIRST IN DAILY READERS

Failing grade for science books

Study says popular texts give useless lessons, lack focus

By Tamara Henry
USA TODAY

Those thick, heavy science textbooks middle school students lug around are "full of disconnected facts" and irrelevant classroom activities, a study out Tuesday says.

Nine widely used middle school textbooks were examined over a four-year period by Project 2061, a long-term effort of the American Association for the Advancement of Science, to improve science, math and technology education in schools.

Not one was rated satisfactory, including the new crop of texts that has just entered the market, project director George Nelson says.

The study says the texts:

▶ Cover too many topics.

▶ Fail to develop any of the topics well.

▶ Offer classroom activities that are nearly useless in helping teachers and students understand important concepts.

"Our students are lugging home heavy texts full of disconnected facts that neither educate nor motivate them," Nelson says. "Because textbooks are the backbone of classroom instruction, we must demand improvement."

Two of the most popular textbooks — *Glencoe Science*, Glencoe/McGraw-Hill, 1997 and *Prentice Hall Science*, Prentice Hall, 1997 — received some of the lowest ratings, Nelson says. A spokesman at Prentice Hall said editors were withholding immediate reaction. Officials at other companies were unavailable.

Three study materials that are not part of any textbooks but teach a particular segment of the curriculum rated much higher than the textbooks. One of them is *Matter and Molecules*, Michigan State University, 1988.

Nelson says two independent teams of middle school teachers, curriculum specialists and professors of science education examined how well each textbook helps students learn key ideas in earth science, life science and physical science.

The project report will be sent to the heads of science textbook divisions.

Well Prepared K-12 Science Teachers

Some Important Considerations

- 150-200,000 science teachers in grades 7-12
- 1,450,000 elementary school teachers also teach science
- Science and mathematics standards require teachers to have knowledge and skills that many did not receive in their teacher preparation programs
- Teachers need 60-80 hours of professional development before changes are evident in classroom practice
- Strongest effects of professional development are in programs that focus on content knowledge and student learning

Policies to Support Improvement

If We Focus on Important Science Learning Goals We Can Achieve Universal Science Literacy When the Comet Returns

2061

1985

1910

1834

1758

1682

Additional AAAS Resources

http://www.project2061.org
http://www.smartschoolboards.org