About Strands

Strands, or strand maps, are networks of benchmarks through which students might progress on their way to the adult literacy goals defined in *Science for All Americans.* The strands show the development of concepts from rudimentary benchmarks at the elementary level through middle-school learning to the sophisticated level of understanding expected of high school graduates. Strand maps do not appear in the book version of *Benchmarks for Science Literacy,* but 30 sample strand maps are included on *Benchmarks on Disk.* Strands can be used in the analysis and planning of a K-12 curriculum and can inspire users to develop additional strands for other goals in *Science for All Americans.*

The strand maps on *Benchmarks on Disk* do not show the text of the included benchmarks, however. Using graphics software, workshop leaders can create flowchart maps that include benchmarks text (see, for example, the **Water Cycle** strand). These graphical strand maps better illustrate the interdependence of benchmarks across the grade-span, sections, and topics. They help participants understand how individual benchmarks contribute to progressive achievement of science literacy by showing how related benchmarks build on and reinforce one another. Seven strand maps are included in this *Guide*.

As you examine strands you will see that sometimes a later benchmark explains an earlier one or brings an earlier concept to a more sophisticated level. Sometimes a benchmark provides an example of a generalization in another benchmark, thus both extending and reinforcing it. Sometimes two or more ideas converge at a higher grade level to form a more complex idea, or they reinforce one another.

Note that the language in the collection of benchmarks is not thoroughly fine-tuned—that is, any one benchmark was not conscientiously tuned to relate optimally to every other related benchmark, especially if the related benchmarks are in different chapters. The process of drawing strand maps reveals these imperfect fits, and subsequent versions will be improved. Project 2061 encourages you to share any new strand maps you develop or any suggestions you have for improving the sample strand maps included on the disk.

Features of Strand Maps on *Benchmarks on Disk*

- The title identifies the *Science for All Americans* topic addressed by the strand.

- A code indicates the chapter, section, and benchmark sequence in *Benchmarks for Science Literacy.*

Strand Map: Water Cycle

9-12 (4B) Weather (in the short run) and climate (in the long run) involve the transfer of energy in and out of the atmosphere. Solar radiation heats the land masses, oceans and air. Transfer of heat energy at the boundaries between the atmosphere, the land masses, and the ocean results in layers of different temperatures and densities in both the ocean and atmosphere. The action of gravitational force on regions of different densities causes them to rise or fall—and such circulation, influenced by the rotation of the earth, produces winds and ocean currents.

6-8 (4B) The cycling of water in and out of the atmosphere plays an important role in determining climatic patterns. Water evaporates from the surface of the earth, rises and cools, condenses into rain or snow, and falls again to the surface. The water falling on land collects in rivers and lakes, soil, and porous layers of rock, and much of it flows back into the ocean.

6-8 (4E) Heat can be transferred through materials by the collisions of atoms or across space by radiation. If the material is fluid, currents will be set up in it that aid the transfer of heat.

3-5 (4B) Things on or near the earth are pulled toward it by the earth's gravity.

3-5 (4B) When liquid water disappears, it turns into a gas (vapor) in the air and can reappear as a liquid when cooled, or as a solid if cooled below the freezing point of water. Clouds and fog are made of tiny droplets of water.

3-5 (4B) Air is a substance that surrounds us, takes up space, and whose movement we feel as wind.

K-2 (4B) Water left in an open container disappears, but water in a closed container does not disappear.

K-2 (4B) Water can be a liquid or a solid and can go back and forth from one form to the other. If water is turned into ice and then the ice is allowed to melt, the amount of water is the same as it was before freezing.

- A single arrow ➔ indicates that one benchmark contributes to another, a double arrow ⇐➔ indicates that two benchmarks reinforce and contribute to each other, and a floating arrow (one without a visible source) indicates that precursors or successors exist in other strands.

The meaning of arrows may differ from one case to the next. Four examples follow:

1. *A concept may increase in sophistication as it proceeds from earlier to later grade spans.*

For example, the understanding that

> Different plants and animals have external features that help them thrive in different kinds of places. (K-2)

can be extended conceptually to

> Individuals of the same kind differ in their characteristics, and sometimes the differences give individuals an advantage in surviving and reproducing. (3-5)

2. *A phenomenon described in an earlier grade span may be explained in a later grade span.*

For example, the understanding that

> Water evaporates from the surface of the earth, rises and cools. . . .(6-8)

can be enriched to include an explanation for why evaporating water rises, namely that

> Transfer of heat energy at the boundaries between the atmosphere, the land masses, and the oceans results in layers of different temperatures and densities in both the ocean and atmosphere. The action of gravitational force on regions of different densities causes them to rise or fall. (9-12)

See *Water cycle* strand.

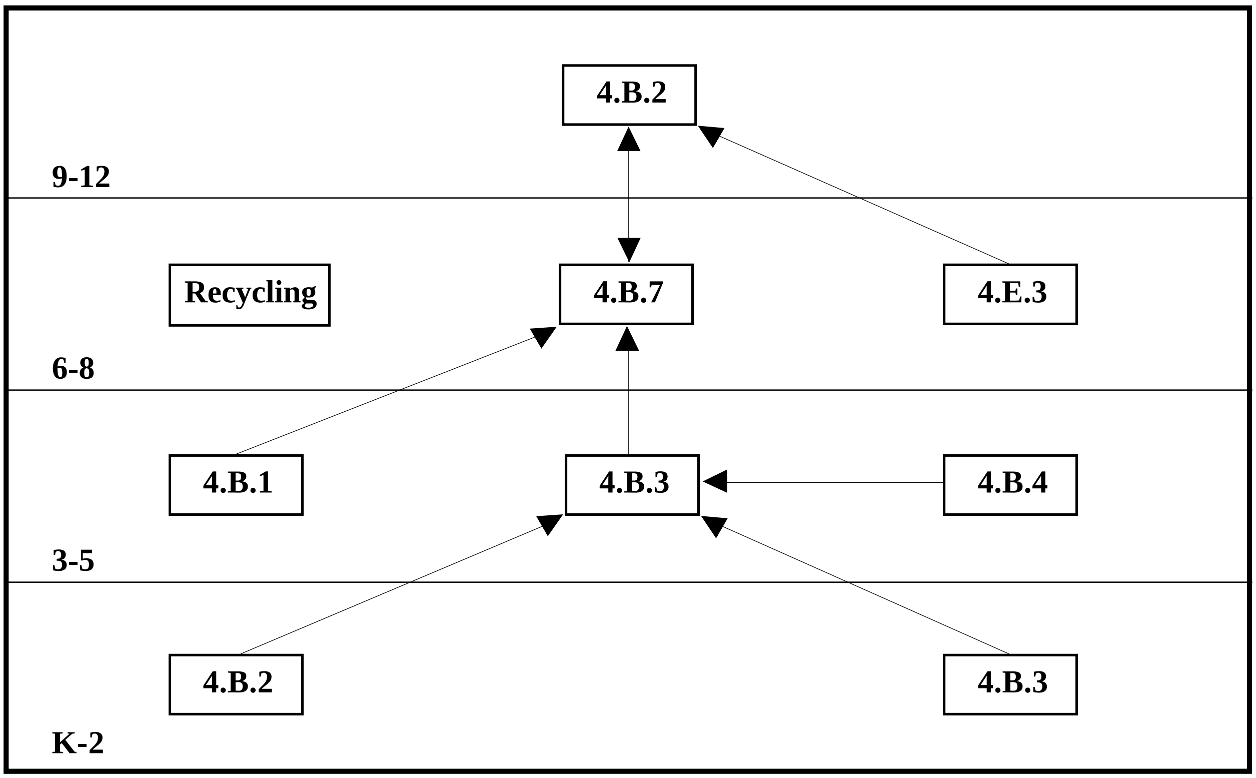
3. *Two or more ideas at one level may converge at the next level to form a more complex idea. Sometimes entire strands must converge to make a complex idea understandable.*

For example, knowing that

> Water can be a liquid or a solid and can go back and forth from one form to the other. (K-2)

> Water left in an open container disappears, but water in a closed container does not disappear. (K-2)

Water Cycle



Overview:

This sequence of benchmarks leads to the SFAA goal that water evaporates from the surface of the earth, rises and cools, condenses into clouds and then into rain or snow, and falls again to the surface, where it collects in rivers, lakes, soil, and porous layers of rock (SFAA Chapter 4, The Physical Setting). This goal appears in grades 6-8 and is extended in grades 9-12 to include an explanation for why evaporated water rises. Before students can understand that “when liquid water disappears, it turns into a gas (vapor) in the air,” they would need to move beyond viewing air as something only produced by wind to accepting it as a permanent substance. Before they can understand rainfall in terms of gravity, they need to know that “things on or near the earth are pulled toward it by the earth’s gravity.”

and

> Air is a substance that surrounds us, takes up space, and whose movement we feel as wind (3-5)

helps students to understand, at the next level, that

> When liquid water disappears, it turns into a gas (vapor) in the air and can reappear as a liquid when cooled, or as a solid if cooled below the freezing point of water. (3-5)

Similarly, at least two strands, “Evidence from existing organisms” and “Fossil evidence for evolution” contribute to the understanding that

> The basic idea of biological evolution is that the earth’s present-day species develop from earlier, distinctly different species. (9-12)

See *Idea of evolution* strand.

4. Two ideas (at the same or different grade ranges) may reinforce one another.

> Knowing something about a generalization makes understanding an example easier, and familiarity with an example broadens and strengthens the generalization.

For example, knowing that

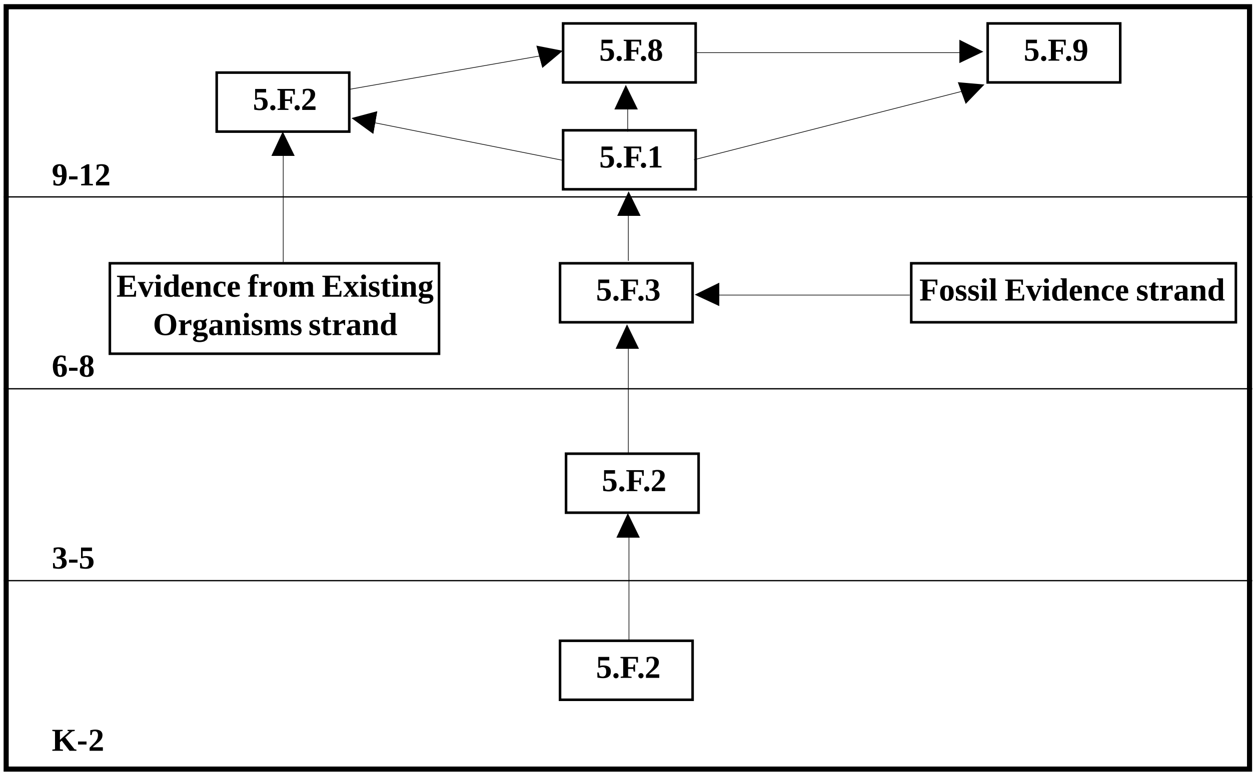
> Some of the same technologies that have improved the length and quality of life for many people have also brought new risks. (6-8)

contributes to and is supported by the understanding that

> Industrialization brings an increased demand for an use of energy. Such usage contributes to the high standard of living in the industrially developing nations but also leads to more rapid depletion of the earth’s energy resources and to environmental risks associated with the use of fossil and nuclear fuels (9-12)

See *Considering costs and benefits of technology* strand.

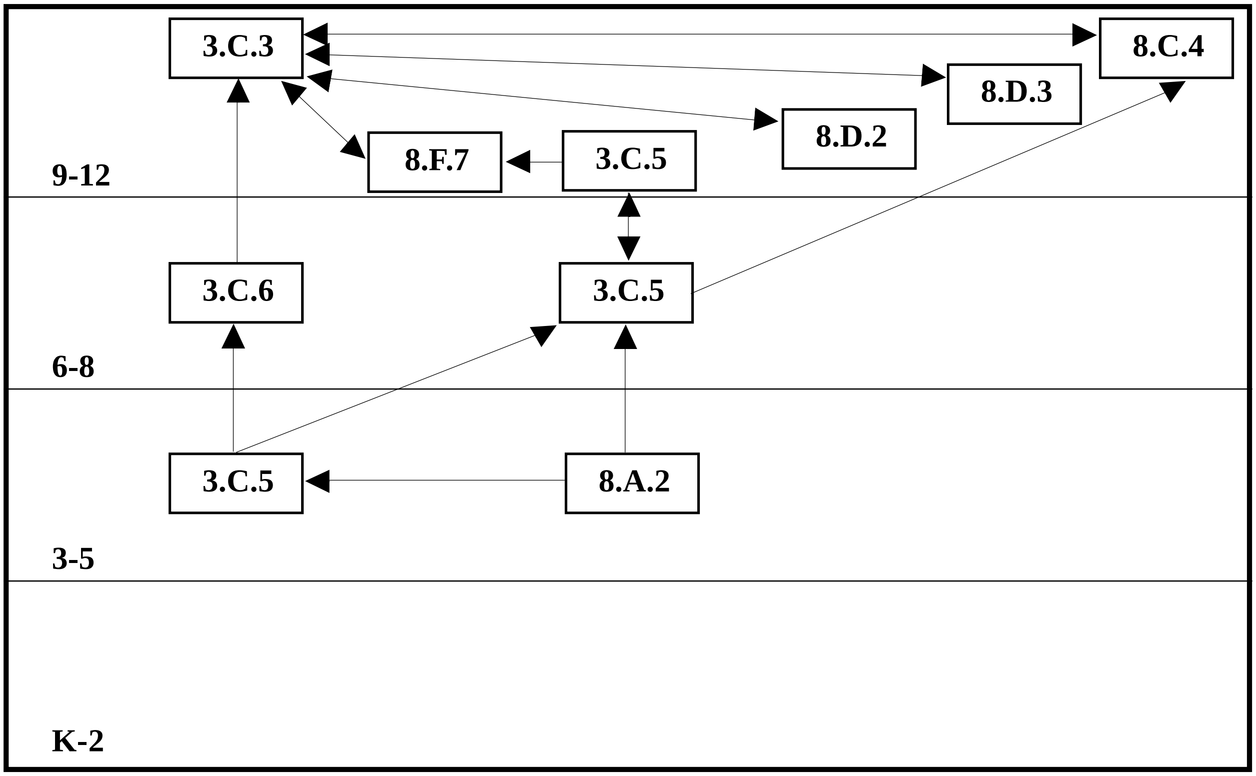
Idea Of Evolution



Overview:

This sequence of benchmarks leads to the SFAA goal of understanding how the earth's present life forms could have evolved from common ancestors reaching back to the simplest one-cell organisms (SFAA Chapter 5, The Living Environment). Understanding the evidence for evolution requires knowledge of the relatedness of organisms and of how fossils form and how their ages are determined. This knowledge is developed in the strands Evidence for Evolution from Existing Organisms and Fossil Evidence for Evolution.

Considering Cost And Benefits Of Technology



Overview:

This array of benchmarks leads to the SFAA goal that a) technology-related issues are rarely simple and one-sided, and b) in deciding on proposals to introduce new technologies or to curtail existing ones, some key questions arise concerning alternatives, risks, costs, and benefits (SFAA Chapter 3, The Nature of Technology). Generalizations about costs and benefits of technology are reinforced by examples of costs and benefits of specific technologies. Some examples are included in this strand; additional examples can be identified in Benchmarks for Science Literacy with the help of the cross-reference box.