Core Concept

1. Our sun is a star and the stars are suns. Even the nearest star lies enormously far beyond our own solar system. Stars are orbited by planets, which may be very different worlds from ours.

Benchmarks for Scientific Literacy and National Science Education Standards:

The universe contains many billions of galaxies, and each galaxy contains many billions of stars. To the naked eye, even the closest of these galaxies is no more than a dim, fuzzy spot. 4A/M1bc

The sun is many thousands of times closer to the earth than any other star. Light from the sun takes a few minutes to reach the earth, but light from the next nearest star takes a few years to arrive. The trip to that star would take the fastest rocket thousands of years. 4A/M2abc

Some distant galaxies are so far away that their light takes several billion years to reach the earth. People on earth, therefore, see them as they were that long ago in the past. 4A/M2de

Commonly held misconceptions:

All stars are the same size, the brightness of a star depends on its distance from earth**.** (Hapkiewicz, A. Naïve Ideas in Earth Science. MSTA Journal, 44(2) (Fall'99), pp.26-30. http://www.msta-mich.org

Stars are evenly distributed through a galaxy or throughout the universe. (Hapkiewicz, A. (1992). Finding a List of Science Misconceptions. MSTA Newsletter, 38(Winter'92), pp.11-14.)

Galaxies are in the solar system

The solar system and galaxies are very "crowded." (Objects are relatively close together.) (Hapkiewicz, A. (1992). Finding a List of Science Misconceptions. MSTA Newsletter, 38(Winter'92), pp.11-14.)

Core Concept

2. Light carries information. Scientists use light to learn about the Universe.

Benchmarks for Scientific Literacy and National Science Education Standards:

Increasingly sophisticated technology is used to learn about the universe. Visual, radio, and X-ray telescopes collect information from across the entire spectrum of electromagnetic waves; computers handle data and complicated computations to interpret them; space probes send back data and materials from remote parts of the solar system; and accelerators give subatomic particles energies that simulate conditions in the stars and in the early history of the universe before stars formed. 4A/H3

Core Concept

3. Some objects emit visible light of their own, while others merely reflect that light

Benchmarks for Scientific Literacy and National Science Education Standards:

Something can be "seen" when light waves emitted or reflected by it enter the eye. *4F/M2*

Light interacts with matter by transmission (including refraction), absorption, or scattering (including reflection). To see an object, light from that object--emitted by or scattered from it--must enter the eye.

Core Concept

4. The light we receive from a star system is composed of different wavelengths. There are wavelengths of light beyond what we can see (the energy of light we can see is the energy of a chemical bond)

Benchmarks for Scientific Literacy and National Science Education Standards:

Human eyes respond to only a narrow range of wavelengths of electromagnetic radiation--visible light. Differences of wavelength within that range are perceived as differences in color. *4F/M5*

Accelerating electric charges produce electromagnetic waves around them. A great variety of radiations are electromagnetic waves: radio waves, microwaves, radiant heat, visible light, ultraviolet radiation, x rays, and gamma rays. These wavelengths vary from radio waves, the longest, to gamma rays, the shortest. In empty space, all electromagnetic waves move at the same speed--the "speed of light." *4F/H3*

Commonly held misconceptions:

Visible light is the only type of light.

All parts of the electromagnetic spectrum can be viewed from Earth.

Core Concept

5. There are potential sources of error in all scientific measurements. Awareness of these potential errors and efforts to minimize them are essential to the identification of important data and ultimately to the advancement of science

Benchmarks for Scientific Literacy and National Science Education Standards:

Consider the possible effects of measurement errors on calculations. 12B/H9

Trace the source of any large disparity between an estimate and the calculated answer. 12B/H7

Notice and criticize arguments based on the faulty, incomplete, or misleading use of numbers, such as in instances when (1) average results are reported, but not the amount of variation around the average, (2) a percentage or fraction is given, but not the total sample size (as in "9 out of 10 dentists recommend..."), (3) absolute and proportional quantities are mixed (as in "3,400 more robberies in our city last year, whereas other cities had an increase of less than 1%), or (4) results are reported with overstated precision (as in representing 13 out of 19 students as 68.42%). 12E/H1

Check graphs to see that they do not misrepresent results by using inappropriate scales or by failing to specify the axes clearly. 12E/H2

A critical component of successful scientific inquiry in grades 9-12 includes having students reflect on the concepts that guide the inquiry. Questions like "How certain are you of those results?" "Is there a better way to do the investigation" "Do we need more evidence?" "What are our sources of experimental error?" "How do you account for an explanation that is different from ours?" make it possible for students to analyze data, develop a richer knowledge base, reason using science concepts, make connections between evidence and explanations, and recognize alternative explanations. (NSES p174)

Core Concept

6. Models are important tools used by scientists working at the frontier of science. A model – physical, visual, or theoretical captures important features of the world and helps us analyze and predict its behavior

Benchmarks for Scientific Literacy and National Science Education Standards:

Mathematical models and computer simulations are used in studying evidence from many sources in order to form a scientific account of the universe. 4A/H4

Models are tentative schemes or structures that correspond to real objects, events or classes of events and that have explanatory power. Models help scientists and engineers understand how things work. Models take many forms including physical objects, plans, mental constructs, mathematical equations, and computer simulations. (NSES p117)

Student inquires should culminate in formulating an explanation or model. Models should be physical, conceptual and mathematical. (NSES p 175)

Core Concept

7. A telescope's main function is to gather light.

Benchmarks for Scientific Literacy and National Science Education Standards:

Technology is essential to science for such purposes as access to outer space and other remote locations, sample collection and treatment, measurement, data collection and storage, computation, and communication of information. 3A/M2

Scientists rely on technology to enhance the gathering and manipulation of data. New techniques and tools provide new evidence to guide inquiry and new methods to gather data, thereby contributing to the advance of science. (NSES p176)

Commonly held misconceptions:
Telescopes are constructed to produce magnification

Additional Science skills and habits of mind

1.Values and Attitudes - Be open to new ideas yet able to question and test own ideas and those others propose

Benchmarks for Scientific Literacy and National Science Education Standards:

Curiosity motivates scientists to ask questions about the world around them and seek answers to those questions. Being open to new ideas motivates scientists to consider ideas that they had not previously considered. Skepticism motivates scientists to question and test their own ideas and those that others propose. (from Benchmarks)

Exhibit traits such as curiosity, honesty, openness, and skepticism when making investigations, and value those traits in others. (12A/H1*)

Scientists value evidence that can be verified, hypotheses that can be tested, and theories that can be used to make predictions (12A/H4** - SFAA)

2. Manipulation and Observation - Use appropriate tools and techniques to gather, analyze and interpret data

Benchmarks for Scientific Literacy and National Science Education Standards:

Learn quickly the proper use of new instruments by following instructions in manuals or by taking instructions form an experienced user. 12C/H1

Use computers for producing tables and graphs and for making spreadsheet calculations. 12C/H2

3. Manipulation and Observation - Develop descriptions, explanations, predictions and models using evidence

Benchmarks for Scientific Literacy and National Science Education Standards:

Organize information in simple tables and graphs and identify relationships they reveal. 12D/M1

Read simple tables and graphs produced by others and describe in words what they show. 12D/M2

Think critically and logically to make the relationships between evidence and explanations (NSES p 145)

4. Computation and Estimation - Use computer spreadsheet, graphing and database programs to assist in quantitative analysis

Benchmarks for Scientific Literacy and National Science Education Standards:

Computation is the process of determining something by mathematical means. Developing good quantitative thinking skills and learning about the world go together. (Benchmarks)

When describing and comparing very small and very large quantities, express them using powers-of-ten notation. 12B/H6*

Use technology and mathematics to improve investigations and communications (NSES p175)

5. Communication - communicate procedures and explanations to others

Benchmarks for Scientific Literacy and National Science Education Standards:

The dissemination of scientific information is crucial to its progress. 1C/H12** (SFAA)

Prepare a visual presentation to aid in explaining procedures or ideas. 12D/M9**

Use tables, charts, and graphs in making arguments and claims in oral and written presentations (12D/H7*)

Communicate scientific procedures and explanations – students should become competent at communicating experimental methods, following instructions, describing observations, summarizing the results of other groups and telling other students about investigations and explanations. (NSES p 148 5-8)