

Science in Focus: Shedding Light on Science

Series Overview

Science provides one way of knowing about the mysteries and splendor of our natural world. Science is a unique collaboration between human perceptions and our ability to reason and build ideas. The concept of light is an appropriate starting point for building an understanding of science because it is through the interaction of light, our eyes, and our brain that we collect most of the information we have about the world.

This series uses light as a theme through which to explore topics in physics, chemistry, biology, and Earth and space science. Unlike most science content courses that approach subject matter through one narrow discipline, these workshops show how light is a common thread that runs through many areas of science. The workshops make connections to real world phenomena as they explore the behavior of light, the transformation of energy, and the role of light in plant production of food, weather and the seasons, and more.

What will you actually see? You will visit elementary classrooms where students are investigating light. You will observe teachers in academic settings studying light and its characteristics. Interviews with experts will further illuminate the topics of energy, human vision, and the Sun's effects on ecosystems, climate, and seasons.

The series emphasizes dynamic interaction with the science content through discussion, activities, and application of the ideas to teaching. The videos and supporting materials suggest many fascinating investigations for you and your students. You will be able to respond to questions such as: What is color? Do plants eat? What causes seasons? Where do winds come from? Where do they go? How does the eye see?

Support resources for the series are available in the form of a print guide and a Web site, as well as instructional ideas contained in the video programs. These resources include activities, lesson plans, assessments, links to other content, and strategies for using community resources. An ongoing activity that builds on the concepts presented throughout the series will be conducted across the eight workshops.

The concepts and activities in this series address the *AAAS Benchmarks* and the *NRC National Science Education Standards* with special attention to habits of mind and the history and nature of science. The series also serves as a model for teaching science to elementary teachers and, as such, may be beneficial for district inservice workshops. While the concepts and activities have been designed with the elementary teacher in mind, the materials are beneficial for any educator interested in learning science concepts and the nature of science.

Workshop Synopses

Workshop 1: SHINE and SHADOW

Light is a form of energy that affects all facets of our lives. In this workshop we will explore how light travels and how shadows are formed.

Workshop 2: LAWS of LIGHT

Light energy has predictable properties when it interacts with matter. In this workshop we will investigate the absorption, reflection, and refraction of light.

Workshop 3: PIGMENTS, PAINT, and PRINTING

The colors that surround us provide a rich visual experience. In this workshop we will investigate the effects of mixing colors of light and colors of pigment.

Workshop 4: COLOR, CONES, and CORNEAS

Humans are able to see objects when light energy enters the eye. In this workshop we will investigate human vision and the perception of color.

Workshop 5: SUNLIGHT to STARCH

Green plants convert light energy into chemical energy. In this workshop we will examine green plants grown with and without light and discover how they use light energy to produce food in the process known as photosynthesis.

Workshop 6: ENERGY and ECOSYSTEMS

The food made by plants is a source of energy for other organisms living in ecosystems. In this workshop we will investigate the flow of energy from plants to animals as we construct food webs and energy pyramids.

Workshop 7: SUN and SEASONS

Light energy from the Sun is absorbed all over the Earth. In this workshop we will examine how the transformed energy heats the Earth unevenly causing seasons.

Workshop 8: WIND and WEATHER

Storms, fronts, and other atmospheric phenomena derive energy from sunlight striking the Earth's surface. In this workshop we will investigate mechanisms that set the air in motion and cause weather.

About the Contributors

Association for the Education of Teachers in Science (AETS):

Dr. Sandra K. Abell is a professor of elementary science education at Purdue University, West Lafayette, Indiana, where she teaches undergraduate elementary science methods and graduate courses in science education. Abell's research aims to understand the process of becoming a teacher of science, from preservice education to student teaching and the induction years, and throughout the teaching career. She enjoys teaching science for understanding in collaboration with practicing elementary teachers.

Dr. Lawrence B. Flick taught elementary and middle school science for 12 years, conducting science fairs and outdoor schools for grades 3 through 9. Flick is currently on the faculty of Oregon State University, and has worked in science teacher education for 14 years teaching a variety of courses in teaching methods, curriculum, and educational research. His research focuses on teaching practices that promote concept development and higher-order thinking.

Dr. Anita Greenwood has worked in science education for 23 years, first as a teacher in the United Kingdom and now at the Graduate School of Education, University of Massachusetts Lowell. She conducts numerous science workshops for teachers at all levels K-12, and also works with preservice science teachers and doctoral students. Her background is in the biological sciences. Dr. Greenwood can be seen in *Case Studies in Science Education* working with elementary teachers as they solve problems experienced while teaching science.

Harvard-Smithsonian Center for Astrophysics:

Dr. Christine Jones is an Astrophysicist at the Harvard-Smithsonian Center for Astrophysics (CFA) where she carried out research in X-ray astronomy. Jones received her Ph.D. in astronomy from Harvard in 1974 for research on binary X-ray sources. She has carried out extensive studies of the hot X-ray emitting gas in galaxies and clusters of galaxies. Jones often collaborates in her research with her husband Bill Forman as well as other colleagues both from CFA and from around the world. Christine and Bill received the first Rossi prize from the American Astronomical Society for the discovery that elliptical galaxies have hot coronae. Her primary research goals are to understand the mass distribution of both dark and luminous components in clusters of galaxies and how clusters evolve over cosmological timescales, and to measure the mass distribution and the evolutionary history of elliptical galaxies.

Pacific University:

Dr. Camille L. Wainwright is a professor of science education at Pacific University in Oregon. In addition to teaching science methods and educational technology classes for elementary and secondary teachers, she is also an adjunct professor in the Physics Department. Currently, Wainwright is a Co-Director of a major NSF grant and the Chair of the Oregon Science Education Council. She has published curriculum for teaching electricity and magnetism, and focuses her research on gender and achievement in science.

Site Discussion

Helpful Hints for Successful Investigations

Included in the materials for each workshop you will find detailed instructions for the content of your Getting Ready and your Going Further Site Investigations. The following hints are intended to help you and your colleagues get the most out of these pre- and post-video discussions.

Designate a Facilitator

Each week, one person should be responsible for facilitating the Site Investigations (or you might select two people -- one to facilitate Getting Ready, the other to facilitate Going Further). The facilitator does not need to be the Site Leader, nor does it need to be the same person(s) each week. We recommend that participants rotate the role of facilitator on a weekly basis.

Review the Site Investigations and Bring the Necessary Materials

Be sure to read over the Getting Ready and Going Further sections of your materials before arriving at each workshop. The Site Investigations will be the most productive if you and your colleagues come to the workshops prepared for the discussions. A few of the Site Investigations require special materials. The facilitator should be responsible for bringing these when necessary. You will need these materials for Workshop 1.

Keep an Eye on the Time

Thirty minutes go by very quickly, and it is easy to lose track of the time. You should keep an eye on the clock so that you are able to get through everything before the workshop video begins. You may want to set a small alarm clock or kitchen timer before you begin the Getting Ready Site Investigation to ensure that you won't miss the beginning of the video. (Sites that are watching the workshops on videotape will have more flexibility if their Site Investigations run longer than expected.)

Record Your Discussions

We recommend that someone take notes during each Site Discussion, or, even better, that you make an audiotape recording of the discussions each week. These notes and/or audiotape can serve as "make-up" materials in case anyone misses a workshop.

Share Your Discussions on the Internet

The Site Investigations are merely a starting point. We encourage you to continue your discussions with a Light Buddy and with participants from other sites on the discussion area of the Web site and on Channel-Talk, the workshop email discussion list.

Workshop 1 - Shine and Shadow

Light is a form of energy that affects all facets of our lives. In this workshop we introduce what light is and how it behaves. To help understand light, we will explore how shadows are formed, and the role of light in seeing.

In particular, we will examine several big ideas about light through watching second grade students explore light and shadows, viewing light demonstrations, hearing fourth graders talk about seeing, visiting with an astronomer, and listening to experts talk about light. We will also ask you to think about your own ideas about light and compare them with the scientific ideas.

Learning Objectives

Participants will understand that:

- Light consists of tiny packets of energy called photons.
- Light energy travels in straight lines until it strikes a surface.
- A shadow is formed when an object blocks the photons that are traveling from a light source.
- Light travels fast, but not instantaneously.
- We see because light from a source is reflected from an object to our eyes.

Standards

National Science Education Standards

K-4 standards:

- Light travels in a straight line until it strikes an object. Light can be reflected by a mirror, refracted by a lens, or absorbed by the object. *Content Standards: K-4: Physical Science: Light, Heat, Electricity, and Magnetism*
- Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations. *Content Standards: K-4: Science as Inquiry: Understandings About Scientific Inquiry*

5-8 Standards:

- Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways. *Content Standards: 5-8: Physical Science: Transfer of Energy*
- 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. *Content Standards: 5-8: Physical Science: Transfer of Energy*

K-12 Standards:

- Although most things are in the process of becoming different — changing — some properties of objects and processes are characterized by constancy, including the speed of light, the charge of an electron, and the total mass plus energy in the universe. Changes might occur, for example, in properties of materials, position of objects, motion, and form and function of systems. Interactions within and among systems result in change. *Content Standards: K-12: Unifying Concepts and Processes: Constancy, Change, and Measurement*
- 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. *Content Standards: K-12: Unifying Concepts and Processes: Evidence, Models, and Explanation*

American Association for the Advancement of Science (AAAS) Project 2061 Benchmarks

By the end of the 2nd grade, students should know that:

- A model of something is different from the real thing but can be used to learn something about the real thing. *Common Themes: 11b Models: K-2*
- One way to describe something is to say how it is like something else. *Common Themes: 11b Models: K-2*

By the end of the 8th grade, students should know that:

- Energy cannot be created or destroyed, but only changed from one form into another. *The Physical Setting: 4e Energy Transformation: 6-8*
- Models are often used to think about processes that happen too slowly, too quickly, or on too small a scale to observe directly, or that are too vast to be changed deliberately, or that are potentially dangerous. *Common Themes: 11b Models: 6-8*
- Different models can be used to represent the same thing. What kind of a model to use and how complex it should be depends on its purpose. The usefulness of a model may be limited if it is too simple or if it is needlessly complicated. Choosing a useful model is one of the instances in which intuition and creativity come into play in science, mathematics, and engineering. *Common Themes: 11b Models: 6-8*

Workshop 2 - Laws of Light

Light energy has predictable properties when it interacts with matter that we refer to as reflection and refraction. In this workshop we will explore what happens to light when it strikes a smooth surface, a rough surface, or a transparent surface.

In particular, we will examine several big ideas about light through viewing demonstrations with light and mirrors, visiting an artist and an astronomer who use mirrors in their work, watching fifth grade students investigate refraction, and listening to experts talk about light. We will also ask you to think about some situations involving reflection and refraction.

Learning Objectives

Participants will understand that:

- Light energy can be absorbed, reflected, and refracted by matter.
- Light energy is reflected off objects at a predictable angle. The angle of the incoming light equals the angle of the outgoing light. This is called the law of reflection.
- Light energy reflects off smooth and rough surfaces following the law of reflection. Rough surfaces create a scattering of the photons, which prevents us from seeing images.
- Light energy changes speed (and thus direction) when crossing the boundary between two different transparent materials in a process called refraction.
- The refractive property of transparent materials can be used to make lenses that focus light (e.g., cameras, eyeglasses, telescopes).

Standards

National Science Education Standards

K-4 Standards:

- Light travels in a straight line until it strikes an object. Light can be reflected by a mirror, refracted by a lens, or absorbed by the object. *Content Standards: K-4: Physical Science: Light, Heat, Electricity, and Magnetism*
- Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations. *Content Standards: K-4: Science as Inquiry: Understandings About Scientific Inquiry*

5-8 Standards:

Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways. *Content Standards: 5-8: Physical Science: Transfer of Energy*

- 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. *Content Standards: 5-8: Physical Science: Transfer of Energy*

K-12 Standards:

- Although most things are in the process of becoming different — changing — some properties of objects and processes are characterized by constancy, including the speed of light, the charge of an electron, and the total mass plus energy in the universe. Changes might occur, for example, in properties of materials, position of objects, motion, and form and function of systems. Interactions within and among systems result in change. *Content Standards: K-12: Unifying Concepts and Processes: Constancy, Change, and Measurement*
- 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. *Content Standards: K-12: Unifying Concepts and Processes: Evidence, Models, and Explanation*

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By the end of the 2nd grade, students should know that:

- A model of something is different from the real thing but can be used to learn something about the real thing. *Common Themes: 11b Models: K-2*
- One way to describe something is to say how it is like something else. *Common Themes: 11b Models: K-2*

By the end of the 8th grade, students should know that:

- Energy cannot be created or destroyed, but only changed from one form into another. *The Physical Setting: 4e Energy Transformation: 6-8*

- Models are often used to think about processes that happen too slowly, too quickly, or on too small a scale to observe directly, or that are too vast to be changed deliberately, or that are potentially dangerous. *Common Themes: 11b Models: 6-8*
- Different models can be used to represent the same thing. What kind of a model to use and how complex it should be depends on its purpose. The usefulness of a model may be limited if it is too simple or if it is needlessly complicated. Choosing a useful model is one of the instances in which intuition and creativity come into play in science, mathematics, and engineering. *Common Themes: 11b Models: 6-8*

Workshop 3 - Pigments, Paints, and Printing

The colors that surround us provide a rich visual experience. In this workshop we will create rainbows and learn how and why these magnificent phenomena occur in the sky.

After looking at the Sun's electromagnetic spectrum we will explore the reflection and refraction of photons of light. We will also examine color televisions and look closely at the pixels which form images, and investigate the primary colors of light and pigments.

Learning Objectives

Participants will be able to:

- Define color as a characteristic of visible light that depends upon its energy and human perception.
- Explain that the only thing we see is light that enters the eye.
- Define what is meant by primary colors.

Standards

National Science Education Standards

K-4 standards:

- Light travels in a straight line until it strikes an object. Light can be reflected by a mirror, refracted by a lens, or absorbed by the object. *Content Standards: K-4: Physical Science: Light, Heat, Electricity, and Magnetism*

5-8 Standards:

- 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. *Content Standards: 5-8: Physical Science: Transfer of Energy*

American Association for the Advancement of Science (AAAS) Project 2061 Benchmarks

By the end of the 2nd grade, students should:

- Raise questions about the world around them and be willing to seek answers to some of them by making careful observations and trying things out. *Habits of the Mind: 12A Values and Attitudes: K-2*

By the end of the 2nd grade, students should:

- Tools such as thermometers, magnifiers, rulers or balances often give more information about things than can be obtained by just observing things without their help. *Nature of Science: 1B Scientific Inquiry: K-2*

By the end of the 5th grade, students should:

- Offer reasons for their findings and consider reasons suggested by others. *Habits of the Mind: 12A Values and Attitudes: 3-5*

By the end of the 8th grade, students should know that:

- Something can be "seen" when light waves emitted or reflected by it enter the eye — just as something can be "heard" when sound waves from it enter the ear. *The Physical Setting: 4F Motion: 6-8*
- Human eyes respond to only a narrow range of wavelengths of electromagnetic radiation — visible light. Differences of wavelength within that range are perceived as different colors. *The Physical Setting: 4F Motion: 6-8*

Workshop 4 - Color, Cones, and Corneas

Humans are able to see objects when light energy enters the eye. In this workshop we will investigate human vision, and interview students to find out their understanding of 'how we see.'

Using models, we will study the function of the major parts of the human eye, and revisit refraction by following the path of light through various lenses. We will also visit an optometrist for a vision check-up, discuss the perception of color, and actually see inside a human eye.

Learning Objectives

Participants will be able to:

- Explain that the only thing we see is light that enters the eye.
- Explain the function of the most important structures in the human eye.
- Explain how light photons of differing energy are detected by the eye leading to the perception of color.

Standards

National Science Education Standards

K-4 standards:

- Light travels in a straight line until it strikes an object. Light can be reflected by a mirror, refracted by a lens, or absorbed by the object. *Content Standards: K-4: Physical Science: Light, Heat, Electricity, and Magnetism*

5-8 Standards:

- 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. *Content Standards: 5-8: Physical Science: Transfer of Energy*

American Association for the Advancement of Science (AAAS) Project 2061 Benchmarks

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- Raise questions about the world around them and be willing to seek answers to some of them by making careful observations and trying things out. *Habits of the Mind: 12A Values and Attitudes: K-2*

By the end of the 2nd grade, students should:

- Tools such as thermometers, magnifiers, rulers or balances often give more information about things than can be obtained by just observing things without their help. *Nature of Science: 1B Scientific Inquiry: K-2*

By the end of the 5th grade, students should:

- Offer reasons for their findings and consider reasons suggested by others. *Habits of the Mind: 12A Values and Attitudes: 3-5*

By the end of the 8th grade, students should know that:

- Light from the sun is made up of a mixture of many different colors of light, even though to the eye the light looks almost white. Other things that give off or reflect light have a different mix of colors. *The Physical Setting: 4F Motion: 6-8*

Workshop 5 - Sunlight to Starch

In this program participants will explore how plants get their food. Starting with seeds, which have their own source of food, the program traces the growth of a plant, the development of chlorophyll in its leaves, and the production of sugar (and starch) in a process known as photosynthesis.

Chlorophyll-containing organisms are able to absorb photons of light energy and use their energy to join carbon dioxide with hydrogen from water. As a result of a whole series of intermediate reactions sugar is made. Light energy is therefore transformed into chemical energy contained within sugar. As a by-product, oxygen is released into the atmosphere.

Sugar is used as the building block for plants. It is transported to all parts of the plant and used to make components of the cell as well as to provide the energy to drive the processes occurring in cells. When plentiful, sugar is converted to starch and stored.

Carbon dioxide is the main ingredient of sugar and consequently this gas is responsible for making the greatest contribution to the dry mass of a plant, be it the smallest daisy or the tallest tree. When asked where a plant gets its food, children will often answer that it comes from the soil. Even after instruction in photosynthesis, it is hard for students to believe that a gas can be the source of the stuff (matter) of which plants (including trees!) are made.

Not only is photosynthesis essential for the plant's growth, it is essential for maintaining life on Earth. Without plants, there would be an abundance of carbon dioxide in our atmosphere which would contribute to global warming. Additionally, the release of oxygen into the Earth's atmosphere during photosynthesis provided the conditions for evolution of a multitude of life forms.

Learning Objectives

Participants will gain:

- An understanding of the process of photosynthesis, namely that chlorophyll in green plants absorbs light energy to combine carbon dioxide and water to make sugar and oxygen.
- A recognition that light energy is absorbed and transformed into chemical energy within sugar

Standards

National Science Education Standards

K-4 Standards:

- Organisms have basic needs. For example, animals need air, water, and food; plants require air, water, nutrients, and light. Organisms can survive only in environments in which their needs can be met. The world has many different environments, and distinct environments support the life of different types of organisms. *Content Standards: K-4: Life Science: The Characteristics of Organisms*

K-4 Standards:

- Although men and women using scientific inquiry have learned much about objects, events, and phenomena in nature, much more remains to be understood. Science will never be finished. *Content Standards: K-4: History and Nature of Science: Science as a Human Endeavor*

5-8 Standards:

- For ecosystems, the major source of energy is sunlight. Energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis. That energy then passes from organism to organism in food webs. *Content Standards: 5-8: Life Science: Population and Ecosystems*

5-8 Standards:

- Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. *Content Standards: 5-8: History and Nature of Science: Nature of Science*

Workshop 6 - Energy and Ecosystems

In this program participants are shown that light energy that has been absorbed by plants during photosynthesis and transformed into chemical energy can now be transferred to other organisms. Energy is contained within food molecules such as sugar and starch made by plants, therefore when animals eat plants, or eat other animals, the energy is passed to them.

However, the transfer of energy between plants and animals is inefficient and there are energy losses. Consequently, energy must constantly be put into natural systems. The source of energy for ecosystems is generally visible light energy.

Energy transfer between organisms can be described by constructing food chains and food webs for each ecosystem. In this program, we shall visit classrooms where children are learning about chains and webs. We shall also look at the interconnectedness of organisms in pond and ocean ecosystems.

Finally, the program will show that matter from the bodies of dead organisms is decomposed by bacteria, fungi and worms. The process of decomposition returns nutrients, such as minerals and carbon dioxide, to the environment for future plant growth.

This program illustrates some important aspects of our understanding of energy:

1. Energy can be transferred and transformed, but it cannot be created or destroyed.
2. Some energy will be lost to the system as it is undergoing a transformation and is generally given off as heat.

While matter in ecosystems can be recycled, energy cannot. Energy flows through ecosystems and must constantly be provided to plants for photosynthesis by the Sun.

Learning Objectives

Participants will gain:

- An understanding that plants and animals are interconnected in ecosystems by their feeding relationships because food contains energy.
- Recognition that energy is transferred and transformed as it flows through an ecosystem from the Sun as the source to producers which make food and on to consumers which eat food.
- Recognition that because the transfer of energy between organisms is inefficient, ecosystems must receive a continuous input of light energy to sustain them.

Standards

National Science Education Standards

K-4 Standards:

- All animals depend on plants. Some animals eat plants for food. Other animals eat animals that eat plants. *Content Standards: K-4: Life Science: Organisms and Their Environments*

5-8 Standards: Populations of organisms can be categorized by the function they serve in an ecosystem. Plants and some micro-organisms are producers – they make their own food. All animals, including humans, are consumers, which obtain food by eating other organisms. Decomposers, primarily bacteria and fungi, are consumers that use waste materials and dead organisms for food. Food webs identify the relationships among producers, consumers, and decomposers in an ecosystem.

- For ecosystems, the major source of energy is sunlight. Energy entering ecosystems as sunlight is transferred by producers into chemical energy through photosynthesis. That energy then passes from organism to organism in food webs. *Content Standards: 5-8: Life Science: Population and Ecosystems*

Workshop 7 - Sun and Seasons

The tilt of the Earth's axis causes the cycle of the seasons. In this workshop we'll discuss how different parts of the Earth receive different amounts of light energy that result in the Earth's seasons. In particular, we will look at the tilt of the Earth's axis and how the hours of daylight change throughout the year. We will also touch on the long-term history of climactic changes on Earth

Learning Objectives

Participants will be able to:

- Describe the apparent motion of the Sun across the sky during a day in winter, spring, summer, and fall using patterns of shadows as supporting evidence.
- Explain the reason for varying lengths of daylight in terms of Earth's orbit around the Sun and the angle of Earth's axis relative to the plane of the orbit.
- Explain the cycle of the seasons in terms of Earth's orbit around the Sun, the angle of Earth's axis relative to the plane of the orbit, and length of daylight.

Standards

National Science Education Standards

K-4 Standards:

- The sun provides the light and heat necessary to maintain the temperature of the earth. *Content Standards: K-4: Earth and Space Science: Objects in the Sky*
- The surface of the earth changes. Some changes are due to slow processes, such as erosion and weathering, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes. *Content Standards: K-4: Earth and Space Science: Changes in the Earth and Sky*
- Weather changes from day to day and over the seasons. *Content Standards: K-4: Earth and Space Science: Changes in the Earth and Sky*

5-8 Standards:

- The solid earth is layered with a lithosphere; hot, convecting mantle; and dense, metallic core. *Content Standards: 5-8: Earth and Space Science: Structure of the Earth System*
- Water, which covers the majority of the earth's surface, circulates through the crust, oceans, and atmosphere in what is known as the "water cycle." Water evaporates from

the earth's surface, rises and cools as it moves to higher elevations, condenses as rain or snow, and falls to the surface where it collects in lakes, oceans, soil, and in rocks underground. *Content Standards: 5-8: Earth and Space Science: Structure of the Earth System*

- Water is a solvent. As it passes through the water cycle it dissolves minerals and gases and carries them to the oceans. *Content Standards: 5-8: Earth and Space Science: Structure of the Earth System*
- Clouds, formed by the condensation of water vapor, affect weather and climate. *Content Standards: 5-8: Earth and Space Science: Structure of the Earth System*
- Fossils provide important evidence of how life and environmental conditions have changed. *Content Standards: 5-8: Earth and Space Science: Earth's History*
- The sun is the major source of energy for phenomena on the earth's surface, such as growth of plants, winds, ocean currents, and the water cycle. Seasons result from variations in the amount of the sun's energy hitting the surface, due to the tilt of the earth's rotation on its axis and the length of the day. *Content Standards: 5-8: Earth and Space Science: Earth in the Solar System*

American Association for the Advancement of Science (AAAS) Project 2061 Benchmarks

By the end of the 2nd grade, students should know that:

- Some events in nature have a repeating pattern. The weather changes some from day to day, but things such as temperature and rain (or snow) tend to be high, low, or medium in the same months every year. *The Physical Setting: 4B The Earth: K-2*

By the end of the 2nd grade, students should know that:

- 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. *The Physical Setting: 4B The Earth: K-2*

By the end of the 5th grade, students should know that:

- The earth is one of several planets that orbit the sun, and the moon orbits around the earth. Stars are like the sun, some being smaller and some larger, but so far away that they look like points of light. *The Physical Setting: 4B The Earth: 3-5*

By the end of the 8th grade, students should know that:

- Energy cannot be created or destroyed, but only changed from one form into another. Most of what goes on in the universe - from exploding stars and biological growth to the operation of machines and the motion of people - involves some form of energy being transformed into another. *The Physical Setting: 4E Energy Transformations: 6-8*

Workshop 8 - Wind and Weather

Climactic conditions in each season are not just the result of the tilt of the Earth's axis. In this workshop we will examine the effect of light on our weather. We will follow the path of light as it enters our atmosphere, and is absorbed, reflected, and radiated as heat by the land and by the water.

We will visit a fifth grade classroom as they explore these phenomena. And we will examine a weather map to discover the significance of high and low pressure.

Learning Objectives

Participants will be able to:

- Draw diagrams and generate examples that explain how sunlight provides the energy that drives weather on Earth.
- Draw diagrams and verbally explain the high and low pressures as one of the two major components driving wind on Earth.
- Draw diagrams and verbally explain how the Coriolis Effect deflects wind into the swirling patterns seen in satellite images.

Standards

National Science Education Standards

K-4 Standards:

- The sun provides the light and heat necessary to maintain the temperature of the earth. *Content Standards: K-4: Earth and Space Science: Objects in the Sky*
- The surface of the earth changes. Some changes are due to slow processes, such as erosion and weathering, and some changes are due to rapid processes, such as landslides, volcanic eruptions, and earthquakes. *Content Standards: K-4: Earth and Space Science: Changes in the Earth and Sky*
- Weather changes from day to day and over the seasons. *Content Standards: K-4: Earth and Space Science: Changes in the Earth and Sky*

5-8 Standards:

- The solid earth is layered with a lithosphere; hot, convecting mantle; and dense, metallic core. *Content Standards: 5-8: Earth and Space Science: Structure of the Earth System*
- Water, which covers the majority of the earth's surface, circulates through the crust, oceans, and atmosphere in what is known as the "water cycle." Water evaporates from the earth's surface, rises and cools as it moves to higher elevations, condenses as rain or snow, and falls to the surface where it collects in lakes, oceans, soil, and in rocks underground. *Content Standards: 5-8: Earth and Space Science: Structure of the Earth System*
- Water is a solvent. As it passes through the water cycle it dissolves minerals and gases and carries them to the oceans. *Content Standards: 5-8: Earth and Space Science: Structure of the Earth System*
- Clouds, formed by the condensation of water vapor, affect weather and climate. *Content Standards: 5-8: Earth and Space Science: Structure of the Earth System*
- Fossils provide important evidence of how life and environmental conditions have changed. *Content Standards: 5-8: Earth and Space Science: Earth's History*
- The sun is the major source of energy for phenomena on the earth's surface, such as growth of plants, winds, ocean currents, and the water cycle. Seasons result from variations in the amount of the sun's energy hitting the surface, due to the tilt of the earth's rotation on its axis and the length of the day. *Content Standards: 5-8: Earth and Space Science: Earth in the Solar System*

American Association for the Advancement of Science (AAAS) Project 2061 Benchmarks

By the end of the 2nd grade, students should know that:

- Some events in nature have a repeating pattern. The weather changes some from day to day, but things such as temperature and rain (or snow) tend to be high, low, or medium in the same months every year. *The Physical Setting: 4B The Earth: K-2*

By the end of the 2nd grade, students should know that:

- 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. *The Physical Setting: 4B The Earth: K-2*

By the end of the 5th grade, students should know that:

- The earth is one of several planets that orbit the sun, and the moon orbits around the earth. Stars are like the sun, some being smaller and some larger, but so far away that they look like points of light. *The Physical Setting: 4B The Earth: 3-5*

By the end of the 8th grade, students should know that:

- Energy cannot be created or destroyed, but only changed from one form into another. Most of what goes on in the universe - from exploding stars and biological growth to the operation of machines and the motion of people - involves some form of energy being transformed into another. *The Physical Setting: 4E Energy Transformations: 6-8*