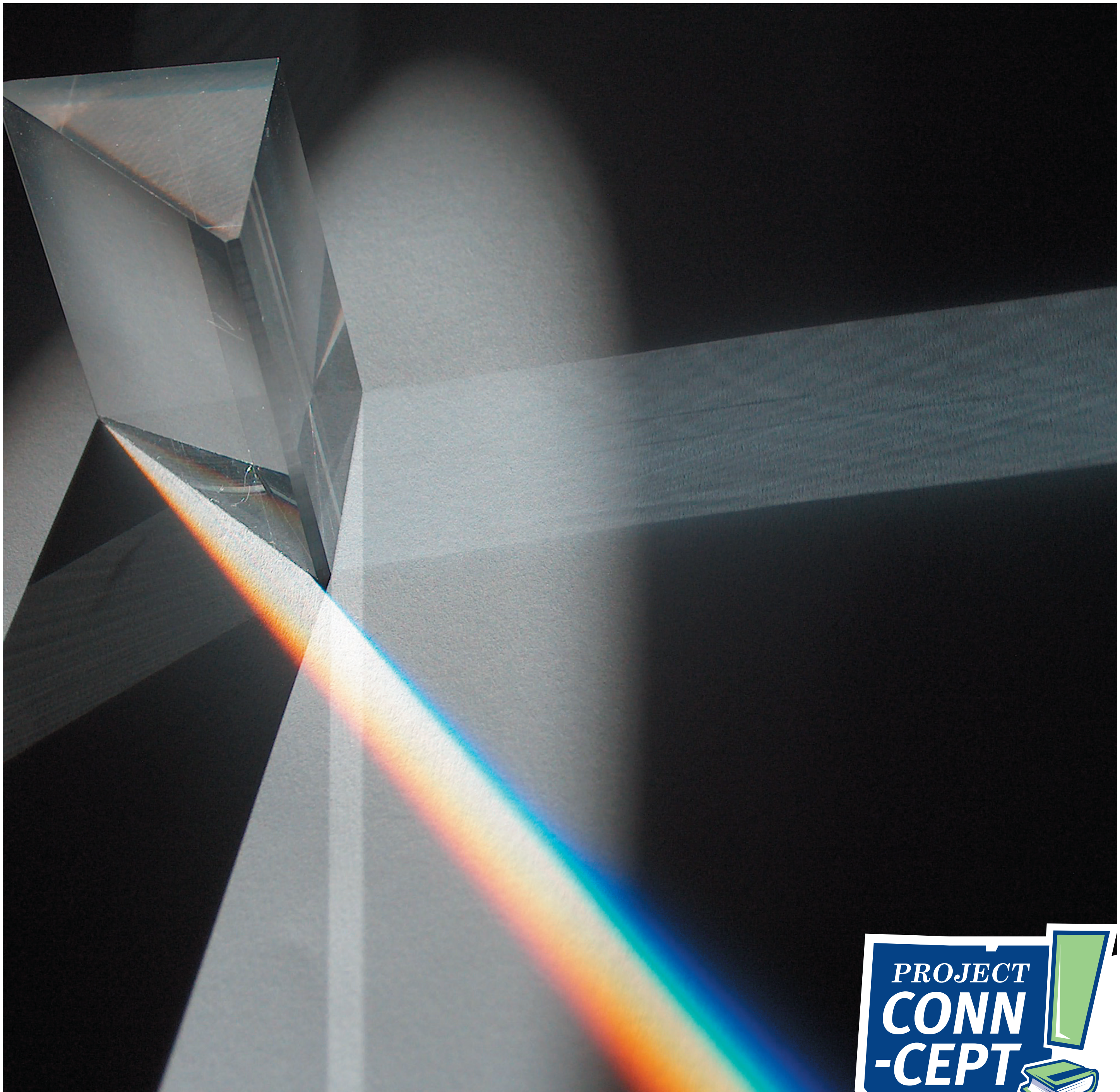
GRADES 4 & 5: LIGHT A RAINBOW OF EXPLORATIONS



Connecticut State Department of Education
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http://www.state.ct.us/sde/

Supported by a Javits Grant
US Department of Education

Project CONN-CEPT Science Units

Astronomy: Sun, Moon, and Stars (K-2)
The World of Matter (1)
Living Things: Changes, Stages and Cycles (2-3)
Eurekas and Ecosystems (4-5)
Light: A Rainbow of Explorations (4-5)
Sound's Story: H-Ear the Pitch (4-5)
Structure and Function: What's Their Junction? (6)
Weather: The Never-Ending Story (6)
Cells: The Story of Life (7)
Reactions and Interactions (7-8)

Project CONN-CEPT Social Studies Units

Time, Change, and Continuity in History (K)
Local Government (3)
What Makes a Region? An Investigation of the Northeast (4)
Goods, Services, Resources, Scarcity and Systems: An Exploration of State Economics (4-5)
Concepts and Tools of the Geographer (6)
With Liberty and Justice for All: A Study of the U.S. Constitution (6-8)

Units in Preparation

Junior Economist: People, Resources, Trade (1-2)
A Habitat is a Home for Plants and Animals: Needs, Resources, Adaptation and Systems (1-2)
May the Force Be with You: Forces, Motion and Simple Machines (2-3)
Comparing Cultures: Traditions, Dwellings, Language, and Cultural Evolution (2-3)
Peopling of the Americas (4-5)
Going to the Source: Using Primary Resources in United States History (6-8)
Exploring the world's Oceans: Chemistry, Geology and Biology (7)
Reactions and Interactions: Chemical Reactions (7-8)

Research for this grant was supported under the Javits Act Program (Grant No. S206A020086) as administered by the Institute of Educational Sciences, U.S. Department of Education. The opinions expressed in this report do not reflect the position or policies of the Institute of Education Sciences or the U.S. Department of Education.

A Shared Story

The exhibit hall was huge, and publishers' banners, suspended from the ceiling, waved back and forth in the air conditioned room. Hundreds of conference participants filled the aisles. Vendors of curriculum materials, eager to share their colorful and glossy wares with passing teachers and administrators, stood at the edge of their displays offering warm smiles, prizes, and publishers' catalogues.

Charlene and Andrew had carefully planned their tour through the aisles and divided up so that they could see all the materials. They looked forward to their time in the vendor area because they needed curriculum materials in social studies and science for their upper elementary and middle school students. They hoped they would find something good. They wanted coherent, comprehensive units that addressed their state and national standards, had good assessments, required students to think their way through content, provided teachers with teaching strategies, and some guidance regarding how to differentiate the curriculum for students with varied learning needs.

They looked at many cleverly designed curriculum packages and kits. Most materials were collections of episodic learning activities. Some contained coherent learning activities for students, but did not teach to the critical concepts and principles embedded in state and national standards. Other materials, claiming to be comprehensive, did not contain aligned pre- and post-assessments, user-friendly teacher information, suggestions for teaching, or techniques for differentiating. Several kits attended to concepts and principles, but none was comprehensive enough to address all the standards for a particular grade level. At least two kits would be required to cover the prerequisite standards. Worse, the cost for the two kits would not include the price for the consumables that would have to be purchased each year to keep the kits adequately stocked. They could hardly pay for the cost of one kit!

Charlene and Andrew met at the back of the hall and compared notes. They were disappointed because they realized that the high-quality, standards-based curriculum materials they wanted were not in the racks. Now what? Were there other vendors? If so, who were they and how could they be contacted? If there were no vendors with the materials they needed, could they write the needed curriculum themselves? Who could help them? Did the district have money to pay stipends for curriculum development? How could they possibly write all the curricula that was required to address the state assessments?

We dedicate this curriculum unit, as well as others written under this Javits grant, to all the teachers who have had experiences like Charlene and Andrew. We hope the unit presented here will meet the needs of educators who live in real classrooms, contend with real time constraints, prepare students adequately for high-stakes assessments, seek high-quality curriculum materials, and strive to meet the varied learning needs of all their students.

Deborah E. Burns
Jeanne H. Purcell

PREFACE

In 2002, the Connecticut State Department of Education was awarded a Javits grant from the U.S. Department of Education called Project CONN-CEPT. The major focus of grant activities was the creation of standards-based curriculum units, K-8, in science and social studies. These rigorous curriculum units have been created for all students because every child must have access to the highest quality curriculum. At the same time, the units also have a particular focus on the needs of advanced learners—those who know more, learn more rapidly, think more deeply, or who are more innovative in a particular area of study. It was our goal to embed learning opportunities for advanced learners that were tightly aligned with the concepts and principles that guided the unit.

The Parallel Curriculum Model

This standards-based curriculum unit has been designed using the *Parallel Curriculum Model* (PCM) (Tomlinson, Kaplan, Renzulli, Purcell, Leppien, & Burns, 2002). The *Parallel Curriculum Model* is a set of four interrelated designs that can be used singly, or in combination, to create or revise existing curriculum units, lessons, or tasks. Each of the four parallels offers a unique approach for organizing content, teaching, and learning that is closely aligned to the special purpose of each parallel. The four parallels include: the Core Curriculum Parallel, the Curriculum of Practice, the Curriculum of Connections, and the Curriculum of Identity.

The *Core Curriculum* addresses the core concepts, principles, and skills of a discipline. It is designed to help students understand essential, discipline-based content through the use of representative topics, inductive teaching, and analytic learning activities. The *Curriculum of Connections* builds upon the Core Curriculum. It is a plan that includes a set of guidelines and procedures to help curriculum developers connect overarching concepts, principles, and skills within and across disciplines, time periods, cultures, places, and/or events. This parallel is designed to help students understand overarching concepts, such as change, conflict, cause and effect, and patterns, as they relate to new content and content areas. The *Curriculum of Practice* is a plan that includes a set of guidelines and procedures to help students understand, use, generalize, and transfer essential knowledge, understandings, and skills in a field to authentic questions, practices, and problems. This parallel is designed to help students function with increasing skill and competency as a researcher, creator, producer, problem solver, or practitioner in a field. The *Curriculum of Identity* is a plan that includes a set of guidelines and procedures to assist students in reflecting upon the relationship between the skills and ideas in a discipline and their own lives, personal growth, and development. This parallel is designed to help students explore and participate in a discipline or field as it relates to their own interests, goals, and strengths, both now and in the future.

The *Parallel Curriculum Model* also contains a new concept called Ascending Intellectual Demand (AID). Ascending Intellectual Demand offers practitioners a way to think about a discipline and each student's steady, progressive movement from novice to expert within that discipline. As students are ready, teachers ask students for increasing levels of cognition, affect, and application. As such, AID is a framework teachers use to increase the challenge level for students by asking them to behave and act in expert-like ways. (Tomlinson, Kaplan, Purcell, Leppien, Burns, & Strickland, 2006).

This unit has been designed using the Core Curriculum Parallel. Core Curriculum addresses the essential concepts, principles, generalizations, and skills of a subject area. It is designed to help students understand essential, discipline-based content through the use of representative topics, inductive teaching, and analytic learning activities. Although the majority of lessons in this unit have been designed using the Core Curriculum Parallel, it also contains several lessons that provide students with opportunities to explore other parallels that are closely connected to the subject matter.

Our Invitation…

We invite you to peruse and implement this curriculum unit. We believe the use of this unit will be enhanced to the extent that you:

- **Study PCM**. Read the original book, as well as other companion volumes, including *The Parallel Curriculum in the Classroom: Units for Application Across the Content Areas, K-12* and *The Parallel Curriculum in the Classroom: Essays for Application Across the Content Areas, K-12*. By studying the model in depth, teachers and administrators will have a clear sense of its goals and purposes.
- **Join us on our continuing journey to refine these curriculum units.** We know better than to suggest that these units are scripts for total success in the classroom. They are, at best, our most thoughtful thinking to date. They are solid evidence that we need to persevere. In small collaborative and reflective teams of practitioners, we invite you to field test these units and make your own refinements.
- **Raise questions about curriculum materials.** Provocative, compelling and pioneering questions about the quality of curriculum material—and their incumbent learning opportunities—are absolutely essential. Persistent and thoughtful questioning will lead us to the development of strenuous learning opportunities that will contribute to our students' life-long success in the 21st century.
- **Compare the units with material developed using other curriculum models.** Through such comparisons, we are better able to make decisions about the use of the model and its related curriculum materials for addressing the unique needs of diverse learners.
- **Examine PCM as one bridge between general and gifted education.** We believe that the rigorousness of PCM has much to offer *all* students, not just those who may already know, do, or understand at very different levels of sophistication.

ACKNOWLEDGEMENTS

We would like to thank our mentors, Carol Tomlinson and Carolyn Callahan. They have been our constant supporters and guides as we moved into uncharted territory related to curriculum development and differentiation.

Over the years we have been guided by the wise counsel of our curriculum writers: Cheryll Adams, Renee Alister, Karen Berk, Fie Budzinsky, Meagan Bulger, Yvette Cain, Lori Cipollini, Leslie Chislett, Megan Coffey, Edie Doherty, Claire Farley, Kurt Haste, Carla Hill, MaryAnn Iadarolla, Caitlin Johnson, Megan Lamontagne, Donna Leake, Lisa Malina, Kay Rasmussen, Martha Rouleau, Cindy Strickland, Mary Grace Stewart, Kim Turret, Ann Marie Wintenberg, and Karen Zaleski. They have worked tirelessly on their curriculum units and provided us with many insights into the curriculum writing process. Although we had a road map at the outset of the writing process, our writers helped us to craft new roads when the old ones no longer worked. We thank them for their integrity, care, innovativeness, and encouragement.

We thank all of the people who featured into the field testing process. These people include teachers in Cheshire, Hartford and Portland Public Schools. We especially want to thank the following building administrators who supported our work: Tory Niles and John Laverty from Hartford; Linda Cahill and Deborah Granier from Portland; and Steve Proffitt, Diane DiPietro, Sharon Weirsman, Russ Hinkley, Beverly Scully, and Mary Karas from Cheshire. The insights from teachers and administrators helped to make our curriculum units stronger and more practical.

Kim Allen, from Project LEARN, provided us with assistance and support in all of our endeavors and made sure that we stayed the course in solid financial standing. Nancy Wight and Gail Heigel, from Cheshire Public Schools, spent untold hours formatting, typing, duplicating, collating, and distributing the experimental units and ordering the numerous student materials and teacher resources that supplement these lessons. They are the masters of due diligence and attention to detail. We also wish to thank Eileen Williams and Patricia Johnson, from the State Department of Education, for formatting, typing, and preparing the pre-assessments and post assessments for the units. They worked tirelessly for many hours after work and on weekends to meet our deadlines and never lost their smiles.

We thank Cheshire Public Schools and the Connecticut State Department of Education for allowing us to take on this tremendous task and allowing us the hours within day (and night) to accomplish all that was required.

Our families and friends deserve special recognition because they offered unwavering support and encouragement. We recognize they made personal sacrifices, and we hope that we have grown as a result.

Most of all, we would like to thank Judy Walsh on whose shoulders these units truly stand. With the greatest of care and unparalleled thoughtfulness and consideration, Judy has edited each manuscript, worked collaboratively with each author to refine each lesson, written lessons when it was necessary, and provided a sense of humor and her wisdom as a teacher. She is selfless and seeks only to advance each author and the project. In every way, she has been our "North Star" on the project.

Format for the Project CONN-CEPT Curriculum Units

Each Project CONN-CEPT curriculum unit is formatted in the same way and contains four components: an overview, the lessons, a content map, and a comprehensive list of resources required in the unit. The *overview* is a chart that includes the lesson principles, concepts and skills, the time allocation, the standards that are explicitly addressed within each lesson, and a brief description of each lesson. The overview provides potential users with a "snap-shot" of the unit, related standards, and classroom activities.

The *lessons* follow the overview and vary in number depending upon the content area and grade level of the unit. Each lesson is comprehensive and addresses 10 curriculum components: content, assessments, introductory and debriefing activities, teaching strategies, learning activities, grouping strategies, products, resources, extensions, and differentiation activities. For the most part, each lesson provides specific information about each of these components. An aligned pre- and post-assessment is included for the entire unit, and aligned formative assessments are provided at critical junctures in the unit. Additionally, each lesson contains all the required black-line masters and materials.

Many lessons contain two features that are unique to Project CONN-CEPT materials: opportunities for Ascending Intellectual Demands (AID) and talent-spotting activities. Ascending Intellectual Demand is a term used to describe learning opportunities that require students to work at increasing levels of discipline-specific expertise (Tomlinson et al). They are appropriate for any student who demonstrates advanced ability or expertise in a discipline. The AID opportunities are labeled using the acronym AID. Additionally, many lessons contain searchlight opportunities. Searchlight opportunities are rich moments during a lesson for teachers to observe students and note those who appear to have heightened interest in the topic under investigation. To support these students' emerging interests, extension ideas are provided.

A *content map* comes after the lessons. Like the overview, the content chart is a snap-shot of the important knowledge in a unit: the major and minor principles, concepts, skills, themes and guiding questions. Teachers who want in-depth information about the knowledge contained in the unit will find this chart useful.

A comprehensive list of *resource materials* concludes each unit. Although the required materials are also listed at the beginning of each lesson, the comprehensive listing provides teachers with a one-page summary of all the materials and it facilitates planning.

Light – Grades 4–5

This unit on light has been designed using the Core Curriculum parallel. Core curriculum addresses the core concepts, principles, generalizations, and skills of a subject area. It is designed to help students understand essential, discipline-based content through the use of representative topics, inductive teaching, and analytic learning activities. Although the majority of lessons in this unit have been designed using the Core Curriculum parallel, it also contains several lessons that provide grade 4/5 students with opportunities to connect the material to another discipline (Curriculum of Connections) as well as a lesson that provides students with the opportunity to explore the methodology of the practicing professional (Curriculum of Practice) and the chance to reflect on themselves as emerging scientists (Curriculum of Identity).

The unit contains 21 lessons that are outlined in the chart below. The first column contains the lesson number and the name of the parallel(s) that the lesson addresses. The second column contains a series of numbers. The numbers reflect the national standards—culled from *National Science Education Standards* (National Research Council, 1996) and *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1993)—that are addressed in each lesson and that are listed and numbered below. Connecticut's standards are also listed in a similar fashion. For brevity's sake, only one or two standards are listed in each row of the chart and represent the major focus of individual sessions. However, the lessons have been designed to build upon each other, and each session builds iteratively upon many of the standards.

Column three contains the principles that guide the lesson. The principles—which state relationships among essential concepts—reflect what we want students to know and be able to do upon completing the lessons. They are derived from the standards, reflect both declarative and procedural knowledge, and illustrate the careful attention that has been given to "teasing apart" the complexity of ideas contained within standard statements.

Column four includes a brief description of the lesson. It provides an overview of some of the teaching and learning activities that are designed to occur within the classroom.

National Standards

Physical Science

1. 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. (NSES, K-4)
2. Light interacts with matter by transmissions (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. (NSES, 5-8)
3. 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. (BSL, 6-8)
4. Some materials conduct heat much better than others. Poor conductors can reduce heat loss. (BSL, 3-5)

Earth and Space Science

5. The sun provides the light and heat necessary to maintain the temperature of the earth. (NSES, K-4)

The Designed World

6. The sun is the main source of energy for people and they use it in various ways. The energy in fossil fuels such as oil and coal comes from the sun indirectly, because the fuels come from plants that grew long ago. (BSL, 3-5)

Scientific Inquiry

7. Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world. (NSES, K-4)
8. Scientists use different kinds of investigations depending on the questions they are trying to answer. Types of investigations include describing objects, events, and organisms; classifying them; and doing a fair test (experimenting). (NSES, K-4)
9. Simple instruments, such as magnifiers, thermometers, and rulers, provide more information than scientists obtain using only their senses. (NSES, K-4)
10. Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge). Good explanations are based on evidence from investigations. (NSES, K-4)

Science and Technology

11. Tools help scientists make better observations, measurements, and equipment for investigations. They help scientists see, measure, and so things that they could not otherwise see, measure and do. (NSES, K-4)

Habits of Mind

12. Students should offer reasons for their findings and consider reasons suggested by others. (BSL, 3-5)
13. Students should use numerical data in describing and comparing objects and events. (BSL, 3-5)

Connecticut Related Content Standards – Grades 3-5

I. Scientific Inquiry

Scientific inquiry is a thoughtful and coordinated attempt to search out, describe, explain and predict natural phenomena.

Scientific Literacy

Scientific literacy includes speaking, listening, presenting, interpreting, reading and writing about science.

Scientific Numeracy

Mathematics provides useful tools for the description, analysis and presentation of scientific data and ideas.

Grade 5

5.1 Energy Transfer and Transformations

What is the role of energy in our world?

Sound and light are forms of energy

- Light is a form of energy that travels in a straight line and can be reflected by a mirror, refracted by a lens, or absorbed by objects.
  (B. 19 Describe how light is absorbed and /or reflected by different surfaces.)

5.2 Structure and Function

How are organisms structured to ensure efficiency and survival?

Perceiving and responding to information about environment is critical to the survival of organisms.

- The sense organs perceive stimuli from the environment and send signals to the brain through the nervous system.
  - o B 20. Describe how light absorption and reflection allow one to see the shapes and colors of objects.
  - o B 21. Describe the structure and function of the human senses and the signals they perceive.

Lesson	Standards	Lesson principles	Lesson description
Pre-assessment 1 (CORE) 45 minutes			This lesson includes a pre-assessment that samples the content in this unit: sunlight is a source of heat and light; light can be reflected, refracted, or absorbed; black is the absence of reflected light, and white is the reflection of all colors; white light can be separated into component colors,; images of objects can be manipulated by understanding light's properties; eyes have parts that have particular functions in the vision process; and animals have eyes with varying structures that enable them to survive in their environments.
2 (CORE/AID) 1 hour	5, 6, 9 CT Standards: I (Expected Performance B INQ. 1, 3, 4, 9)	• Sunlight is a source of heat and light. • Sunlight can be focused on objects.. • Sunlight can be captured and used in technology.	In this lesson, students will examine the power of the sun's light (energy) to heat up objects. Students will have opportunities to see the effect of the sun's light on black construction paper as compared to white construction paper. They will also explore sunlight's effect on sand and water in order to address the differences between the ways in which the earth's land masses heat up as compared to its water bodies. AID extension opportunities are offered for students who need more challenge.
3 (CORE/ PRACTICE/ IDENTITY) 50 minutes	5, 10 CT Standards: I (Expected Performance B INQ. 1, 5, 6, 9, 10)	• Light can be absorbed by substances. • Sunlight affects different substances in different ways. • Land masses heat up faster than water masses. • Scientists work by observing,, describing, and using data to explain phenomena and share information • Anybody can be a scientist	Students continue their analysis of the data regarding the sun's effect effect on soil and water temperatures. They will apply graphing skills and their understanding of experimental variables, as they graph the results of the lab activity. They will then draw a conclusion as to which material, soil or water, heats up more quickly as a result of a given amount of sunlight. An extension activity addresses the Identity Parallel with students.
4 (CORE) 55 minutes	4, 12, 13 CT Standards: I (Expected Performance B INQ. 1, 3, 4, 5, 9) 5.1 (Expected Performance: B 19)	• Sunlight is absorbed by substances. • Light interacts with materials differently, depending on the color of the material it strikes.	In this lesson students will continue the exploration of the nature of light. They will examine the absorption of the sun's light (energy) by various colored papers, as well as ice cubes covered in colored cellophane to see if there is a relationship between the amount of sunlight absorbed and the color of material.
5 (CORE/AID) 1 hour	1, 2, 10 CT Standards: I (Expected Performances B INQ. 1, 2, 3, 4, 5, 6) 5.1 (Expected Performances: B19, B20)	• Light can be reflected and allows us to see things. • Light travels in the dark. • Light travels in straight lines. • Light has natural and artificial sources.	Students will explore the concept of light in that it is the "stuff" that enables us to see things. They investigate how light travels and how it is produced. Using a teacher demonstration, students will see how light can travel through the dark and follow a path, thus producing a "light pipe." They will discuss natural and artificial light sources and investigate the directionality of light with a short lab. An AID activity challenges students to create a diagram of a light bulb and label the parts.

Lesson	Standards	Lesson principles	Lesson description
6 (CORE/AID) 50 minutes	2, 3, 8 CT Standards: I (Expected Performances : B INQ. 1, 3, 4, 5, 6) 5.1 (Expected Performances B 19, B 20)	• Light can be reflected light and allows us to see things. • White is a reflection of all colors. • Certain primary colors can be mixed to produce new colors.	This lesson will provide an opportunity to explore the concept of reflection of light and the fact that white light has components that can be separated. The latter concept lays the foundation for why certain objects and materials vary in color. For students who need additional challenge there is an AID activity that involves viewing various colored objects through laser glasses that filter out certain components (wavelengths) of light. As a result students will deepen their understanding color composition.
7 (CORE/AID) 1 hour, 15 minutes	2, 3, 11 CT Standards: I (Expected Performances : B INQ. 1, 3, 4, 5, 6,) 5.1 (Expected Performance B 19) 5.2 (Expected Performance B 20)	• White light can be separated into colors	Students will explore the separation of white light into an array of colors. In addition, the lesson will introduce students to the absorption and reflection of light and their relationship to the production of specific colors, as seen by the human eye. Several AID activities are offered for students who need an additional challenges.
8 (CORE/ AID) 1 hour	1, 2, 10 CT Standards: I (Expected Performances : B INQ. 1, 3, 5, 6, 9) 5.1 (Expected Performance B 19) 5.2 (Expected Performance B 20)	• Black is the absence of reflected light, and white is the reflection of all colors. • Objects reflect certain colors of light and absorb other colors because of their chemical nature. • Light can be bent	Students will share what they learned about rainbows as a way of connecting the science of light refraction to the world around them. Students will be able to explain why a red shirt is seen as red and not some other color and they will be able to explain whether white and black are colors. Finally, using light boxes, students discover that when light travels from one type of substance to another, it changes it direction or is refracted. Students also observe an increase in intensity of light where beams cross and realize that bending light can be used to human advantage. An interesting AID activity provides students have with the opportunity to explore the colors of a sunset.
9 (CORE/AID) 50 minutes	1, 8, 10 CT Standards I: (Expected Performances : B INQ. 1, 3, 4, 5, 6) 5.1 (Expected Performance B 19,)	• Light can be bent • Objects under water are not located where they visibly appear to be.	Students will extend their understanding about light's behavior, as they explore such things as why objects under water are not located where they appear to be. The concept of refraction or the bending of light will surface as the reason behind the apparent mysterious behavior of objects when immersed in water. An AID extension activity uses the principles of the lesson to explore a trick using a coin and a cup of water.
10 (CORE) 50 minutes	2, 10 CT Standards I: (Expected Performances: B INQ. 1, 5) 5.1 (Expected Performance B 19)	• Objects transmit light to varying degrees.	Students will discover the behavior of substances that do not transmit light versus those that transmit visible light entirely and those that transmit it partially: opaque, transparent and translucent materials, respectively. Then students will participate in a scavenger hunt in the room, looking for substances that fall in one of the three categories dealing with the opacity of light.

Lesson	Standards	Lesson principles	Lesson description
11 (CONNECTIONS/ AID) 55 minutes	7, 8, 10 CT Standards: I (Expected Performances : B INQ. 1, 2, 3, 4, 5, 6)	• Black is the absence of reflected light. • Mixtures can be separated through physical and chemical means.	This lesson leads students to see connections in science disciplines. One of the fields in physics is the study of light. This study contrasts to the field of chemistry that includes the study of colors in clothing and other materials, such as inks. The latter involves examining the specific chemicals, dyes, which absorb and reflect light differently. Students will explore the connection between the separation of light into its colored components and separation of colored materials, ink dyes, based on their solubility behaviors, via a technique called chromatography. Students will see the connection between black pigments that are composed of all colors, and the consequential absorption of all of the colors from white light and the reflection of nothing. Students explore how the colored components of black ink can be separated. An AID activity introduces students to the concept of chromatography using various solvents besides water to improve separation results.
12 (CORE/AID) 1 hour, 5 minutes	1, 7, 10 CT Standards: I (Expected Performances : B INQ. 1, 3, 5, 6, 9, 10) 5.1 (Expected Performances B 19)	• Light reflects in different ways depending upon the nature of the material it hits. • Smooth, flat, shiny surfaces (mirrors) produce the best reflections. • Light is reflected by a mirror at the same angle at which it strikes the mirror. • Light that hits irregular surfaces goes in all directions.	In this lesson, students will explore how light behaves when it hits various textured surfaces. They will discover that when light hits a flat surface, it reflects off that surface at the very same angle the light hit it. They will also explore the concept of diffusion of light, the way light behaves when it reflects from various types of surfaces that are not flat Students and then compare these results to light's reflection from flat surfaces. There are two AID extension activities for students who can handle manage independent research.
13 (CORE/ CONNECTIONS/ AID) 1 hour, 15 minutes	1, 10, 11 CT Standards: I (Expected Performances : B INQ. 1, 3, 6) 5.1 (Expected Performances B 19)	• Light can be made to change direction. • Light's reflective behavior can be used to create tools to help us see better.	In this lesson students will manipulate light, using its known behaviors, to accomplish a task. By the end of the lab, they will discover that they have actually used the properties of light to construct a useful tool, a periscope. They will see the connection between properties of light and their application to the production of tools to serve human purposes. Two AID extension activities are offered for students who need more challenge.
14 (CORE/AID) 1 hour, 5 minutes	2, 7, 8 CT Standards: I (Expected Performances : B INQ. 1, 2, 4, 5, 6) 5.1 (Expected Performances B 19)	• Images of objects can be manipulated by understanding light's properties. • The reflective image that strikes our eye is actually inverted. • The human brain inverts image	Students will make a "pinhole" camera and explore the nature of images via this device in this lesson. They will discover the relationship between the amount of light and the clarity of images. In addition, students will explore why things are out of focus at times. By the end of the lesson, they will discover that there is a difference between what they think they see and a "real" image. AID students have an opportunity to explore the pinhole camera further.

Lesson	Standards	Lesson principles	Lesson description
15 (CORE) 1 hour, 10 minutes	2, 7, 11 CT Standards: 5.1 (Expected Performances B 19) 5.2 (Expected Performances B 20)	• Images of objects can be manipulated by understanding light's properties. • The reflective image that hits our eye is actually inverted. • The human brain inverts images.	Students will review the concept of focused and unfocused light with an introductory activity. The lesson will continue with the idea that tools can be designed that help us to capture images by using light's behaviors. Students will examine how lenses change what we see and how they can be used to make a lens camera. Either through demonstration or through small group student exploration, a lens camera will be compared to a "pinhole camera" and to the human eye in terms of structure and function. One goal for students is to define for themselves what focused or "out-of-focus" means and to relate the focusing of images to adjusting the separation distance between the lens and the image. In addition, the lesson further helps the students observe that the image with a lens is brighter than the image produced by the pinhole camera, but it is still reversed and inverted.
16 (CORE) 50 minutes	7, 11 CT Standards: I (Expected Performances: . 1, 3, 5, 6, 9) 5.1 (Expected Performances B 19)	• Clear images can be intentionally produced using light's properties. • The reflected image we see is inverted. • Light can be focused using lenses. • Lenses change the way we see things.	This lesson will explore how lenses can be used to manipulate images for our benefit. Students will investigate how a scene changes in appearance depending on its distance from a lens. They will begin to understand the connection between this relationship and its application in such technologies as cameras and telescopes.
17 (CORE/AID) 1 hour	2, 10 CT Standards: I (Expected Performances : B INQ. 1, 5, 6, 9) 5.2 (Expected Performances B 20)	• Clear images can be intentionally produced using light's properties. • The reflected image we see is inverted. • Light can be focused using lenses. • Lenses change the way we see things.	The exploration of the human eye begins in this lesson by seeing what happens to images as they enter the eye and hit its lens. Students will actually be describing images seen in their partner's eye called Purkinje images. As a result of this examination, they will secure evidence for the existence of something that moves the lens, the iris.
18 (CORE) 55 minutes	2, 7 CT Standards: I (Expected Performances : B INQ. 1, 2, 3, 5, 6, 8) 5.2 (Expected Performances B 20, B 21)	• Eyes have parts that have particular functions in the vision process. • An eye operates in a similar fashion to a camera.	This lesson begins with a pre-assessment to see what students know about the structure of the eye. This information enables the teacher to recognize what terms can and cannot be used during the remainder of the lesson in which students examine the nature of how the eye handles light. Students will ultimately be able to see the similarity between the lens of a camera and that of a human eye.

Lesson	Standards	Lesson principles	Lesson description
19 (CORE) 45 minutes	7, 8 CT Standards: I (Expected Performances : B INQ. 1) 5.2 (Expected Performances B 21)	• Eyes have parts with particular functions in the vision process. • An eye is like a human camera.	Students and teacher discuss the similarity between the lens of a camera and that of a human eye, using drawings that can be labeled. Diagrams are then distributed that show both the eye and the camera and outline the similarities.
20 (CONNECTIONS) 2 hours, 30 minutes	7, 10, 12 CT Standards: I (Expected Performances : B INQ. 1, 2, 6, 7, 8,) 5.1 (Expected Performances B 20)	• Animals have eyes with varying structures that enable them to survive in their environments. • Animals have adaptations that assist them with survival in their habitats.	Students will explore the concept of structure and function as seen in the biological sciences by researching the extensive variety of eyes that animals have. Students will discover that the diversity in animal eye structures has enabled organisms to adapt to and survive in the vast number of habitats that exist all over the world. Each student will have an opportunity to share his or her findings with classmates during either a poster or a PowerPoint presentation.
Post Assessment 21 (CORE) 45 minutes		All principles in the unit	Post assessment

References

American Association for the Advancement of Science. (1993). *Project 2061: Benchmarks for science literacy.* New York: Oxford University Press.

Connecticut State Department of Education. (2004). *Core science curriculum framework.* Hartford, CT: Connecticut State Department of Education.

National Research Council. (1996). *National science education standards.* Washington, DC: National Academy Press.

Tomlinson, C. A., Kaplan, S. N., Renzulli, J. S., Purcell, J., Leppien, J., & Burns, D. (2002). *The parallel curriculum: A design to develop high potential and challenge high-ability learners.* Thousand Oaks, CA: Corwin Press.

CONTENTS

Preface	Page I
Acknowledgements	Page III
Format	Page V
Introductions to Light: A Rainbow of Explorations	Page VI
Lesson 1 Pre-Assessment Time Allocation: 45 minutes	Page 1
Lesson 2 Time Allocation: 1 hour	Page 11
Lesson 3 Time Allocation: 50 minutes	Page 21
Lesson 4 Time Allocation: 55 minutes	Page 29
Lesson 5 Time Allocation: 1 hour	Page 41
Lesson 6 Time Allocation: 50 minutes	Page 53
Lesson 7 Time Allocation: 1 hour, 15 minutes	Page 65
Lesson 8 Time Allocation: 1 hour	Page 77

CONTENTS

Lesson 9 Page 89
Time Allocation: 50 minutes

Lesson 10 Page 103
Time Allocation: 50 minutes

Lesson 11 Page 109
Time Allocation: 55 minutes

Lesson 12 Page 117
Time Allocation: 1 hour, 5 minutes

Lesson 13 Page 131
Time Allocation: 1 hour, 15 minutes

Lesson 14 Page 139
Time Allocation: 1 hour, 5 minutes

Lesson 15 Page 151
Time Allocation: 1 hour, 10 minutes

Lesson 16 Page 161
Time Allocation: 50 minutes

Lesson 17 Page 169
Time Allocation: 1 hour

Lesson 18 Page 177
Time Allocation: 55 minutes

Lesson 19 Page 185
Time Allocation: 45 minutes

Lesson 20 Page 191
Time Allocation: 2 hours, 30 minutes

Lesson 21: Post Assessment Page 205
Time Allocation: 45 minutes

Curriculum Map Page 215

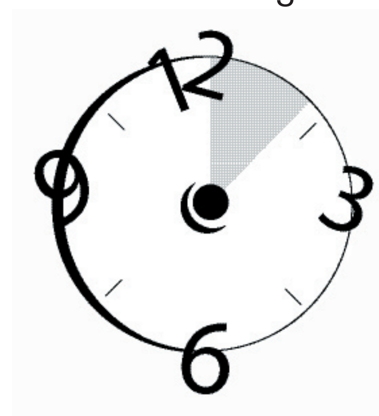
Materials and Resource List Page 225

Enlightening Explorations with Light and Using Light's Properties to See Better Pre-assessment

Core (Pre-assessment)

Time Allocation: 45 minutes

Required Materials and Resources on Page 225



Lesson Overview

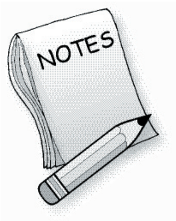
Students in this lesson answer pre-assessment questions that should their current understandings regarding the nature of light and some of its technological applications, such as eye glasses and cameras.

Guiding Questions

- Does sunlight affect the earth's land and water masses differently?
- How do we make sunlight work for us?
- Why do we wear more light colored clothes in the summer than in the winter?
- Does light travel in the dark?
- Does light have a direction of travel?
- What things can produce and/or give off light?
- Are white and black colors?
- Why is a red shirt red?
- How are rainbows formed?
- Can light be bent?
- Is there anything else visible light can do besides being absorbed, reflected or refracted?
- Does a surface's texture affect the way in which light bounces off it?
- How do we use light's properties to improve what we see?
- Is an eye like a camera?
- Why do animals have so many different types of eyes?

BIG IDEA

What do I know about light and its properties?



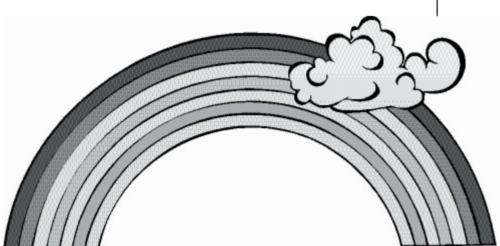
Content Goals

Universal Theme(s)

- Science involves making hypotheses, theories and conceptual models to represent, explain and predict phenomena.
- Scientific evidence consists of observations and data on which to base scientific explanations.
- Using evidence to understand interactions allows individuals to predict changes.

Principles and Generalizations

- Sunlight is a source of heat and light.
- Light can be absorbed by substances.
- Light can be reflected light and allows us to see things.
- White light can be separated into component colors.
- Light can be bent.
- Objects transmit light to varying degrees.
- Black is the absence of reflected light, and white is the reflection of all colors.
- Light reflects in different ways, depending on the nature of the material it hits.
- Light can be made to change direction.
- Images of objects can be manipulated by understanding light's properties.
- Clear images can be intentionally produced using light's properties.
- Eyes have parts that have particular functions in the vision process.
- An eye is like a human camera.
- Animals have eyes with varying structures that enable them to survive to their environments.



Concepts

- Focused sunlight
- Absorption of light
- Independent and dependent variables
- Light's direction of travel
- Natural versus artificial light sources

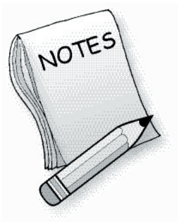
- Reflection of light
- Primary colors
- Secondary colors
- Separation of white light
- Refraction of light
- Chromatography (AID)
- Transmission of light
- Opaque
- Transparent
- Translucent
- Visible light
- Ultraviolet light
- Chromatography
- Mixture
- Diffusion of light
- Manipulation of light
- Focused and unfocused light
- Inverted image
- Real image
- Lens
- Vision
- Structure and function of eye parts
- Adaptation

Teacher Information

N/A

Skills

- Predict
- Make observations
- Record data
- Interpret data
- Identify characteristics
- Compare and contrast
- See relationships



Materials and Resources
Pre-assessment for the Light: A Rainbow of Explorations Unit

Preparation Activities
1. Copy **Pre-asssessment for the Light Unit** for each student.
2. Copy **Possible Answers to the Pre-asssessment for the Light Unit.**

Introductory Activity
N/A

Pre-assessment
Pre-asssessment for the Light: A Rainbow of Explorations Unit

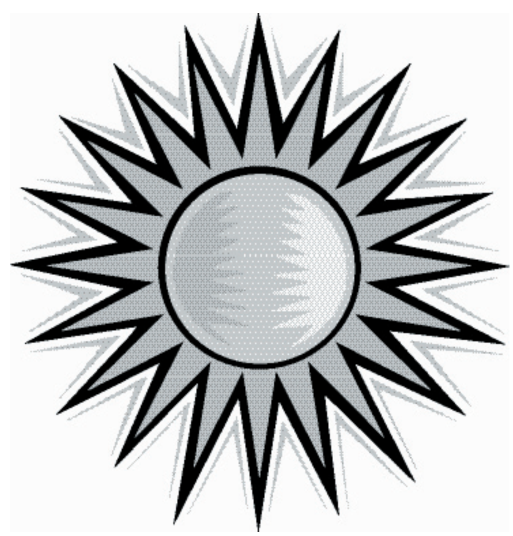
Teaching and Learning Activities (45 minutes)
1. Explain to students that the pre-assessment will be used as a tool by you to measure their previous knowledge. Emphasize that they should make their best effort on the assessment but should not worry if they do not know some of the questions.
2. Distribute the **Pre-asssessment for the Light: A Rainbow of Explorations Unit**

Products and Assignments
Students' assessment results

Extension Activities
N/A

Post Assessment
N/A

Debriefing and Reflection Opportunities
N/A



Name ____ Date __________________

Pre-assessment for the Light: A Rainbow of Explorations Unit

1. If you had to choose between a black or white shirt, which would you wear in the summer? Explain your choice.

2. Which heats up faster, land or water?

3. Which cools off faster, land or water?

4. Name two ways we make sunlight work for us, in addition to growing plants.

5. Why is there often a breeze during the day that comes off the water at the shore, along ocean areas?

6. Explain how we see objects in the light.

Name ____ Date ________________

7. Is black a color? Explain your answer.

8. Why do you see yellow when you look at a yellow shirt and not some other color?

9. If you shine a red light on a green leaf, what color will the leaf appear and why?

10. If you were in a store and purchased a red shirt and brought it home and took it out of the bag in your house and found it to really be orange, what could you tell me about the lights in the store? Be specific about your answer.

11. How does the angle of incoming light bouncing off a mirror compare to the angle at which it leaves the mirror's surface?

12. Why is it difficult to retrieve a golf ball from a water hazard when you use a ball scoop?

13. If you were sitting under a desk and wanted to see something on top of a desk, what would you use or build to accomplish this task? Assume that your teacher could give you any materials she had in school. What would you call your “tool”?

14. What do eye glass lenses do to light to help improve certain people’s vision?

15. Describe at least **four** ways in which a eye is similar to a camera.

16. Based on your experiences, what are the characteristics of an excellent reflective surface?

Name ____ Date ________________

Possible Answers to the Pre-assessment for the Light: A Rainbow of Explorations Unit

1. If you had to choose between a black or white shirt, which would you wear in the summer? Explain your choice.

I would wear a white shirt because black absorbs all light, and it would make me hotter. White reflects all colors, so I would be cooler in a white shirt.

2. Which heats up faster, land or water?

Land heats up faster.

3. Which cools off faster, land or water?

Land cools off faster.

4. Name two ways we make sunlight work for us in addition to growing plants.

Sunlight is used in solar powered things like calculators and in solar panels that produce electricity for homes and businesses.

5. Why is there often a breeze during the day that comes off the water at the shore, along ocean areas?

There is a breeze because the land is hotter than the water. The warm air rises and the cooler air over the ocean rushes in to replace the warm air, thus creating a breeze that comes off the water.

6. Explain how we see objects in the light.

We see objects in light because the light bounces off the object and strikes our eyes.

7. Is black a color? Explain your answer.

No, black is not a color. Black things absorb all light.

8. Why do you see yellow when you look at a yellow shirt and not some other color?

Yellow shirts reflect yellow light, which is why we see yellow. The shirt absorbs the other colors that make up white light.

9. If you shine a red light on a green leaf, what color will the leaf appear and why?

The leaf will appear black because the only color a green leaf reflects is green and if you do not shine a light on it that has a green component, it will absorb everything and appear black.

10. If you were in a store and purchased a red shirt and brought it home and took it out of the bag in your house and found it to really be orange, what could you tell me about the lights in the store? Be specific about your answer.

The lights in the store were not like white lights because all the colors were not produced. I think red and yellow make orange, so perhaps the light had more red and thus the shirt reflected red light. Since the light in the store had no yellow, the shirt did not reflect any yellow, so I did not see the shirt as orange in the store.

11. How does the angle of incoming light bouncing off a mirror compare to the angle at which it leaves the mirror's surface?

The light that hits a mirror bounces off at the same angle as it struck the mirror.

12. Why is it difficult to retrieve a golf ball from a water hazard when you use a ball scoop?

When you look at an object underwater from an angle, the location of the object is not really where it appears to be. This is because water bends light rays when they pass through water at an angle other than perpendicular to the water. This action changes the apparent location of objects when seen from outside the water.

13. If you were sitting under a desk and wanted to see something on top of a desk, what would you use or build to accomplish this task? Assume your teacher could give you any materials she had in school. What would you call your "tool"?

I would use mirrors and build something like a periscope to see what was on top of the desk.

14. What do eye glass lenses do to light to help improve certain people's vision?

They magnify and/or focus images.

15. Describe at least **four** ways in which a eye is similar to a camera. Identify the parts that are similar and their functions.

Both close and open to let in light that comes in (pupil and eyelid versus lens cap or slider).

Both can adjust the amount of light (iris and shutter).

Both can capture an image of what it is out there.

Both have protection (e.g., eyelid versus lens cap).

Both have the ability to focus light.

Both have screens that respond to light (retina versus film).

The eye has a optic nerve, and a digital camera has a cable that takes a signal away from the eye.

16. Based on your experiences, what are the characteristics of an excellent reflective surface?

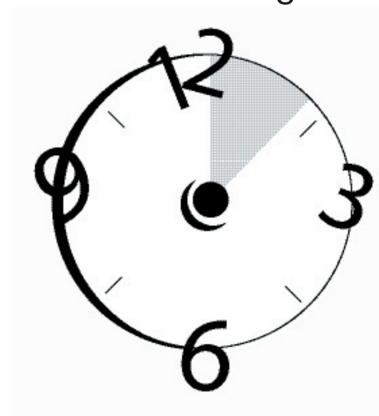
An excellent reflective surface is shiny and smooth.

Enlightening Explorations with LIGHT

Core/AID

Time Allocation: 1 hour

Required Materials and Resources on Page 225



Lesson Overview

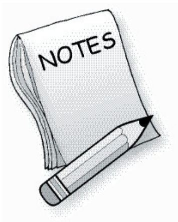
In this lesson, students examine the power of the sun's light (energy) to heat up objects. Students will have opportunities to see the effect of the sun's light on black versus white construction paper. They will also explore sunlight's effect on sand and water in order to address the difference between the ways in which the earth's land masses heat up as compared to its water bodies.

Guiding Questions

- Does sunlight affect the earth's land masses and water masses differently?
- How do we make sunlight work for us?

BIG IDEA

Sunlight affects land masses and water masses differently.



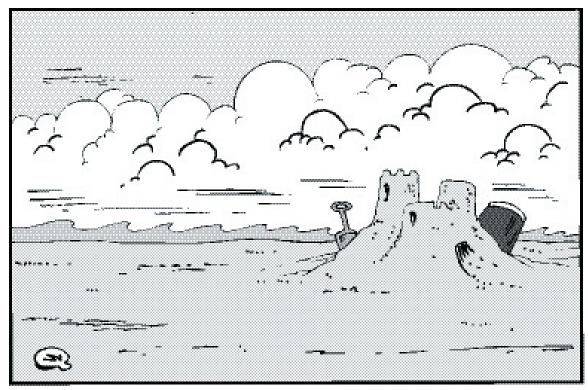
Content Goals

Universal Theme(s)

- Science involves making hypotheses, theories and conceptual models to represent, explain and predict phenomena.
- Scientific evidence consists of observations and data on which to base scientific explanations.
- Using evidence to understand interactions allows individuals to predict changes.

Principles and Generalizations

- Sunlight is a source of heat and light.
- Sunlight can be focused on objects.
- Sunlight can be captured and used in technology.

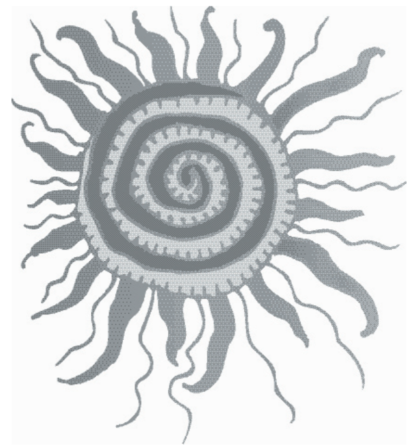


Concepts

- Focused sunlight
- Absorption of light

Teacher Information

- An optional teacher demonstration on the effects of sunlight on black material versus white material could be used, depending upon students' prior knowledge.
- The word "energy" is not to be emphasized. The point of the exploration is for students to discover the attributes of light, one of which is that it is a source of heat and light and that these aspects can be harnessed for our purposes.
- When the students perform the sand and water experiment, they want to carefully record where they locate the thermometers. The sand will warm up faster than the water, unless the sand is very deep and/or the water is very shallow.
- A black material will heat up faster than the same material in white.
- Black objects absorb more energy (heat) than white objects.



Skills

- Predict
- Make observations
- Record data

Materials and Resources

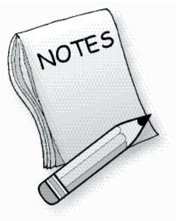
1. Window with direct sunlight exposure or table lamp
2. Trays (2 per student or student group)
3. Water (enough to fill each tray 2/3 full)
4. Sand (enough to fill each tray 2/3 full)
5. Thermometers (2 per student or student group)
6. Black and white construction paper (1 piece for teacher demonstration #1)
7. Table lamp if no window/sun is available in the classroom (teacher demonstration #1)
8. Hand lens (teacher demonstration #2)
9. Container with water (e.g., squirt bottle) for teacher demonstration #2
10. Pictures or real devices that harness sunlight to assist humankind (e.g., solar panels, photoelectric cells and telescopes).

Preparation Activities

1. Choose a sunny day and locate an open area where you can take students, preferably a grassy rather than blacktop area.
2. Copy **Does Sunlight Affect Bodies of Water Differently than It Affects Land Masses?**
3. Gather devices or pictures of devices that harness sunlight to assist man, as these will be helpful (e.g., solar panels, photoelectric cells and telescopes).
4. Set up 2 trays for each student lab group, one 2/3 filled with sand and the other 2/3 filled with water.

Introductory Activity (15 minutes)

- Inform the class that you will be setting up a demonstration and that you need their help.
- Tell one student in the class to place one piece of white construction paper and one of black in a window that gets full sun (if no full sun is available, use a table lamp as a source of energy).



- Tell the student to place a thermometer on top of each piece of paper and to record the initial temperature on the board.
- While the "construction paper demonstration" is going on, ask students what they know about sunlight. Ask them questions like: Does sunlight affect things differently? How? Write down what students think they know about sunlight and keep it. Their answers will be used at the end of the lesson to compare what they know now with what they learned, as a result of the lab activities.
- Explain to students that they will be doing several activities that explore how sunlight affects substances.
- Distribute the materials and handout for the activity, **Does Sunlight Affect Bodies of Water Differently than It Affects Land Masses?**
- Read the lab with students. Tell them they will be stopping at item # 5 today.
- Tell students that they will be collecting data regarding the effect of sunlight on sand and water.
- Ask students what the sand is analogous to on the earth's surface. Students should recognize that it represents the earth's land masses.
- Question students as to what the water in the experiment will represent. They should recognize that it represents the earth's oceans, lakes and other bodies of water.
- Inform students that they will ultimately be able to answer the question, "Does sunlight affect the earth's water bodies differently than it affects land masses?"
- Call upon an additional student at five minutes to take another temperature reading of the construction papers.
- Instruct students that they will be collecting data outside and that they will need their lab sheet, materials and writing implement.
- Tell students to come get their trays and thermometers. Go outside or if you have room in your classroom on windowsills, have the students do the lab inside.
- Ask another student to read the temperature of the two pieces of construction paper one more time and record them on the board before the groups begin the lab activity.

Pre-assessment

N/A

Teaching and Learning Activities (40 minutes)

1. If you take students outside, do not forget to bring your hand lens and squirt bottle for the second teacher demonstration and your pictures and/or bag of solar-powered items to share with students after the demonstration #2 (focusing sun's light to make fire).

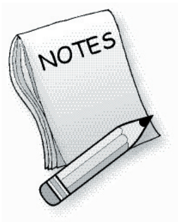
2. Direct students to their work areas.

3. Instruct them to start the lab activity, **Does Sunlight Affect Bodies of Water Differently than It Affects Land Masses?**

4. After they take their first reading, tell students to predict what they think will happen and to record their predictions in the appropriate area on the lab activity sheet, item #5.

5. Tell students to stop by your area between their readings.

6. While students are taking their readings every 5 minutes, begin t*eacher demonstration #2*. Have a discussion about your demonstration in between student temperature readings.
   - Take a lens and focus sunlight to a small bright spot on a piece of newspaper. Have a squirt bottle filled with water to douse the flames.
   - The newspaper should start to ignite because the sun's energy is being brought to bear on a small spot on the paper.
   - Remind students NOT to do this at home unless their parents are supervising them because sometimes there can be dry grasses, leaves or bushes that might catch fire.
   - Ask students what this demonstration tells them about sunlight. They do not have to respond with the term *energy*, although they probably will. Ask students what they think the lens is actually doing to the sunlight's rays. Students probably will use the term "focus." Discuss the idea that sunlight rays are all around, and that the lens serves the purpose of directing some of these rays to a certain point for the purpose of accumulating its intensity. Emphasize the redirection of the sun's rays for a specific purpose; hence, we have



harnessed some of the sun's energy to do something for us. The most important conclusion students should reach is that the sun's power can be *used* to do things.

- Ask student responses about technology they know that uses the sunlight as a source of power (energy). Students will probably respond with such things as solar powered heaters, calculators, walkway lights and even solar-powered cars. **SEARCHLIGHT:** For students who demonstrate a particular interest in this topic or who have demonstrated that they learn the material more quickly than their peers, the extension activities can be used.
- Show students some of the pictures and/or devices you brought in that use the sun's energy (e.g., solar calculator, solar-powered garden, stepping stone).

After students have finished collecting enough data to see that sand heats up faster than water (walk among student groups and examine their results after 20 minutes or so), return to the classroom and have a fourth student read and record the temperatures of the black and white construction paper.

Discuss the results with students. They should conclude that black construction paper heated up faster and more fully than the white piece. They might say, "Black things absorb more energy than white things" or something similar.

9. Since light energy is absorbed differently by white versus black objects, ask students if they think objects that are colored red, blue, green or yellow vary in how they heat up. Tell them they will be investigating this question soon.

Products and Assignments

N/A

Extension Activities

1. (AID) Discuss with students the ways they know that the sun's energy is harnessed. The most important example is a plant's ability to trap sunlight and convert it into plant material. A solar panel is a man-made example of something that can trap and use the sun's energy. A telescope is able to

focus light in such a way that objects, such as those in outer space, can be seen at great distances. This discussion can be as limited or as in- depth as you desire. It will depend on the science background and interest of the students.

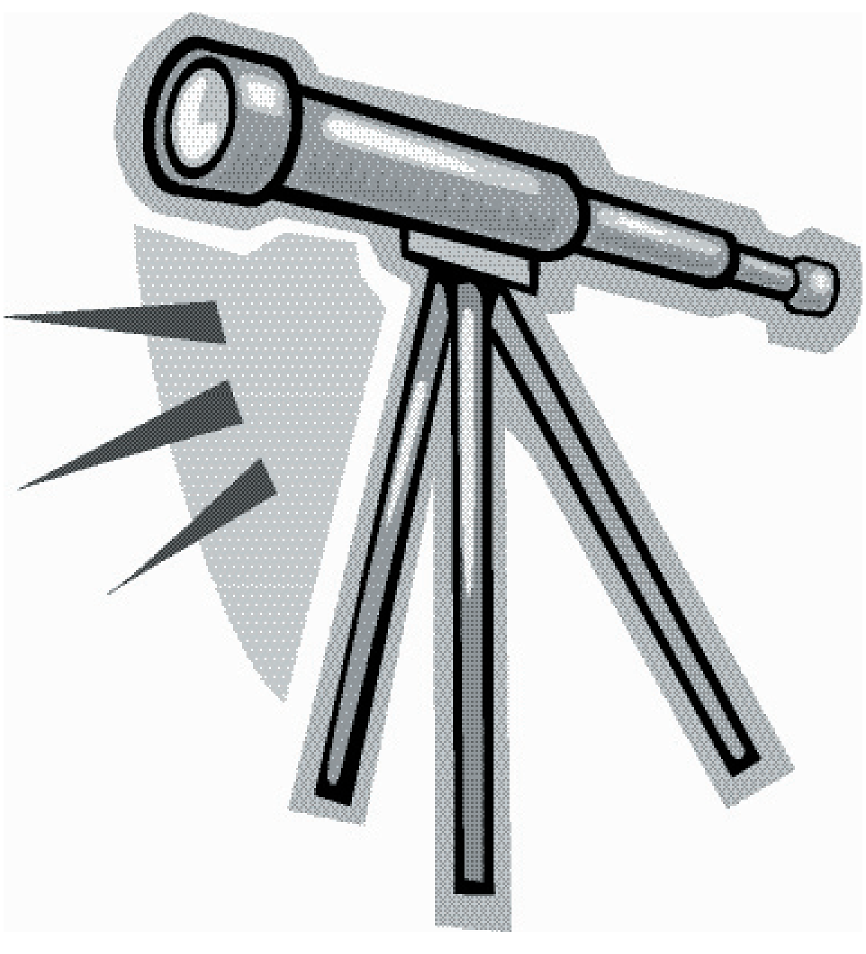
2. (AID) Have students who need a challenge and already understand that the sun is a burning star, do some research to answer the question, "When will the sun burn out?"

Post Assessment

N/A

Debriefing and Reflection Opportunities (5 minutes)

1. If time permits, invite students to share some of their predictions and results, if not it can wait until the next day.
2. Tell students that they will be graphing and analyzing their data and discussing the results tomorrow.



Name ____ Date _______________

Does Sunlight Affect Bodies of Water Differently than It Affects Land Masses?

Instructions:

1. Take a tray of sand, a tray of water and two thermometers.
2. Insert a thermometer into each tray so that the "bulb" of the thermometer is under the sand and the water. Rest it on the edge of the tray, angled down into the sand/water. Make sure the thermometer is the same depth in each tray.
3. Wait until the temperature indicated in the thermometer stops changing (a few minutes), and then record the starting (initial) temperature of the water and the sand on your chart.
4. Place the two trays outside in the sun or on a windowsill that gets direct sunlight.
5. Record the temperature of the substances every 5 minutes. Use the data table below:

Temp after 5 min.	Temp after 10 min.	Temp after 15 min.	Temp after 20 min.	Temp after 25 min.	Temp after 30 min.
Sand					
Water					

6. Make a prediction for this activity: What do you think will happen to the temperature of your two trays (sand and water) if you place them in a sunny location where the sun can shine on them all day? Explain your prediction (a prediction is the reason behind why you think what you think).

7. Get graph paper and plot the soil and water temperature data versus time on the same graph paper. You will connect the data points and draw two graphs, one for the temperature of the soil versus time and one for the temperature of the water versus time. Make sure you make the two graphs distinguishable. You can use different color pens or pencils for each or you can use different symbols for the different sets of data points. Before beginning the plotting of your data points, answer the following questions:

   a. Which item, variable, was under your control?

   b. Which item, variable, was NOT under your control?

Name ____ Date ________________

8. Put the variable you could control (independent variable) on the y-axis and put the variable you could not control (dependent) on the x-axis.

9. Draw a line graph of the temperature for each tray on the same graph, using the horizontal (bottom) line for time and the vertical (side) line for the temperature. Make sure to label both axes.

10. For homework answer the questions below:

Questions:

1. Describe the temperature changes of both materials. Did they change at the same rate or at different rates?

2. What do you think happened to the sun's light to cause the temperature of the sand and the water to rise?

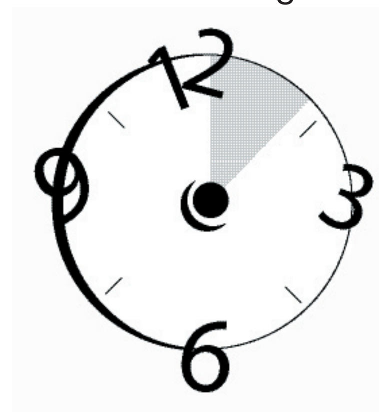
3. When do you see or feel examples of this behavior in your life?

Enlightening Explorations with LIGHT

Core/Practice/Identity

Time Allocation: 50 minutes

Required Materials and Resources on Page 225



Lesson Overview

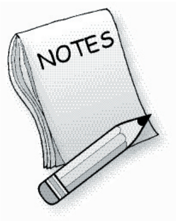
In this lesson, students continue their analysis of the data regarding the sun's effect on soil and water temperatures. Students will apply graphing skills and their understanding of experimental variables, as they graph the results of the previous day's lab activity. They will then draw the conclusion as to which material soil or water heats up more quickly, as a result of a given amount of sunlight. A discussion will follow then as to why it is often cooler at the ocean during the day and warmer in the evenings than it is inland.

Guiding Questions

- Does sunlight affect the earth's land versus water masses differently?
- Would you like to be a physicist and explore some aspect of light?

BIG IDEA

Independent and Dependent Variables



Content Goals

Universal Theme(s)

- Science involves making hypotheses, theories and conceptual models to represent, explain and predict phenomena.
- Scientific evidence consists of observations and data on which to base scientific explanations.
- Using evidence to understand interactions allows individuals to predict changes.

Principles and Generalizations

- Light can be absorbed by substances.
- Sunlight affects different substances in different ways.
- Land masses heat up faster than water masses.
- Scientists work by observing, describing, and using data to explain phenomena and share information.
- Anybody can be a scientist

Concepts

- Absorption of sunlight
- Independent and dependent variables

Teacher Information

- An independent variable is something that changes but yet its changes are controlled by the scientist or student during an experiment. Its changes are predetermined. A dependent variable in an experiment is one that is being studied and its changes are not controlled.
- The independent variable in this experiment is the time (we set the time change interval at 5 minutes).
- The dependent variable in this experiment is the temperature.

  Water heats up and cools off more slowly than land. Therefore, during the day water is cooler than the land, which heats up rapidly, and provides an on-shore, cool breeze. Because the water loses heat less quickly than land, it is warmer in the evenings near its shores. The land cools off more quickly, and thus off-shore breezes can occur in the evening hours.

Diagrams will help you see this principal by using a beach/ocean location. You can access diagrams at the following website: www.physicalgeography.net/fundamentals/7o.html The site was created by Dr. Michael Pidwirny, University of British Columbia Okanagan.

Skills

- Interpret a graph
- Compare and contrast
- See relationships

Materials and Resources

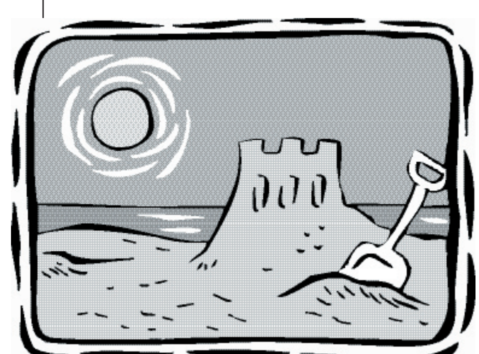
1. Graph paper (1 sheet per student)
2. Colored pencils to make two different graphs on the same sheet of graph paper.

Preparation Activities

Make a copy for yourself of the **Answers to the Questions for Does Sunlight Affect Bodies of Water Differently than It Affects Land Masses?**

Introductory Activity (5 minutes)

- Distribute graph paper to each student.
- Ask the students to take out their temperature measurements from the lab activity, **Does Sunlight Affect Bodies of Water Differently than It Affects Land Masses?**



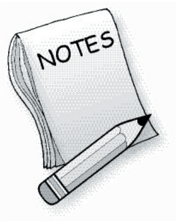
Pre-assessment

N/A

Teaching and Learning Activities (35 minutes)

1. Tell students that they will be doing two graphs based on the effect of the sun's light on the temperature of the soil and the temperature of the water.

2. Question students to see if any of them know the proper scientific term that scientists use to describe a thing that change during an experiment. Tell



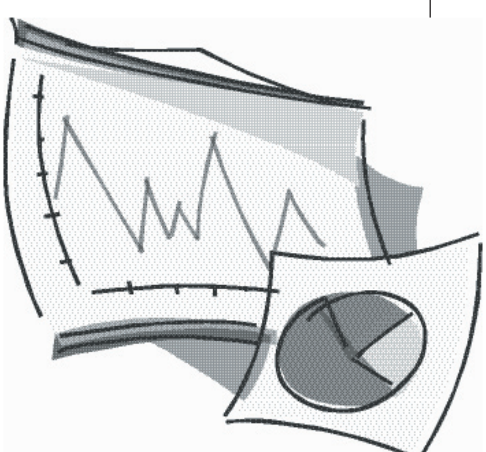
them to use the word "variable." Ask students if they recognize any root word that is part of the word "variable" (vary). Ask students what the word "vary" means (change).

3. Tell students that some things that change can be controlled and other cannot.

4. Before students start their graphs, instruct them to identify which variable (the thing that changes) they controlled and which variables was being studied or was out of their control. Have them write their answers down on their activity sheet.

5. Have students share and explain their answers regarding which variable they could control. They should recognize that the time interval to take measurements was in their control. Some students may choose "soil" or "water" to be their independent variable. However, they do not understand that the material choice to examine is NOT a variable. Once the materials were chosen to study, they remained the same throughout the data collection. The time interval of five minutes was a variable but it was controlled (set ahead of time) by them.

6. Ask them which variable was out of their control and to explain why it was out of their control. Students should recognize that the temperature readings of the materials being studied, soil and water, during each measurement process were not predictable and were out of their control.



7. If students do not know the terms "independent and dependent variables," make sure the students are introduced to these terms and associate them with the specific variables in this experiment, the color of the paper and temperature, respectively.

8. Tell the students that they are acting like scientists and that scientists want to do things in a consistent manner, so they can understand each others' experimental results. Explain that as a result of the desire for clear communication, scientists decided to always put the independent variable on the y-axis and the dependent variable on the x-axis, when graphing data.

9. Students are **not** expected at this level to memorize the two terms, dependent and independent variables, but the proper scientific terminology should be used. It is more important that they understand that during experiments, things change or vary and that some of these things scientists control, like time, and others that are being studied are not controlled, such as temperature change in this experiment. In addition, they need to appreciate that scientists do share information with one another and clear rules and methods for communication help them in this process of sharing.

10. Help them with their graphs in class and tell them to start answering the questions on the lab sheet if they finish early. Otherwise, the questions are to be answered for homework.

Products and Assignments
Student graphs

Extension Activities
Ask students how they liked acting like scientists today when they worked with independent and dependent variables and created their graphs. Explain that the scientists who study light are physicists. Some physicists work in laboratories doing research; some teach at schools and universities; some work in practical areas, such as developing electronic and optical equipment; others work with nuclear energy and aerospace technology. Still others apply their knowledge to astronomy. Write a journal entry in which you explore the possibility of being a physicist or an astronomer. Give specific reasons as to why you think you would or would not want to explore such a career.

Post Assessment
N/A

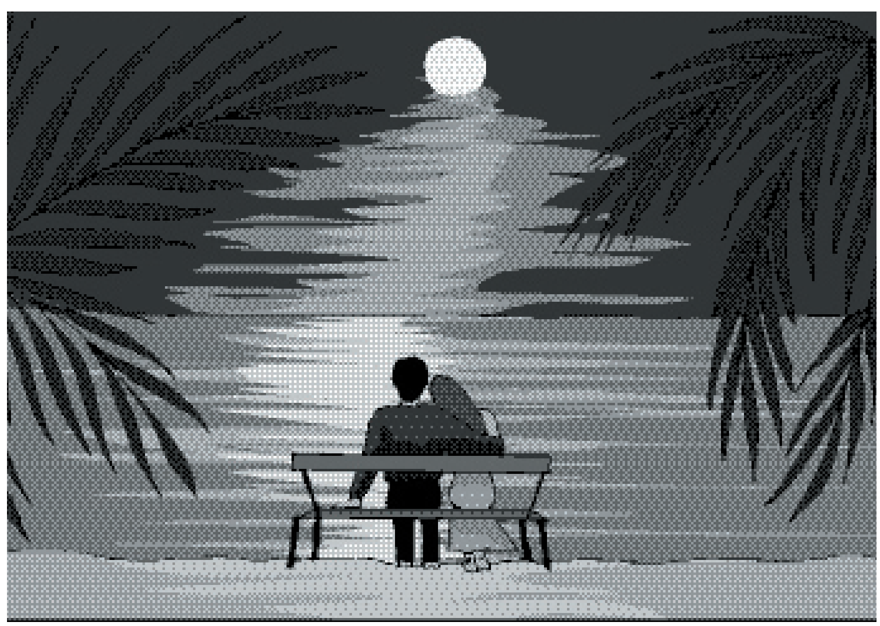
Debriefing and Reflection Opportunities (10 minutes)

1. Review the idea that the sun heats up materials and that different materials heat up at different rates.
2. Tell students that when sunlight is absorbed, its energy is converted to heat or what is called "thermal energy."
3. Ask them if they have ever heard of the word "thermos"? Brainstorm with

NOTES

students other words that begin with the prefix "thermo." They should generate words such as thermos, thermometer, thermal underwear, thermal blanket and geothermic energy.

4. Finally, using the knowledge they have gained from their lab activity, invite students to discuss breezes at the ocean during the day versus the night.
5. Ask students if they have noticed any differences in the nature of the breezes during the daytime versus the nighttime. Ask them about the direction of the breezes and the temperatures.
6. After establishing that there are differences, ask students what may be causing these differences. Some students may be able to describe the fact that during the day there is a cooler breeze that comes in off the water (the water is cooler during the day than the land) and that at night the breeze reverses and in fact it feels warmer near the water (the water is warmer during the night because it loses it heat less quickly than the land does and therefore retains more heat).



Answers to the Questions for Does Sunlight Affect Bodies of Water Differently than It Affects Land Masses?

1. Describe the temperature changes of both materials. Did they change at the same rate or at different rates?

The temperature of the sand and water both went up, but the sand's temperature went up faster.

2. What do you think happened to the sun's light to cause the temperature of the sand and the water to rise?

I think the sunlight was used by the sand and water. It was absorbed and used to make the temperature go up.

3. When do you see or feel examples of this behavior in your life?

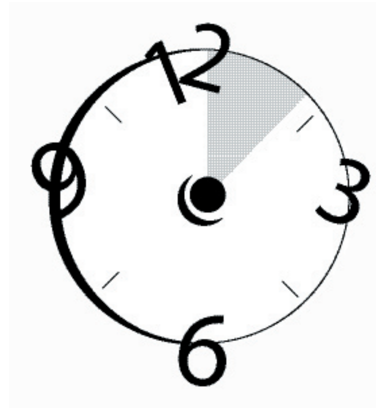
In addition to the examples in the activities, students may respond with examples such as the following: when the asphalt gets really hot on summer days, when the car seats get really hot on summer days, when cold food left in the sun warms up faster than the cold food in the shade, when a room in the house that has a lot of light entering it is warmer than the darker rooms.

Enlightening Explorations with LIGHT

Core

Time Allocation: 55 minutes

Required Materials and Resources on Page 225



Lesson Overview

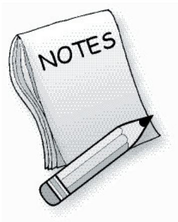
In this lesson, students will continue the exploration of the nature of light. They examine the absorption of the sun's light (energy) by various colored papers, as well as ice cubes covered in colored cellophane to see if there is a relationship between the amount of sunlight absorbed and the color of material.

Guiding Questions

- Why do we wear more light colored clothes during the summer than the winter?

BIG IDEA

Darker colored objects absorb more sunlight than lighter colored objects



Content Goals

Universal Theme(s)

- Science involves making hypotheses, theories and conceptual models to represent, explain and predict phenomena.
- Scientific evidence consists of observations and data on which to base scientific explanations.
- Using evidence to understand interactions allows individuals to predict changes.

Principles and Generalizations

- Sunlight is absorbed by substances.
- Light interacts with materials differently depending on the color of the material it strikes.

Concepts

Absorption of light

Teacher Information

Darker colored objects absorb more sunlight than lighter colored objects.

Skills

- Predict
- Make observations
- Record data
- Read a thermometer
- Compare and contrast
- See relationships

Materials and Resources

Sunny day materials

1. Writing implements (1 per student group)
2. Focusing lenses (magnifying glass) (1 per student or student group)
3. Water bottles with sport spouts so they can be used to squirt (1 per student or student group)

4. Red, yellow, pink, white, black, brown and blue construction paper (cut the paper into 6" x 6" squares and give one of each color to each student or student group)
5. (Optional) Clipboard

Cloudy/rainy day materials

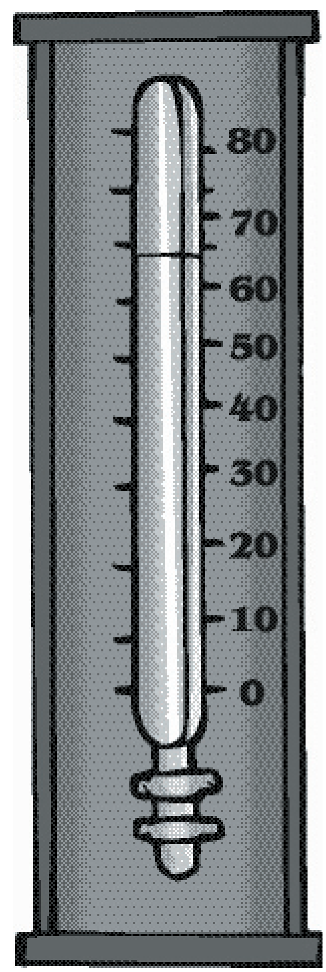
1. Thermometers for the colored-paper teacher demonstration (2)
2. Ice cubes (4)
3. 6" squares of red, blue, green, and yellow cellophane paper
4. Rubber bands (4)
5. Lamp with an incandescent bulb (preferably a desk lamp that points downward)
6. Clear plastic cups (4)
7. Clock (A wall clock will be fine.)
8. (Optional) Clipboard (1 per student or student group)

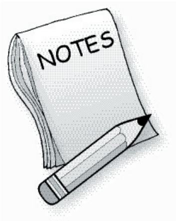
Preparation Activities

1. Copy **Data Table for *Does Color Make a Difference?***
2. Copy the lab activity, **Does Sunlight Affect Various, Colored Construction Paper Differently?**

Introductory Activity (10 minutes)

- Collect students' homework, the previous day's lab sheet and answers to the lab activity questions from **Does Sunlight Affect Bodies of Water Differently Than It Affects Land Masses?**
- Discuss the answers to the questions (see **Answers to the Does Sunlight Affect Bodies of Water Differently Than It Affects Land Masses?**)
- If it is a rainy day or you want to do two activities to clarify the idea that light is absorbed differently by the same object, depending upon its color, distribute the student worksheet, **Data Table for Does Color Make a Difference?**
- If it is a sunny day, distribute the materials for the lab activity, **Does Sunlight Affect Various, Colored Construction Papers Differently?**





Pre-assessment
N/A

Teaching and Learning Activities (40 minutes for each activity)

1. Do the following as a demonstration or a small group lab activity if it is a rainy day or you want two activities to develop student understanding. Distribute the **Data Table for Does Color Make a Difference?**

2. Have the students gather around a table. Place an ice cube in the center of several pieces of red cellophane. Pull up the corners to make a sack and then close it tightly with a rubber band. Repeat this procedure with the blue, green, and yellow cellophane.

3. Put each ice cube sack in a cup and place it directly under a lamp with an incandescent bulb. Position the bulb as closely as possible to the cellophane sacks without touching the sacks. All the cups with the cellophane sacks must be the same distance away from the bulb.

4. Inform students that they will compare the rate at which each ice cube melts completely.

5. Every two minutes let students examine the ice cubes and write their observations in the appropriate box on the **Data Table for Does Color Make a Difference?** When an ice cube melts completely, have them note it on the chart. Tell students to keep observing the ice cubes until all four cubes have melted.

6. Instruct them to answer the questions on the sheet.

7. Collect their answers and then examine them with the class.

8. When discussing the question regarding any observed time differences, make sure that students recognize that dark-colored cellophane absorbs more heat in a given amount of time than light-colored cellophane and therefore melts more quickly than the ice cubes in the lighter-colored cellophane papers.

9. Conclude the session by asking, "After this experiment, what color clothes do you think are more appropriate for summer? Why?"

Do the following lab activity on a sunny day:

1. Inform students that they will engage in a lab activity, **Does Sunlight Affect Various, Colored Construction Paper Differently?** in which they will explore whether or not the color of paper makes any difference in the time it takes to ignite.

2. Tell them that they will be taking a lens and focusing sunlight to a small bright spot on the different pieces of colored construction paper.

3. Ask them what factor they are exploring. Students should recognize that it is the time it takes for each differently colored paper to ignite. Have them write their answer under question #1 on their lab activity sheet.

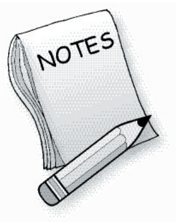
4. Question them again about why they are investigating time to ignition.

5. Direct them to a neighbor and share their questions with each other, giving each other feedback.

6. Call upon at least two students to come forward and write their question on the board.

7. Review the questions with the class. The students should be writing questions that are similar to the following: "What is the relationship between the color of paper and the time it takes sunlight to ignite it?" "Does sunlight affect papers with different colors in different ways?" Even a question that involves the word "heat" is okay. For instance a student may write, "Do darker colored papers heat up more or less quickly than lighter colored papers?" Student questions will depend on how much previous understanding they have about sunlight's interaction with varied colored materials.

8. Ask them about what other factors or variables they must be concerned about besides the one they are investigating when they test each colored paper. In other words, what variables do they have to keep constant? They



should recognize that the lens has to be held at the same angle and distance from the colored papers during the experiment. Tell them to put their answers under question #2 on their lab activity sheet.

9. Instruct students to make a prediction as to the order in which the papers will ignite, going from fastest to slowest. Tell them to put their answers under question #3 on their lab activity sheet.

10. Inform students that they will be collecting data outside and that they will need their lab sheets, magnifying glass and a writing implement.

11. Remind students to have a squirt bottle filled with water to douse the flames.

12. Take students outside.

13. **Show students to their work areas.**

14. At the conclusion of the lab investigation, have the students share their observations by putting their observations on a class data table on the front board, similar to the one below:

Group #	**Paper Color**	**Time to**
1		
	Blue Red Yellow Pink Brown White Black	

2		
	Blue Red Yellow Pink Brown White Black	

15. Discuss the class's results with them.

16. Check to be sure that students did discover that the darker colors took a shorter time to ignite than the lighter colors and that white construction paper took the most time and the black the least.

17. Ask students what must be happening to the amount of sunlight captured by darker colored paper as compared to lighter colored paper. Students should conclude that the darker materials must absorb more of the sunlight energy because the paper ignites faster than the lighter colored paper.

Products and Assignments

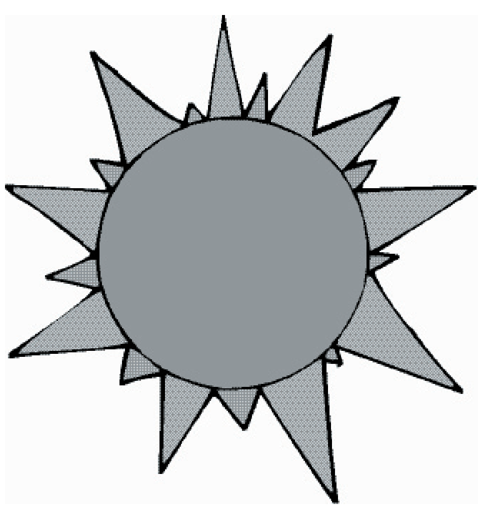
- Students' data and answers for the lab activity, **Does Sunlight Affect Bodies of Water Differently Than It Affects Land Masses?**
- Students' data and answers for the lab demonstration/activity, **Data Table for Does Color Make a Difference?** and/or for the lab activity, **Does Sunlight Affect Various-Colored Construction Paper Differently?**

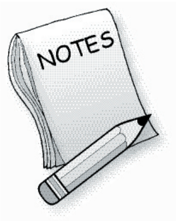
Extension Activities

N/A

Post Assessment

N/A





Debriefing and Reflection Opportunities (5 minutes)

1. Elicit responses from students to ensure that the main conclusion they draw from these experiences is that light affects different colored material differently.
2. Discuss with students the answer they put down to the question, "Why do we wear more light colored clothes during the summer than the winter?" Students should realize that light colored clothing will absorb less heat in a given amount of time and therefore, would be more appropriate to wear in the summer.

Name ______________________________ Date ______________

Data Table for Does Color Make a Difference?

Time	Red	Blue	Green	Yellow
2 minutes				
4 minutes				
6 minutes				
8 minutes				

1. Which cellophane color held the first completely melted ice cube?

2. Which cellophane color held the last completely melted ice cube?

3. How do you explain any time differences?

Name ________________________________ Date ______________

Does Sunlight Affect Various, Colored Construction Paper Differently?

1. What is the variable we are investigating in this lab? Write down a question that we are trying to answer.

2. What are some of the things we cannot let vary as we test each piece of colored paper?

3. Make a prediction as to whether the colored papers will differ in ignition times. If you think there will be a difference, put the paper colors in some sort of order that show which might ignite faster than the others.

4. Take your focusing lens and hold it in such a manner that you get a bright spot on the blue piece of construction paper. Have your water bottle ready to put out any flames.

5. Note the time.

6. Make sure your hand is motionless throughout the process and that you do not move the lens while you are waiting for the paper to ignite.

7. As soon the paper ignites, record the time it took to ignite in the data collection sheet below.

8. Repeat steps 2-5 for each of the different colored construction paper pieces.

Data Collection Table

Blue	
Red	
Yellow	
Pink	
Brown	
White	
Black	

Name ______________________________ Date ____________

Questions for the Lab, Does Sunlight Affect Various, Colored Construction Paper Differently?

1. How does color affect the rate of heat absorption?

2. Did the amount of heat absorbed vary? If so what conclusion can you draw about what caused the amount of heat to be absorbed to vary?

3. Why do we wear more light colored clothes during the summer than the winter?

Possible Answers to the Questions for the Lab, Does Sunlight Affect Various, Colored Construction Paper Differently?

1. How does color affect the rate of heat absorption?

The darker the color the faster heat is absorbed and therefore the darker colored object's temperature rises more quickly.

2. Did the amount of heat absorbed vary? If so what conclusion can you draw about what caused the amount of heat to be absorbed to vary?

Yes, the amount of heat varied. The darker colored paper pieces got hotter than the lighter-colored ones.

3. Why do we wear more light colored clothes during the summer than the winter?

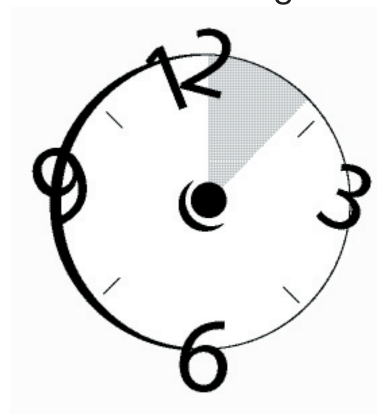
We wear lighter-colored clothes in the summer because they absorb less heat in a given amount of time than darker-colored clothes.

Enlightening Explorations with LIGHT

Core/AID

Time Allocation: 1 hour

Required Materials and Resources on Page 225



Lesson Overview

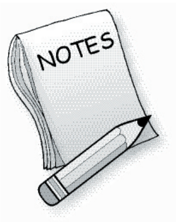
Students will explore the concept of light in that it is the "stuff" that enables us to see things. They will explore how light travels and how it is produced. Using a teacher demonstration, students will see how light can travel through the dark and follow a path thus producing a "light pipe." They will discuss natural and artificial light sources and investigate the directionality of light with a short lab activity.

Guiding Questions

- Does light travel in the dark?
- Does light have a direction of travel?
- What things can produce and/or give off light?

BIG IDEA

How does light travel and how is it produced?



Content Goals

Universal Theme(s)

Scientific evidence consists of observations and data on which to base scientific explanations.

Principles and Generalizations

- Light can be reflected and allows us to see t
- Light travels in the dark.
- Light travels in straight lines.
- Light has natural and artificial sources.

Concepts

- Light's direction of travel
- Reflection of light
- Natural versus artificial light sources

Teacher Information

- Total internal reflection (TIR) is the phenomenon which involves the entire reflection of incident light off the boundary. TIR only takes place when both of the following two conditions are met:
    - o The light is in the denser medium and approaching the less dense medium.
    - o The angle of incidence is greater than the so-called critical angle.
- When the angles of incidence are greater than 48.6 degrees (the critical angle), all of the energy (the **total** energy) carried by the incident wave to the boundary stays within the water (**internal** to the original medium) and undergoes **reflection** off the boundary. When this happens, total internal reflection occurs.
- The teacher demonstration of internal reflection illustrates the principles by which **optical fibers** work. The use of a long strand of plastic (or other material such as glass) to pipe light from one end of the medium to the other is the basis for modern day use of optical fibers. Optical fibers are used in communication systems and micro-surgeries. Since total

internal reflection takes place within the fibers, no incident energy is ever lost due to the transmission of light across the boundary. The intensity of the signal remains constant.

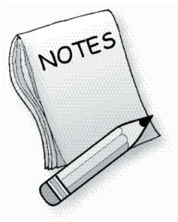
- http://www.adnc.com/img/photos/fiber.jpg This website shows the light coming from a fiber optic cable.
- Fireflies turn their flashes of light on and off as part of the courtship and mating process. Fireflies produce light in their abdominal area through a chemical reaction known as bioluminescence (the production of light by a chemical reaction that originates in an organism). The light is produce by a combination of four different ingredients, luciferin, luciferase (enzyme that speeds up the reaction), oxygen and ATP. The light production process in fireflies produces very little heat, and the light is actually referred to as "cold light." The "cold light" has a 96% efficiency rating compared to an incandescent light that has only 10% efficiency. Light sticks form light via a chemical reaction involving hydrogen peroxide and a solution containing a phenyl oxalate ester. The hydrogen peroxide solution is contained in a small fragile glass vial in the middle of the stick. When the stick is bent, the glass vial breaks. The chemical reaction between these two reactants eventually causes a fluorescent dye to emit light, a process called chemical luminescence. Light sticks vary in color because of the chemical make-up of the fluorescent dye in the stick.
- Light can bounce off objects and thus be reflected.
- Light travels in straight lines.

Skills

- Make observations
- Record data
- Identify characteristics
- Compare and contrast
- See relationships

Materials and Resources

1. 1-liter, black-painted (except for a circular area the size of a flashlight head) plastic bottle (teacher demonstration)
2. Flashlight (teacher demonstration -the flashlight must have the intensity of a *Maglite*)



3. Water in a container (teacher demonstration)
4. Pushpin (teacher demonstration)
5. Funnel that fits into the head of the plastic bottle (teacher demonstration)
6. Piece of clay to seal the interface between the top of the bottle and the funnel (teacher demonstration)
7. Aluminum or plastic tray to catch water (teacher demonstration)
8. Black construction paper (1 piece per student or student group)
9. Various light sources (e.g., lamp. match, space heater, flashlight, butane lighter, light stick)
10. 4" x 6" index cards (3 per student or student group)
11. Flashlight (1 per student or student group)
12. Light sticks (6") can be purchased on line at such sites as www.nicaboyne.com or www.glowgranny.com for about $.50 a piece. More inexpensive but smaller glow sticks 1 1/2 and 4 inch stick can be purchased for $.10 and $.32, respectively at www.illuminationz.com

Preparation Activities

1. For the teacher demonstration (Step #1 in **Teaching and Learning Activities**), prepare:
    - A 1-liter plastic bottle by painting it black except for an area the same diameter as the head of the flashlight that has a high intensity. The circle should be located about 3 inches up from the bottom of the bottle.
    - On the opposite side of the bottle of where the center of the circle is located, insert a pushpin.
    - Wiggle the push pin around to make the hole a bit wider than the diameter of the push pin.
    - Place a funnel on top of the bottle and secure it with clay.
    - Have a source of water ready to pour into the funnel/bottle system (jug or watering can filled with water)

2. Copy the lab activity, **Does Light Travel in a Specific Direction?**
3. Copy the **Light Source Table** lab activity.

Introductory Activity (5 minutes)

- Question students about how sunlight gets to the earth. They should respond with answer that relates to the fact that it travels through outer space.

- Ask students if light can be seen traveling across a room. Ask them how light can travel to the earth across outer space. Inquire whether it really travels through the dark or whether there is some material up in space that we do not know about that assists light in getting to earth? List their responses on the board. Do not evaluate their responses. The purpose of this brainstorming activity is to assess what students think about light's behavior.
- Inform students that you will do a demonstration from which they can draw a conclusion about light's ability to travel in the dark and follow curved pathways.

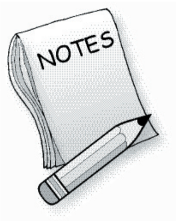
Pre-assessment
N/A

Teaching and Learning Activities (50 minutes)

1. After darkening the room, ask for two student volunteers to assist you.
    - Place the funnel/bottle setup in an aluminum/plastic tray.
    - Ask one student to put a finger over the pushpin hole so that when you fill the bottle with water, it will not leak out.
    - Fill the plastic bottle with water via the funnel.
    - Tell the other student to shine the flashlight through the "flashlight hole" and out the pushpin hole while the other student removes his/her finger from the hole. A stream of water should come out the side of the bottle that has the pushpin hole. The light should be "trapped" inside the stream.

2. Students in class should see no light coming from the sides of the black bottle as the black prevents light from coming out the sides. Only light coming from the water should be visible to students.

3. Ask students if light can travel in the dark (yes, because it got through the darkened bottle. Ask students what is happening to the light in the water. Students should conclude that light is being reflected within the "tube of water" and that it bends along curves. The water is acting like a "light pipe." This reflection is called "internal reflection" because all the light is being kept internally and follows the path of the water. The boundary of the water



keeps it inside. Internal reflection only happens under specific conditions. You can mention that fiber optic cables are based on the concept of internal reflection (see Teacher Information).

4. Begin a discussion regarding what objects can give off light. Ask the students where they see light coming from in the darkened room and what the source is for the light that they see. Students should be able to see light coming around the window curtains and around the door. The light from around the curtains comes from the sun (at night from security lighting) and the light around the door comes from light bulbs in the hall. **SEARCHLIGHT:** Be on the lookout for students who show advanced knowledge and interest, as they may be good candidates for the extension activity.

5. Distribute and review the **Light Source Table** and tell students to fill in the boxes as the discussion on light sources proceeds.

6. Make a chart, **Possible Answers to Light Source Table** like the one below and discuss the sources of light for the objects you brought in to class.

7. Produce light for students in various ways and discuss the nature of the light source. Use things like a flashlight, lamp, match and space heater. Ask students what happens if you rub two sticks together quickly over a pile of dry leaves.

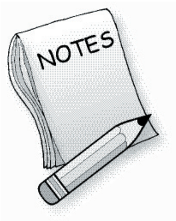
8. Demonstrate light production using a light stick. Invite students to share what they know about how light is produced in light sticks.

9. Ask students what other products, if any, are generated by the light production effort (heat production). Inquire if they have ever seen fireflies. Challenge the class to find out how fireflies produce light by tomorrow and finish filling in the chart then.

10. By the end of the discussion and tomorrow's research on fireflies, product a chart that looks like the one that follows:

Possible Answers to Light Source Table

Object:	Light Source:	Natural or Artificial Source	Other Product(s):
Sun	Sun burning (chemical reaction)	Natural	Heat
Flashlight	Batteries (chemical reaction inside)	Artificial	Heat
Lamp	Bulb (electricity)	Artificial	Heat
Match	Match head (chemical)	Artificial	Heat
Space heater	Wires (electricity)	Artificial	Heat
Two sticks rubbed together	Friction	Natural	Heat
Fireworks	Chemical reactions	Artificial	Heat
Student home example 1 (toaster)	Coils (electricity)	Artificial	Heat
Student home example 2 (oven)	Coils (electricity or gas)	Artificial	Heat
Student home example 3 (hair dryer)	Wires (electricity)	Artificial	Heat
Light stick	Chemical reactions	Artificial	Little or no heat
Fireflies	Chemical reactions	Natural	Little or no heat



11. For homework instruct students that they must find two objects at home that produce light and identify the source, natural or artificial light, and state what other products are formed. Tell them if they find a source no one else has identified, they will receive a treat of your choice.

12. Instruct students to work with their lab partners on the lab activity, **Does Light Travel in a Specific Direction?**

13. Invite students to share their results of the lab activity, **Does Light Travel in a Specific Direction?** They should conclude that light travels in a straight line.

Products and Assignments

- Students' lab activity worksheets, **Does Light Travel in a Specific Direction?**
- Students' homework assignment on sources of light in the home
- Students' voluntary research on how fireflies produce light

Extension Activities

(AID) For students who like to know "how things work," challenge them to create a diagram of a light bulb and label the parts. If there is more than one student who is interested in doing this research, assign them different types of light bulbs (incandescent versus fluorescent). Upon completion of their research and diagrams/posters, have the student(s) give a short oral presentation to inform the class how a light bulb works using their diagrams. Display the diagrams/posters in the room.

Post Assessment

N/A

Debriefing and Reflection Opportunities (5 minutes)

1. Instruct students to write down in their journals whether light can travel around a corner.
2. Ask them also to write whether they think that light can travel through space without any other medium to assist it.
3. Invite students to verbally share their responses. Students might say that light cannot "bend" around corners like sound does because it travels in straight lines or they might not know the correct answer. You might also want to discuss the question, "How did light travel around the corner in the stream of water? Invite students to share their answers. Students might realize that the light "bounced" (reflected) from one side of the water stream to the other as it traveled. Regardless of the accuracy of student answers to these questions, assure them that by the end of the next several of lessons, after they have had a chance to explore the nature of light in greater depth, they will discover answers to these questions on their own.

Name ______________________ Date___________

Light Source Table

Object:	**Light Source:**	**Natural or Artificial Source**	**Other Product(s):**
Sun			
Flashlight			
Lamp			
Match			
Space heater			
Two sticks rubbed together			
Fireworks			
Student home example 1 (toaster)			
Student home example 2 (oven)			
Student home example 3 (hair dryer)			
Light stick			
Fireflies			

Name ____________________________ Date ________________

Does Light Travel in a Specific Direction?

1. Place a hole in each of two index card. Make sure the holes line exactly up with each other.
2. Arrange two index cards so that their holes are in a straight line. Then place the third index card in back of the other two. The holes in the first two cards must be lined-up. Leave about two or three inches between each of the cards.
3. Use the modeling clay to stand the cards up in a straight line.
4. Shine a flashlight straight through the first hole.

Does the light from the flashlight pass through both holes onto the last card? Why do you think this happened?

____

____

5. Now move the center card slightly over to one side.
6. Shine a flashlight straight through the first hole again.

Does the light from the flashlight pass through both holes onto the last card? Why do you think this happened?

____

____

What can you conclude about how light travels if it cannot get through two holes that are not lined up?

____

____

Name ____________________________ Date ________________

Answers to Does Light Travel in a Specific Direction?

1. Place a hole in each of two index card. Make sure the holes line exactly up with each other.
2. Arrange two index cards so that their holes are in a straight line. Then place the third index card in back of the other two. The holes in the first two cards must be lined-up. Leave about two or three inches between each of the cards.
3. Use the modeling clay to stand the cards up in a straight line.
4. Shine a flashlight straight through the first hole.

Does the light from the flashlight pass through both holes onto the last card? Why do you think this happened?

Yes, because the holes are lined up.

5. Now move the center card slightly over to one side.
6. Shine a flashlight straight through the first hole again.

Does the light from the flashlight pass through both holes onto the last card? Why do you think this happened?

No, because the holes are not lined up

What can you conclude about how light travels if it cannot get through two holes that are not lined up?

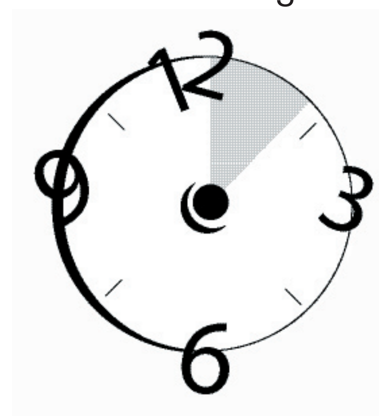
It travels in a straight line.

Enlightening Explorations with LIGHT

Core/AID

Time Allocation: 50 minutes

Required Materials and Resources on Page 225



Lesson Overview

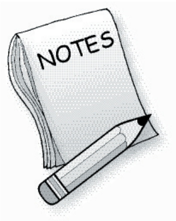
Students are innately curious as to why certain materials and objects have the colors they do. They probably do not really know that without reflection of light, nothing would be visible to us. They are curious about such things as rainbows and why they form. This lesson will provide an opportunity to explore the concept of reflection of light and the fact that white light has components that can be separated. The latter concept lays the foundation for why certain objects and materials vary in color. Without the existence of an array of colors that make up white light, there could be no variance in light absorption and reflection, hence no variation in colors.

Guiding Questions

- What makes something look white?
- What is essential for us to be able to see anything?

BIG IDEA

White light is the reflection of all colors.



Content Goals

Universal Theme(s)

- Science involves making hypotheses, theories and conceptual models to represent, explain and predict phenomena.
- Scientific evidence consists of observations and data on which to base scientific explanations.
- Using evidence to understand interactions allows individuals to predict changes.

Principles and Generalizations

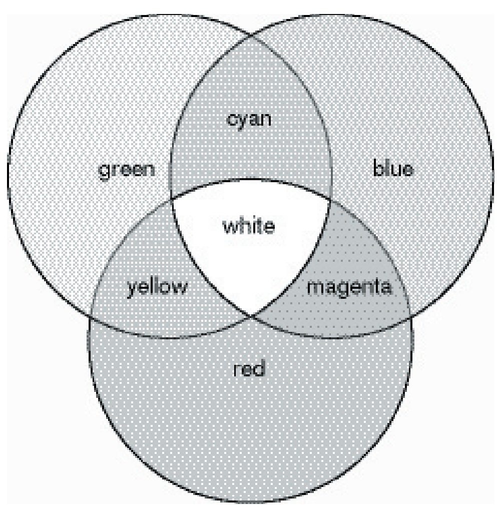
- Light can be reflected light and allows us to see things.
- White is a reflection of all colors.
- Certain primary colors can be mixed to produce new colors.

Concepts

- Reflection of light
- Primary colors
- Secondary colors
- Absorption of light

Teacher Information

- White light is the reflection of all colors.
- Primary colors can be mixed to form secondary colors.
- The following diagram shows the results of mixing primary colors.



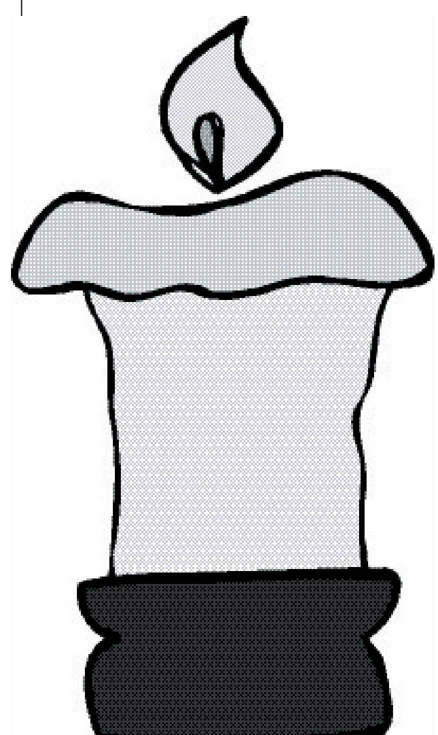
Enlightening Explorations with LIGHT

Skills

- Predict
- Make observations
- Record data
- Identify characteristics
- Compare and contrast
- See relationships

Materials and Resources

1. Candle (teacher demonstration)
2. Matches (teacher demonstration)
3. Sheet of white paper (teacher demonstration)
4. Single lens
5. Outside window
6. Pieces of red cellophane - 12 total, 6" square, 3 pieces to cover each of 4 flashlights
7. Pieces of green cellophane - 12 total, 6" square, 3 pieces to cover each of 4 flashlights
8. Pieces of blue cellophane - 12 total, 6" square, 3 pieces to cover each of 4 flashlights
9. Small flashlights (12 can be shared amongst the groups, three will be used by each group at a time)
10. Rubber bands (3 of each per student group)
11. Neon laser glasses (borrowed from a physics lab)
12. Neon "Exit" or "For Sale" sign that can be purchased at most hardware stores.
13. Pink, magenta, purple and white construction paper (1 piece of each)

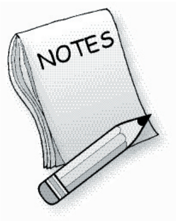


Preparation Activities

1. Copy the lab activity, **Color My World.**
2. Copy the lab activity, **Data Collection Sheet for the Lab Activity, Color My World.**
3. Print a copy of **The Answers for the Color My World Activity.**

Introductory Activity (5 minutes)

- Form lab groups of three students each.



- Collect homework, **Light Source Table**, and invite students to share some of the objects in their homes that produce light. Add these to the chart on the board that was started yesterday. Tell them to add the objects to their tables.
- Ask if another product besides light is associated with these sources of light. Students should realize that heat production is associated with most of these light production examples (e.g., stove top, toaster, candle burning and butane lighter), except for the bioluminescence and chemical luminescence examples.
- Invite any students who researched how fireflies produce light to share some of their findings. If no students have done any research, then share some of the basic information with them depending on their interest level.
- Begin a brief discussion of what light does when it hits an object. Invite a student to come to the front of the room and stand opposite you and ask the student if he or she can see all of you. Ask the child what enables him or her to see you. He or she will probably say something similar to "because of my eyes." Reply, "What do your eyes have to do with it?" Some students may use the words *reflection* and *light* in the same sentence. Have the volunteer back up and go as far away from you as possible and ask him or her if he or she can still see you. The child will answer, "Yes." Have the student sit on the floor and ask him or her if he or she can still see you. Again, the answer will be yes. Ask why the student can still see you although his or her eyes are way below the top of your head. Lead students to realize that the light being reflected from an object, such as you, hits the object from all angles and is reflected in all directions, thus enabling you to be seen regardless of the position of the observer, assuming there is no other object in the way of his or her vision.
- Light a candle. Hold a single lens in front of it and ask the students up front if they see anything. The students will answer, "No."
- Place a piece of white paper near the lens. An image of the candle will be reflected from the candle onto the white paper. Ask the students if they see anything. They will describe the inverted candle image.
- Ask the class what are the "ingredients" needed for a person to see something. They should say, reflected light and an eye.
- Distribute the materials for the lab activity, **Color My World** and **Data Collection Sheet for the Lab Activity, Color My World.**
- Inform students that they may be sharing the flashlights.

Pre-assessment
N/A

Teaching and Learning Activities (40 minutes)

1. Instruct students to work with their lab partners on the lab activity, **Color My World.**

2. After the lab is completed and the questions are answered, invite students to share their results.

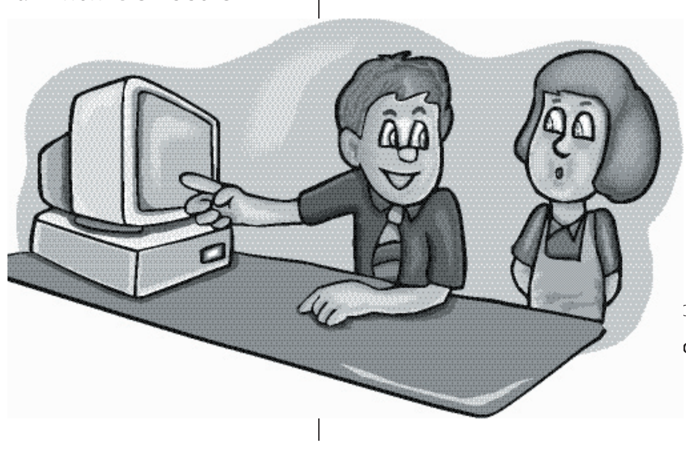
3. First discuss the students' results for steps 1-7. Select a member from each group to answer question 2 for each of the colors of cellophane. Ask a member of another group to answer question 4. Ask a member from another group question 5, and repeat for question 6 and 7. Go over the "why" behind each specific result, leading students to understand that the white light passing through the cellophane is absorbed, "filtered" and the only light making it through is the color of the cellophane.

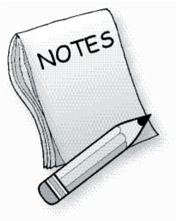
4. Go over the process of absorption of the components of white light when two pieces are overlapped and why the scene or object appears black (see answers below).

5. Ask the remaining groups of students that have not yet participated in the discussion to put the results of their color addition activity, steps 8-12 into a table on the board similar to the data table in the lab worksheet.

6. Collect students' **Data Collection Sheet for the Lab Activity, Color My World.**

Products and Assignments Students' **Color My World** and **Data Collection Sheet for the Lab Activity, Color My World**





Extension Activities

1. (AID) If you have access to a pair of laser glasses (physics teachers might have a pair and a red one, [neon] would be great), you can have students look at neon "Exit" or "For Sale" sign. The neon red color will be absorbed and the sign will appear black. Then have the students look at various colored construction paper, starting with a pink piece first. The construction paper will appear blue.
2. Next, ask the students to explain the color change. They probably will say something similar to, "the glasses took out the red color." Ask them what is the color that results when you mix red and blue. Remind them about their observations from the **Color My World** activity. They should say "magenta."
3. Then ask them how this color might be changed to pink. They should realize magenta mixed with white (all colors) could be made to appear pink.
4. Finally, instruct them to write a paragraph that can include a diagram that describes what changes happen to the room light as it goes from striking the pink construction paper, undergoing some change with parts of it reaching your eyes. Students should be able to demonstrate that glasses filter out the red light (particular wavelength) before that component of the reflected light can reach your eyes. The rest of the light that bounces off the "pink paper" is blue. In other words, the red component of the dyes in the construction paper is filtered out, leaving blue dyes that then reflect blue light to your eyes. All of the other visible colors (green, yellow, etc) from the room's white light are absorbed by the paper. The students may not mention the dyes or know that chemicals in materials are responsible for absorbing certain wavelengths of light and reflecting others, thus giving objects their respective colors. However, they should understand that something in the paper absorbs certain components (wavelengths) of light and reflects others.

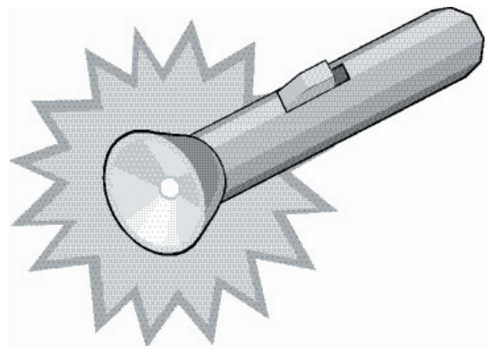
Post Assessment

N/A

Debriefing and Reflection Opportunities (5 minutes)

1. Ask the question, "What is essential for us to see anything?" Students should realize we need to have reflected light so it can strike our eyes.
2. During the review of the data for the **Color My World** activity, discuss the idea of primary and secondary colors and the idea that many times the colors we see are a blend of other colors. Ask students what are we seeing when we see white light. Students should start to realize that the light coming to their eyes, when they see white, is a combination of colors being bounced, "reflected," to their eyes.

Name ______________________ Date_____________



Color My World

1. Hold a piece of red cellophane in front of an outside window.

2. Describe what the outside looks like below:

3. Repeat steps 1 & 2 above for each of the other two cellophane pieces and describe what you see for each below.

4. What do you think is happening to some of the components of white light as they pass through the cellophane?

5. What happened to the red component of white light as it passed through the cellophane?

6. Place a red and green filter on top of each other and look outside again. What did you see?

7. Why do you think what you saw in (#6) above happened?

8. Take one of the three flashlights and cover them with three layers of red cellophane.

9. Repeat step #8 with the other two flashlights except use green cellophane on one flashlight and blue cellophane on the other – three layers of cellophane on each flashlight.

10. Predict the resultant color when a flashlight or any two combined flashlight beams strikes a white wall. When using two flashlights, the two beams must overlap one another on the wall. Enter your prediction into the table, **Color My World,** below.

11. Go into a dark area like a closet and shine the red flashlight on a white area. Hold the green flashlight the same distance away and shine it on the red spot on the wall. What do you see? Finish filling out the table using the appropriate colored flashlights.

Name ________________________________ Date ________

Data Collection Sheet for the Lab Activity, Color My World

Flashlight Color/Colors of Flashlight Beams Combined	Prediction	Color Produced On Wall	Other Product(s):
1. Red			
2. Red and green			
3. Blue			
4. Blue and green			
5. Red and blue			
6. Red, blue and green			

12. What is white light?

Name ______________________________ Date ________

The Answers for the Color My World Activity

1. Hold a piece of red cellophane in front of an outside window.
2. Describe what the outside looks like below:

It appears red.

3. Repeat steps 1 & 2 above for each of the other two cellophane pieces and describe what you see for each below.

The green cellophane made the outside appear green.

The blue cellophane made the outside appear blue.

4. What do you think is happening to some of components of the white light as they pass through the cellophane?

Some of it is being absorbed by the cellophane, depending on the color of the cellophane.

5. What happened to the red component of white light as it passed through the cellophane?

Nothing happened to the red component of the white light. It was transmitted through the red cellophane. All of the colors except the color of the cellophane being used are absorbed by the particular cellophane. For instance, the blue cellophane absorbs every color from white light except blue. It transmits blue light that then hits an outside scene and is reflected back to our eyes; thus the scene appears blue.

6. Place a red cellophane and green cellophane on top of each other and look outside again. What did you see?

Nothing, darkness

7. Why do you think what you saw in (#6) above happened?

The red cellophane let only red light through to the green cellophane. The latter then absorbs the red light leaving no transmission of light.

8. Take one of the three flashlights and cover it with three layers of red cellophane.

9. Repeat step #8 with the other two flashlights except use green cellophane on one flashlight and blue cellophane on the other – three layers of cellophane on each flashlight.

10. Predict the resultant color when a flashlight or any two combined flashlight beams strikes a white wall. When using two flashlights, the two beams must overlap one another on the wall. Enter your prediction into the table, **Color My World,** below.

Color My World Table

Flashlight Color/Colors of Flashlight Beams Combined	Prediction of Resultant Color	Color Produced On Wall
1. Red	Student prediction	Red
2. Red and green	Student prediction	Yellow
3. Blue	Student prediction	Blue
4. Blue and green	Student prediction	Cyan
5. Red and blue	Student prediction	Magenta
6. Red, blue and green	Student prediction	White

11. Go into a dark area, like a closet and shine the red flashlight on a white area. Hold the green flashlight the same distance away and shine it on the red spot on the wall. What do you see? Finish filling out the table.

12. What is white light?

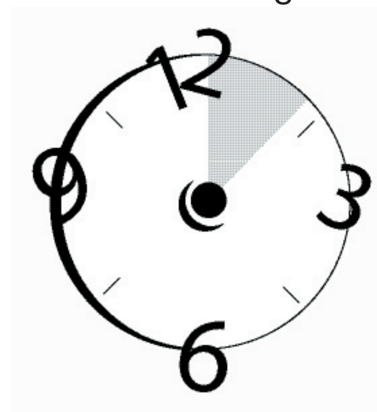
White light is a combination of all colors of light.

Enlightening Explorations with LIGHT

Core/AID

Time Allocation: 1 hour, 15 minutes

Required Materials and Resources on Page 225



Lesson Overview

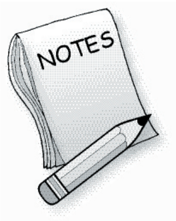
Students will explore the separation of white light into an array of colors. In addition the lesson will introduce students to the absorption and reflection of light and their relationship to the production of specific colors, as seen by the human eye.

Guiding Questions

- Can white light be separated into different components?

BIG IDEA

White light can be separated into colors.



Content Goals

Universal Theme(s)

- Science involves making hypotheses, theories and conceptual models to represent, explain and predict phenomena.
- Scientific evidence consists of observations and data on which to base scientific explanations.
- Using evidence to understand interactions allows individuals to predict changes.

Principles and Generalizations

White light can be separated into colors.

Concepts

- Reflection of light
- Absorption of light
- Color spectrum
- Separation of white light
- (AID) Chromatography

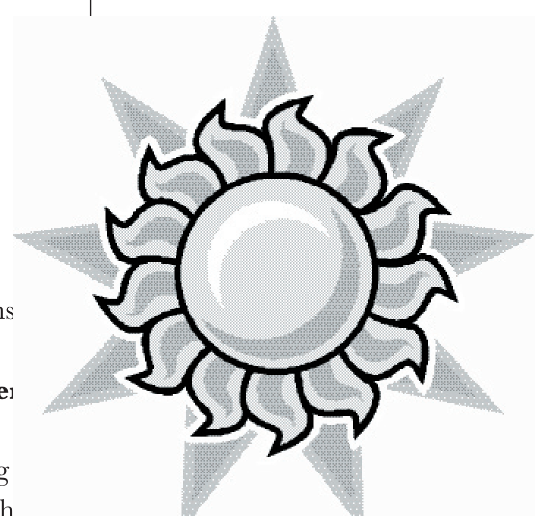
Teacher Information

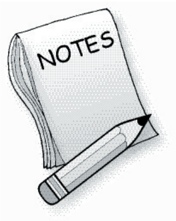
- The students will see that a green leaf appears black under a red filter. The reason for this is the red filter takes out all of the white light passing through it and is transparent to only the red frequency. When a red light is used, then the light hitting the leaf is only red and the green leaf will absorb it all, reflect none and appear black.
- A spectroscope is an instrument that separates white light into its colors.
- When sunlight passes through raindrops in the air, the water droplets act like prisms.
- The water prism will display a spectrum of colors.
  - o Because the altitude of the sun over the horizon changes daily, the water prism will work better at some times of the year than others. Sunlight will enter the prism directly in the winter when the sun angle is low in the sky. In the summer, the sun angle is very high and its light may not enter the prism at the

proper angle for dispersion to take place. This problem can be corrected by using a mirror to reflect the light at the proper angle.

- o Commercial versions of water prisms are available from science supply catalogs.
- o The water prism serves to introduce the explanation behind rainbow formation.
- o View diagrams from *Windows to the Universe*, at http://www.windows.ucar.edu/ Look for images of the disbursement of light as a result of traveling through water and enlarged views of light rays as they travel through water.

- The following site www.phy.ntnu.edu.tw/java/Rainbow/rainbow/html has an interactive "applet" for seeing how a drop of water in the atmosphere interacts with the components of red light. You can click on different colors (red, blue and green) and see how they are bent, refracted, differently by the water drop. This site is entitled the "Physics of Rainbows."
- You can also have students use the concept of reflection to play billiards using the java applet, "Billiards and Physics."
- Students can further explore colors by going to the Virtual Physics Lab Site and using their java applets. There are many other interactive java applets on this site students might want to explore.
- The sun is composed of burning gases. These gases are two elements, hydrogen and helium, each with their own particular spectra, which is used to identify them.
- (AID) Students doing the **Leaf Chromatography Extension Activity** should have different leaves to investigate. The chromatograms they produce may be different and can assist in deepening students' understanding of the results of the **When is a Green Leaf not Gree** activity.
- Chromatography means "color writing." The students will be dissolving the chemicals in a leaf and separating them using paper chromatograph The chemicals have different tendencies to "climb up" the paper (via capillary action) by staying in solution or coming out of solution and sticking to the paper as a blotch or streak of color. The differences in solubility tendencies allows for the separation of the pigments in leaves.





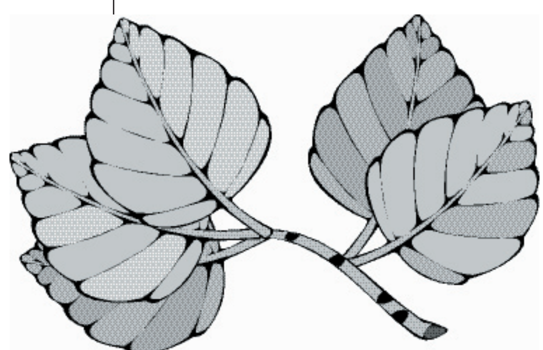
Skills

- Predict
- Make observations
- Record data
- Identify characteristics
- Compare and contrast
- See relationships

Materials and Resources

1. White light, yellow light and fluorescent light source (teacher demonstration; 1 of each kind).
2. Mirrors, prisms and lenses can be ordered at www.wolverinesports.com/mirrors.html
3. Red light bulb or a red gel (3 or 4 depending on the number of observation stations you want to set up for small groups of students)
4. Green leaves (3 or 4 depending on the number of observation stations you want to set up for small groups of students)
5. Toilet paper or paper towel tube, 6" long tube with 1 1/2" diameter (1 per student group)
6. Replica diffraction gratings (1 per student group) The item # is 65681-00 (package of 25 for $14.95) can be obtained from *Science Kit & Boreal Lab*, P.O. Box 5059, San Luis Obispo, CA 93403, via phone at 800-828-7777 or online at www.sciencekit.com . Shipping charges are 10% of the order with a minimum of $5 per order.
7. Source of light (e.g., lamp with bulb) (1 per student group)
8. Small square-sided tray (e.g., baking tray) (1 per student group)
9. Water
10. White paper (1 piece per student group)
11. Mirror (at least 6" tall and 3" wide, 1 per student group)
12. Clay (small piece per student group) to support the mirror or mirror supports can be ordered using a science catalogue.
13. Sunlight or a flashlight
14. Prism (teacher demonstration)
15. (AID) Spectroscopes (1 per student or student group) These can be ordered from Ward's Natural Science or online at www.wardsci.com. The 6" spectroscopes are $9.50 for 6 and have the item number 25 V 4998.

16. (AID) Masking tape (1 roll)
17. (AID) Paper towel (1 sheet per student or student group)
18. (AID) Green leaves (1 for each student or group of students)
19. (AID) Assorted leaves for chromatography (1 leaf for each student or student group)
20. (AID) Beaker or plastic cup (1 for each student or group of students)
21. (AID) Stirring rod (1 for each student or group of students)
22. (AID) Hot water (1 for each student or group of students)
23. (AID) Filter paper (1 for each student or group of students)
24. (AID) Scissors (1 for each student or group of students)
25 (AID) Plastic wrap (1 piece large enough to cover the top of a beaker for each student or group of students)
26. (AID) Hand lens (1 for each student or group of students)
27. (AID) Pencils (1 for each student or group of students)
28. (AID) Isopropyl alcohol (1 plastic bottle approximately 16 ounces)
29. (AID) Aluminum pie plate or pan
30. (AID) Ruler

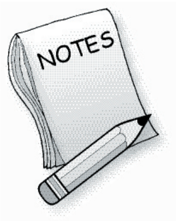


Preparation Activities

1. Copy the lab activity, **When is a Green Leaf not Green?**
2. Set up several "leaf stations" around the room with a source of red light and a leaf for students to observe.
3. Make copies of the lab activity, **From Boring to Beautiful – White Light's Transformation!**
4. Make copies of the homework sheet, **Homework Assignment - How do rainbows form?**
5. Make copies of the **Leaf Chromatography Extension Activity.**

Introductory Activity (30 minutes)

- Review the concept of light absorption by doing a demonstration that shows how different colors of light affect the appearance of an object.
- Darken the room and shine different lights, such as white (incandescent), fluorescent and yellow light on different colored objects. Observe the apparent color changes.
- Ask students what they think may be happening. Students may not yet understand that objects reflect the light that matches the color they appear



and absorb other colors. However, by the end of the next activity, they should realize that an object that has color is actually reflecting that color to their eyes and absorbing other colors (wavelengths) of light.

- Distribute and review the instructions for the lab activity **When is a Green Leaf not Green?** Ask students to record their predictions for the appearance of the leaf placed under a source of red light only. Tell students to record their predictions on their lab sheet.
- Assign lab partners.
- Upon completion of their observations, tell students to answer questions #5 and #6 for homework. Evaluate these later on and then assess if students realize that black is not a color, as black objects do not reflect light; therefore, it cannot be a "color" of light. Also assess if students' understanding that the color of an object that is seen by the eye is a result of reflected light. Students' answers to question #6 should assist you in your assessment. **SEARCHLIGHT:** Look for students who need an additional challenge who may benefit from the extension activities.

Pre-assessment

N/A

Teaching and Learning Activities (40 minutes)

1. Instruct students to proceed with *Part 1 - Build and Use Spectroscope* of the **From Boring to Beautiful – White Light's Transformation!** lab activity.

2. Upon completion of Part One, discuss with students what they observed during the lab activity.

3. Ask them why the instrument they constructed is called a "spectroscope."

4. Direct students to proceed with *Part 2 – Water Colors of the lab* activity.

5. Upon completion of Part Two, discuss with students what they observed during this part of the lab activity.

6. After the lab is completed, do a demonstration. Take a prism and create a spectrum using the sunlight from a window or use a flashlight if no sunshine is available.

7. Talk with students about the colors they see and ask them where the colors come from. Students should realize that the colors come from the white light being broken into its components.

8. Question students about what they actually created with the water and mirror. They should recognize that they actually created a "water prism."

Products and Assignments

- Students' spectroscopes
- Assignments: **Homework Assignment – How do rainbows form?**

Extension Activities

1. (AID) Distribute the instructions for the leaf chromatography lab.
2. (AID) Have students investigate how spectroscopes are used in the real world.
3. (AID) Another related question that students might want to explore is: "How did scientists find out what the sun was made of?"

Post Assessment

N/A

Debriefing and Reflection Opportunities (5 minutes)

1. Tell students you will be collecting their sheets tomorrow for the lab activity, **When is a Green Leaf not Green?** and that they are to answer questions # 5 and 6 for homework.
2. Ask students where else they have seen a spectrum like the one produced by the "water prisms" before. Most students will have seen a rainbow. Ask if anyone knows how a rainbow is created. Let students share their ideas for a few minutes.
3. Suggest to students that they take out a garden hose, keep the sun at their back and try to product their own rainbow.
4. Inquire if students have ever heard of a "secondary rainbow."
5. For homework have them find some information about rainbow formation. The question to give them on the board is: "How do rainbows form?"
6. Distribute the sheet, **Homework Assignment - How do rainbows form?**
7. Tell them that you will ask them for their information regarding the formation of rainbows tomorrow.

Name ____________________________________ Date ________

When is a Green Leaf not Green?

1. Predict what color the leaf will be under red light:

2. Have students observe a leaf color in regular light and under a red light or red gel.
3. Tell students to record their observations below:

Color of leaf in regular light:

Color of leaf in red light:

4. What happened to the original color in the leaf?

5. Is black a color? Explain your thinking.

6. Why is a red shirt red?

Name ______________________________ Date ________

The Answers for the Activity, When is a Green Leaf not Green?

1. Predict what color the leaf will be under a red light source:

Various student responses

2. Have students observe a leaf color in regular light and under a red light or red gel.
3. Tell students to record their observations below:

Color of leaf in regular light:

green

Color of leaf in red light:

black

4. What happened to the original color in the leaf?

The green leaf absorbs all the red light that is shining on it, as a result of the red filter that allows only red light to pass through it. Therefore, the leaf reflects no visible light and appears black.

5. Is black a color? Explain you thinking.

Black is not a color because objects that appear black absorb all light and reflect none. Objects that reflect no light have no color.

6. Why is red shirt red?

A red shirt is red because it reflects the red light from white light and absorbs the other colors.

Name ____________________________________ Date ________

Leaf Chromatography Extension Activity

1. Tear a leaf into small pieces. Make them as small as possible.
2. Put the pieces of leaf in a beaker
3. Pour enough alcohol into the beaker to cover the leaf pieces completely
4. Use the stirring rod to mix the leaf pieces and alcohol.
5. Cover the beaker with plastic wrap and set it in an aluminum pan or pie plate that is half full of hot water.
6. Let the leaves soak overnight.
7. Cut the filter into a strip that is 2 cm wide and about 10 cm long.
8. Tape the filter paper to a pencil.
9. You will be laying the pencil across the top of the beaker or plastic cup with the filter paper attached by tape. Wind the tape around the pencil so that only the tip of the paper touches the alcohol
10. Lay the pencil on top of the beaker or plastic cup.
11. Observe the liquid as it travels up the paper using capillary action.
12. When the leaf solution has almost reached the top of the filter paper, remove the strip from the beaker or plastic cup and place it on a paper towel to dry.
13. Observe the strip with a hand lens.

Name ______________________ Date_____________

From Boring to Beautiful – White Light's Transformation!

Part 1 Build and Use a Spectroscope

1. Cover one end of the tube with dark paper in which a small slit is cut.
2. Hold a grating at the other end.
3. Look through tube at a light. Turn the grating until you see a band of colors.
4. Fasten the grating to the end.
5. Point the tube toward a light, and look through the grating and a bit to the side of the slit.
6. Describe what you see below:

7. Why do you think the instrument you have made is called a "spectroscope"? (Use a dictionary if you need some assistance.)
8. Focus the spectroscope on a piece of black construction paper. Write down what you observed?

Part 2 Water Colors

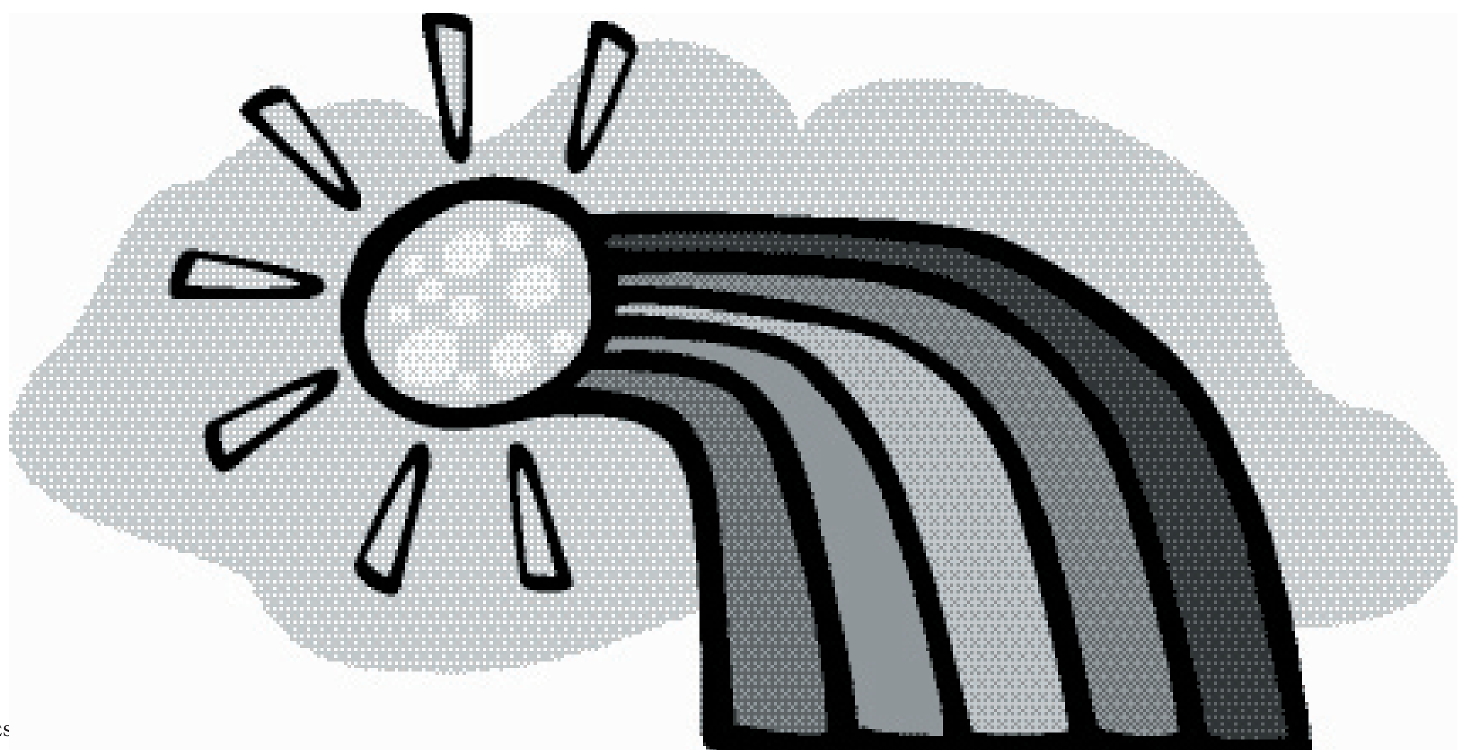
1. Fill a tray about 1 inch deep with water.
2. Set the tray near a sunlit window.
3. Lean a pocket mirror in the water on the side of the tray farthest from the window so that the sunlight falls upon it **after** passing through the water.
4. Adjust the mirror until you see something on the upper part of the wall or the ceiling of the room.
5. Use a piece of clay to attach the mirror to the side of the tray and hold it in place.
6. Hold a piece of white paper above the mirror and see if you can see something clearer on the paper.
7. Repeat the above except use a flashlight as your source of light.
8. Answer the question below:
   What are the water and mirror doing to the white light?

Now that you have completed several activities in which you broke white light into its spectrum and you have explored "blackness," explain why you agree or disagree with the following statement:
"Neither black nor white are colors."

Name ______________________ Date_____________

Homework Assignment - How do rainbows form?

Write a description of how rainbows form below:

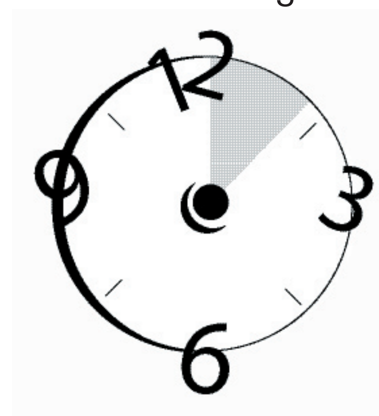


Enlightening Explorations with LIGHT

Core/AID

Time Allocation: 1 hour

Required Materials and Resources on Page 225



Lesson Overview

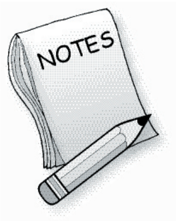
Students will share what they learned about rainbows as a way of connecting the science of light refraction to their real world. In addition, students will discuss the absorption and reflection of light and the relationship to the production of specific colors, as seen by the human eye. For instance, students will be able to explain why a red shirt is seen as red and not some other color. Finally, students will be able to answer the question as to whether white and black are colors or not and explain their answers.

Guiding Questions

- Are white and black colors?
- Why is a red shirt red?
- How are rainbows formed?

BIG IDEA

Understanding the colors of rainbows and sunsets.



Content Goals

Universal Theme(s)

Scientific evidence consists of observations and data on which to base scientific explanations.

Principles and Generalizations

- Black is the absence of reflected light and white is the reflection of all colors.
- Objects reflect certain colors of light and absorb other colors because of their chemical nature.

Concepts

- Absorption of light
- Reflection of light
- Separation of white light
- Refraction of light

Teacher Information

- Black is the absence of color because all colors are absorbed. Students should not see anything when they focus their spectroscope on a black piece of paper.
- White is not a color but rather a reflection of all colors.
- A red shirt appears red because the red chemical dyes in the shirt reflect the red light, red wavelengths, and absorb all of the other components of white light.
- A rainbow is formed when billions of tiny, clear drops of water are suspended in the air on a rainy day. Each drop acts like a tiny prism, refracting the light from the sun in slightly different directions, depending on the color. You see a rainbow when the sun is behind your head and you're looking at water drops falling through the air such as in a rain shower or a waterfall. The colors of a primary rainbow that reach your eyes have been bent in the neighborhood of 40 to 42 degrees by water drops hit by light from the sun. Each color is bent at a slightly different angle, which is why you see individual colors. You will see a rainbow

above the eastern horizon when the sun is setting in the west or over the western horizon when the sun is rising in the east.

- View a diagram of the reflection of light from falling raindrops to produce an ordinary or what is known as a primary rainbow at: http://sundog.clara.co.uk/rainbows/primary/htm
- Red light is bent less with violet being bent the most, so red is on top of a primary rainbow, whereas violet is on the bottom. A primary rainbow forms at 42 degrees above the horizon and a secondary rainbow forms at 51 degrees above the horizon.
- In a secondary rainbow the colors are reversed because some of the incoming light is bent twice inside the water droplets, and the bow covers a band between 51 to 54 degrees above the horizon.
- View primary and secondary rainbows at: http://hyperphysics.phy-astr.gsu.edu/hbase/atmos/rbowpri/html
- (AID) Circles of light, halos occur around the moon and are caused by the bending of light by ice crystals. If the circles are made of separate colors of the spectrum, the ring is called a corona.
- (AID) In the extension activity where students simulate a corona, the spaces between the tiny water droplets bend the light causing a circle of light to be formed.
- (AID) The drawing for the sunset/blue sky activity was taken from the site: http://www.exploratorium.edu/snacks/blue_sky.html
- (AID) A common misconception regarding colors associated with sunrises and sunsets is that dust and man-made pollution are responsible for the colorful displays. However, if this were true, large cities would be celebrated for their twilight hues instead of deserts and tropics. In fact, clean air is the main ingredient common to brightly colored sunrises and sunsets. The correct explanation for colored sunrises and sunsets is related to the angle of the sun with respect to the earth's atmosphere and the distance sun's light rays must travel through the atmosphere.
- (AID) When the sun is directly overhead, the sunlight has to only pass through a few miles worth of thick atmosphere. At sunrise or sunset the sun is lower in the sky, closer to the horizon and the path through the atmosphere is longer. The sun first appears yellow, then deep orange and finally just before it drops below the horizon, it glows deep red. This is because instead of shining straight down, the sun's rays now have to pierce miles and miles of occasionally water-filled air close to the surface

of the earth. This causes blue light, a shorter wavelength of light, to be scattered by the atmosphere (blue light is scattered ten times more than red light). Thus, the blue light does not reach your eye (this is why the sky is blue at other times of the day), leaving only the longer wavelengths like orange and red to reach us.

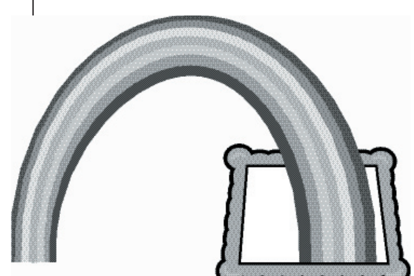
- (AID) Some bright students might know that violet light has an even shorter wavelength than blue light: It scatters even more than blue light does. Thus, they might ask why the sky isn't violet. It turns out that there is just not enough of it. The sun puts out much more blue light than violet light, so most of the scattered light in the sky is blue.
- (AID) When you debrief, remind students that light usually travels in straight lines, unless it encounters the edges of some material. This scattering affects what happens to the various wavelengths of light. The angle of the sun and the amount of pollution do contribute to the appearance of the sky. However, it is the location of the sun that most contributes to the colors of a sunset or sunrise. A sunset diagram can be viewed from the following site: http://scifun.chem.wisc.edu/HomeExpts/BlueSky.html
- To make a "light box" do the following:
    - o On one of the small ends (width) of an open shoebox draw two vertical, 10 cm lines, at least 3 cm from the top and the bottom of the box.
    - o Cut a narrow slit along each line.
    - o Put the sheet of white paper in the bottom of the box.
    - o Carefully place a jar full of water in the box. Make sure the jar is in line with the two slits.

Skills

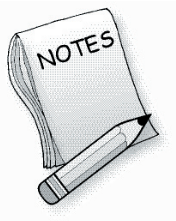
- Make observations
- Record data
- Identify characteristics
- Compare and contrast
- See relationships

Materials and Resources

1. Greenler Robert. (1991). *Rainbows, Halos, and Glories.* Cambridge Press. This book is a very good source of information on sky phenomena
2. An article in the journal *Science and Children* February, 2004 issue called, "What causes rainbows?" is another good source of information. In the article they give a link to the www.scilinks.org site. This site is filled with science information and activities and many of the major science book publishers have links to this site embedded within their texts. This site is free to NSTA members if you have your membership number. In addition, you can log on as a guest and use the codes associated with the articles in the *Science and Children journal*. The code from this particular article, which links to a page dealing with activities on the properties of light, is SC020402.
3. Pictures and explanations of rainbows, both primary and secondary, can be obtained from the Internet Google Search tool. Click on Images and type in "primary rainbows" + "secondary rainbows" in the search box.
4. A site that shows how rainbows work is: http://www.usatoday.com/weather/tg/wrainbow/wrainbow.htm . Another interactive site, www.phy.ntnu.edu.tw/java/Rainbow/rainbow/html contains a "java applet" for seeing how a drop of water in the atmosphere interacts with the component of light. The light ray can be moved and the changes in the reflections within the droplet are visible along with the changes in location of the rays exiting the drop. Although students will not understand all the aspects of this interactive applet, they will enjoy the exploration and walk away with the idea that light rays can do many things as they travel through the atmosphere. It also has other java applets that can be accessed



5. Cardboard shoebox (4 if the teacher is going to make the light boxes or one per student or student group if the students are going to make their own light boxes. If they do make them, add 20 minutes to the activity.)
6. Metric ruler (4 if the teacher is going to make the light boxes or 1 per student or student group)
7. Scissors (4 if the teacher is going to make the light boxes or 1 per student or student group)
8. Sheet of white paper (4 if the teacher is going to make the light boxes or 1 per student or student group)
9. Small glass jar (4 if the teacher is going to make the light boxes or 1 per student or student group)



10. Pen (4 if the teacher is going to make the light boxes or 1 per student or student group)
11. Water
12. Flashlight (one for one or two student groups) (at least one with a sharp beam if the extension activity is to be done)
13. (AID) milk (2 ounces per group)
14. Container, plastic rectangular (1 per student or student group)

Preparation Activities

1. Copy the lab activity, **Boxing with Light!** for all students.
2. Print out one copy of the **Answers to Boxing with Light.**
3. Copy the extension activity **Can You Explain the Colors of a Sunset?**
4. Print out one copy for yourself of the **Answers to Can You Explain the Colors of a Sunset?**
5. Place four light boxes around the room.

Introductory Activity (20 minutes)

- Collect and review students' answers to the homework assignment by asking students whether or not black is a color. Invite students to share what they wrote on their lab sheet, **When is a Green Leaf not Green?** Lead students to understand that black cannot be a color because objects that are black reflect no light, instead they absorb all colors.
- Continue discussing the homework by asking students to share their ideas regarding why a red shirt is red. Lead students to understand that the chemicals in the shirt reflect red light and absorb the other colors that make up white light.
- Discuss the answer to the question, "Is white a color?" Lead students to realize that it is made up of all colors that it reflects, so white itself cannot be a color.
- Ask students what they learned last night about the creation of primary and secondary rainbows. Using students' collective information, lead students to understand how a rainbow is formed and to be able to describe the major differences between a primary and secondary rainbow, as described in the **Teacher Information** section above. **SEARCHLIGHT:** Look for students who have advanced insight into the

topic and/or students who need an additional challenge. Encourage them to undertake one or both of the extension activities

- Inform students that they will be continuing with their exploration of the nature of light.
- Review with students what they know light can now do to objects. They should say that it can be absorbed or reflected.
- Tell students that today they will be discovering something else light can do when it hits objects.

Pre-assessment

N/A

Teaching and Learning Activities (30 minutes)

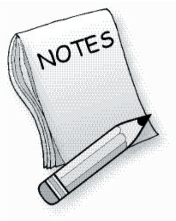
1. Share with students they will be looking into one of four light boxes stationed around the room (students can be asked to build their own if time permits).

2. Distribute and review the instructions for the **Boxing with Light!** activity.

3. Create pairs of students. Darken the room and tell students to start the lab activity, **Boxing with Light!**

4. Instruct students to answer all the questions.

5. After students complete the lab activity and questions, debrief with them to ensure they begin to get the idea that when light travels from one type of substance to another, light changes its direction or in other words is bent or "refracted." Discuss question #5 with them and make sure they all observed the increase in intensity of the light where the beams crossed. Make sure they realize that bending light, as demonstrated in the outside fire demonstration using a magnifying glass, can be used to human advantage. Lenses can be made to work for us. Review the answer to question #6 as well. Make sure they recognized that the sides of the glass jar were acting as lenses in the light box activity,



Products and Assignments

Students' homework assignment, **When is Green Leaf not Green?**

Extension Activities

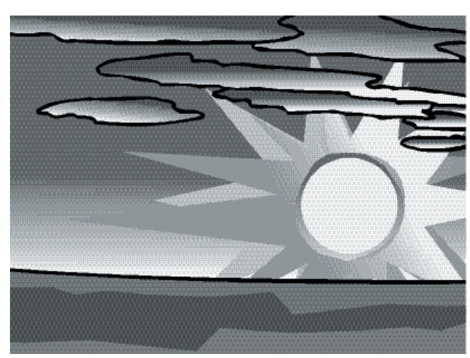
1. (AID) Have students explore why the sky changes colors specifically during sunsets and sunrises by setting up the lab activity, **Can You Explain the Colors of a Sunset?**
2. For students who have a special interest in sky phenomena, the "corona effect" can be demonstrated by blowing over a cooled piece of glass plate until the glass has fogged up and looking through it at a distant light. The piece of glass should be very clean and be placed in a refrigerator for about an hour. Ask students to try and explain the ring of colored light that surrounds the bright center. Ask students where else students may have seen a corona. Students might mention during car rides during a foggy or rainy night. The tiny droplets on the wind shield scatter the light from oncoming cars.

Post Assessment

N/A

Debriefing and Reflection Opportunities (10 minutes)

Ask students to share their ideas as to what actually caused the light to bend. Students should recognize that traveling through the glass and water caused the light to bend several times. Lead them to the idea that when light travels from one type of substance to another type, it changes its direction or in other words is bent or "refracted."



Name ________________________________ Date ______________

Boxing with Light

1. Go with your partner to a light box.

2. Take turns shining a flashlight through the two slits on the box and record your observations below:

3. Move the jar so you can get the parallel light rays that bend as they travel through the jar to cross over each other. Record below what happens to the brightness, intensity, of the light where the bent rays intersect.

4. What happened when we used the hand lens outside in the sun during the first lesson in this unit?

5. What do you think we were doing to the sun's light rays?

6. When you think about and compare the demonstration we did with a hand lens/fire outside, what acted in a similar way to the hand lens in this activity?

Name ________________________________ Date ____________

Answers to Boxing with Light

1. Go with your partner to a light box.
2. Take turns shining a flashlight through the two slits on the box and record your observations below:

Students should see the light bend.

3. Move the jar so you can get the parallel light rays that bend as they travel through the jar to cross over each other. Record below what happens to the brightness, intensity, of the light where the bent rays intersect.

The point where the light rays intersect is brighter.

4. What happened to the paper when we used the hand lens outside in the sun during the first lesson in this unit?

The light rays were concentrated to the point where they set the paper on fire.

5. What do you think the lens was doing to the sun's light rays?

The sun's light rays were bent by the hand lens and concentrated on one point to increase the intensity, so that they ignited the paper.

6. When you think about and compare the demonstration we did with a hand lens/fire outside, what acted in a similar way to the hand lens in this activity?

The sides of the jar were acting like the lenses in the magnifying glass. They were bending the light and focusing it.

Name ______________________ Date_____________

Can You Explain the Colors of a Sunset?

1. Darken the room.
2. Fill a clear container 3/4 full of water.
3. Shine a beam of light into a container of water and hold a white piece of paper behind the container. What do you see?

4. Add a drop or two of milk into the water container. Repeat step #1. What do you see?

5. Move the flashlight to the top of the container and shine it down on the water/milk mixture. Did you see any change in color? If so, what could this represent in nature?

6. Add additional drops of milk and look at the beam from the side of the tank and then from the end of the tank. Have your partner look at the solution from all angles. Then switch places.

7. Explain below what you think causes the colors of a sunset:

Name ______________________ Date_____________

Answers to Can You Explain the Colors of a Sunset?

1. Darken the room.
2. Fill a clear container 3/4 full of water.
3. Shine a beam of light into a container of water and hold a white piece of paper behind the container. What do you see?

I see some white light coming out the other end. It is difficult to see much light.

4. Add a drop or two of milk into the water container. Repeat step #1. What do you see?

I see yellowish/orange light.

5. Move the flashlight to the side and top of the container and shine it down on the water/milk mixture. Did you see any change in color? If so what could this represent in nature?

It appears bluish, certainly less yellow. The flashlight at the top could represent the sun during the day shining down through the atmosphere. When you look at the milk/water, which represents the atmosphere, it appears blue. At sunset and sunrise the sun is lower in the sky, and the sun light (flashlight) travels through more atmosphere so when you see it, it appears yellow/orange/red just the way real sunrises and sunsets look.

6. Add additional drops of milk and look at the beam from the side and top of the tank and then from the end of the tank. Have your partner look at the solution from all angles. Then switch places.

Students' responses will vary, as to the color changes they see. They may say that the colors become blue from the side and more orange. The beam seems to spread more.

7. Explain below what you think causes the colors of a sunset:

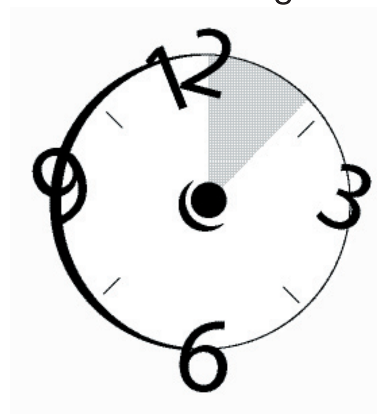
The changing position of the sun (lowering) in the sky causes the varying colors of a sunset.

Enlightening Explorations with LIGHT

Core/AID

Time Allocation: 50 minutes

Required Materials and Resources on Page 225



Lesson Overview

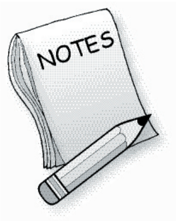
Students will extend their understandings about light's behavior, as they explore such things as why objects under water are not located where they appear to be. The concept of refraction or the bending of light will surface as the reason behind the apparent mysterious behavior of objects when immersed in water.

Guiding Questions

- Can light be bent?
- Why are objects that are under water, not exactly where you expect them to be when you reach for them?

BIG IDEA

Light can be bent.



Content Goals

Universal Theme(s)

- Science involves making hypotheses, theories and conceptual models to represent, explain and predict phenomena.
- Scientific evidence consists of observations and data on which to base scientific explanations.
- Using evidence to understand interactions allows individuals to predict changes.

Principles and Generalizations

- Light can be bent.
- Objects under water are not located where they visibly appear to be.

Concepts

Refraction of light

Teacher Information

- When light travels from one medium to another, it is bent because of the change in its speed.
- When light travels from the air into water or a solid, it slows down.
- Light is always bent, that is refracted, toward the perpendicular line formed where the light intersects an object. Therefore, when light strikes an object at the perpendicular point, there is no bending. **Part 1** of the lab activity, **Does Light Get "Bent Out of Shape"?** demonstrates this fact.
- When you look at a fish from the top of a tank, the light goes straight through the water and since the light is perpendicular to the water and bending of light is always toward the perpendicular line, there is no bending of light in this case. Therefore, the fish is actually located where it appears to be.
- In **Part 2** of the lab activity, **Does Light Get "Bent Out of Shape"?** students will find that it is more difficult to remove the cube that was in the container filled with water because the light is bent by the water, and therefore, the cube is not located where the eye appears to see it.

Skills

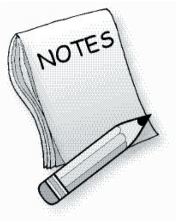
- Predict
- Make observations
- Record data
- Identifying characteristics
- Compare and contrast
- See relationships

Materials and Resources

1. **Part 1** of the lab activity, **Does Light Get "Bent Out of Shape"?** needs a wide, deep glass container filled with water, so that light can be shown through it at many angles and perpendicularly. A wide vase or tall beaker would do (one for one or two student groups)
2. Clear plastic or glass containers (6 per student group)
3. Cube (wood, plastic or metal) (1 per student group) Each grou the same type of cube.
4. Tweezers (1 pair per student group)
5. Straws or pencils (six per student group)
6. White vinegar
7. Karo™ syrup
8. Salt water solution (saturated)
9. Vegetable oil
10. Rubbing alcohol
11. Salt water solution
12. (AID) Cup (one per student or student group)
13. (AID) Coin (one per student or student group)
14. (AID) Container with a pour spout, a small watering can or a gravy separator will work. The reason for the spout is so the location of the coin will not be disturbed as the water is added to the cup in the extension activity.

Preparation Activities

1. Copy the lab activity, **Does Light Get "Bent Out of Shape"?** for all students.
2. Print out one copy of the **Answers to Does Light Get "Bent Out of Shape"?**
3. Make a salt water solution.



Introductory Activity (5 minutes)

- Collect students' lab sheets, **Boxing with Light!**
- Tell students that they will be continuing with their exploration of the nature of light.
- Distribute the materials for the lab activity, **Does Light Get "Bent Out of Shape"?**
- Assign lab partners

Pre-assessment

N/A

Teaching and Learning Activities (40 minutes)

1. Tell students that they will start with **Part 1** of the lab, **Does Light Get "Bent Out of Shape"?**

2. Upon completion of **Part 1**, have a brief discussion before moving on with the remainder of the lab. Discuss with students the answer to **Part 1's** question, "Does light always bend as it travels from air to water?" They should conclude that light usually bends as it enters water except when it is perpendicular to it.

3. Tell students to proceed with **Part 2** of the lab activity.

4. Debrief after **Part 2** by asking students to describe their experiences when they tried to remove the cube with the tweezers.

5. Direct the students to finish **Parts 3** and **4** of the lab activity.

6. Discuss the results of the last two parts with students. Select volunteer student groups to share their "straw drawings" in various liquids by putting them on the board or on overheads. Ask the students what they can conclude regarding the relationship between a liquid's "thickness," (you can introduce the term "viscosity" if you like, but it is not important that students know this term) and the degree to which reflected light from the straw bends as it travels from that liquid to the air.

7. Tell them to answer all the questions for homework that they did not finish today.

Products and Assignments

Students' lab sheet, **Boxing with Light!**

Extension Activities

(AID) Encourage students who need an additional challenge to do the activity, **Light Plays Tricks on Us ALL!** that requires students to draw an explanation for the outcome of the activity. Students will see the effect of adding water to a cup holding a coin. The light that originally bounced off the coin did not hit the student's eyes. However, the water creates the second medium (air being the first). As the light bounces off the coin and travels across the water/air boundary, it is bent as it travels out of the water into the air, thus allowing the student to see an object, a coin, that they could not see before.

Post Assessment

N/A

Debriefing and Reflection Opportunities (5 minutes)

Ask students to think about what advice they would give a friend, if the friend were attempting to clean a fish tank and had to remove the fish first. Tell them they will be writing their advice to a friend in question #2 of Part 2 of the lab. Remind them that the lab sheets will be collected tomorrow and that the questions must be completed.

Name ___________________________ Date ____________

Does Light Get "Bent Out of Shape"?

Part 1: Does Light Always Bend as It Travels from Air to Water?

1. Circle below whether you think light bends or not when it travels from air into water and explain your prediction.

I think light always bends when it goes from air to water because ___________________

I think light does not always bend because ___________________________________

2. Take a clear deep container and fill it with water.
3. Shine a light directly over the top of the water and describe the path that the light takes as it travels from the air into the water below:

4. Repeat step # 2 above except shine the light at a high angle to the water. Describe the path of light below:

5. Repeat step # 2 above except shine the light at a low angle to the water. Describe the path of light below:

6. Pick another angle and shine the light at a low angle to the water. Describe the path of light below:

Name ______________________________ Date ______________

Questions:

1. As light travels from air into water, describe what usually happens below:

2. Answer the question posed at the beginning of Part 1, "Does light always bend as it travels from air to water?"

Part 2: Now You Have It - Now You Don't!

1. Get two small clear containers.
2. Pour water into one of the small clear containers.
3. Place the cube inside an empty container.
4. Squat down next to the table and look at the cube from the side of the container.
5. Try to remove the cube using the tweezers (remember, you are looking from the side).
6. Now place the cube inside the container with water.
7. Squat down next to the table and look at the cube from the side of the container.
8. Try to remove the cube using the tweezers (remember, you are looking from the side).

Questions:

1. Was it easier or more difficult to remove the cube that was in the container filled with water?

2. What instructions would you give someone to get a fish out of a fish tank using a scoop net?

Part 3: Am I Seeing Things?

1. Fill a clear container 3/4 full with water.
2. Put a pencil in the container.
3. Look at the container from the side.
4. Describe what you see.

Part 4: Really Bent Out of Shape!

1. Each container should be filled halfway with one of the six liquids listed in your data table.
2. Place a straw or a pencil in each clear container.
3. Squat down next to the table and observe the pencil in each of the solutions.
4. Record your observations about how the straws/pencils look in each container.

Name ______________________________ Date ____________

Data Table

Water	Karo Syrup	Rubbing Alcohol
Vegetable Oil	White Vinegar	Salt Water

Describe any relationship you see between how thick or thin the solution is and what happens to the pencil:

Name ___________________________ Date _____________

Answers to Does Light Get Bent Out of Shape?

Part 1: Does Light Always Bend as It Travels from Air to Water?

1. Circle below whether you think light bends or not when it travels from air into water and explain your prediction.

I think light always bends when it goes from air to water because ___________________

I think light does not always bend because ___________________________________

2. Take a clear deep container and fill it with water.
3. Shine a light directly over the top of the water and describe the path that the light takes as it travels from the air into the water below:

4. Repeat step # 2 above except shine the light at a high angle to the water. Describe the path of light below:

5. Repeat step # 2 above except shine the light at a low angle to the water. Describe the path of light below:

7. Pick another angle and shine the light at a low angle to the water. Describe the path of light below:

Questions:

1. As light travels from air into water describe what usually happens below:

It bends.

Name ______________________________ Date _______________

2. Answer the question posed at the beginning of Part 1, "Does light always bend as it travels from air to water?"

No, if it is right on top of the tank, perpendicular to it, it does not bend.

Part 2: Now You Have It - Now You Don't!

1. Get two small clear containers.
2. Pour water into one of the small clear containers.
3. Place the cube inside an empty container.
4. Squat down next to the table and look at the cube from the side of the container.
5. Try to remove the cube using the tweezers (remember, you are looking from the side)
6. Now place the cube inside the container with water.
7. Squat down next to the table and look at the cube from the side of the container.
8. Try to remove the cube using the tweezers (remember, you are looking from the side)

Questions:

1. Was it easier or more difficult to remove the cube that was in the container filled with water?

It was more difficult.

2. Write below what instructions you would give someone to get a fish out of a fish tank using a scoop net:

You need to take a net and go in down from the top of the tank because the light will not bend and the fish will not change its apparent location. In other words, "what you see is what you get."

Part 3: Am I Seeing Things?

1. Fill a clear container 3/4 full with water.
2. Put pencil in the container.
3. Look at the container from the side.
4. Describe what you see.

Part 4: Really Bent Out of Shape!

1. Each container should be filled halfway with one of the six liquids listed in your data table.
2. Place a straw or a pencil in each clear container.
3. Squat down next to the table and observe the pencil in each of the solutions.
4. Record your observations about how the straws/pencils look in each container.

Name ______________________________ Date ____________

Data Table

Water	Karo Syrup	Rubbing Alcohol
Vegetable Oil	White Vinegar	Salt Water

Describe any relationship you see between how thick or thin the solution is and what happens to the pencil:

The amount of bend changes with the thickness.

Name ____ Date __________

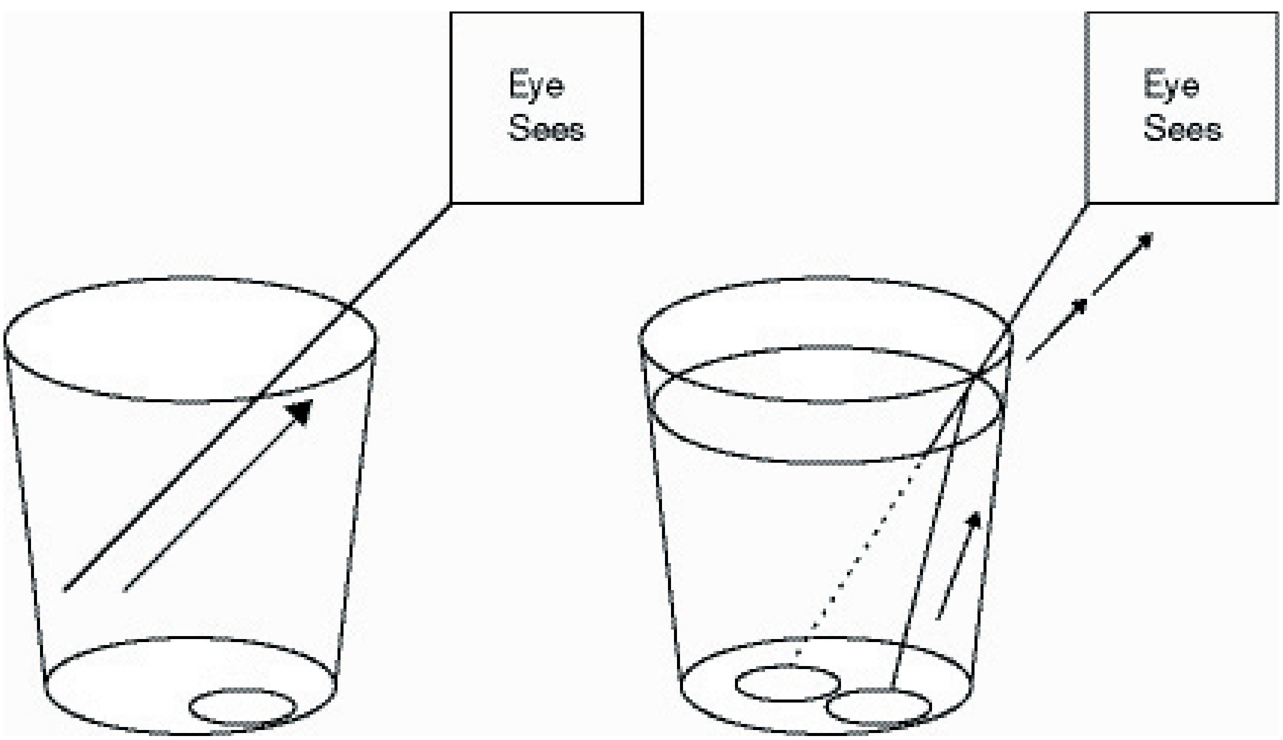
Extension Activity - Light Plays Tricks On Us All!

1. Put the coin in the empty container.
2. Crouch down until you can no longer see the coin. (Don't go down too far -just until you can no longer see the coin.)
3. Get a container with a spout and have your partner slowly pour the water into the container. (**You must pour it slowly so you do not move the coin.**)

What happened?

This experiment differs from the ones we have done earlier in that we are not using a source of light like the sun or a flashlight and sending the light from the air into the water and watching the light's behavior. Instead, we are seeing light being bounced off the coin, which reaches our eyes. It travels through the water and out into the air. What do you know that happens when light travels from one medium to another?

Using the drawings below explain why we can see the coin only after the water is poured in.

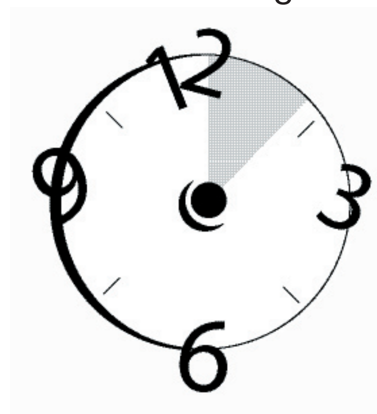


Enlightening Explorations with LIGHT

Core/AID

Time Allocation: 50 minutes

Required Materials and Resources on Page 225



Lesson Overview

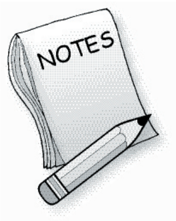
Shine a flashlight on a piece of glass and compare what happens to the glass when it is exposed to ultraviolet or infrared light. Students will discover the behavior of substances that do not transmit light versus those that transmit visible light entirely and those that transmit it partially, opaque, transparent and translucent materials, respectively. Then students will participate in a scavenger hunt in the room, looking for substances that fall in one of the three categories dealing with the opacity of light.

Guiding Questions

- Is there anything else visible light can do besides being absorbed, reflected or refracted?

BIG IDEA

Objects transmit light to varying degrees.



Content Goals

Universal Theme(s)
Scientific evidence consists of observations and data on which to base scientific explanations.

Principles and Generalizations
Objects transmit light to varying degrees.

Concepts
- Transmission of light
- Opaque
- Transparent
- Translucent
- Ultraviolet light

Teacher Information
- Glass and water are transparent to visible light.
- Visible light goes in and out of glass at the same frequency.
- Infrared and ultraviolet light are absorbed by glass and transformed into heat.
- Ultraviolet rays are high energy rays of light.
- Infrared rays are low energy rays of light.

Skills
- Make observations
- Compare and contrast
- See relationships

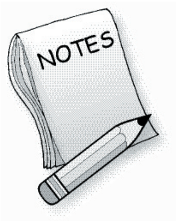
Materials and Resources
1. Flashlight
2. Glass
3. Jar of honey
4. Glass of milk
5. Window with sunlight or ultraviolet or infrared sources of light

Preparation Activities

1. Copy the worksheet, **All, Some & None Scavenger Hunt**
2. Make sure you have examples of opaque, transparent and translucent substances in the room. A glass of water could be sitting on a counter as an example of a translucent material.

Introductory Activity (20 minutes)

- Collect the students' lab sheets, **Does Light Get "Bent Out of Shape?"** and review the answers to the questions.
- Shine a flashlight onto a piece of clear glass.
- Ask the class if the light is being reflected. They should say it is not being reflected.
- Call upon a student to come to the front of the room. Instruct the student to feel the glass and comment on its temperature.
- Inquire from the student if the temperature is rising. The student will say it is not.
- Ask the class if the light is being absorbed. They should say no.
- Question the class then about what is happening. Students should say something similar to the light is "passing through." Inform them them that is what we call *transmission* of light.
- Tell the student to take the glass to the window and place it in the sun. If sun is not out, use a UV or infrared lamp.
- Instruct the student to feel the glass's temperature. The student will see that the temperature has gone up.
- Ask the class what is the difference between the light from the sun and the light from a flashlight. Students might know that sunlight has ultraviolet rays.
- Query students about what they know about ultraviolet light. Lead them to recognize that these rays of light are the harmful rays that come from the sun and that they can damage the skin.
- Tell students that glass does not absorb visible light, but it does absorb the sun's ultraviolet light and that heats it up
- Tell them glass is a special substance, that is *transparent* to visible light but *opaque* (it absorbs the ultraviolet rays) to ultraviolet rays. It allows visible light to pass through without change but changes UV rays from sunlight into heat as they pass into glass.



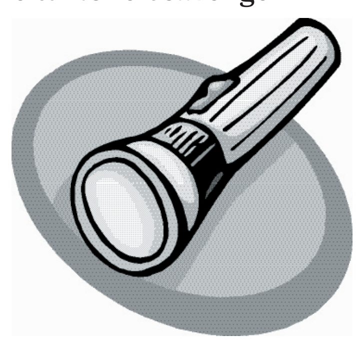
- Inform students that any substance that does not allow light to pass through is referred to as an opaque substance.
- Shine a flashlight through a glass of milk and a jar of honey. Ask students what happens to the beam of light. Students should see that it does not pass through the milk and spreads out or has been diffused by the honey. Tell them that the material in the honey scatters the light so you cannot see objects clearly through a *translucent* object, whereas the milk is opaque.

Pre-assessment
N/A

Teaching and Learning Activities (20 minutes)
1. Distribute and review the lab activity, **All, Some & None Scavenger Hunt.**

2. Instruct students to go around the room and identify substances as opaque, transparent, or translucent.

Products and Assignments
- Students' homework assignment, **Does Light Get "Bent Out of Shape?"**
- Students' sheets from the lab activities, **All, Some & None Scavenger Hunt.**



Extension Activities
N/A

Post Assessment
N/A

Debriefing and Reflection Opportunities (10 minutes)
1. Reconvene the class and put a similar chart to the one from **All, Some & None Scavenger Hunt** on the board or on chart paper and collect information from each group and discuss their findings. Again students do not have to memorize the terms but should understand that materials respond differently to light and some have a greater tendency to let light pass through than others.

2. You can relate this concept to packages of food. Milk is put in opaque containers so that light does not pass through it. It is opaque. Ask students if they have noticed any other containers that are specially designed to be resistant or "opaque" to light, especially ultraviolet light. Students may have seen that some materials are put into brown bottles so that light does not pass through the container into the material inside.

Name ______________________________ Date ______________

All, Some & None Scavenger Hunt

Directions:
Today you are going on a scavenger hunt within the classroom. You are to locate, observe, examine, and record objects that fit into each column listed below in the chart. Each group is allowed to use one flashlight to test your objects. You must stay together as a group during the scavenger hunt.

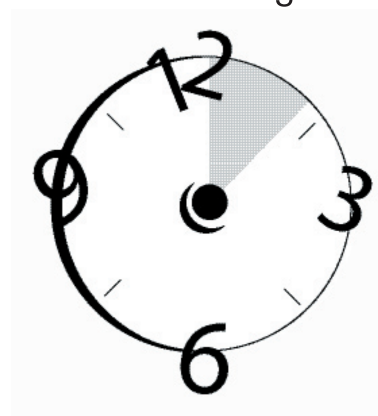
Objects that let <u>no light</u> pass through	**Objects that let <u>some light</u> pass through**	**Objects that let <u>all light</u> pass through**
1.	1.	1.
2.	2.	2.
3.	3.	3.
4.	4.	4.
5.	5.	5.

Enlightening Explorations with LIGHT

Connections/AID

Time Allocation: 55 minutes

Required Materials and Resources on Page 225



Lesson Overview

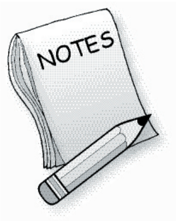
This lesson leads students to see connections in science disciplines. One of the fields in physics is the study of light. This contrasts to the field of chemistry that includes the study of colors in clothing and other materials, such as inks. The latter involves examining the specific chemicals called dyes that absorb and reflect light differently. In this lesson students can explore the connection between the separation of light into its colored components and separation of colored materials, ink dyes, based on their solubility behaviors, via a technique called chromatography. Students will again see the connection between black pigments that are composed of all colors, and the consequential absorption of all of the colors from white light and the reflection of nothing.

Guiding Questions

- What makes black ink black?

BIG IDEA

Chromatography



Content Goals

Universal Theme(s)

Scientific evidence consists of observations and data on which to base scientific explanations.

Principles and Generalizations

- Black is the absence of reflected light.
- Mixtures can be separated through physical and chemical means.

Concepts

- Absorption of light
- Reflection of light
- Chromatography
- Mixture

Teacher Information

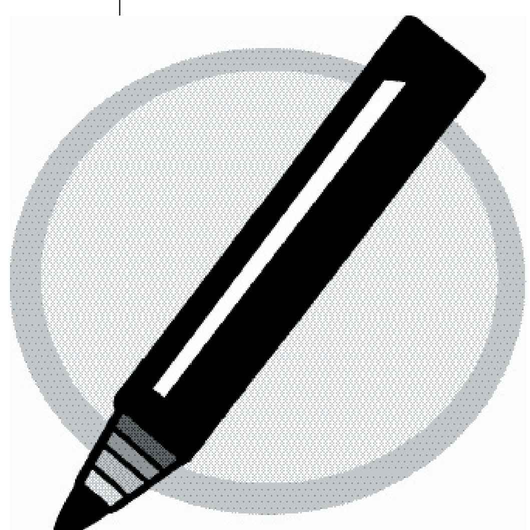
- The prefix "chromo" is from the Greek meaning "color."
- Chromatography is a separation technique that uses a solvent (liquid) and a medium like a paper towel to separate substances within a mixture (e.g., ink). The substances of a mixture, like black ink, each have their own preferences for solvent or the paper towel, and therefore each stays in solution for varying times depending on the chemical nature of the substances in the mixture. The longer the material stays in solution, the "farther up it travels" before it comes out and deposits on the chromatography paper, in this case paper towels, coffee filters or laboratory filter paper, whichever you choose to use. In this way the various components of a mixture can be demonstrated to exist.
- Students, who did the extension activity, **Leaf Chromatography Extension Activity,** will have been introduced already to the concept, so perhaps they could be paired with students who have not had any previous experience with this separation technique.

Skills

- Make observations
- Record data
- Identify characteristics
- Compare and contrast
- See relationships

Materials and Resources

1. Pair of scissors (1 per student or student group)
2. Meter stick (1 per student or student group)
3. Plastic straws (4 per student or student group)
4. Troughs cups, bowls, etc. – anything that can be used to hold water and suspend 4 straws above the water with taped filter paper or paper towel strips on them in order to separate five different types of felt pen inks
5. Masking tape
6. Filter paper, paper towels or coffee filters
7. Four different brands of water-color black markers (12 of each brand)
8. Water
9. Permanent marker (teacher demonstration)



Preparation Activities

Make copies of the lab activity, **Are All Black Felt Pens Created Equal?**

Introductory Activity (5 minutes)

1. Distribute and review the materials for the lab activity, **Are All Black Felt Pens Created Equal?**

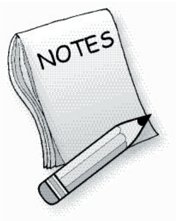
2. Assign lab partners.

Pre-assessment

N/A

Teaching and Learning Activities (40 minutes)

1. Instruct students to proceed with **Are All Black Felt Pens Created Equal?**



2. Show the students your demonstration setup. Tell them while they are doing their investigation, you will be investigating black ink as well.

3. Do not tell them that you are using permanent ink.

4. Upon completion of the lab activity, discuss the results with students.

5. Ask them such questions as, "Did all of your ink mixtures separate? Which one separated the most? The least? What does the number of streaks tell you about the ink mixture?

6. Assign students to finish answering the questions for homework.

Products and Assignments
N/A

Extension Activities
(AID) In order to extend students' understandings of chromatography, students will use several ink pens and do chromatography experiments using several different solvents besides water, such as alcohol, to see if the change in solvent helps some of the inks separate more easily, especially the pen ink used by the teacher.

Post Assessment
N/A

Debriefing and Reflection Opportunities (10 minutes)
1. Ask students what they think makes black ink, black. They should say that the colored components in it absorb the light and reflect none, so the ink appears black.
2. Ask a student to come up front and examine your ink line. The student should report that you had no streaks of color, and the black ink line did not move. Ask students what they think happened. "Was my ink just 'too tired' or is this black ink made of something different your black ink?"
3. Suggest that perhaps the substances in your black ink are different and do not like to "go along for the ride," so to speak, as the substances did in their black ink. Suggest that maybe there is something different about them

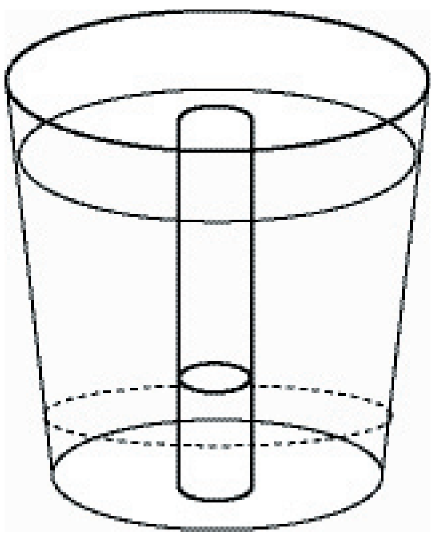
that causes them to "like" the filter paper much better than the water, and therefore, not go into the water at all and instead "sit tight" on the paper. Ask students, "Based on our evidence, are all black felt pens created equal?" They should say no because the inks did not behave the same way under the same experimental conditions.

4. Ask students whether they think we could change the experimental conditions to test whether the teacher's felt pen ink, permanent ink, does actually contain other colored components. Suggest that perhaps we should use a different liquid besides water to try and make the permanent ink dissolve and do some "traveling" up the paper to see if it does have other components. If there is an interested student, suggest that he or she carry out this investigation with alcohol as the solvent.

Name ______________________________ Date ________

Are All Black Felt Pens Created Equal?

1. Put 1.5 cm of water into the bottom of your container (e.g., pail, trough, large cups).
2. Cut one piece of filter paper, paper towels or coffee filters into strips about 2.5 cm wide and just long enough to have the bottom of the strips just touch the water for every pen you intend on testing.
3. Draw a thin ink line with the pen across the filter paper about 1 cm above the bottom of the filter paper.
4. Repeat Step # 3 for all the pens you want to test. Make sure you know which is which (you can label the filter paper at the top).
5. Attach all the papers to the straw(s) using a piece of masking tape. Place as many strips of filter paper on a straw as there is room.
6. Make sure the filter paper hangs straight down and that when you put it on top of your water container, the bottom of the strip will touch the top of the water, without letting the pen line go in the water.



7. Draw a picture for what you see on each filter strip below:

8. Compare the chromatograms and answer the question, "Are all black felt ink pens created equal?" Explain your answer.

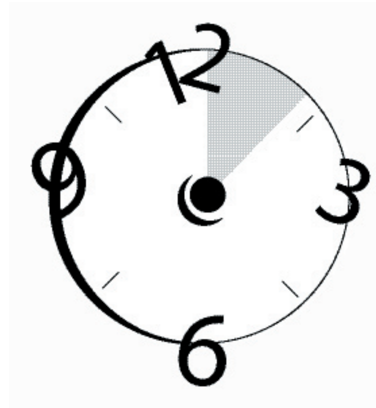
9. For homework look up the prefix, "chromo" and write down the definition.

Enlightening Explorations with LIGHT

Core/AID

Time Allocation: 1 hour, 5 minutes

Required Materials and Resources on Page 225



Lesson Overview

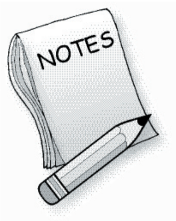
In this lesson, students will explore how light behaves when it hits various textured surfaces. They will discover that when light hits a flat surface, it reflects off that surface at the very same angle the light hit it. They will also explore the concept of diffusion of light, the way light behaves when it reflects from various types of surfaces that are not flat and then compare these results to light's reflection from flat surfaces.

Guiding Questions

- Does a surface's texture affect the way in which light bounces off it?

BIG IDEA

Light reflects in different ways depending upon the nature of the material it hits.



Content Goals

Universal Theme(s)

- Science involves making hypotheses, theories and conceptual models to represent, explain and predict phenomena.
- Scientific evidence consists of observations and data on which to base scientific explanations.
- Using evidence to understand interactions allows individuals to predict changes.

Principles and Generalizations

- Light reflects in different ways depending upon the nature of the material it hits.
- Smooth, flat, shiny surfaces (mirrors) produce the best reflections.
- Light is reflected by a mirror at the same angle at which it strikes the mirror.
- Light that hits irregular surfaces goes in all directions.

Concepts

- Reflection of light
- Diffusion of light

Teacher Information

- Light that hits irregular surfaces is called *diffuse* reflections.
- Light that reflects from smooth, shiny surfaces is called *specular* reflections. The word "specular" comes from the Latin word *speculum* that means mirror.
- Light is reflected by a mirror at the same angle (angle of reflection) at which it strikes the mirror (angle of incidence). The correct scientific terms can be introduced during this lesson but students would not be required to memorize them.

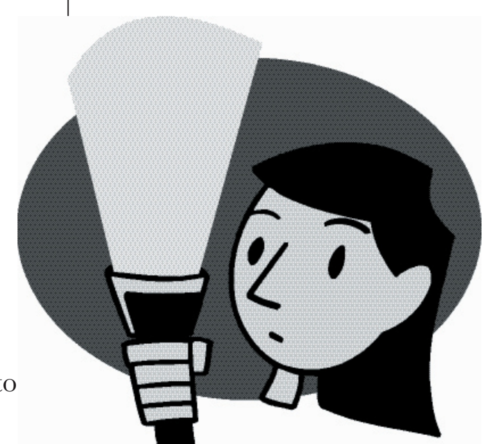
Skills

- Predict
- Make observations
- Estimate angle measures
- Measure angles (AID)

- Identify characteristics
- Compare and contrast
- See relationships

Materials and Resources

1. Flashlight (1 per student or student group)
2. Toilet paper cardboard tube (1 per student or student group)
3. Masking tape (1 per student or student group)
4. Aluminum foil, 10 cm x 10 cm (1 piece per student or student group)
5. Piece of cardboard (1 per student or student group)
6. Scissors (1 pair per student or student group)
7. Small ball of modeling clay or mirror support (1 per student or student group) Mirror supports come in plastic or wood and can be purchased from science supply houses or at www.wolverinesports.com
8. Piece of white construction paper (1 per student or student group)
9. Reflective items such as aluminum foil, shiny wrapping paper, clean glass, mirror, tin, etc. (1 of each per student or student group)
10. Small mirror (1 per student or student group)
11. (AID) Protractor (1 per student or student group)
12. Comb and a piece of cardboard long enough to attach a comb (1 per student or student group)

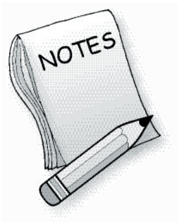


Preparation Activities

1. Copy **What's Light's Angle** lab activity.
2. Print a copy of the **Answers to What's Light's Angle?** for your use.

Introductory Activity (15 minutes)

- Collect students' lab sheets from the activity, **Are All Black Felt Pens Created Equal?**
- Tell students to build a "light beamer" by taping a toilet cardboard tube to the end of the flashlight, so the light shines through the tube.
- Give each lab group a piece of aluminum foil big enough to cover the end of the tube.
- Instruct students to carefully poke a small hole in the center of the aluminum foil, about the diameter of a pencil, and tape it over the end of their tube.



- With the room darkened, have students turn on their light beamers and shine the light across the room onto the wall and then onto the ceiling. Tell students to describe how the light travels down and what happens when the light hits a surface.
  Select a few students to read what they wrote. Students should see that the light from the beamer makes a smaller "dot or circle" where it strikes the wall or ceiling – or any object for that matter. The light appears to go directly from the beamer to the lit up circle in a straight line. If there is dust in the air, students will see the light beam light up the dust in its path, tracing exactly where it goes from the light to the circle. However, once the light hits the wall or ceiling, it seems to bounce or reflect in all directions. This must be true because everyone in the room can see the circle, meaning that the light from the circle went towards everyone in the room.
- Ask students if they can see the color of the ceiling. If not, ask them what would assist them in seeing the true color. Students will realize that they would need a brighter light source, which would bounce more light off the ceiling or wall surface and thus enable it to be seen better.

Pre-assessment
N/A

Teaching and Learning Activities (40 minutes)

1. Instruct students to proceed with the lab activity, **What's Light's Angle?**

2. Invite students to share their observations at the end of Activity 1. Some of the groups may discover that the angle at which light hits the mirror is the same as the angle that it leaves the mirror surface.

3. Tell students to start Activity 2.

4. Walk around the room, making sure students are able to follow the instructions. Make sure the students realize that the beamer is to be laid along the side (not the bottom) of the paper, angled in towards the mirror such that the light beam strikes the mirror and is "splayed" along the paper, forming a reflected beam that can be traced to identify the incoming

(incident) ray and the reflected ray and measure or approximate those angles, depending on their skills. Later in the activity, the students are expected to change the incident angle to see that the reflected angle changes similarly.

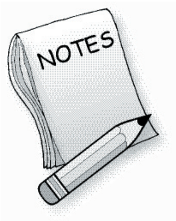
5. Discuss the results of Step #4 with students. They should note that when the light beam goes from the beamer to the mirror, it travels in a straight line, and then bounces off the mirror. They should see that the reflected beam seems to bounce from the mirror symmetrically around a line drawn perpendicular (right angle) at the point of bouncing. (If the beam comes into the mirror at an angle of 30 degrees, it seems to bounce at a similar angle of 30 degrees on the other side of the line drawn perpendicular to the point of the light's impact on the mirror). If the mirror is tilted slightly down towards the paper, the light beam will "trace" its path across the paper. The light beam seems to move in straight lines to and from the mirror.

6. Instruct students to continue with the lab, filling in the table.

7. If some students did not find that the angle in is equal to the angle out, have them do one more trial with a different partner, preferably from a group that did conclude that the angles were equal.

8. Introduce the terms "angle of incidence" and "angle of reflection" and state that they are equal when light strikes an object. In other words, the "coming out" angle seems always to be the same as the "going in" angle, just on the other side of the line drawn perpendicular to the mirror at the point of bouncing. The point is **not to memorize the terms** but rather to expose students to the common language that scientists use. The emphasis must be on the concept that the incoming and outgoing angles of light that hit a flat, shiny surface are equal.

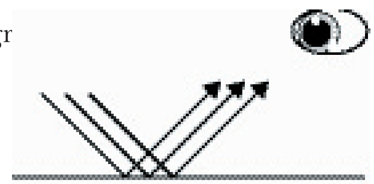
9. Ask the students if they have ever seen their reflection in an object that is not a mirror. List their responses on the board. Discuss what these items all have in common. Why did all these items reflect light? Students should recognize that they are all shiny surfaces that **do not absorb** light but rather reflect it.



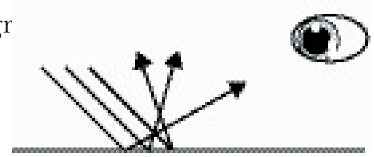
10. Instruct students to complete Activity 3.

11. After the students have finished Activity 3, demonstrate how the wrinkling of the foil with this activity affected the light waves. (Keep the room dark.) First line up four mirrors in a straight line. Use the unwrinkled foil paper. Shine four flashlights (one at each mirror) at the same time. The light bounces back straight (See Diagram #1). Then angle each mirror a little in different directions to simulate the wrinkled paper. Once again shine the flashlights. This time the light is bouncing back at different angles (See Diagram #2) and would not all reach your eye, thus the intensity is reduced.

Diagr



Diagr



Products and Assignments

Students' lab sheets from the activity, **Are All Black Felt Pens Created Equal?**

Extension Activities

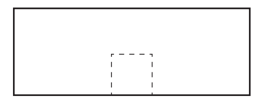
1. (AID) Ask students who show an aptitude for math or a significant enthusiasm for the activity to try to measure the angles using a protractor.
2. (AID) For students who need further challenge, invite them to research how a laser works and what applications lasers currently have (e.g., How are lasers used in eye surgery? How are lasers used in the military? How are lasers used in cosmetic surgery?)

Debriefing and Reflection Opportunities (10 minutes)

1. Discuss how the light beam in the light reflection activity seemed to hit the mirror and return, while remaining on the same side of the mirror. It does not appear to penetrate the object (mirror) and as such it is said to have been "reflected." Point out that this is one of the behaviors of light. Ask students what would be the opposite of "reflection." They should be able to respond with the term, "absorption."
2. In addition, ask students what happened to the light beam as they changed the light source's angle. They should conclude that light bouncing off the mirror surface does so at the same angle as it came in.
3. Question students about what happens to the behavior of light when it hits something like the chrome on a brand new car's front fender versus what they would see in the chrome of a car after it was in a "fender bender."
4. Discuss with students what happened to light rays when they hit an irregular surface. Use the term "diffused" to describe what happened to light as it bounced in all directions as a result of hitting an irregular surface. Tell the students that this is the correct scientific term, and that you will use it although they do not have to memorize it.
5. Ask students the following question, "If you had more than one mirror, what could you do with the light?" Students should be able to conclude that with more than one mirror, a light beam could be made to change directions twice. Both times, it would bounce around the perpendicular line drawn to the point of bouncing for each mirror. Tell them they will be working with multiple mirrors in tomorrow's lab activity.

Name ________________________________ Date______________

What's Light's Angle?



Activity 1: What happens to light when you comb it!

1. Cut a one-inch hole across on the bottom edge of a piece of cardboard.

2. Hold the cardboard with the 1-inch hole. Be sure the hole is on the edge touching the table.

3. Tape a comb to the cardboard so the comb's teeth are over the hole.

4. Have your partner hold a mirror facing the comb but slightly at an angle.

5. Shine the flashlight through the hole so the light rays pass through the comb's teeth and hit the mirror. What do you see?

6. Try this activity several times but change the angle of the mirror. Write down your observations.

Activity 2: What is the angle here?

1. With the room lights back on, tape the white construction paper on the top of your desk.
2. Put the modeling clay or a mirror support at the top center of your white construction paper and use it to stand up the mirror at the edge of your paper so that the mirror side is facing the white paper.
3. Lay your light beamer on your desk along the side edge of your white paper and aim the light beam so that it shines across your paper and hits the mirror. Adjust the tilt of the mirror so the bounced light beam goes across your paper. Write down what you observe. Write down what you think will happen when you shine the light beamer so it hits the mirror.

Name ________________________________ Date______________

4. Change the position of the light so that you change the angle at which the light hits the mirror. Estimate the angle even if you use descriptors like “small” “medium” and “large.” Observe what happens and write down what you observe in the table below:

Table for What’s Light’s Angle?

Trial Number	Angle In	Angle Out
#1		
#12.		
#13.		

Write a sentence below that describes what happens to light when it hits a mirror. Include the word “angle” in your sentence.

____

____

Activity 3: Does Surface Type Affect How Light Behaves?

1. Take a sample of the reflective items in the front of the room.
2. Predict and rank the items from the "best reflection" to the "worst reflection." Share your lists with other students and explain your thinking.

3. Look at your reflection in each material. Compare your observations to your predictions. Were there any differences?

4. Go get another piece of aluminum foil. **Do not** wrinkle the foil.

5. Select the side with the best reflection (shiny side).

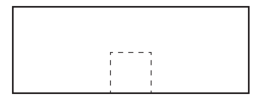
6. Make sure the room is dark. Shine the light at an angle on the shiny side and observe the light rays. Look at your own reflection and draw and/or describe your observations below:

7. Wrinkle the foil paper without tearing it. Shine the light on the shiny side and draw and/or describe what the light rays are doing below.

8. Discuss your observations with your partner. Were there any differences in the light reflecting off the foil paper? Were there any differences in your reflection? Why do you think this occurred?

Name ________________________________ Date______________

Answers to What's Light's Angle?



Activity 1: What happens to light when you comb it!

1. Cut a one-inch hole across on the bottom edge of a piece of cardboard.

2. Hold the cardboard with the 1-inch hole. Be sure the hole is on the edge touching the table.

3. Tape a comb to the cardboard so the comb's teeth are over the hole.

4. Your partner should hold a mirror facing the comb but slightly at an angle.

5. Shine the flashlight through the hole so the light rays pass through the comb's teeth and hit the mirror. What do you see?

The angle at which the light strikes the mirror equals the angle at which it leaves the mirror.

6. Try this activity several times but change the angle of the mirror. Write down your observations.

The angles at which the light strikes the mirror always equal the angles at which they leave the mirror.

Activity 2: What is the angle here?

1. With the room lights back on, tape the white construction paper on the top of your desk.
2. Put the modeling clay or a mirror support at the top center of your white construction paper and use it to stand up the mirror at the edge of your paper so that the mirror side is facing the white paper.
3. Lay your light beamer on your desk along the side edge of your white paper and aim the light beam so that it shines across your paper and hits the mirror. Adjust the tilt of the mirror so the bounced light beam goes across your paper. Write down what you observe. Write down what you think will happen when you shine the light beamer so it hits the mirror.

Name ________________________________ Date______________

4. Change the position of the light so that you change the angle at which the light hits the mirror.
   Tell students to estimate the angle even if they use descriptors like "small" "medium" and "large."
   Tell students to observe what happens and write down what they observe in the table below:

Table for What's Light's Angle?

Trial Number	Angle In	Angle Out
Position #1	30 degrees or small	30 degrees, same as angle in
Position #2	45 degrees or medium	45 degrees, same as angle in
Position #3	60 degrees or large	60 degrees, same as angle in

Write a sentence below that describes what happens to light when it hits a mirror. Include the word "angle" in your sentence.

The angle of incoming light when it hits a mirror equals the angle at which it leaves the mirror.

Activity 3: Does Surface Type Affect How Light Behaves?

1. Take a sample of the reflective items in the front of the room.
2. Predict and rank the items from the "best reflection" to the "worst reflection."
   Share your lists with other students and explain your thinking.

Students' individual responses

3. Look at your reflection in each material. Compare your observations to your predictions. Were there any difference?

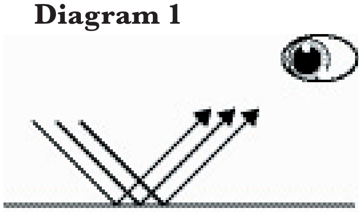
Students' individual responses

4. Go get another sheet of aluminum foil. **Do not** wrinkle the foil.

5. Select the side with the best reflection (shiny side).

6. Make sure the room is dark. Shine the light at an angle on the shiny side and observe the light rays. Look at your own reflection and draw and/or describe your observations below:

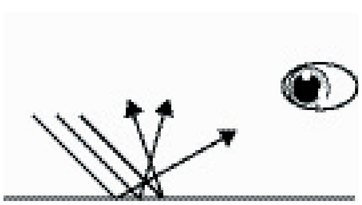
Diagram 1



My image is clear.

7. Wrinkle the foil paper without tearing it. Shine the light in the shiny side and draw and/or describe the light rays.

Diagram 2



My image is not clear.

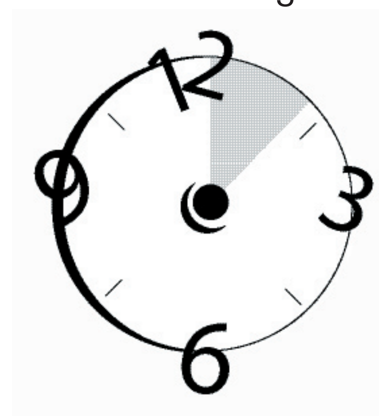
8. Discuss your observations with your partner. Were there any differences in the light reflecting off the foil paper? Were there any differences in your reflection? Why do you think this occurred?

Using Light's Properties to See Better

Core/Connections/AID

Time Allocation: 1 hour, 15 minutes

Required Materials and Resources on Page 225



Lesson Overview

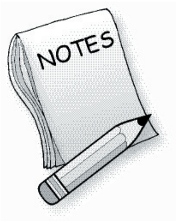
In this lesson, students will manipulate light, using its known behaviors, to accomplish a task. By the end of the lab activity, they will discover they have actually used the properties of light to construct a useful tool, a periscope. They will see the connection between properties of light and their application to the production of tools to serve human purposes.

Guiding Questions

- How can we use light's properties to help us?

BIG IDEA

Using light's properties to create a useful tool, the periscope



Content Goals

Universal Theme(s)

Scientific evidence consists of observations and data on which to base scientific explanations.

Principles and Generalizations

- Light can be made to change direction.
- Light's reflective behavior can be used to create tools to help us see better.

Concepts

- Reflection of light
- Manipulation of light

Teacher Information

- Light always reflects away from a mirror at the same angle that it hits the mirror. In your periscope, light hits the top mirror at a 45-degree angle and reflects away at the same angle, which bounces it down to the bottom mirror. That reflected light hits the second mirror at a 45-degree angle and reflects away at the same angle, right into your eye.
- When you are making a periscope, it's important to make sure that your mirror is positioned at a 45-degree angle. Using geometry relationships and the fact that when two sides of a right triangle are equal the interior angles are 45 degrees, you can use any size carton or box and do the following to ensure the mirror is placed at a 45 degree angle. Just measure how wide your box is. Then measure that same distance up the side of the box from the bottom and make a mark. The line between your mark and the opposite corner of the box will be at 45 degrees.

Skills

- Make observations
- Identify characteristics
- See relationships

Materials and Resources

1. Small flat mirrors (4 per student or student group)

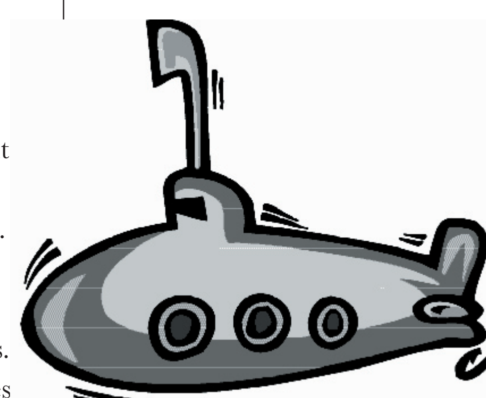
2. Small object like a block (1 per student or student group)
3. Flashlight
4. Small ball of modeling clay or mirror support (1 per student or student group)
5. Masking tape (1 roll per student or student group)
6. Scissors (1 per student or student group)
7. The following site, http://www.sciencetoymaker.org/periscope/ can be visited to obtain directions for another version of the periscope.
8. Shoebox or milk cartons depending on which version of the periscope you are going to have students build (1 shoebox per group or 2 milk cartons per group)

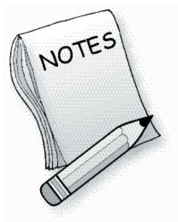
Preparation Activities

1. Two weeks prior to teaching this lesson, send home a letter requesting shoe boxes or milk cartons, depending upon which version of a periscope you plan to have students make.
2. Copy the lab activity, **Help Me See!**
3. Copy the **Instructions to Build a Periscope Version 1** or **Instructions to Build a Periscope Version 2** for yourself and for any students who may not have the ability to create their own version of a periscope.

Introductory Activity (5 minutes)

- Collect the shoeboxes students brought in. For those that forgot, remind them to bring them in tomorrow.
- Collect students' sheets for the lab activity **What's Light's Angle?**
- As a way to review the previous day's exploration of the behavior of light when it hits shiny, flat objects, ask students what happens to light when it hits a mirror and how does the resulting image appear. Students should say that it bounces or is reflected off a mirror and the image seen in the mirror is sharp and clear.
- Ask them what they know about the angle of light reflection when rays hit a shiny, flat surface.
- Query them about what happens to light when it hits an irregular surface. They should indicate that it is spread out (diffused) in many directions, thus making the image blurry or unclear. **SEARCHLIGHT:** Be aware of students who demonstrate an advanced understanding of the concepts. You may want to suggest that they complete one of the extension activities





- Tell students that they will be doing some exploring today with more than one mirror in an effort to make light do what they want it to!
- Assign lab partners.

Pre-assessment
N/A

Teaching and Learning Activities (60 minutes)

1. Give each lab group a copy of the lab worksheet, **Help Me See!**

2. Provide each lab group with their supplies: tape, scissors, two mirrors and a small object like a block.

3. Instruct students to complete the activity **Help Me See!**

4. After students have finished the activity, ask them what they discovered. Were they able to see the block by specifically positioning the mirror?

5. Challenge students with the following task, **Making a Periscope:** Instruct students to place the object on top of the desk and have a volunteer sit under the desk. Tell students that their task is to use their materials to create something that will enable the student under the desk to see the object on top of the desk. Encourage the students to use their own creativity. If a group is stalled, use probing questions to guide them in the right direction. Also see the **Instructions to Build a Periscope Version 1 and Version 2.** They can be used as a handout for students who do not have the skills or insight to create their own version of a periscope.

6. Call upon students to share the devices they constructed.

7. Ask them if the tool they created to see the object on top of the desk is similar to anything they have seen or heard of before. Students should realize that they have made a tool similar to a *periscope*. Tell them that the word periscope comes from two Greek words, ***peri***, meaning "around," and ***scopus***, "to look." A periscope lets you look around walls, corners, or other obstacles. Ask them what uses periscopes and discuss the fact that submarines have

periscopes so the sailors inside can see what's on the surface of the water, even if the ship itself is below the waves.

Products and Assignments

- Students' **What's Light's Angle?**
- Students' shoebox periscopes

Extension Activity

1. (AID) Ask students who show a particular interest in light behavior and its technological applications to investigate how fiber optic cables work and how they are used in industry. They can choose their own mode of presentation of the information and they should be asked to share their findings with their classmates.
2. (AID) Have students who are interested in magic tricks inve some tricks that magicians do that use mirrors to create illu

Post Assessment

N/A

Debriefing and Reflection Opportunities (10 minutes)

Invite students again to share the devices they constructed. Emphasize the idea that light can be manipulated by people to assist in various tasks. Ask them to share what other tools exist that use reflection to assist humans in their various endeavors. Students will probably mention such things as microscopes and telescopes. They may not think of mirrors used to detect things around corners or by magicians in their magic tricks.

Name ________________________________ Date______________

Help Me See!

Place the block on the circle. Use modeling clay or a mirror support to stand a mirror on the line. Use the other mirror to reflect light waves so you will be able to see the block in the mirror standing with the modeling clay.

Block

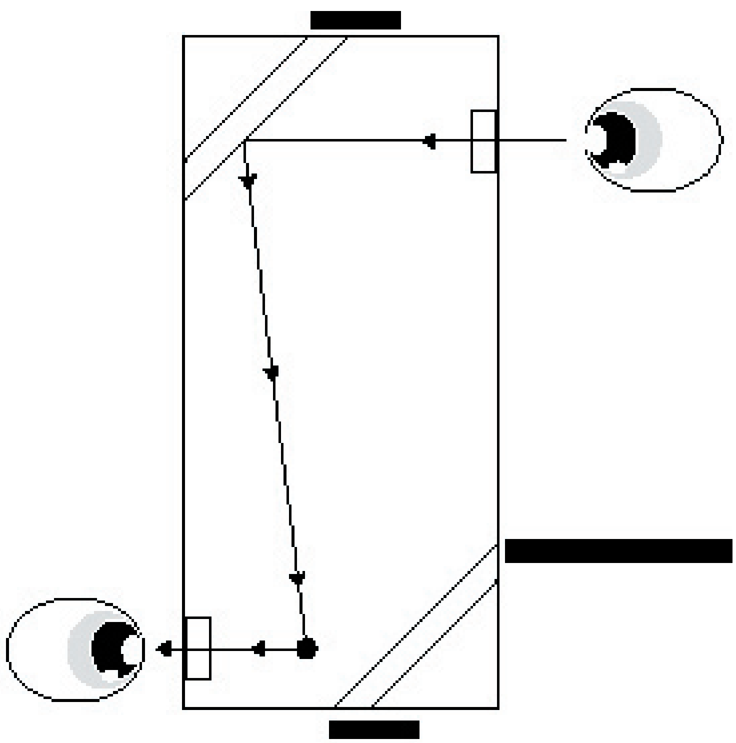
Use molding clay to stand a mirror here. Use the mirror to reflect light waves so you can see the block on this mirror.

Look this direction only!

Name ______________________________ Date __________

Instructions for Building a Periscope – Version 1

1. Cut holes into a shoebox about the size of a quarter.
2. Tape mirrors at 45 degree angles as shown in the diagrams below:



Name ________________________________ Date ______________

Instructions for Building a Periscope – Version 2

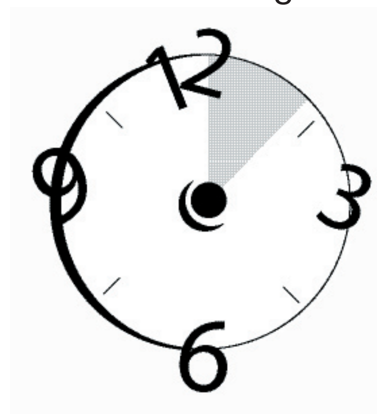
Visit the following website for complete instructions with diagrams:
http://www.sciencetoymaker.org/periscope/When you reach the website, click on the directions for making one or two periscopes.

Using Light's Properties to See Better

Core/AID

Time Allocation: 1 hour, 5 minutes

Required Materials and Resources on Page 225



Lesson Overview

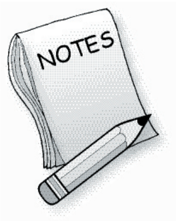
This lesson will further explore the concept of the manipulation of light by investigating the focusing of light in order to see things better. Students will make a "pinhole" camera and explore the nature of images via this device. They will discover the relationship between the amount of light and the clarity of images. In addition, students will explore why things are out of focus at times. By the end of the lesson, they will discover that there is a difference between what they think they see and a "real" image.

Guiding Questions

- Is what the eye detects really what we see?
- How do we use light's properties to improve what we see?

BIG IDEA

The reflective image that strikes our eye is actually inverted.



Content Goals

Universal Theme(s)

- Science involves making hypotheses, theories and conceptual models to represent, explain and predict phenomena.
- Scientific evidence consists of observations and data on which to base scientific explanations.
- Using evidence to understand interactions allows individuals to predict changes.

Principles and Generalizations

- Images of objects can be manipulated by understanding light's properties.
- The reflective image that strikes our eye is actually inverted.
- The human brain inverts images.

Concepts

- Focused and unfocused light
- Inverted image
- Real image

Teacher Information

- Answers to the lab activities are found at the end of the lesson.
- The pinhole in the index card and the pinhole camera make it possible to bring objects closer to your eyes and still keep them in focus. Without the pinhole too much light enters your eyes and the image of what you are looking at becomes increasingly blurry, as you bring the object closer and closer.
- When a pinhole camera is aimed at an object, the only light rays that get from the window to the wax paper "screen," are the ones that go through the pinhole. Because the light only travels in straight lines, the light rays that go through the pinhole continue their straight path. This means that the rays coming from the top of the window scene strike the screen on its bottom and vice versa; the light rays coming from the bottom of the window scene strike the wax paper at its top. The same thing holds true for light that comes from the sides of the window scene. The light from the left side ends up on the right side of the wax paper and vice

versa. This principle means the image that is seen on the wax paper is an inverted and reversed version of the actual scene.

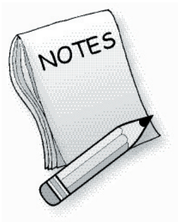
- Light travels in straight lines. In earlier activities students shone their light beamers through small holes in index cards and saw a small "ray" of light continue in a straight line through the hole and hit a surface. That property of light now allows students to create a device that can make an image of a well-lit scene.

Skills

- Predict
- Make observations
- Measurement
- Record data
- Identify characteristics
- Compare and contrast
- See relationships

Materials and Resources

1. Index card (1 per student)
2. Hand held magnifier (1 per student group)
3. Pin (1 per student group)
4. Lamp with a 60 watt bulb in it (optional) (1 per student group)
5. Beeler & Branley. (1957). *Experiments with Light*. New York: Thomas Crowell Company. This text was helpful in designing the activities in the lesson.
6. Elastic bands (2 per student group)
7. Scissors (1 or 2 pair per student group)
8. Wax paper (1 piece per student group)
9. Aluminum foil (1 piece per student group)
10. Paper towel tube or gift wrapping tube (1 per student group)
11. Toilet issue tube (1 per student group)-- Make sure that the toilet tissue tube is wider than the towel or wrapping paper tube so that it will slide over the longer tube.
12. Nautilus eye (pinhole in design) – You can print one at the following website: http://cogsci.bme.hu/~ikovacs/latas2005/prepII-2.html Page down when you get to the website and you will see that figure 2/5 is a great illustration of a nautilus eye.



Preparation Activities

1. Copy the lab activity, **Is Smaller Sometimes Better?** for students.
2. Copy the **Answers to the Questions from the Lab Activity, Is Smaller Sometimes Better?** for yourself.
3. Copy the lab activity, **Using Light to Form Images** for students.
4. Copy the **Answers to Lab Activity, Using Light to Form Images** for yourself.
5. Copy the lab activity, **Pinhole Camera Extension Activity** for students.
6. Make a copy of the Answers to the **Questions from the Pinhole Camera Extension Activity** for yourself.

Introductory Activity (20 minutes)

- Distribute and review the sheet for lab activity, **Is Smaller Sometimes Better?**
- Assign lab partners.
- Circulate among the lab groups as they answer the questions.
- When all of the groups have finished all of the questions, bring the class back together and discuss the answers to the questions. Students will have information about what helps the eye see something clearly, what we call "focused images." Through discussion of the activity's results, students will determine that cutting down the amount of light allows one to bring images closer to the eye and still have them remain in focus. The difference between "focused and unfocused light" should be clearer.

Pre-assessment

N/A

Teaching and Learning Activities (40 minutes)

1. Tell students to proceed with the lab activity, **Using Light to Form Images.**

2. Tell the students that they will be making a pinhole camera.

3. Darken the room as much as possible.

4. When students have finished the lab activity, **Using Light to Form Images,** discuss their results. They should have seen an upside down,

reversed left to right image of the window scene. Print an image from http://www.icapsvitamins.com/media/what-is-sight.gif to show students.

5. Bring out a diagram of the eye of the mollusk nautilus (see #12 under preparations), so that students can see how it resembles a pinhole camera. Discuss the fact the eye is poor at gathering light, so the nautilus is the only organism with this type of simple eye.

Products and Assignments

Students' lab activity, **Help Me See!**

Extension Activity

(AID) For students who need further challenge, encourage them to undertake the lab activity, **Pinhole Camera Extension Activity.**

Post Assessment

N/A

Debriefing and Reflection Opportunities (5 minutes)

When students have finished the lab activity **Using Light to Form Images,** discuss their results. They should have seen an upside down, reversed left to right image of the window scene, with left on right, right on left, and the window upside down. It was much smaller in size (size varies with length of tube), and some students may have seen colors in the scene if enough light was present. The inverted image is formed because light travels in straight lines, and the rays that reflect from the top of the image are angled in such a way that they pass through the pinhole and end up hitting the wax paper on the bottom area of the paper.

Name ______________________________________ Date ________

Is Smaller Sometimes Better?

1. Bring a pin closer and closer to your eyes and describe what happens to the image below:

2. Bring your index finger closer and closer to your eyes and describe what happens to the image below:

3. Put a pinhole in the middle of the index card.
4. Hold the card as close to your face as possible and look through the hole at a pin held in your other hand. Describe how the image of the pin changes as you bring it closer.

5. Repeat this bringing your index finger closer and closer to you. Describe what you see.

6. Go to the lamp in the room and look at the top of the bulb and try and read the writing on it. Then look at the top of the bulb using the pinhole of your index card. Describe the difference in what you see.

7. Why do you think the images changed when you used the index card with a pinhole?

8. When is smaller sometimes better?

Answers to Questions from the Lab Activity, Is Smaller Sometimes Better?

1. Bring a pin closer and closer to you eyes and describe what happens to the image below:

The pin gets larger and blurrier.

2. Bring your index finger closer and closer to your eyes and describe what happens to the image below:

The index finger gets larger and blurrier.

3. Put a pinhole in the middle of the index card.
4. Hold the card as close to your face as possible and look through the hole at a pin held in you other hand. Describe how the image of the pin changes as you bring it closer.

The pin gets larger and larger as it approaches.

5. Repeat this bringing your index finger closer and closer to you. Describe what you see.

The finger gets larger, and the ridges on the finger tip appear to look like small hills.

6. Go to the lamp in the room and look at the top of the bulb and try and read the writing on it. Then look at the top of the bulb using the pinhole of your index card. Describe the difference in what you see below:

The writing is very difficult to read when looking directly at the light bulb. When the pinhole is used, the writing can be read clearly.

7. Why do you think the images changed when you used the index card with a pinhole?

The pinhole reduced the amount of light reaching my eyes so that the image could be seen more clearly by the eye.

8. When is smaller sometimes better?

Smaller is better when you are trying to focus on certain things so you can see them better. A small pin hole in an index card allows us to see things up close, and as a result they are bigger and easier to see. In addition, they remain clear. All this change is a result of cutting down the amount of light that reaches my eyes.

Name ____________________________ Date ________

Using Light to Form Images

1. Cut a 10 cm x 10 cm piece of wax paper and a 10 cm x 10 cm piece of aluminum foil.
2. Take the cut piece of wax paper, wrap it around one end of the longer tube (towel or wrapping paper), so that the paper is smooth over the end and hold it there with an elastic band.
3. Take the cut piece of aluminum foil, wrap it around the end of the toilet tissue tube so that the foil is smooth over the end and hold it there with an elastic band.
4. Take the pin and carefully make a very small hole in the center of the aluminum foil at the end of the tube. Make only **one** hole.
5. Slide the toilet tissue tube over the longer tube.
6. Before you look out the window through the pinhole in the aluminum foil, draw what you think will appear on the wax paper. Do not worry about your drawing skills; just make a sketch of the major objects that you see out the window

7. Describe what you **actually** see on the wax paper below, being careful to notice as many details as you can.

8. Extra Credit: Knowing light travels in straight lines, and the light in the image you saw in your "pinhole camera" came from the scene you could see without the camera, **draw a diagram** to show how the light from several points in the real scene traveled from the real scene to form the image on the wax paper.

Answers to the Questions from the Lab Activity, Using Light to Form Images

1. Cut a 10 cm x 10 cm piece of wax paper and a 10 cm x 10 cm piece of aluminum foil.
2. Take the cut piece of wax paper, wrap it around one end of the longer tube (towel or wrapping paper), so that the paper is smooth over the end and hold it there with an elastic band.
3. Take the cut piece of aluminum foil, wrap it around the end of the toilet tissue tube so that the foil is smooth over the end and hold it there with an elastic band.
4. Take the pin and carefully make a very small hole in the center of the aluminum foil at the end of the tube. Make only **one** hole.
5. Slide the toilet tissue tube over the longer tube.
6. Before you look out the window through the pinhole in the aluminum foil, draw what you think will appear on the wax paper. Do not worry about your drawing skills just make a sketch of the major objects that you see out the window

Students will probably draw the image as it appears to them, when in fact, they will soon find out the image is actually inverted. They will soon realize that the image the eye picks up, the actual or real image, is always inverted.

7. Describe what you **actually** see on the wax paper below, being careful to notice as many details as you can.

When student s look at the wax paper end of the tube, they should be able to discern an upside down, reversed left to right image of the window scene, with left on right, right on left, and the window upside down. It will be much smaller in size (size varies with length of tube) and may show the colors in the scene if enough light is present.

8. Extra Credit: You know light travels in straight lines. You also know that the light in the image you saw in your "pinhole camera" came from the scene you could see without the camera. **Draw a diagram** to show how the light from several points in the real scene traveled from the real scene to form the image on the wax paper in your pinhole camera.

Student diagrams should show the object on one side with straight lines running from each point on the object through the hole in the pinhole camera to that point in the image. As all the light "rays" pass through one point, the image is reversed top to bottom and left to right. More specifically, the rays coming from the top of the window scene strike the screen on its bottom and vice versa, the light rays coming from the bottom of the window scene strike the wax paper at its top. The same thing holds true for light that comes from the sides of the window scene. The light from the left side ends up on the right side of the wax paper and vice versa. This means the image that is seen on the wax paper is an inverted and reversed version of the actual scene.

Name ______________________________ Date__________

Pinhole Camera Extension Activity

1. Make the pinhole in the aluminum foil a little bit bigger. Write a description of what happens to the image as the hole gets bigger.

2. What happens as you increase the distance between the inner tube's wax paper (pull inner tube out) and the pinhole end of the tube? Explain why you think this happens.

3. What would happen if the lights in the room were turned on? Try it and see and then explain why you think that happened.

Answers to the Questions from the Pinhole Camera Extension Activity

1. Make the pinhole in the aluminum foil a little bit bigger. Write a description of what happens to the image as the hole gets bigger.

The image should get fuzzier, as the light from each point on the object can illuminate a larger point on the image, thus overlapping other points and making the image less focused (fuzzier).

2. What happens as you increase the distance between the inner tube's wax paper (pull inner tube out) and the pinhole end of the tube? Explain why you think this happens.

A longer tube will create a larger image on the wax paper. The image is larger because the rays can spread out more when making the image.

3. What would happen if the lights in the room were turned on? Try it and see and then explain why you think that happened.

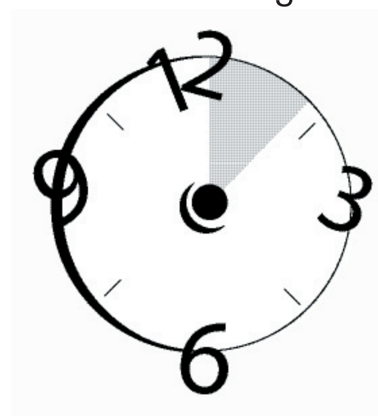
With the room lights on, it is much harder to see the image. The image is "seeable" based upon contrast of intensities. The pinhole camera is viewing an object that is giving off a limited amount of light; when the room lights are on, the image light on the wax paper is not as bright as the light reflected off the wax paper from the room lights. It is similar to viewing a match lit on the stage in a theater; if the house and stage lights are all off and the room is in total darkness, the match looks very bright. But if the house lights and/or stage lights are brightly lit, the candle may not even be visible as the amount of light given off by the candle flame is small compared to the stage lights.

Using Light's Properties to See Better

Core

Time Allocation: 1 hour, 10 minutes

Required Materials and Resources on Page 225



Lesson Overview

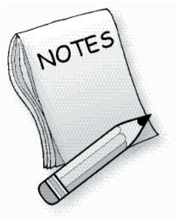
Students will review the concept of focused and unfocused light with an introductory activity. The lesson will continue with the idea that tools can be created that help us to capture images by using light's behaviors. Students will examine how lenses change what we see and how they can be used to make a lens camera. Either through demonstration or through small group student exploration, students will compare the structure and function of a lens camera to a "pinhole camera" and to the human eye. One goal is for students is to define for themselves what focused or "out-of-focus" means and to relate the focusing of images to varying distances between the lens and an image. In addition, the lesson further helps the students observe that the image with a lens is brighter than the image produced by the pinhole, but it is still reversed and inverted.

Guiding Questions

- Is what the eye detects really what we see?
- How do we use light's properties to improve what we see?

BIG IDEA

Focused and unfocused light



Content Goals

Universal Theme(s)

- Science involves making hypotheses, theories and conceptual models to represent, explain and predict phenomena.
- Scientific evidence consists of observations and data on which to base scientific explanations.
- Using evidence to understand interactions allows individuals to predict changes.
- Properties of some objects and processes are characterized by change.
- Form and function are interdependent.

Principles and Generalizations

- Images of objects can be manipulated by understanding light's properties.
- The reflective image that hits our eye is actually inverted.
- The human brain inverts images.
- Models help us visualize things we cannot ordinarily see.

Concepts

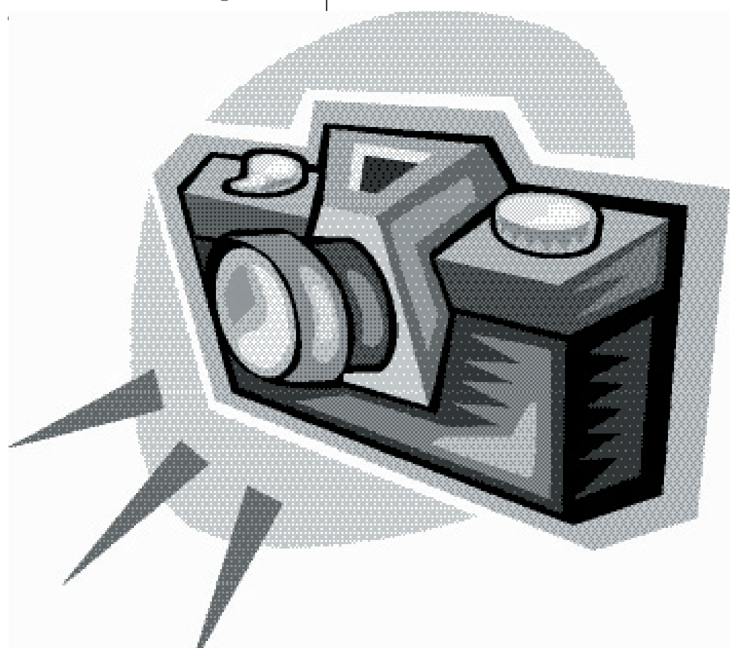
- Focused and unfocused light
- Inverted image
- Real image
- Model

Teacher Information

- When students first move the lens away from the paper, they should see a crisp, accurate image of the print. This image is "focused." However, when they move the hand-held lens too far from the sheet, the image becomes fuzzy. This image is called "unfocused" or "out of focus." Answers to the lab activities are found below.
- The pinhole in the index card and the pinhole camera make it possible to bring objects closer to your eyes and still keep them in focus. Without the pinhole too much light enters your eyes and the image of what you are looking at becomes increasingly blurry, as you bring the object closer and closer.

Using Light's Properties to See Better

- A single lens camera is similar to the pinhole camera, except that the pinhole is replaced with a single lens and uses two paper tubes, one with a slit up its side so you can slide the two tubes together or apart to adjust the distance between the lens and the image.
- The focal distance of a lens is the distance between a lens and an image that is exactly in focus. Sometimes the term used is '

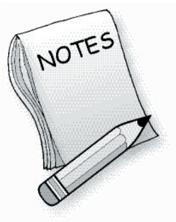


Skills

- Predict
- Make observations
- Measure
- Record data
- Identify characteristics
- Compare and contrast
- See relationships

Materials and Resources

1. Hand held magnifier (1 per student group)
2. White paper (1 piece per student group)
3. Flashlight for demonstration
4. Matches
5. Lamp with a 60 watt bulb in it (optional) (1 per student group)
6. Beeler & Branley. (1957). *Experiments with light*. New York: Thomas Y. Crowell Company. This book was helpful in designing the activities in this lesson.
7. Single lenses (one for each single lens camera that is constructed)
8. Wax paper (one piece per single lens camera)
9. Paper towel tube or gift wrapping tubes (for teacher demonstration)
10. Scissors (for teacher demonstration)
11. Scotch tape
12. Masking tape
13. Paper towel tubes or gift wrapping tubes (one per single lens camera)
14. Toilet issue tube (one per single lens camera). Make sure that one tube can fit inside the other. Usually the paper towel or toilet paper tube fits inside the gift wrapping paper tube.



Preparation Activities

1. Copy the lab activity, **A Lens in Motion Creates Some Commotion!** for students.
2. Copy **Answers to the Questions from the Lab Activity, a Lens in Motion Creates Some Commotion!**

Set up the teacher demonstration single lens camera that is out of focus to start because of the long length of the tube as follows:

- Scotch tape the wax paper onto one end of a paper towel tube.
- Smooth down the edges of the wax paper and tape by running a ring of masking tape around the bottom of the taped wax paper edges.
- Scotch tape a single lens onto one end of the wrapping paper tube.
- Place the paper towel tube into a long gift wrapping tube.

4. Copy and use the instructions for **Building and/or Using a Lens Camera** to make the single lens cameras ahead of time or give a pair of students the instructions so that they can construct their own camera.
5. Copy **Answers to the Questions from the Lab Activity, Building and/or Using a Lens Camera.**

Introductory Activity (25 minutes)

- Collect students' lab sheets, **Is Smaller Sometimes Better?** and **Using Light to Form Images.**
- In order to review the concept of focused and unfocused light, tell students in the next activity that they will be taking a hand lens and looking through it at a small object at different distances.
- Assign students to lab groups.
- Distribute a handheld lens and the lab activity sheet, **A Lens in Motion Creates Some Commotion!**
- Tell students to write their observations on the lab sheet.
- After they finish this short activity, ask students to share their results. Students should see that when the hand-held lens is held in direct contact with the print on the paper, the image is almost the same as without the lens. As the lens is lifted away from the paper, the image of the letters enlarges, and then gets blurry.
- Distribute a piece of white paper to each group and a flashlight if there is no window available to each group.

- Darken the room as much as possible.
- Tell students to go to a window or use a flashlight as a light source and focus light in a darkened room through the lens onto a piece of paper until they get a clear image.
- After they all have established this image, ask them what would they call the distance between the lens and the paper when the image is clear. Lead students to the scientific term for that distance, the **focal distance** or **focal length.**
- Tell them to **measure this distance,** as it will be used during the following lab activity.
- As a demonstration, take a flashlight and adjust it to the finest beam you can get. Have a student hold a hand-lens in the path of the light. Have another student blow smoke into a region around the light and lens. The light will be brought to a pinpoint somewhere beyond the lens, about one foot if a reading glass is used. This is called the **focal point** of a lens.
- These words are not to be memorized or tested but are to be used by you as the teacher, as they are scientific terms with which, over time, students should become familiar.
- Do another demonstration using a full-length paper towel and one gift wrapping tube.
- Tell students they will be building a "lens camera" in the next activity and comparing its structure and function to the "pinhole camera" previously built.

Pre-assessment

N/A

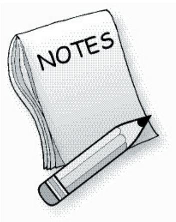
Teaching and Learning Activities (40 minutes)

1. Distribute the instructions for **Building and Using a Lens Camera** to each group.

2. Discuss the answers to the three questions for the lab.

Products and Assignments

- Students' lab activity sheets, **Is Smaller Sometimes Better?**
- Students' lab activity sheets **Using Light to Form Images**



Extension Activity

N/A

Post Assessment

N/A

Debriefing and Reflection Opportunities (5 minutes)

Ask students to share their results of the lab activity.

Name ______________________________ Date ________

A Lens in Motion Creates Some Commotion!

1. Describe what you see when you hold the lens close to the object.

2. Describe what you see when you pull the lens farther away from the object.

3. Why do you think the object changes in its appearance?

Name ____________________________________ Date ________

Answers to Questions from the Lab Activity A Lens in Motion Creates Some Commotion!

1. Describe what you see when you hold the lens close to the object.

It looks sharp, clear and about the same size.

2. Describe what you see when you pull the lens farther away from the object.

The object gets larger, then gets blurry.

3. Why do you think the object changes in its appearance?

When the image is focused, all the light from a point on the object shines on one spot in the image. When the image is out of focus, the light from one spot is spread out over a larger area, thus "fuzzing" up the image by blending the points of the image together.

Name ______________________________ Date ________

Building and Using a Lens Camera

Instructions:

1. Get two tubes, one that can fit inside the other.
2. Cut the first tube so that it is 11 cm (about 4 1/2 inches) long.
3. Cut the second tube which is wider (has a larger diameter than the first) so it is 10 cm (about 4 inches) in length.
4. Using scotch tape, tape your lens to the end of the first tube that is wider.
5. Cut a 10 cm x 10 cm piece of wax paper and wrap it around one end of the second tube (narrower tube), holding it in place with the Scotch tape.
6. Run a ring of masking tape around the outside of the wax paper edges in order to smooth the area so it slides easier into the first tube.
7. Squeeze the second tube a bit and insert it into the open end of the first tube.
8. Point the lens end of this camera at the window and look at the wax paper end. Adjust the position of the two tubes, making the camera longer or shorter until you can make the image on the wax paper focused.

Observations:

1. Compare the image made in the wax paper from the "pinhole camera" to the image in the wax paper made by the "lens camera." Describe what you see.

2. Describe as many differences as you can. Explain why the differences exist in what the images look like using the pinhole versus the lens camera.

3. Point your lens camera at another object, either further away or closer. Adjust your lens camera to make the image as "focused" as you can. What must you do to make it focused as you "look" at objects that are at different distances away?

Name ______________________________ Date ________

Answers to the Questions from the Lab Activity, Building a Lens Camera

Instructions:

1. Get two tubes, one that can fit inside the other.
2. Cut the first tube so that it is 11 cm (about 4 1/2 inches) long.
3. Cut the second tube which is wider (has a larger diameter than the first) so it is 10 cm (about 4 inches) in length.
4. Using scotch tape, tape your lens to the end of the first tube that is wider.
5. Cut a 10 cm x 10 cm piece of wax paper and wrap it around one end of the second tube (narrower tube), holding it in place with the scotch tape.
6. Run a ring of masking tape around the outside of the wax paper edges in order to smooth the area so it slides easier into the first tube.
7. Squeeze the second tube a bit and insert it into the open end of the first tube.
8. Point the lens end of this camera at the window and look at the wax paper end. Adjust the position of the two tubes, making the camera longer or shorter until you can make the image on the wax paper focused.

Observations:

1. Compare the image made in the wax paper from the "pinhole camera" to the image in the wax paper made by the "lens camera." Describe what you see.

The image is reversed and upside down, similar to the image we saw in the pinhole camera.

2. Describe as many differences as you can. Explain why the differences exist in what the images look like using the pinhole versus the lens camera.

The image is brighter because more light came through the lens than could come through the pinhole. However, the image only forms clearly (in focus) at one distance, unlike the pinhole camera.

3. Point your lens camera at another object, either further away or closer. Adjust your lens camera to make the image as "focused" as you can. What must you do to make it focused as you "look" at objects that are at different distances away?

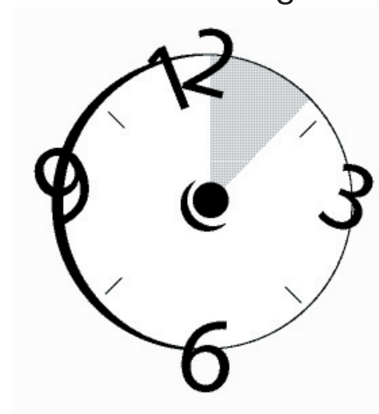
When the object is further away, the image screen must be brought closer to the lens to keep it focused, and the image is smaller. When the object is closer, the image screen must be moved farther away to keep it focused, and the image is larger.

Using Light's Properties to See Better

Core

Time Allocation: 50 minutes

Required Materials and Resources on Page 225



Lesson Overview

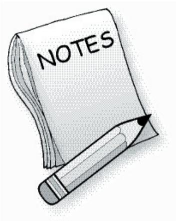
This lesson will explore how lenses can be used to manipulate images for our benefit. Students will investigate how a scene changes in appearance depending on its distance from a lens. They will begin to understand the connection between this relationship and its application in such technologies as cameras and telescopes.

Guiding Questions

- How do we use light's properties to improve what we see?

BIG IDEA

Lenses change the way we see things.



Content Goals

Universal Theme(s)

Scientific evidence consists of observations and data on which to base scientific explanations.

Principles and Generalizations

- Clear images can be intentionally produced using light's properties.
- The reflected image we see is inverted.
- Light can be focused using lenses.
- Lenses change the way we see things.

Concepts

- Focused and unfocused light
- Inverted image
- Lens

Teacher Information

- Answers to the lab activity are found below:
- An image will be in focus at a distance beyond a lens that is equal to the distance the object is in front of the lens.
- When a lens is placed at twice the focal distance, the focused image will appear the same size as the object and inverted.
- When a lens is placed beyond twice the focal distance, the focused image will appear smaller and inverted.
- When an object is placed between twice the focal distance and the focal point, the focused image will appear larger and inverted.
- When an object is placed between the focal point and the lens, the image does not appear on the screen (paper) at all but can be seen if you look through the lens directly at the object. You will see not only the object but its image. The image is larger and right side up.

Skills

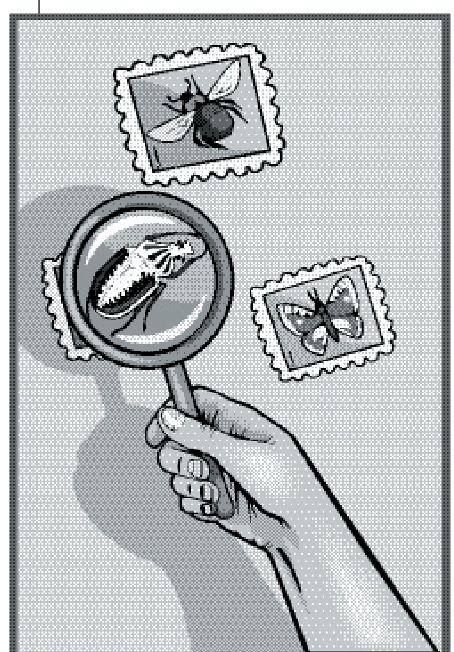
- Make observations
- Measure

Using Light's Properties to See Better

- Record data
- Identify characteristics
- Compare and contrast
- See relationships

Materials and Resources

1. A bucket of sand readily available to be used to put out a small fire as a safety precaution
2. Beeler & Branley. (1957). *Experiment with light*. New York: Thomas Crowell Company. This book has excellent drawings of the images produced by objects positioned at varying distances from a handheld lens.
3. Handheld lens (reading glass) (1 per student group)
4. White paper (1 sheet per student group)
5. One good flashlight with a beam adjuster so that the beam can be made more intense.
6. Butcher paper or newspaper (enough to cover the area where students will set up their candle, lens and white paper.
7. Pen or pencil
8. Metric ruler (1 per student group)
9. Candle or a Maglite flashlight that can be used as a candle (1 per student group)
10. Matches (1 box or book per student group)
11. Dunkin' Donut small paper cup or equivalent size (1 per student group)

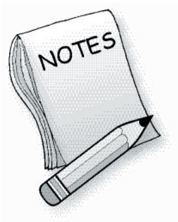


Preparation Activities

Copy the lab activity, **Let's Focus on Lenses** for students.

Introductory Activity (10 minutes)

- Collect the lab worksheets, **A Lens in Motion Creates Some Commotion!** and the lab sheets from **Building and/or Using a Lens Camera.**
- Tell students to get out their hand lenses and the measurements of the focal distance that they determined yesterday for their lens.
- Review what is meant by focal point for an image and the focal distance for a lens by asking students for their definitions.



Pre-assessment
N/A

Teaching and Learning Activities (35 minutes)

1. Tell the students that they will be exploring images and their focal points and distances in the next activity called **Let's Focus on Lenses.**

2. Distribute and review the sheet for lab activity, **Let's Focus on Lenses.**

3. Circulate among the lab groups as they conduct the lab and answer the questions.

4. Remind students to do the homework assignment (#18 **Let's Focus on Lenses**) that will be collected tomorrow.

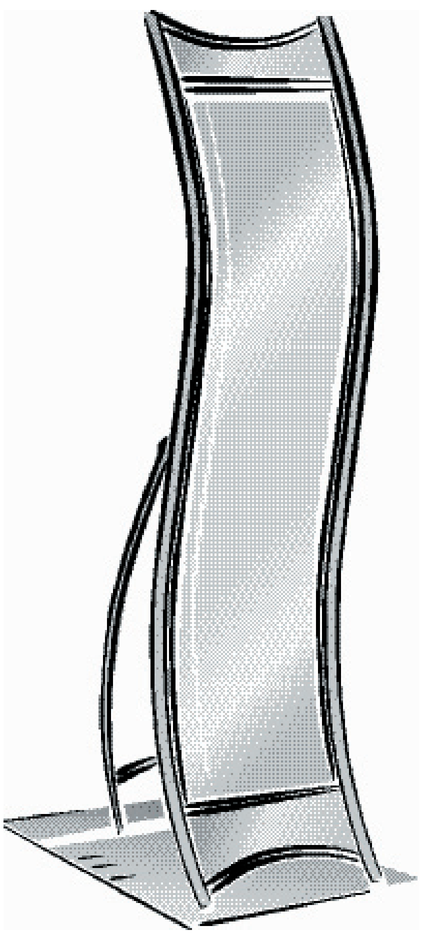
Products and Assignments

- Students' sheets from the lab activities, **A Lens in Motion Creates Some Commotion!** and **Building and/or Using a Lens Camera.**
- Remind the students about looking in a mirror at their image at home.

Extension Activities
N/A

Post Assessment
N/A

Debriefing and Reflection Opportunities (5 minutes)
Remind students to do the homework assignment (#18 on **Let's Focus on Lenses**) Tell them to think of the lab activity that was done today, as they answer the homework question regarding the appearance of the image in the mirror at home.



Name ___________________________________ Date ________

Let’s Focus on Lenses

1. Lay butcher or newspaper across the length of your table.
2. Turn a small paper cup upside down and use a pencil or pen to poke a hole in its center.
3. Place the small paper cup in the center of your work table.
4. Set the hand lens in an upright position into the hole of the small paper cup to hold the lens erect.
5. Place a lighted candle or a Maglite flashlight that can be used as a candle, **two times** the focal distance from the lens. Use the distance you measured yesterday.
6. Take a piece of white paper and hold it on the other side of the lens, opposite the candle. Visit the following website to see how this will look: http://www.doitpoms.ac.uk/tlplib/DD1-6/images/diagram10.gif . The image and the object in this case will both be the candle.

7. Move the paper back and forth until the image is clearly in focus.
8. Mark the spot where the image was clear with a pen or pencil.
9. Describe what the image looks like below, including its size:

10. Measure the distance from the lens to the spot you marked on the paper where the image was the sharpest.

a. Distance from lens to image on paper = ___________ cm

b. How does the distance from the lens to the image compare to the distance between the lighted candle and the lens?

Name ______________________________ Date _______

11. Move the candle 6-8 cm further away from the lens. What happens to the image?

12. Move the piece of paper toward the lens until the candle appears sharply on the paper. What happens to the size of the image?

13. What technology have you seen or used that has a lens that captures smaller images of scenes for you and allows you to preserve them on paper?

14. What technology have you seen that has a lens that makes images larger for you and allows many people in a room to view the image at one time?

15. Place the candle at a spot halfway between the lens and the focal distance.

16. Hold up the paper on the other side of the lens. Do you see any image?

17. Look through the lens at the candle. Describe what you see.

18. For homework go home and stand about 4-6 feet from a mirror (a long mirror would be better for this). Look at the image in the mirror and describe its location "behind the mirror" by comparing it to your location in front of the mirror.

Answers to Questions from the Lab, Let's Focus on Lenses

1. Lay butcher or newspaper across the length of your table.
2. Turn a small paper cup upside down and use a pencil or pen to poke a hole in its center.
3. Place the small paper cup in the center of your work table.
4. Set the hand lens in an upright position into the hole of the small paper cup to hold the lens erect.
5. Place a lighted candle or a Maglite flashlight that can be used as a candle, **two times** the focal distance from the lens. Use the distance you measured yesterday.
6. Take a piece of white paper and hold it on the other side of the lens, opposite the candle.
7. Move the paper back and forth until the image is clearly in focus.
8. Mark that spot with a pen or pencil.
9. Describe what the image looks like below, including its size:

The image is inverted and appears to be the same size as the candle.

10. Measure the distance from the lens to the spot you marked on the paper where the image was the sharpest.

a. Distance from lens to image on paper = ____________ cm

b. How does the distance from the lens to the image compare to the distance between the lighted candle and the lens?

They are the same.

11. Move the candle 6-8 cm further away from the lens. Move the paper until the image is focused. What happens to the image?

The image gets smaller and inverted.

12. Put the candle back to its original position and then move it 6-8 cm closer to the lens. Move the paper until the image is focused. What happens to the image?

The image gets larger and inverted.

13. What technology have you seen or used that has a lens that captures smaller images of scenes for you and allows you to preserve them on paper?

Camera

14. What technology have you seen that has a lens that makes images larger for you and allows many people to view the image at one time?

Projector

15. Place the candle at a spot halfway between the lens and the focal distance.
16. Hold up the paper on the other side of the lens. Do you see any image?

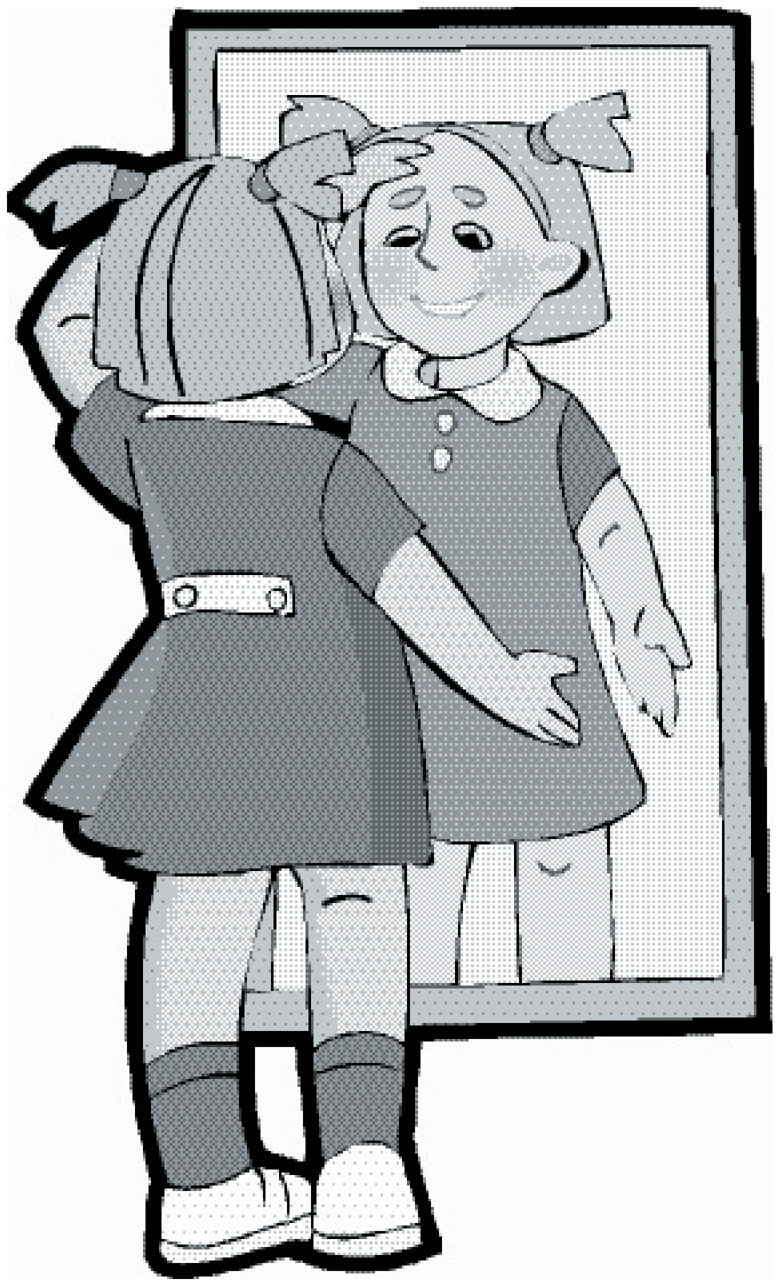
No

17. Look through the lens at the candle. Describe what you see.

The candle image is larger and right side up.

18. For homework go home and stand about 4-6 feet from a mirror (a long mirror would be better for this). Look at your image in the mirror and describe its location "behind the mirror" by comparing it to your location in front of the mirror.

The image appears to be as far behind the mirror as I was standing away from the mirror.

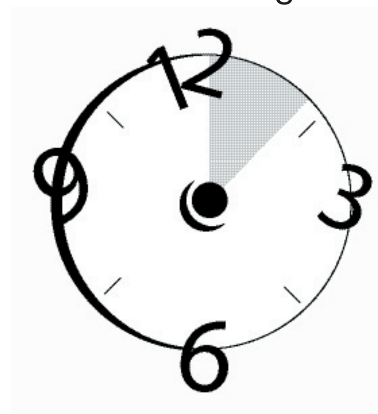


Using Light's Properties to See Better

Core/AID

Time Allocation: 1 hour

Required Materials and Resources on Page 225



Lesson Overview

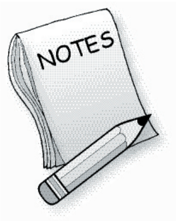
This lesson will start the exploration of the human eye by seeing what happens to images as they enter the eye and hit its lens. Students will actually be describing images seen in their partner's eye called Purkinje images. As a result of this examination, they will secure evidence for the existence of something that moves the lens, the iris.

Guiding Questions

- How do we use light's properties to improve what we see?

BIG IDEA

Exploring the human eye



Content Goals

Universal Theme(s)

Scientific evidence consists of observations and data on which to base scientific explanations.

Principles and Generalizations

- Clear images can be intentionally produced using light's properties.
- The reflected image we see is inverted.
- Light can be focused using lenses.
- Lenses change the way we see things.

Concepts

- Focused and unfocused light
- Inverted image
- Lens

Teacher Information

- Answers to the lab activities are found below:
- Images are clarified if the light is sent through a pinhole. However, the drawback of this method is that there is often insufficient light so the image is dim. If the pinhole is enlarged, more light is gathered but the image becomes blurry. The rays from each point on the object pass through different parts of the hole and reach different parts of the screen, thus spreading out (blurring) the image of that point.
- An image will be in focus at a distance beyond a lens that is equal to the distance the object is in front of the lens.
- Humans can see better in dim light because they have eye lenses that focus the light and thus increase its intensity. This is a significant advantage over other organisms, such as the nautilus that has an "eye" similar to a pinhole camera.
- The images formed in each of the lab partner's eyes are called Purkinje images. It is not important for students to know this term, but if any student wants to read more about these images, of which there are four, giving them the proper scientific name for these images will enable them

to get more information readily. The images are a result of reflections off the cornea's front and back surfaces and reflections off the front and back surfaces of the eye's lens.

- The colored part of the eye is called the iris. It controls light levels inside the eye similar to the aperture on a camera. The round opening in the center of the iris is called the pupil. The iris is embedded with tiny muscles that dilate (widen) and constrict (narrow) the pupil size.

Skills

- Make observations
- Measure distance
- Record data
- Identify characteristics
- Compare and contrast
- See relationships

Materials and Resources

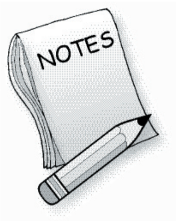
1. A bucket of sand readily available to be used to put out a small fire as a safety precaution
2. Candle (one per student group)
3. Matches (box or book per student group)
4. Meter stick (one per student group)
5. Falk, David, Brill, Dieter & Stork, David. (1986). *Seeing the Light Optics in Nature, Photography, Color, Vision, and Holography*. New York: Harper and Rowe. The lab, **Keep an Eye on an Eye** is based on an activity found in this book.

Preparation Activities

Copy the lab activity, **Keep an Eye on an Eye** for students.

Introductory Activity (15 minutes)

- Collect the lab sheets, **Let's Focus on Lenses** that include students' homework answers.
- Call upon student volunteers to describe where their image appeared to be located in the mirror. Students should have seen that the image appeared to be as far behind the mirror as he or she was standing in front



of the mirror. In other words they should have seen that the two distances were equal.

- Ask the students what they think this distance is called -- either the distance from them to the mirror or the distance behind the mirror to where the image appears. If they have trouble with recognizing that this is the focal distance, remind them about yesterday's lab activities where they saw that the image of the candle was best in focus at the same distance as the candle itself was from the lens.
- Tell students to take their finger and press lightly against the eye next to the nose and look straight ahead. Ask them to look for a black circle. Where do they see it? They should see the circle on the opposite side of the eye. The reason students see a black spot opposite to where they touched their eye lid is because the gentle finger pressure restricts blood flow in the retina at that position and the retinal cells cannot respond. The dark spot that is seen near the ear results because the image on the retina is inverted. Light from the side near your ear is imaged on the retina near your nose, so students see a black spot toward the outside area, not the inside where they pressed.
- Assign students to lab groups.

Pre-assessment

N/A

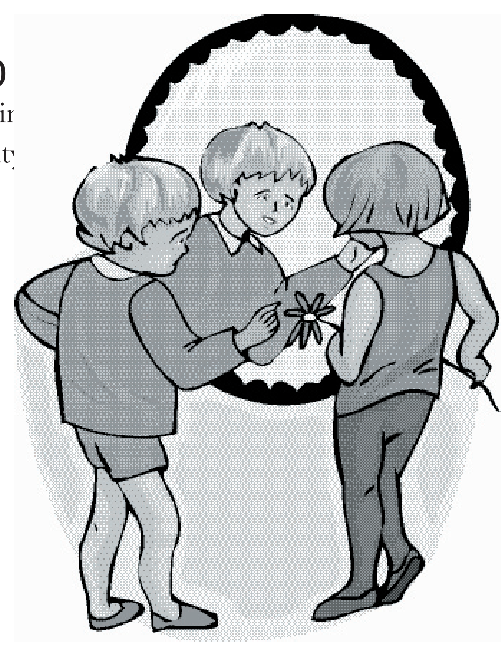
Teaching and Learning Activities (40 minutes)

1. Tell the students that they will be exploring and how we see by engaging in an activity called **Keep an Eye on an Eye.**

2. Distribute and review the sheet for lab activity.

3. Darken the room.

4. Have each lab group get a candle and matches and tell them to separate from each other. Remind them to be careful with the matches and point out where the bucket of sand is located.



5. Circulate among the groups as they conduct the lab.

6. After they complete the activity, have students share their results.

7. Tell them you will be collecting their worksheets tomorrow and they should finish writing the answers for homework if necessary.

Products and Assignments

Students' sheets from the lab activities, **Let's Focus on Lenses**

Extension Activities

(AID) For students who need further challenge, inform them that the images they studied in their partner's eye are called Purkinje images. Tell them to find out how many images there are and exactly how they are formed.

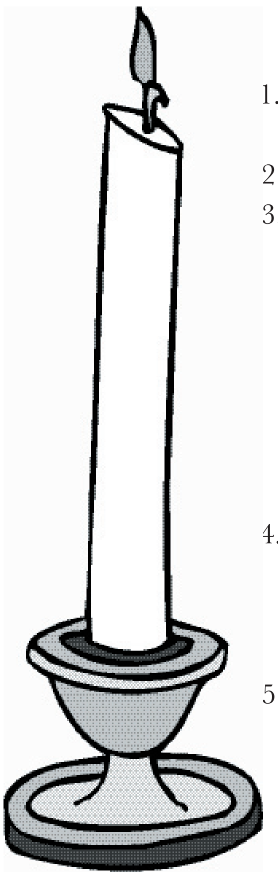
Post Assessment

N/A

Debriefing and Reflection Opportunities (5 minutes)

1. Call upon students to share their results of the lab activity.
2. Make sure to discuss question #7 and state that this evidence seems to indicate that some part of the eye is able to move the lens. Ask students if anyone has an idea as to what that part may be. If they do not know, it is fine because the connection to the iris and its function will be made clear in later lessons.

Name ___________________________________ Date ________



Keep an Eye on an Eye

1. Hold a lit candle about 1/2 meter from your partner's eye. Make sure the candle is held slightly to the side of your partner's gaze.
2. Look carefully at your partner's eye.
3. Describe what you see below, making sure to include quantity, size and the color of anything you see.

4. Tell your partner to look at your ear and describe what happens to the image(s) in the eye.

5. After one of you has looked in the other's eye, switch roles so that each of you has a chance to look into one another's eye.

6. What do you think is reflecting these images back to your eye?

7. If you saw any of the image(s) move after you were asked to look at your partner's ear, what might have cause it to move?

Answers to Questions from the Lab Activity, Keep an Eye on an Eye

1. Hold a lit candle about 1/2 meter from your partner's eye. Make sure the candle is held slightly to the side of your partner's gaze.
2. Look carefully at your partner's eye.
3. Describe what you see below making sure to include quantity, size and the color of anything you see.

There are three images of the candle. The first is brighter than the other two. It is smaller than the real candle and it is upright like the candle. The second image is similar to the first except it is dimmer. The third image is blurred and inverted.

4. Tell your partner to look at your ear and describe what happens to the image(s) in the eye.

The third image moves.

5. After one of you has looked in the other's eye, switch roles so that each of you has a chance to look into one another's eye.

6. What do you think is reflecting these images back to your eye?

Students may answer in general ways such as "parts of the eye" or more specifically by identifying the parts, such as "the lens of the eye probably reflects the candle image."

7. If you saw any of the image(s) move after you were asked to look at your partner's ear, what might have cause it to move?

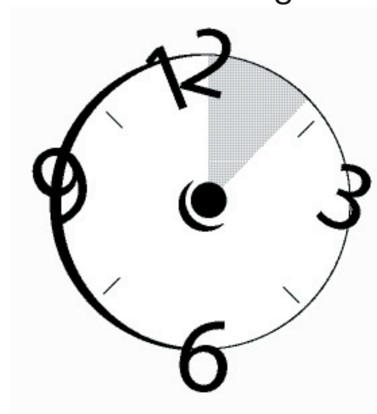
Students may answer in general ways such as "part of the eye must have moved" or more specifically by identifying a specific part that moved, such as "the lens of the eye probably moved" or "some muscle in the eye moved."

Using Light's Properties to See Better

Core

Time Allocation: 55 minutes

Required Materials and Resources on Page 225



Lesson Overview

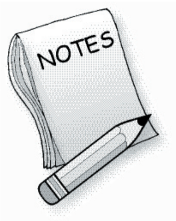
The lesson begins with a pre-assessment to see what students know about the structure of the eye. This information enables the teacher to recognize what terms can and cannot be used during the remainder of the lesson in which students examine the nature of how the eye handles light. Students will ultimately be able to see the similarity between the lens of a camera and that of a human eye.

Guiding Questions

- How does an eye adjust to light?
- Is an eye like a camera?

BIG IDEA

Structure of the human eye



Content Goals

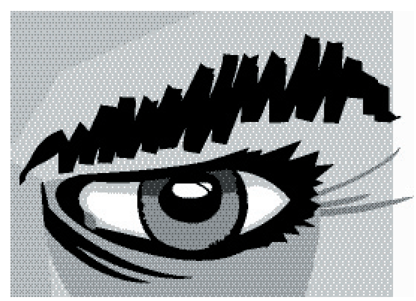
Universal Theme(s)
Scientific evidence consists of observations and data on which to base scientific explanations.

Principles and Generalizations
- Eyes have parts that have particular functions in the vision process.
- An eye operates in a similar fashion to a camera

Concepts
- Vision
- Structure and function of eye parts

Teacher Information
Pupils always widen and narrow together, which explains the observations made in Step #5 of the **Lab Activity, Keep an Eye on an Eye Revisited.**

Skills
- Make observations
- Identify characteristics
- Compare and contrast
- See relationships



Materials and Resources
1. Pencil (1 per student)
2. *Eye Analyzer* (1 per student group –see Preparation Activities below)
   - Poster board
   - Cardboard tubes
   - Pocket mirrors 4” by 4”
   - Tape
3. Diagram, transparency or projected computer image of the structure of an eye http://www.nei.nih.gov/health/eyediagram/images/diagram.gif
4. Diagram of a simple camera: http://www.phys.ufl.edu/~avery/course/3400/camera/eb_camera_screen.gif

5. Falk, David, Brill, Dieter & Stork, David. (1986). *Seeing the Light Optics in Nature, Photography, Color, Vision and Holography.* New York: Harper and Rowe. The demonstration ideas are based on an activity found in this book.

Preparation Activities

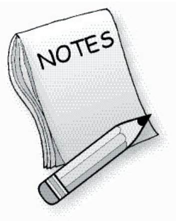
1. Make the *eye analyzers* by cutting 12" by 12" poster board squares (measurements do not have to be exact), one for each lab group that you have. Parents could be helpful in constructing these.
2. Place a cardboard tube (paper towel or wrapping paper tube cut in half) on the side of the poster board near an edge. You will be creating a hole for the tube to slide into by drawing a circle around the perimeter of the tube. Cut out the circle and insert the tube.
3. Attach a small pocket mirror to each using tape.
4. Print the diagrams of both the eye (#3 under materials) and the camera (#4 under materials) You will have to cover the correct part names on the diagrams. Using these diagrams, prepare the pre-assessment, **Eye-dentify These Parts if You Can and It's Okay if You Can't!**
5. Copy the lab activity, **Keep an Eye on an Eye Revisited** for each student.

Introductory Activity (10 minutes)

- Collect the students' worksheets from the lab activity, **Keep an Eye on an Eye.**
- Distribute the pre-assessment activity, **Eye-dentify These Parts if You Can and It's Okay if You Can't!**
- Explain the purpose of the pre-assessment to students and assure them that if they do not know any of the parts, it is fine.
- Instruct them to use pencil, so if any of their answers are incorrect, they can fix them later.
- After five minutes, collect the pre-assessment.
- Assign students to lab groups.

Pre-assessment

Eye-dentify These Parts if You Can and It's Okay if You Can't!



Teaching and Learning Activities (40 minutes)

1. Explain to students that they will be exploring what and how we see in an activity called **Keep an Eye on an Eye Revisited.**

2. Have each lab group get an *Eye Analyzer* and review the instructions for the lab activity, **Keep an Eye on an Eye Revisited.**

3. Distribute and review the sheet for lab activity.

4. Circulate among the groups as they conduct the lab.

5. Reconvene the class and discuss the students' observations and tell them to finish answering the questions for homework.

6. Redistribute the student diagrams of the eye and the camera and tell them to finish labeling these diagrams using book or Internet resources, friends, family or whatever it takes to fill in the diagrams.

Products and Assignments

- Students' sheets from the lab activities, **Keep an Eye on an Eye**
- Students will be assigned for homework to complete and/or correct the worksheet, **Eye-dentify These Parts if You Can and It's Okay if You Can't!** using any resources they choose.

Extension Activities

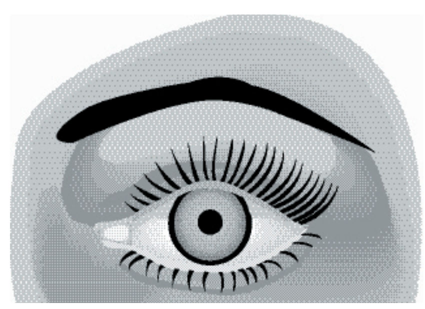
N/A

Post Assessment

N/A

Debriefing and Reflection Opportunities (5 minutes)

Reconvene the class and discuss the students' observations and tell them to finish answering the questions for homework.



Name ______________________________ Date ________

Eye-dentify These Parts if You Can and It's Okay if You Can't!

Eye --Place the name of each of the parts near the line that extends from that part.

Camera—Place the name of each of the parts near the line that extends from that part.

Name ___________________________________ Date ________

Keep an Eye on an Eye Revisited

1. Hold the tube up to one eye and look at the other eye in the mirror.
2. With both eyes open go look out the window or at a light and then look at a dark corner or floor area.
3. Have your partner do steps 1 and 2.
4. Describe below what happens to your eye as you go from bright to dark areas and then back to bright:

5. Take the *eye analyzer* and cover the end of the tube with your hand and then look at the window or a light and describe below what you see in the mirror:

6. Did you expect what happened to your open eye in Step #5 to happen?

7. Extra Credit: How might you explain what happened in Step #5?

Answers to the Lab Activity, Keep an Eye on an Eye Revisited

1. Hold the tube up to one eye and look at the other eye in the mirror.
2. With both eyes open go look out the window or at a light and then look at a dark corner or floor area.
3. Have your partner do steps 1and 2.
4. Describe below what happens to your eye as you go from bright to dark areas and back to bright:

Some students may be more general with their answers than others. The actual correct names for the eye parts are not necessary at this point. Students may write things such as, "the opening in your eye changes size" or "the pupil gets smaller in bright light and large in dark areas."

5. Take the *eye analyzer* and cover the end of the tube with your hand and then look at the window or a light and describe below what you see in the mirror:

The pupil that is not covered widens even though it is looking at bright light.

6. Did you expect what happened to your open eye in Step #5 to happen?

No, I expected my eye opening (pupil) to get smaller as I looked to a brighter area, but it did not.

7. Extra Credit: How might you explain what happened in Step #5?

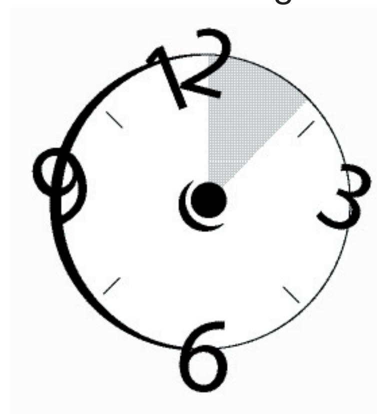
Maybe both eyes have to do the same thing and since I covered the tube first and put one eye in the dark, the other eye did the same thing.

Using Light's Properties to See Better

Core

Time Allocation: 45 minutes

Required Materials and Resources on Page 225



Lesson Overview

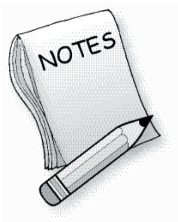
The lesson begins with a discussion of the similarity between the lens of a camera and that of a human eye, using drawings that can be labeled. Diagrams are then distributed that show both the eye and the camera and outline the similarities.

Guiding Questions

- Is an eye like a camera?

BIG IDEA

Our camera, the human eye



Content Goals

Universal Theme(s)

Scientific evidence consists of observations and data on which to base scientific explanations.

Principles and Generalizations

- Eyes have parts with particular functions in the vision process.
- An eye is like a human camera.

Concepts

- Vision
- Structure and function of eye parts

Teacher Information

N/A

Skills

- Compare and contrast
- See relationships

Materials and Resources

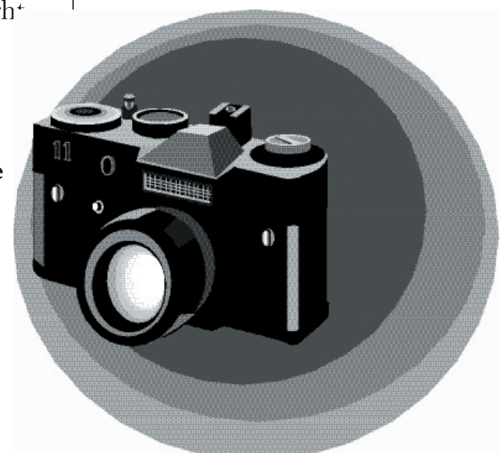
Colored diagrams of the eye comparing it to a camera were adapted from those found at the following website: http://member.rivernet.com.au/balehirs/Bishyp7dOlderEyes.htm#Eye%20Anatomy

Preparation Activities

1. Prepare the worksheet **Is the Eye Similar to a Camera** for all students by going to the following two websites: http://www.nei.nih.gov/health/eyediagram/images/diagram.gif diagram of human eye http://www.phys.ufl.edu/~avery/course/3400/camera/eb_camera_screen.gif diagram of a camera. Download the diagrams and place on the above worksheet. Do not put in part names for the human eye.
2. Create the worksheet **Diagrams for all students** by going to the following website: http://www.contact-lense-center.com/Human-Eye-and-Camera.jpg

Using Light's Properties to See Better

Print the image and then write in parenthesis the following: next to retina, write *the film*; next to optic nerve, write *the cable*; next to pupil, write *opening* or *apertur*e; next to lens write *focusing*, next to iris, write the *shutter*. Beneath the diagram of the camera, write, "The aperture of the camera is similar to the pupil of the eye. The aperture (or the pupil) controls how much light enters the camera or the eye."



Introductory Activity (5 minutes)

- Collect the homework and the lab activity sheets from the **Keep an Eye on an Eye Revisited lab.**
- Distribute the worksheet, **Is the Eye Similar to a Camera?**

Pre-assessment

N/A

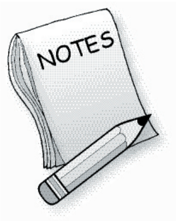
Teaching and Learning Activities (30 minutes)

1. Ask students if they see any similarity between the simple camera diagram and the eye. Students should mention things similar to the following:
    - Both the eye and a camera have an opening. In the eye it is called a pupil and in a camera it is called an aperture.
    - Both the eye and a camera have a lens.
    - A camera has film to record the image that it sees, and the eye has a place (retina) that detects images and light.
    - Both the eye and the camera need lighting in order to see things.
    - A camera has a shutter to control how much light it allows.
    - The eye uses the pupil to control how much light it uses.
    - Both the eye and the camera are able to focus.

2. The students will not necessarily use the correct terms which is okay as long as they see the similarity in function of the parts. Use the correct terms and have students label the diagrams with the correct terms but do not expect students to memorize these.

Products and Assignments

Students' sheets from the lab activities, **Keep an Eye on an Eye Revisited lab.**



Extension Activities
N/A

Post Assessment
N/A

Debriefing and Reflection Opportunities (10 minutes)

1. Distribute and review the handout, **Diagrams.**
2. Ask students whether it matters how much light you have when you take a picture with a camera. Students probably will know that the amount of light that gets through the camera/eye determines the brightness of the image, which compares to the ability to see better with more light.
3. As a review you could darken the room and ask students to look at each other's pupils with the room lights on and off to see the iris opening up/shutting down to control the amount of light entering the eye.
4. Ask students why do they think the human eye is more like the lens camera than the "pinhole" camera? Students should realize that the human eye has a lens like the camera, unlike the pinhole camera. The lens allows more light into the eye, like the camera, and allows humans to see more because it can gather more light from dimmer objects.

Name ____________________________________ Date ________

Is the Eye Similar to a Camera?

Prepare the worksheet **Is the Eye Similar to a Camera** for all students by going to the following two websites: http://www.nei.nih.gov/health/eyediagram/images/diagram.gif
diagram of human eye
http://www.phys.ufl.edu/~avery/course/3400/camera/eb_camera_screen.gif
diagram of a camera
Download the diagrams and place on the above worksheet. Do not put in part names for the human eye.

Diagrams

Create the worksheet **Diagrams** for all students by going to the following website: http://www.contact-lense-center.com/Human-Eye-and-Camera.jpg

The Eye, Our Living Camera

A Camera

- The diagram represents a simple camera. The aperture of the camera is similar to the pupil of the eye. The aperture (or the pupil) controls how much light enters into the camera (or the eye).
- The iris in the eye is like the shutter in newer cameras. It controls the size of the opening, the pupil for the eye and the aperture for the camera.
- Light from an object enters through the aperture of the camera and is focused on the film of the camera by the lens. The lens of a camera can be moved back and forth to help focus the image on the film. The lens in the eye uses a different mechanism in that it does not move back and forth but **changes shape** to help focus the light on the retina.
- The film is simply a screen, like the retina, except it captures the image permanently once the camera is clicked.
- The flash of the camera simply provides more light in the area that is being photographed because the film of the camera is not as sensitive as the retina.
- The cable from a digital camera may be considered similar to the optic nerve as it takes the signal to the computer just like the optic nerve takes a signal to the brain.

How an Eye Adjusts Its Lens to Help Focus Light on the Retina

The following website has diagrams of the lens in the human eye and how it changes shape to focus on a distant object or a close object. http://member.rivernet.com.au/balehirs/Bishyp7dOlderEyes.htm#Eye%20Anatomy

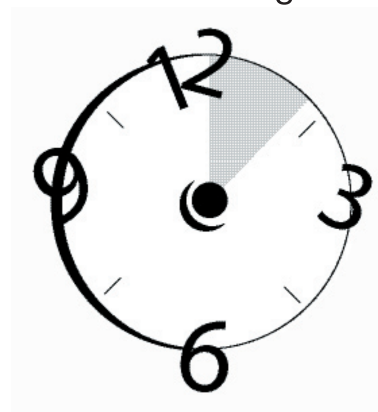
Note the change in the shape of the lens in the lower diagram. It is less elongated.

Using Light's Properties to See Better

Connections

Time Allocation: 2 hours, 30 minutes

Required Materials and Resources on Page 225



Lesson Overview

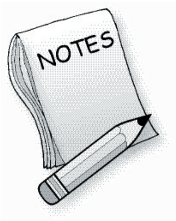
Students will explore the concept of structure and function as seen in the biological sciences by researching the extensive variety of eyes that animals have. The way animals see light depends on their needs, such as the way they catch food, the way they avoid prey, their form of locomotion, and their greatest activity period, daytime or nighttime. Students will discover that the diversity in animal eye structures has enabled organisms to adapt to and survive in the vast number of habitats that exist all over the world. Each student will have an opportunity to share his or her findings with classmates during either a poster or PowerPoint presentation.

Guiding Questions

- Why do animals have so many different types of eyes?

BIG IDEA

Animals have big eyes with varying structures that enable them to survive in their environments.



Content Goals

Universal Theme(s)

Scientific evidence consists of observations and data on which to base scientific explanations.

Principles and Generalizations

- Animals have eyes with varying structures that enable them to survive in their environments.
- Animals have adaptations that assist them with survival in their habitats.

Concepts

- Structure and function of animals' eyes
- Adaptation

her Information

Compound eyes are the most abundant in nature. Insects and some marine animals have them. These eyes consist of hundreds of long tubes bunched together like a bunch of soda straws. At the external tip of each tube is a fixed lens that focuses light rays toward a group of light-sensitive cells located at the bottom of the tube. The tubes can fan out giving the eye its rounded structure. Each tip of a compound eye picks up an image of the section of the world in front of it and sends it to the brain where it is merged with all the other images to form a mosaic-like picture. Although they do not focus light, these eyes are very good at detecting motion.

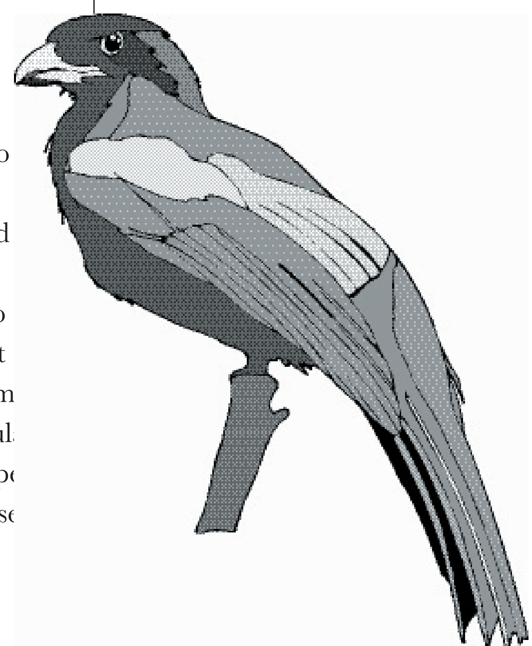
View a picture of the compound eye of the mosquito at the following site: http://ebiomedia.com/gall/eyes/octopus-insect.html

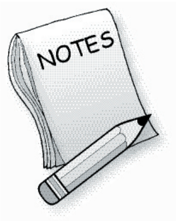
Another good site for information on animal eyes is located at: http://www.eyedesignbook.com/ch3/eyech3-g.html#f3-39

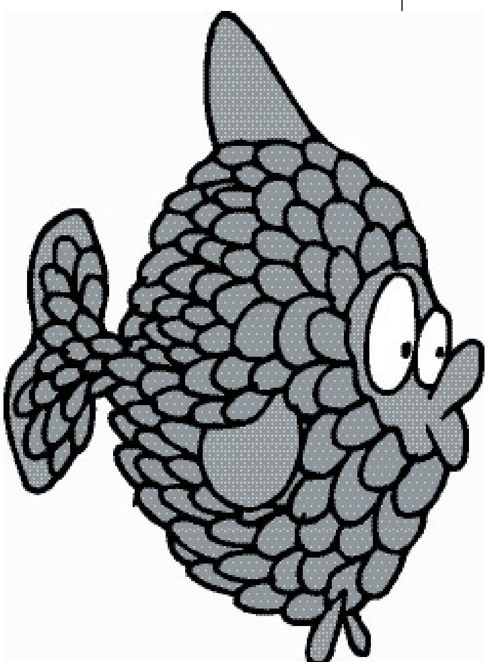
Muller & Rudolph. (1966). *Light and Vision.* Life Science Library NE Time Inc. is an excellent book to use for information regarding the eyes of different animals. The following is some of the information that might assist you in selecting organisms for students to research:

Using Light's Properties to See Better

- o Giant gecko has four diamonds adaptation. It hunts day and night -- eye opens wide at night and then forms the diamonds during day.
- o Domestic cat has oval-shaped pupil. It can open wide for night hunting and form a slit during daytime
- o Green whip snake has a keyhole shaped pupil. The wider part helps it to see peripherally, and the front slit area focuses straight ahead.
- o Skate has a fringed awning to protect it from too much sunlight.
- o Anableps (the four-eyed fish) is a tropical fish that swims with half of its two eyes above the surface of the water and the other half of the eye below the water. The fish has two pupils, one that focuses down into the water and the other that looks up. Each eye has a lens with one facet for looking out of the water and another for seeing in it. This complex eye lens can focus two images simultaneously from above and below the water so it is called a four-eyed fish. These fish eyes are large and bulging, like those of a frog. Because it can see out of the water, it is difficult for fishermen to catch this fish.
- o Fiddler crab has compound eyes on stalks that can be moved about to extend their visual horizons to 360 degrees.
- o Japanese goldfish (Celestial) have eyes that are on top of the head and they are looking directly above the surface of the water.
- o Queen conch is a large seagoing snail that has eyes at the ends of two long tentacles. The eyes have lenses and a high concentration of light sensitive cells that help the organism in dim light on the ocean bottom
- o Mudskipper is a small fish that has eyes that are mounted on a muscul turret that allows the eyes to pop up above the surface. The mudskipp cannot focus under water. Its eyes can be lowered into a muscular bas and covered over with a layer of skin.
- o Chameleons have eyes that swivel independently.
- o Hawks have eyes that weigh more than their brain.
- o Mole rat lives underground and has little use for an eye and as such only has a tiny slit.
- o Flying squirrel has eyes that take up most its skull, especially since it must leap from branch to branch in pitch darkness.
- o Tarsier, a nocturnal creature, has the largest eyes in proportion to its head of any known mammal.
- o Dragonfly has two large eyes made up of thousands of six-sided units.







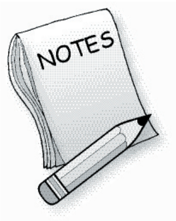
- Squirrel has eyes on each side of its head, located in its forward sloping cheeks. The eyes are up high enough so that the squirrel can look back over its head, down its spine to see if anything is pursuing it.
- Toads have eyes that are used to hold prey. Toads eat worms and only have upper teeth to hold them. The eyes have adapted such that they can be lowered through a trapdoor in the roof of the toad's mouth. These extremely muscular eyes can then hold the worms down.
- Octopuses have a unique characteristic. Their eyes have a rotational ability and a consistent orientation in relation to gravity. Using their statocyst, (a balance organ common to many invertebrates), the pelagic or water-dwelling cephalopods are able to always keep their slit-shaped pupils in a horizontal position. Therefore, the brain can always safely interpret visual information on the basis that the eyes are horizontally aligned, though the body may be at any angle in the three dimensional water column. Other information about the octopus eye can be found at http://ebiomedia.com/gall/eyes/octopus-insect.html. Many biological lenses consist of up to hundreds of thousands of nanolayers, each of which has a slightly different refractive index. The layers form a smooth density gradient that helps to focus light. In human eyes, this lens is made up of about 22,000 layers. But animals that live in water, which has a high refractive index compared with air, need stronger lenses. The octopus eye, for example, can focus light five times more strongly than a human eye.
- Anaconda snake has eyes and nostrils positioned on top of the head to allow the snake to breathe and see prey while lying underwater.
- Shark eyes may not be able to form clear images or detect color as our eyes can, but sharks are better than people at seeing in dim light. Even in the dark of night sharks can quickly pick up any flickering movement and sense its direction. Shark eyes need to handle wide water pressure variations, as they range from shallow to deep water looking for food. The inner eye and retina have to compensate for pressure differences on the eye's outer surface. Their eyes are relatively small for the overall size of their bodies. Since the shark's visual acuity has been sacrificed for more sensitivity to low-light vision, it probably sees a lower resolution image than humans. There are a variety of sharks each having slightly different eyes. For example, the hammerhead shark has eyes on lobes that extend from the head. This is probably for an improved stereo effect to increase

the ability to estimate distances to targets for high-speed interception. The eyes of the blue shark and others have more typical spacing, but they still need a fair amount of resolution to hunt for their food. The following figures illustrate shark eye exterior and section views. (p. 110, *Vision in the Animal World*, R. H. Smythe, Macmillan Press, 1975)

- o Flounder has eyes with a unique placement. These flat bottom-dwelling fish frequently need to hide in the sand from predators. Since both of their eyes are on the same side of their bodies, they can watch for predators when they lie flat in the sand. This seems to be a fundamental feature of the flounder, but not at birth.
- o Vultures have eyes that are adapted to give an overall view with a magnifying area in the center, enabling it to locate possible food sources and see the exact site in detail. They see eight times better than humans.
- o Toad eyes feel flat surface. A toad's eye can be used to help push his food down his throat.
- o Owls have saucer-like, sensitive eyes to help them see at night. They tend to have a large aperture for their overall body size. Owl eyes do not rotate as much as human eyes do, but an owl's head can turn a considerable angle to accomplish the same purpose. They also have good stereo vision and depth perception because of their eyes being separated by a significant distance.
- o Penguins' underwater world requires different eyesight than humans need. Penguin eyes are sensitive to the colors of the sea -- violets, blues, and greens. Their eyes also have a second transparent eyelid, serving as "goggles" while the animal is underwater.
- o Other animals students may research are the eel, cormorant, and the squid.

Skills

- Research information
- Recognize attributes
- Compare and contrast
- Make decisions
- Communicate orally and visually
- Use creative thinking such as originality



Materials and Resources

1. A variety of pictures of different kinds of eyes from organisms.
2. Poster board (one piece for each student who chooses to make a poster for his or her presentations)
3. Markers
4. Scissors
5. Internet access (optional)
6. Magazines with pictures of different animals (e.g., *National Geographic*)
7. Folders (one per student)

Preparation Activities

1. Place the pictures of animals with various types of eyes around the room.
2. Prepare a list of animals from which students will select one. The animals in the **Teacher Information** list above could be used.
3. Copy the **Criteria for the Presentation on Other Animals' Eyes** and the rubric for the various presentations, depending upon on which format each student is using.
4. Copy the **Rubric for the Poster.**
5. Copy the **Rubric for the PowerPoint Presentation.**

Introductory Activity (5 minutes)

- Collect the worksheet, **Is the Eye Similar to a Camera?**
- Instruct students to select an animal and use book and Internet resources to find as much information as they can about the structure and function of the animal's eyes.

Pre-assessment

N/A

Teaching and Learning Activities (90 minutes)

1. Go over what is meant by the terms *structure* and *function* as they relates to eyes. Use the human eye as the example. Talk about the body parts, two eyes and cones, respectively, that enable us to have binocular and color vision. The term "cones" is not important but the concept is. Students need to know that there has to be something that makes up the retina that can detect color.

2. Tell students to look at the pictures around the room and also at the list of animal choices they have.

3. Make a list of what animal each student wants to research.

4. After students have finished their research, tell them their homework is to share what they learned with their classmates. The format they choose to share their information can be either a poster or *PowerPoint* presentation.

5. Distribute and review copies of the sheet, **Criteria for the Presentation on Other Animals' Eyes.**

6. Distribute and review appropriate rubrics to each student.

7. Take the students to the library and/or computer lab to do their research.

8. Inform students that they will do a two to three minute presentation.

9. Tell them that they will work on their posters or PowerPoint presentations tomorrow.

Products and Assignments

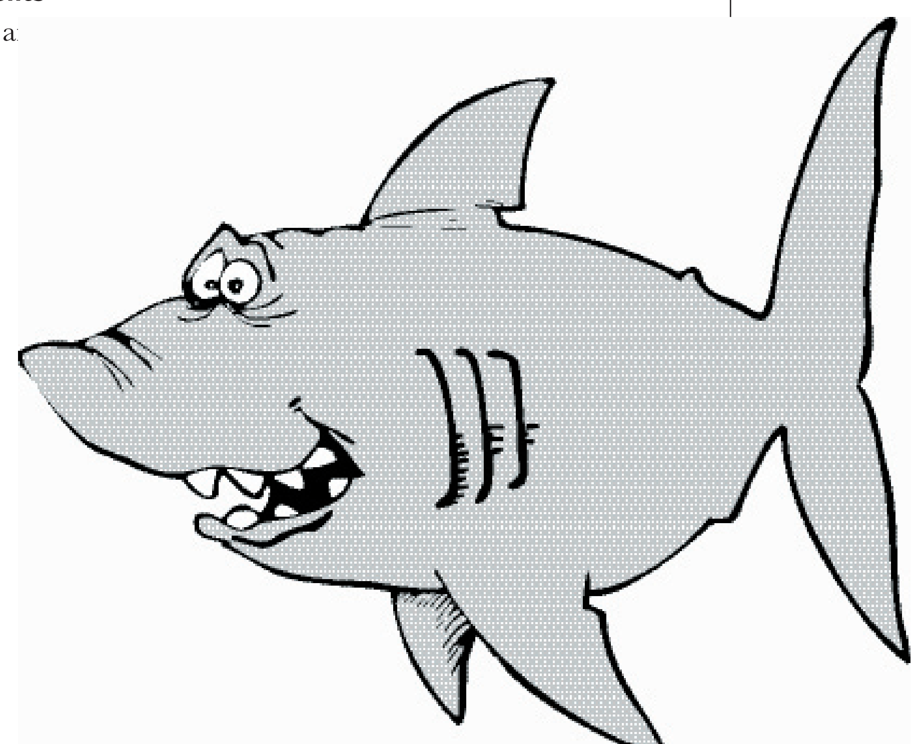
Students' research notes a

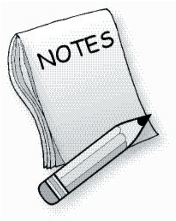
Extension Activities

N/A

Post Assessment

N/A





Debriefing and Reflection Opportunities (55 minutes)

1. Each student will share his or her findings with class members who will have an opportunity to ask each students questions.
2. The concept of adaptation is important to review during the presentations. The animals' eyes vary because of the variety of habitats that the various organisms occupy. Their eyes have developed over time into ones that enable the organisms to survive in the particular environment in which they live.

Name ________________________________ Date _________

Criteria for the Presentation on Other Animals' Eyes

1. The content of your research must be accurate.

2. The science content must be understood by you.

3. The content must include some aspect of the structure of the animal's eye.

4. The content must include some aspect of the function of the animal's eye.

5. The content must include a discussion of how the eye is specifically adapted for the animal's habitat. In other words, the unusual nature or uniqueness of the animal's eye must be presented.

6. The presentation includes photographs, diagrams or drawings that are relevant and complement the science content. Each image is cited in the text and is identified. The number of images is appropriate, and they enhance the understanding of the eye adaptations in animals.

7. Grammar and spelling are flawless, and the flow provides a logical pathway of ideas. There is a consistent and engaging style throughout the presentation.

8. All research notes and information must be kept in a folder and turned in with the poster or PowerPoint presentation.

9. A list of resources including any Internet sites and sources of pictures, drawings or diagrams must be placed in the folder.

Name ______________________________________ Date _______

Rubric for the Poster

Criteria	1	2	3	4	Your Score
Quality of Science Content	Information is cursory or incorrect. Little understanding of content is evident from presentation.	Some solid information is presented; however, some information is incorrect or cursory.	Information is clear and correct throughout most of presentation.	Information is clear and correct throughout.	1 2 3 4
Understanding of Material	Apparent misunderstanding of material is evident.	Limited understanding of material is displayed by vague, unclear language.	Adequate understanding of the material and logical presentation delve into some conceptual ideas in science.	Clear understanding of material displayed by lucid, logical and fluid presentation of the science concepts and content	1 2 3 4
Quality of Research	Research was insufficient or so fragmented that the science understandings being presented were unclear.	Research effort was incomplete but what was presented was appropriately weaved throughout the presentation.	Research was fairly comprehensive and adeptly weaved throughout the presentation.	Research was comprehensive and clearly documented. The research information was adeptly weaved throughout the presentation	1 2 3 4
Criteria	Many of the criteria required to be included are missing or contain insufficient information.	Some of the criteria are missing and the lack of sufficient research is evident in some of the required areas.	Although the criteria were addressed, they could have been addressed more thoroughly as a result of more extensive research.	All of the criteria were completely and thoroughly addressed.	1 2 3 4

Rubric for the Poster

Criteria	1	2	3	4	Your Score
Poster Graphics	Images do not connect to text and/or are not relevant and do not deepen understanding of animal eye adaptations.	Images are not always relevant and thus do not provide additional insight as to eye adaptations. Text citations are not always present.	Images are mostly relevant and add to the understanding of animal eye adaptations. Text citations are usually present and identify the images.	Images are relevant, and complement the text. Each image is cited in the text and identified. The number of images is appropriate, and they do enhance the understanding of the eye adaptations in animals.	1 2 3 4
Mechanics	Text contains many spelling/ grammar errors. Sentences seem disconnected, and there is carelessness throughout.	Text contains some spelling/ grammar errors with little logical structure or flow to sentences. There is evidence of carelessness in writing.	Grammar and spelling are nearly flawless with logical sequence apparent. Some wording is careless with inconsistency in style.	Grammar and spelling are flawless, and the flow provides a logical pathway of ideas. Consistent and engaging style is present throughout.	1 2 3 4
Poster Design	The poster is either cluttered or too empty. There is no text/image balance. No attention is paid to variation in design.	Some parts of the poster are either cluttered or empty. Inconsistent attention is paid to sizing of graphics, placement of graphics and text.	Most of the poster contains well-placed objects, with thoughtful text/ image balance.	Objects and text on the poster are well-placed and sized. Poster is not cluttered or too empty.	1 2 3 4
Speaking Skills	Speaker presented in a monotone and seemed uninterested in material	Speaker had little eye contact, fast speaking rate, little expression, and mumbling	Speaker had clear articulation of ideas but apparently lacks confidence with material	Speaker had exceptional confidence with material displayed through poise, clear articulation, eye contact, and enthusiasm	1 2 3 4

Name ______________________________________ Date _______

Rubric for the PowerPoint Presentation

Criteria	1	2	3	4	Your Score
Quality of Science Content	Information is cursory or incorrect. Little understanding of content is evident from presentation.	Some solid information presented; however, some information is incorrect or cursory.	Information is clear and correct throughout most of presentation.	Information is clear and correct throughout.	1 2 3 4
Understanding of Material	Apparent misunderstanding of material	Limited understanding of material displayed by vague, unclear language	Adequate understanding of the material and logical presentation delve into some conceptual ideas in science	Clear understanding of material is displayed by clear, logical and fluid presentation of the science concepts and content	1 2 3 4
Quality of Research	Research was insufficient or so fragmented that the science understandings being presented were unclear.	Research effort was incomplete but what was presented was appropriately weaved throughout the presentation.	Research was fairly comprehensive and adeptly weaved throughout the presentation.	Research was comprehensive and clearly documented. The research information was adeptly weaved throughout the presentation	1 2 3 4
Criteria	Many of the criteria required to be included are missing or contain insufficient information.	Some of the criteria are missing, and the lack of sufficient research is evident in some of the required areas	Although the criteria were addressed, they could have been addressed more thoroughly as a result of more extensive research.	All of the criteria were completely and thoroughly addressed.	1 2 3 4

Name ______________________________________ Date _______

Rubric for the PowerPoint Presentation

Criteria	1	2	3	4	Your Score
Slide Graphics	Images do not connect to text and/or are not relevant and do not deepen understanding of animal eye adaptations.	Images are not always relevant and thus do not provide additional insight as to eye adaptations. Text citations are not always present.	Images are mostly relevant and add to the understanding of animal eye adaptations. Text citations are usually present and identify the images.	Images are relevant, and complement the text. Each image is cited in the text and identified. The number of images is appropriate, and they do enhance the understanding of the eye adaptations in animals.	1 2 3 4
Mechanics	Text contains many spelling/ grammar errors. Sentences seem disconnected, and there is carelessness throughout.	Text contains some spelling/ grammar errors with little logical structure or flow to sentences. There is evidence of carelessness in writing.	Grammar and spelling are nearly flawless. Logical sequence is apparent. Some wording is careless with inconsistency in style.	Grammar and spelling are flawless, and the flow provides a logical pathway of ideas. Consistent and engaging style is present throughout.	1 2 3 4
Slide Effects	Effects are limited or not present.	One or more than one type of effect is used; however, some or all effects detract from presentation.	More than one type of effect is used. Effects enhance presentation.	Effects are varied, yet cohesive, and they significantly enrich the presentation.	1 2 3 4

Name ______________________________________ Date _______

Rubric for the PowerPoint Presentation

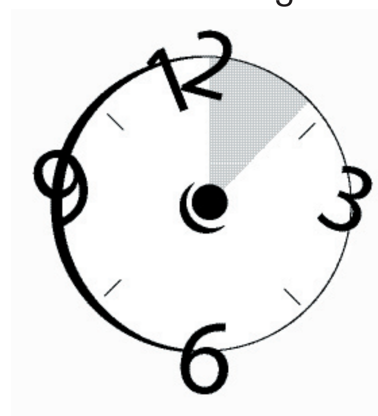
Criteria	1	2	3	4	Your Score
Speaking Skills	Speaker presented in a monotone and seemed uninterested in material.	Speaker had little eye contact; fast speaking rate, little expression, and mumbling	Speaker had clear articulation of ideas but apparently lacks confidence with material	Speaker had exceptional confidence with material displayed through poise, clear articulation, eye contact, and enthusiasm	1 2 3 4
Overall Presentation Design	Many slides are either cluttered or empty. There is no text/image balance. No attention is paid to variation in design.	Some slides are either cluttered or empty. Inconsistent attention is paid to sizing of graphics, placement of graphics and text, and text wrapping.	Most slides contain well-placed objects, with thoughtful text/image balance.	Objects on all slides are well placed and sized. Slides are not cluttered or too empty.	1 2 3 4

Enlightening Explorations with LIGHT and Using Light's Properties to See Better

Core (Post Assessment)

Time Allocation: 45 minutes

Required Materials and Resources on Page 225



Lesson Overview

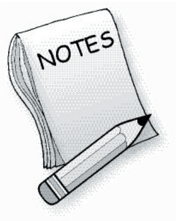
Students in this lesson answer post assessment questions that should reveal their current understandings regarding the nature of light and some of its technological applications, such as eye glasses and cameras.

Guiding Questions

- Does sunlight affect the earth's land versus water masses differently?
- How do we make sunlight work for us?
- Why do we wear more light colored clothes in the summer than in the winter?
- Does light travel in the dark?
- Does light have a direction of travel?
- What things can produce and/or give off light?
- Are white and black colors?
- Why is a red shirt red?
- How are rainbows formed?
- Can light be bent?
- Is there anything else visible light can do besides being absorbed, reflected or refracted?
- Does a surface's texture affect the way in which light bounces off it?
- How do we use light's properties to improve what we see?
- Is an eye like a camera?
- Why do animals have so many different types of eyes?

BIG IDEA

What did I learn about light and its technological applications?



Content Goals

Universal Theme(s)

- Science involves making hypotheses, theories and conceptual models to represent, explain and predict phenomena.
- Scientific evidence consists of observations and data on which to base scientific explanations.
- Using evidence to understand interactions allows individuals to predict changes.

Principles and Generalizations

- Sunlight is a source of heat and light.
- Light can be absorbed by substances.
- Light can be reflected light and allows us to see things.
- White light can be separated into component colors.
- Light can be bent.
- Objects transmit light to varying degrees.
- Black is the absence of reflected light, and white is the reflection of all colors.
- Light reflects in different ways depending on the nature of the material it hits.
- Light can be made to change direction.
- Images of objects can be manipulated by understanding light's properties.
- Clear images can be intentionally produced using light properties.
- Eyes have parts that have particular functions in the vision process.
- An eye is like a human camera.
- Animals have eyes with varying structures that enable them to survive to their environments.

Concepts

- Focused sunlight
- Absorption of light
- Independent and dependent variables
- Light's direction of travel
- Natural versus artificial light sources

Using Light's Properties to See Better

- Reflection of light
- Primary colors
- Secondary colors
- Separation of white light
- Refraction of light
- Chromatography (AID)
- Transmission of light
- Opaque
- Transparent
- Translucent
- Visible light
- Ultraviolet light
- Chromatography
- Mixture
- Diffusion of light
- Manipulation of light
- Focused and unfocused light
- Inverted image
- Real image
- Lens
- Vision

Teacher Information

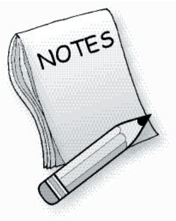
N/A

Skills

- Predict
- Make observations
- Record data
- Interpret data
- Identify characteristics
- Compare and contrast
- See relationships

Materials and Resources

Post Assessment for the Light: A Rainbow of Explorations Unit



Preparation Activities

1. Copy the **Post-asssessment for the Light: A Rainbow of Explorations Unit** for students.
2. Make a copy of the **Possible Answers to the Post-asssessment for the Light: A Rainbow of Explorations Unit.**

Introductory Activity

N/A

Pre-assessment

N/A

Teaching and Learning Activities (45 minutes)

1. Explain to students that the final assessment will be used by you to measure their knowledge of this unit. Emphasize that they should make their best effort on the assessment.

2. Distribute the **Post-asssessment for the Light Unit.**

Products and Assignments

Students' Post Assessment results

Extension Activities

N/A

Post Assessment

Post-asssessment for the Light Unit

Debriefing and Reflection Opportunities

N/A

Name ____ Date __________________

Post Assessment for the Light: A Rainbow of Explorations Unit

1. If you had to choose between a black or white shirt, which would you wear in the summer? Explain your choice.

2. Which heats up faster land or water?

3. Which cools off faster land or water?

4. Name two ways we make sunlight work for us, in addition to growing plants.

5. Why is there often a breeze during the day that comes off the water at the shore, at the shore, along ocean areas?

6. Explain how we see objects in the light.

Name ____ Date ________________

7. Is black a color? Explain your answer.

8. Why do you see yellow when you look at a yellow shirt and not some other color?

9. If you shine a red light on a green leaf, what color will the leaf appear and why?

10. If you were in a store and purchased a red shirt and brought it home and took it out of the bag in your house and found it to really be orange, what can you tell me about the lights in the store? Be specific about your answer.

11. How does the angle of incoming light bouncing off a mirror compare to the angle at which it leaves the mirror's surface?

12. Why is it difficult to retrieve a golf ball from a water hazard when you use a ball scoop?

Name ______________________________ Date ______________

13. If you were sitting under a desk and wanted to see something on top of a desk what would you use or build to accomplish this task? Your teacher could give you any materials she had in school. What would you call your "tool"?

14. What do eye glass lenses do to light to help improve certain people's vision?

15. Describe at least **four** ways in which a eye is similar to a camera.

16. Based on your experiences, what are the characteristics of an excellent reflective surface?

Name ____ Date ________________

Possible Answers to the Post Assessment for the Light: A Rainbow of Explorations Unit

1. If you had to choose between a black or white shirt, which would you wear in the summer? Explain your choice.

I would wear a white shirt because black absorbs all light and it would make me hotter. White reflects all colors so I would be cooler in a white shirt.

2. Which heats up faster land or water?

Land heats up faster.

3. Which cools off faster land or water?

Land cools off faster.

4. Name two ways we make sunlight work for us in addition to growing plants.

Sunlight is used in solar powered things like calculators and in solar panels that produce electricity for homes and businesses.

5. Why is there often a breeze during the day that comes off the water at the shore, along ocean areas?

There is a breeze because the land is hotter than the water and the warm air rises and the cooler air over the ocean rushes in to replace the warm air, thus creating a breeze that comes off the water.

6. Explain how we see objects in the light.

We see objects in light because the light bounces off the object and strikes our eyes.

7. Is black a color? Explain your answer.

No, black is not a color. Black things absorb all light.

8. Why do you see yellow when you look at a yellow shirt and not some other color?

Yellow shirts reflect yellow light, which is why we see yellow. The shirt absorbs the other colors that make up white light.

9. If you shine a red light on a green leaf, what color will the leaf appear and why?

The leaf will appear black because the only color a green leaf reflects is green and if you do not shine a light on it that has a green component, it will absorb everything and appear black.

10. If you were in a store and purchased a red shirt and brought it home and took it out of the bag in your house and found it to really be orange, what could you tell me about the lights in the store? Be specific about your answer.

The lights in the store were not like white lights because all the colors were not produced. I think red and yellow make orange so perhaps the light had more red and thus the shirt reflected red light. Since the light in the store had no yellow, the shirt did not reflect any, so I did not see the shirt as orange in the store.

11. How does the angle of incoming light bouncing off a mirror compare to the angle at which it leaves the mirror's surface?

The light that hits a mirror bounces off at the same angle as it struck the mirror.

12. Why is it difficult to retrieve a golf ball from a water hazard when you use a ball scoop?

When you look at an object under water from an angle, the location of the object is not really where it appears to be. This is because water bends light rays when it passes through water at an angle other than perpendicular to the water. This changes the apparent location of objects when seen from outside the water.

13. If you were sitting under a desk and wanted to see something on top of a desk what would you use or build to accomplish this task? Your teacher could give you any materials she had in school. What would you call your "tool"?

I would use mirrors and build something like a periscope to see what was on top of the desk.

14. What do eye glass lenses do to light to help improve certain people's vision?

Magnify and/or focus images

15. Describe at least **four** ways in which a eye is similar to a camera. Identify the parts that are similar and their functions.

Both close and open to let in that comes in (pupil and eyelid versus lens cap or slider).

Both can adjust the amount of light (iris and shutter).

Both can capture an image of what it is out there.

Both have protection (e.g., eyelid versus lens cap).

Both have the ability to focus light.

Both have screens that respond to light (retina versus film).

Eye has a optic nerve and digital camera has a cable that takes signal away from eye.

16. Based on your experiences, what are the characteristics of an excellent reflective surface?

An excellent reflective surface is shiny and smooth.

“Curriculum Map”

Author: Fie Budzinsky
Curriculum Map: Light: A Rainbow of Explorations
Grade Level: 4-5

Major Principles and Generalizations	Time Allocation and Parallel	Minor Principles and Generalizations	Concepts	Skills	Themes	Guiding Questions
1. Pre-assessment	CORE 45 minutes	• Sunlight is a source of heat and light. • Light can be absorbed by substances. • Light can be reflected light and allows us to see things. • White light can be separated into component colors. • Light can be bent. • Objects transmit light to varying degrees. • Black is the absence of reflected light and white is the reflection of all colors. • Light reflects in different ways, depending on the nature of the material it hits. • Light can be made to change direction. • Images of objects can be manipulated by understanding light's properties. • Clear images can be intentionally produced using light properties. • Eyes have parts that have particular functions in the vision process. • An eye is like a human camera. • Animals have eyes with varying structures that enable them to survive to their environments.	• Focused sunlight • Absorption of light • Independent and dependent variables • Light's direction of travel • Natural versus artificial light sources • Reflection of light • Primary colors • Secondary colors • Separation of white light • Refraction of light • Chromatography (AID) • Transmission of light • Opaque • Transparent • Translucent • Visible light • Ultraviolet light • Chromatography • Mixture • Diffusion of light • Manipulation of light • Focused and unfocused light • Inverted image • Real image • Inverted image • Lens • Vision • Structure and function of eye parts • Adaptation	• Predict • Make observations • Record data • Interpret data • Identify characteristics • Compare and contrast • See relationships	• Science involves making hypotheses, theories and conceptual models to represent, explain and predict phenomena. • Scientific evidence consists of observations and data on which to base scientific explanations. • Using evidence to understand interactions allows individuals to predict changes.	• Does sunlight affect the earth's land versus water masses differently? • How do we make sunlight work for us? • Why do we wear more light colored clothes in the summer than in the winter? • Does light travel in the dark? • Does light have a direction of travel? • What things can produce and/or give off light? • Are white and black colors? • Why is a red shirt red? • How are rainbows formed? • Can light be bent? • Is there anything else visible light can do besides being absorbed, reflected or refracted? • Does a surface's texture affect the way in which light bounces off it? • How do we use light's properties to improve what we see? • Is an eye like a camera? • Why do animals have so many different types of eyes?

Major Principles and Generalizations	Time Allocation and Parallel	Minor Principles and Generalizations	Concepts	Skills	Themes	Guiding Questions
2. Sunlight is a source of heat and light.	CORE/AID 1 hour	• Sunlight can be focused on objects. • Sunlight can be captured and used in technology.	• Focused sunlight • Absorption of light	• Predict • Make observations • Record data	• Science involves making hypotheses, theories and conceptual models to represent, explain and predict phenomena. • Scientific evidence consists of observations and data on which to base scientific explanations. • Using evidence to understand interactions allows individuals to predict changes.	• Does sunlight affect the earth's land masses and water masses differently? • How do we make sunlight work for us?
3. Light can be absorbed by substances.	CORE/ PRACTICE/ IDENTITY 50 minutes	• Sunlight affects different substances in different ways. • Land masses heat up faster than water masses. • Scientists work by observing, describing, and using data to explain phenomena and share information. • Anybody can be a scientist.	• Absorption of light • Independent and dependent variables	• Interpret data • Compare and contrast • See relationships	• Science involves making hypotheses, theories and conceptual models to represent, explain and predict phenomena. • Scientific evidence consists of observations and data on which to base scientific explanations. • Using evidence to understand interactions allows individuals to predict changes.	• Does sunlight affect the earth's land masses and water masses differently? • Would you like to be a physicist and explore some aspect of light?

Major Principles and Generalizations	Time Allocation and Parallel	Minor Principles and Generalizations	Concepts	Skills	Themes	Guiding Questions
4. Sunlight is absorbed by substances.	55 minutes CORE	• Light interacts with materials differently depending on the color of the material it strikes	• Absorption of light	• Predict • Make observations • Record data • Read a thermometer • Compare and contrast • See relationships	• Science involves making hypotheses, theories and conceptual models to represent, explain and predict phenomena. • Scientific evidence consists of observations and data on which to base scientific explanations. • Using evidence to understand interactions allows individuals to predict changes.	• Why do we wear more light colored clothes in the summer than in the winter?
5. Light can be reflected light and allows us to see things.	CORE/AID 1 hour	• Light can travel in the dark. • Light travels in straight lines. • Light has natural and artificial sources.	• Light's direction of travel • Reflection of light • Natural versus artificial light sources	• Make observations • Record data • Identify characteristics • Compare and contrast • See relationships	• Scientific evidence consists of observations and data on which to base scientific explanations.	• Does light travel in the dark? • Does light have a direction of travel? • What things can produce and/or give off light?
6. Light can be reflected light and allows us to see things	CORE/AID 50 minutes	• White is a reflection of all colors. • Certain primary colors can be mixed to produce new colors.	• Reflection of light • Primary colors • Secondary colors • Absorption of light	• Predict • Make observations • Record data • Identify characteristics • Compare and contrast • See relationships	• Science involves making hypotheses, theories and conceptual models to represent, explain and predict phenomena. • Scientific evidence consists of observations and data on which to base scientific explanations. • Using evidence to understand interactions allows individuals to predict changes.	• What makes something look white? • What is essential for us to see anything?

Major Principles and Generalizations	Time Allocation and Parallel	Minor Principles and Generalizations	Concepts	Skills	Themes	Guiding Questions
7. White light can be separated into colors.	CORE/AID 1 hour, 15 minutes		• Reflection of light • Absorption of light • Color spectrum • Separation of white light • Chromatography (AID)	• Predict • Make observations • Record data • Identify characteristics • Compare and contrast • See relationships	• Science involves making hypotheses, theories and conceptual models to represent, explain and predict phenomena. • Scientific evidence consists of observations and data on which to base scientific explanations. • Using evidence to understand interactions allows individuals to predict changes.	• Can white light be separated into different components?
8. Black is the absence of reflected light and white is the reflection of all colors.	CORE/AID 1 hour	• Objects reflect certain colors of light and absorb other colors because of their chemical nature.	• Absorption of light • Reflection of light • Separation of white light • Refraction of light	• Make observations • Record data • Identify characteristics • Compare and contrast • See relationships	• Scientific evidence consists of observations and data on which to base scientific explanations.	• Are white and black colors? • Why is a red shirt red? • How are rainbows formed?
9. Light can be bent.	CORE/AID 50 minutes	• Objects under water are not located where they visibly appear to be.	• Refraction of light	• Predict • Make observations • Record data • Identify characteristics • Compare and contrast • See relationships	• Science involves making hypotheses, theories and conceptual models to represent, explain and predict phenomena. • Scientific evidence consists of observations and data on which to base scientific explanations. • Using evidence to understand interactions allows individuals to predict changes.	• Can light be bent? • Why are things under water, not exactly where you expect them to be when you reach for them?

Major Principles and Generalizations	Time Allocation and Parallel	Minor Principles and Generalizations	Concepts	Skills	Themes	Guiding Questions
10. Objects transmit light to varying degrees.	CORE 50 minutes		• Transmission of light • Opaque • Transparent • Translucent • Ultraviolet light	• Make observations • Compare and contrast • See relationships	• Scientific evidence consists of observations and data on which to base scientific explanations.	• Is there anything else visible light can do besides being absorbed, reflected or refracted?
11. Black is the absence of reflected light.	CONNECTIONS/ AID 55 minutes	• Mixtures can be separated by physical and chemical means.	• Absorption of light • Reflection of light • Chromatography • Mixture	• Make observations • Record data • Identify characteristics • Compare and contrast • See relationships	• Scientific evidence consists of observations and data on which to base scientific explanations.	• What makes black ink black?
12. Light reflects in different ways depending on the nature of the material it hits.	CORE/AID 1 hour, 5 minutes	• Smooth, flat, shiny surfaces (e.g., mirrors) produce the best reflections. • Light is reflected by a mirror at the same angle at which it hit the mirror. • Light that hits irregular surfaces goes in all directions.	• Reflection of light • Diffusion of light	• Predict • Make observations • Estimate angle measures • Measure angles (AID) • Identify characteristics • Compare and contrast • See relationships	• Science involves making hypotheses, theories and conceptual models to represent, explain and predict phenomena. • Scientific evidence consists of observations and data on which to base scientific explanations. • Using evidence to understand interactions allows individuals to predict changes.	• Does a surface's texture affect the way in which light bounces off it?

Major Principles and Generalizations	Time Allocation and Parallel	Minor Principles and Generalizations	Concepts	Skills	Themes	Guiding Questions
13. Light can be made to change direction.	CORE/ CONNECTIONS/ AID 1 hour, 15 minutes	• Light's reflective behavior can be used to create tools to help us see better.	• Reflection of light • Manipulation of light	• Make observations • Identify characteristics • See relationships	• Scientific evidence consists of observations and data on which to base scientific explanations.	• How can we use light's properties to help us?
14. Images of objects can be manipulated by understanding light's properties.	CORE/AID 1 hour, 5 minutes	• The reflective image that hits our eye is actually inverted. • The human brain inverts images	• Focused and unfocused light • Inverted image • Real image	• Predict • Make observations • Measure • Record data • Identify characteristics • Compare and contrast • See relationships	• Science involves making hypotheses, theories and conceptual models to represent, explain and predict phenomena. • Scientific evidence consists of observations and data on which to base scientific explanations. • Using evidence to understand interactions allows individuals to predict changes.	• Is what the eye detects really what we see? • How do we use light's properties to improve what we see?
15. Images of objects can be manipulated by understanding light's properties.	CORE 1 hour, 10 minutes	• The reflective image that hits our eye is actually inverted. • The human brain inverts images. • Models help us visualize things we cannot ordinarily see.	• Focused and unfocused light • Inverted image • Real image • Model	• Predict • Make observations • Measure • Record data • Identify characteristics • Compare and contrast • See relationships	• Science involves making hypotheses, theories and conceptual models to represent, explain and predict phenomena. • Scientific evidence consists of observations and data on which to base scientific explanations. • Using evidence to understand interactions allows individuals to predict changes. • Properties of some objects and processes are characterized by change. • Form and function are interdependent.	• Is what the eye detects really what we see? • How do we use light's properties to improve what we see?

Major Principles and Generalizations	Time Allocation and Parallel	Minor Principles and Generalizations	Concepts	Skills	Themes	Guiding Questions
16. Clear images can be intentionally produced using light's properties.	CORE 50 minutes	• The reflected image we see is inverted. • Light can be focused using lenses. • Lenses change the way we see things	• Focused and unfocused light • Inverted image • Lens	• Make observations • Measure • Record data • Identify characteristics • Compare and contrast • See relationships	• Scientific evidence consists of observations and data on which to base scientific explanations.	• How do we use light's properties to improve what we see?
17. Clear images can be intentionally produced using light's properties.	CORE/AID 1 hour	• The reflected image we see is inverted. • Light can be focused using lenses. • Lenses change the way we see things	• Focused and unfocused light • Inverted image • Lens	• Make observations • Measure distance • Record data • Identify characteristics • Compare and contrast • See relationships	• Scientific evidence consists of observations and data on which to base scientific explanations.	• How do we use light's properties to improve what we see?
18. Eyes have parts that have particular functions in the vision process.	CORE 55 minutes	• An eye operates in a similar fashion to a camera	• Vision • Structure and function of eye parts	• Make observations • Identify characteristics • Compare and contrast • See relationships	• Scientific evidence consists of observations and data on which to base scientific explanations.	• How does an eye adjust to light? • Is an eye like a camera?

Major Principles and Generalizations	Time Allocation and Parallel	Minor Principles and Generalizations	Concepts	Skills	Themes	Guiding Questions
19. Eyes have parts with particular functions in the vision process.	CORE 45 minutes	• An eye is like a human camera.	• Vision • Structure and function of eye parts	• Compare and contrast • See relationships	• Scientific evidence consists of observations and data on which to base scientific explanations.	• Is an eye like a camera?
20. Animals have eyes with varying structures that enable them to survive to their environments.	CONNECTIONS 2 hours, 30 minutes	• Animals have adaptations that assist them with survival in their habitats.	• Structure and function of animals' eyes • Adaptation	• Research information • Recognize attributes • Compare and contrast • Make decisions • Communicate orally and visually • Use creative thinking such as originality	• Scientific evidence consists of observations and data on which to base scientific explanations.	• Why do animals have so many different types of eyes?
21. Post Assessment	CORE 45 minutes	See pre-assessment	See pre-assessment	See pre-assessment	See pre-assessment	See pre-assessment

“Materials and Resources List”

Lesson	Primary Materials	Books	Additional Materials (Supplied by Teacher or Students)
1	Pre-assessment for the Light Unit (included)		.
2	Trays (2 per student or student group), water, (enough to fill each tray 2/3 full), Sand (enough to fill each tray 2/3 full), thermometers (2 per student or student group), black and white construction paper (1 piece for teacher demonstration #1), hand lens (teacher demonstration #2), container with water (e.g., squirt bottle) for teacher demonstration #2		Window with direct sunlight exposure or table lamp (teacher demonstration #1) Pictures or real devices that harness sunlight to assist humankind (e.g., solar panels, photoelectric cells and telescopes)
3	Graph paper (1 sheet per student), colored pencils for each student to make two different graphs on the same sheet of graph paper		
4	Sunny day materials: writing implements (2 per student group), focusing lenses (magnifying glass) 1 per student or student group, Water bottles with sport spouts so they can be used to squirt (1 per student or student group), red, yellow, pink, white, black, grown, and blue construction paper (cut the paper into 6" x 6" squares and give one of each color to each student or student group), clipboard (optional) Cloudy/rainy day materials: thermometers for the colored-paper teacher demonstration (2), ice cubes (4), 6" squares of red, blue, green, and yellow cellophane, rubber bands (4), lamp with an incandescent bulb (preferable a desk lamp that points downward) Clear plastic cups (4), clock (wall clock will be fine), clipboard, I per student or student group (optional)		
5	Black construction paper (1 piece per student or student group), 4" x 6" index cards (3 per student or student group), flashlight (1 per student or student group), 6" light sticks (1 per student or student group)		1-liter, black painted (except for a circular area the size of a flashlight head) plastic bottle (teacher demonstration), flashlight for teacher demonstration (flashlight must have the intensity of a *Maglite*, water in a container, pushpin (teacher demonstration), funnel that fits into the head of the plastic bottle (teacher demonstration), piece of clay to seal interface between top of bottle and the funnel, aluminum or plastic tray to catch water (teacher demonstration)

Lesson	Primary Materials	Books	Additional Materials (Supplied by Teacher or Students)
6	Pieces of red cellophane – 12 total, 6" square, 3 pieces to cover each of 4 flashlights, pieces of green cellophane – 12 total, 6" square, 3 pieces to cover each of 4 flashlights, pieces of blue cellophane, 6" square, 3 pieces to cover each of 4 flashlights, small flashlights (12 can be share amongst the groups), three will be used by each group at a time, rubber bands (3 of each per student group), pink, magenta, purple, and white construction paper (1 piece of each)		Candle, matches, and sheet of white paper (teacher demonstration), single lens, outside window, neon laser glasses (borrowed from a physics lab), Neon "Exit" or "For Sale" sign
7	Replica diffraction gratings (1 per student group) The item # is 65681-00 (package of 25 for $14.95) can be obtained from Science Kit & Boreal Lab, P.O. Box 5059, San Luis Obispo, CA 93403, via phone at 800-828-7777 or online at www.sciencekit.com . Shipping charges are 10% of the order with a minimum of $5 per order, source of light (e.g., lamp with bulb) (1 per student group), small square-sided tray (e.g., baking tray) (1 per student group), water, white paper (1 piece per student group), mirror (at least 6" tall and 3"wide, 1 per student group), clay (small piece per student group) to support the mirror or mirror supports can be ordered using a science catalogue, sunlight or a flashlight, (AID) Spectroscopes (1 per student or student group) These can be ordered from Ward's Natural Science or online at www.wardsci.com. The 6" spectroscopes are $9.50 for 6 and have the item number 25 V 4998., (AID) Masking tape (1 roll), (AID) Paper towel (1 sheet per student or student group), (AID) beaker or plastic cup (1 for each student or group of students), (AID) Stirring rod (1 for each student or group of students), (AID) Hot water (1 for each student or group of students), (AID) Filter paper (1 for each student or group of students), (AID) scissors (1 for each student or group of students), (AID) Plastic wrap (1 piece large enough to cover the top of a beaker for each student or group of students), (AID) hand lens (1 for each student or group of students), (AID) pencils (1 for each student or group of students), (AID) Isopropyl alcohol (1 plastic bottle approximately 16 ounces), (AID) aluminum pie plate or pan, (AID) ruler		White light, yellow light and fluorescent light source (teacher demonstration; 1 of each kind), mirrors, prisms and lenses can be ordered at www.wolverinesports.com/mirrors.html, , red light bulb or a red gel (3 or 4 depending on the number of observation stations you want to set up for small groups of students), green leaves (3 or 4 depending on the number of observation stations you want to set up for small groups of students), toilet paper or paper towel tube, 6" long tube with 1 1/2" diameter (1 per student group), prism (teacher demonstration), (AID) green leaves (1 for each student or group of students, (AID) assorted leaves for chromatography (1 leaf for each student or student group)
8	Cardboard shoebox (4 if the teacher is going to make the light boxes or one per student or student group if the students are going to make their own light boxes. (If they do make them, add 20 minutes to the activity.), metric ruler (4 if the teacher is going to make the light boxes or 1 per student or student group), scissors (4 if the teacher is going to make the light boxes or 1 per student or student group), sheet of white paper (4 if the teacher is going to make the light boxes or 1 per student or student group), small glass jar (4 if the teacher is going to make the light boxes or 1 per student or student group), pen (4 if the teacher is going to make the light boxes or 1 per student or student group), water, flashlight (one for one or two student groups) (at least one with a sharp beam if the extension activity is to be done), (AID) milk (2 oz. per group), container, plastic rectangular (1 per student or student group)	Rainbows, Halos, and Glories by Robert Greenler, An article in the journal Science and Children, Feb. 2004 issue, "What Causes Rainbows?"	Pictures and explanations of rainbows, both primary and secondary which can be obtained from the Internet Google Search tool. Click on Images and type in "primary rainbows." Two sites that show how rainbows work are: http://www.usatoday.com/weather/tg/wrainbow/wrainbow.htm . and www.phy.ntnu.edu.tw/java/Rainbow/rainbow/html

Lesson	Primary Materials	Books	Additional Materials (Supplied by Teacher or Students)
9	Wide deep glass container filled with water, so light can be shown through it at many angles and perpendicularly: a wide vase or tall beaker would do (one for one or two student groups), clear plastic or glass containers (6 per student group), cube (wood, plastic, or metal) (1 per student group, but make sure each group uses the same type of cube), tweezers (1 pair per student group), straws or pencils (six per student group), salt water solution, (AID) cup (one per student or student group), (AID) coin (one per student or student group), (AID) container with a pour spout, a small watering can or gravy separator will work		White vinegar, corn syrup, salt water solution (saturated), vegetable oil, rubbing alcohol salt water solution
10	Flashlight, glass		Jar of honey, glass of milk, window with sunlight or ultraviolet or infrared sources of light
11	Scissors (1 pair per student or student group), meter stick (1 per student or student group), plastic straws (4 per student or student group), troughs cups, bowls, etc. – anything that can be used to hold water and suspend 4 straws above the water with taped filer paper or paper towel strips on them in order to separate five different types of felt pen inks(, masking tape, filter paper or coffee filters, four different brands of water-color black markers (12 of each brand), water, permanent black marker (for teacher demonstration)		
12	Flashlight (1 per student or student group), masking tape (1 roll per student or student group), piece of cardboard (1 per student or student group) scissors (1 pair per student or student group), small ball of modeling clay or mirror support (1 per student or student group), piece of white construction paper (1 per student or student group), small mirror (1 per student or student group), (AID) protractor (1 per student or student group)		Toilet paper cardboard tube (1 per student or student group), aluminum foil 10 cm x 10 cm (1 piece per student or student group, reflective items such as aluminum foil, shiny wrapping paper, clean glass, mirror, tin, etc. (1 each per student or student group), comb and a piece of cardboard long enough to attach a comb (1 per student or student group)
13	Small flat mirrors (4 per student or student group), small object like a block (1 per student or student group), flashlight, small ball of modeling clay or mirror support (1 per student or student group), masking tape (1 roll per student or student group), scissors (1 pair per student or student group		Shoebox or milk cartons depending on which version of the periscope you are going to have students build (1 shoebox per group or 2 milk cartons per group), the following website can be visited for directions for the milk carton version of the periscope: http://www.scienctoymaker.org/periscope
14	Index card (1 per student), hand held magnifier (1 per student group), pin (1 per student group), elastic bands (2 per student group), scissors (1 or 2 pairs per student group	*Experiments with Light* by Beeler & Branley (helpful but not required)	Lamp with a 60 watt bulb in it (1 per student group) (optional), wax paper (1 piece per student group), aluminum foil (1 piece per student group), paper towel tube or gift wrapping tube (1 per student group), toilet tissue tube (1 per student group) (Make sure this tube is wider than the towel or wrapping tube so that it will slide over the longer tube.)

Lesson	Primary Materials	Books	Additional Materials (Supplied by Teacher or Students)
15	Hand held magnifier (1 per student group), white paper (1 piece per student group), flashlight for demonstration, scissors (for teacher demonstration), Scotch tape, masking tape,	*Experiments in Light* by Beeler & Branley (helpful but not required)	Matches, lamp with a 60 watt bulb in it (1 per student group) (optional), wax paper (one piece per single lens camera), paper towel tube or gift wrapping tubes (for teacher demonstration), paper towel tubes or gift wrapping tubes (1 per single lens camera), toilet tissue tube (one per single lens camera) Make sure that one tube can fit inside the other.
16	Handheld lens (reading glasses) (1 per student group), white paper (1 sheet per student group), one good flashlight with a beam adjuster so that the beam can be made more intense, pen or pencil, metric ruler (1 per student group), candle or Maglite flashlight that can be used as a candle (1 per student group), small paper cup (1 per student group)	*Experiments in Light* by Beeler & Branley (helpful but not required)	A bucket of sand readily available to be used to put out a small fire as a safety precaution, Butcher paper or newspaper (enough to cover the area where students will set up their candle, lens, and white paper), matches (1 box or book per student group)
17	Candle (I per student group), meter stick (1 per student group)	*Seeing the Light Optics in Nature, Photography, color, vision and Holography* by David Falk, Dieter Brill, & David Stork (helpful but not required)	A bucket of sand readily available to be used to put out a small fire as a safety precaution, matches (box or book per student group)
18	Pencil (one per student), eye analyzer (1 per student group) materials for this include the following: poster board, cardboard tubes, pocket mirrors 4" x 4", and tape (See directions for assembly in Preparation Activities), diagram, transparency or projected computer image of the structure of an eye http://www.nei.nih.gov/health/eyediagram/images/diagram.gif , diagram of a simple camera: http://www.phys.ufl.edu/~avery/course/3400/camera/eb_camera_screen.gif	*Seeing the Light Optics in Nature, Photography, Color, Vision and Holography* by David Falk, Dieter Brill & David Stork (helpful but not required)	
19	Colored diagrams of the eye comparing it to a camera were adapted from those found at the following website: http://member.rivernet.com.au/balehirs/Bishyp7dOlderEyes.htm#Eye%20Anatomy		
20	Poster board (one piece for each student who chooses to make a poster for his or her presentation), markers, scissors, folders (one per student)		A variety of pictures of different kinds of eyes from organisms, Internet access (optional), magazines with pictures of different animals (e.g., *National Geographic*)
21	**Post Assessment for the Light Unit** (included)		