

CURRICULUM GUIDE FOR

Light Energy

(This kit also includes the Catch it! CSDE Embedded Task)

*Additional Resources for this unit can be found on Wallingford's W Drive:
W:\SCIENCE - ELEMENTARY\Light Energy gr 5*

**Wallingford Public Schools
5th Grade
Science**

The initial draft of this material was developed by the CT Center for Science Inquiry Teaching and Learning, is based upon work supported by the Connecticut State Department of Higher Education through the No Child Left Behind Act of 2001, Title II, Part A, Subpart 3, Improving Teacher Quality State Grant Funds; CFDA#84.367B

*This unit was developed based on the scope and sequence approved by
Wallingford Board of Education June 13, 2007.*

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Section 1 UNIT OBJECTIVES

Stage one of Understanding by Design identifies the desired results of the unit including the related state science content standards and expected performances, enduring understandings, essential questions, knowledge and skills. What should students understand, know, and be able to do?

The knowledge and skills in this section have been extracted from Wallingford’s K-5 Science Scope and Sequence.

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Section 2 ASSESSMENTS

Stage two of Understanding by Design identifies the acceptable evidence that students have acquired the understandings, knowledge, and skills identified in stage one. How will we know if students have achieved the desired results and met the content standards? How will we know that students really understand?

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Section 3 LESSON IDEAS

What will need to be taught and coached, and how should it best be taught, in light of the performance goals in stage one? How will we make learning both engaging and effective, given the goals (stage 1) and needed evidence (stage 2)? Stage 3 of Understanding by Design helps teachers plan learning experiences that align with stage one and enables students to be successful in stage two. Lesson activities are suggested, however, teachers are encouraged to customize this stage to their own students, maintaining alignment with stages one and two.

The CSDE Embedded Task Catch it! teacher manual is also included in this kit.

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Section 4 TEACHER BACKGROUND NOTES

These science content background notes were created for teacher use only. We anticipate that these notes will provide you, the teacher, with some useful background information as you facilitate inquiry activities for your students. These notes are not meant to be an overview of the unit, but as background information for you that go beyond the content of this particular unit. These notes should not be replicated for your students; however, you may share some of the content when appropriate for the developmental level of your students.

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Section 5 MATERIALS

- **Materials List**

This list identifies the list of materials found in the kit.

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- **Literature Resources**

These literature resources have been purchased to supplement the kit and are housed in each elementary school library.

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UNIT SUMMARY

This unit invites students to explore light. Through investigations students will be provided the opportunity to learn concepts such as the absorption, reflection, and refraction of light. Students will also explore how white light is separated into colors and explain how humans perceive different colors. Students will also learn about how they eye is similar to a camera and how various instruments can enhance our vision.

STAGE 1- STANDARDS/GOALS

What should students understand, know, and be able to do? Stage one identifies the desired results of the unit including the related state science content standards and expected performances, enduring understandings, essential questions, knowledge and skills.

Enduring Understandings	Essential Questions
<p><i>Insights earned from exploring generalizations via the essential questions (Students will understand THAT...)</i> <i>K-12 enduring understandings are those understandings that should be developed over time, they are not expected to be mastered over one unit or one year.</i></p>	<p><i>Inquiry used to explore generalizations</i></p>
<p><u>Overarching Enduring Understandings:</u></p> <ul style="list-style-type: none"> • Science is the method of observation and investigation used to understand our world. (K-12) • Inquiry is the integration of process skills, the application of scientific content, and critical thinking to solve problems. (K-12) <p><u>Unit Specific Enduring Understandings:</u></p> <ul style="list-style-type: none"> • Light is a form of energy. • Light travels in a straight line through any material. • Light can be absorbed by materials, reflected off the surface of materials, and refracted at the surface between two materials when it passes through. • White light is a blend of all colors of the visible spectrum and can be separated into individual colors. • Structure and function of the human eye allows us to see. • Various instruments can be used to enhance vision. 	<ul style="list-style-type: none"> • How is inquiry used to investigate the answers to questions we pose? • How does light travel? • What happens when light strikes a surface? • How does light affect the colors we see? • How do we see? • What are the similarities/ differences between a camera and the human eye? • How do various instruments improve vision?

Knowledge and Skills

What students are expected to know and be able to do

**The knowledge and skills in this section have been extracted from Wallingford's
K-5 Science Scope and Sequence.**

Knowledge

- K1. Identify different sources of light.
- K2. Determine the path the light takes from a given light source. (straight line) (EP B19)
 - Illustrate the path the light takes after hitting a mirror. (Reflect) (EP B19)
- K3. Discuss the difference between reflection and refraction. (EP B19 and B25)
- K4. Identify what different surfaces can absorb light and reflect light. (EP B19)
 - Translucent
 - Transparent
 - Opaque
- K6. Demonstrate how white light is a combination of all colors of light. (EP B20)
- K7. Illustrate how white light can be separated into colors. (prisms) (EP B20)
- K8. Describe how we see different colors in our environments. (EP B20)
 - Absorption
 - Reflection
- K9. Identify the five main parts of the eye. (cornea, lens, pupil, iris, retina) (EP B24)
- K10. Explain the function of each part of the eye. (EP B24)
- K11. Relate the parts of the camera to the parts of the eye. (compare and contrast) (EP B24)
- K12. Describe the uses of different instruments that enhance our vision such as eyeglasses, magnifiers, periscopes and telescopes. (EP B25)

Skills

- Generate testable questions and questions that need to be answered using print resources.
 - Revise questions to be testable
- Observe objects and describe commonalities and differences among them.
 - Observe how light travels and the properties of light
- Classify in a variety of ways based on properties.
- Predict what might happen.
- Design a fair test to answer an investigable question.
- Revise plan based on observation/ results.
- Conduct simple investigations.
 - Investigate the properties of light
 - Investigate and explain how various objects affect how light travels
 -
- Collect and record data using appropriate tools, such as:
 - Metric ruler
 - Timer
 - Scales
 - Non-standard measuring devices
- Organize appropriate and accurate measurements and observations, using:
 - Graphic organizers
 - Charts and graphs

- Illustrations or diagrams
- Journaling
- Draw conclusions based on data, observations, or findings.
- Communicate results or information in an appropriate manner, using:
 - Presentations
 - Visuals
 - Simple reports

Content Standard(s)	
<i>Generalizations about what students should know and be able to do.</i>	
CSDE Content Standards (CSDE Science Framework 2004)	CSDE Primary Expected Performances (CSDE Science Framework 2004)
<p>5.1- Sound and light are forms of energy.</p> <ul style="list-style-type: none"> ◆ Sound is a form of energy that is produced by the vibration of objects and is transmitted by the vibration of air and objects. ◆ 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. <p>5.2- Perceiving and responding to information about the environment is critical to the survival of organisms.</p> <ul style="list-style-type: none"> ◆ The sense organs perceive stimuli from the environment and send signals to the brain through the nervous system. <p>5.4- Humans have the capacity to build and use tools to advance the quality of their lives.</p> <ul style="list-style-type: none"> ◆ Advances in technology allow individuals to acquire new information about the world. 	<p>B19. Describe how light is absorbed and/or reflected by different surfaces.</p> <p>B20. Describe how light absorption and reflection allow one to see the shapes and colors of objects.</p> <p>B21. Describe the structure and function of the human senses and the signals they perceive. (the human eye)</p> <p>B24. Compare and contrast the structures of the human eye with those of the camera.</p> <p>B25. Describe the use of different instruments, such as eye glasses, magnifiers, periscopes and telescopes, to enhance our vision.</p>

<p><i>Scientific Inquiry</i></p>	<p>B INQ.1 Make observations and ask questions about objects, organisms and the environment.</p> <p>B INQ.2 Seek relevant information in books, magazines and electronic media.</p> <p>B INQ.3 Design and conduct simple investigations.</p> <p>B INQ.4 Employ simple equipment and measuring tools to gather data and extend the senses.</p>
<p><i>Scientific Literacy</i></p>	<p>B INQ.5 Use data to construct reasonable explanations.</p> <p>B INQ.6 Analyze, critique and communicate investigations using words, graphs and drawings.</p> <p>B INQ.7 Read and write a variety of science-related fiction and nonfiction texts.</p>
<p><i>Scientific Numeracy</i></p>	<p>B INQ.8 Search the Web and locate relevant science information.</p> <p>B INQ.9 Use measurement tools and standard units (e.g., cm, m, g, kg) to describe objects and materials.</p> <p>B INQ.10 Use mathematics to analyze, interpret and present data.</p>

STAGE 2 – DETERMINE ACCEPTABLE EVIDENCE

How will we know if students have achieved the desired results and met the content standards? How will we know that students really understand? Stage two identifies the acceptable evidence that students have acquired the understandings, knowledge, and skills identified in stage one.

Performance Task(s) <i>Authentic application in new context to evaluate student achievement of desired results designed according to GRASPS. (Goal, Role, Audience, Setting Performance, Standards)</i>	Other Evidence <i>Other methods to evaluate student achievement of desired results.</i>
<p>Submarine Periscope Design – Lesson 5 – Page 6</p> <p>Design a Night Light - Lesson 4 – Page 3</p> <p>Stage Lighting – Lesson 8 – Page 9</p> <p>Guided Inquiry Investigation (<i>see last lesson in Lesson Ideas Section</i>)</p>	<ul style="list-style-type: none"> • Light Quiz - Lesson 4 – Page 2 • How are Images Reflected in Flat Mirrors? – Lesson 5 – Page 7 • What is White Light? – Lesson 8 – Page 8 • Sally’s Buckets – Lesson 9 – Page 10 • Writing prompts using the essential questions after each lesson – Page 11 • Light and the Eye CMT “like” Questions – all lessons – Page 12 • Light Assessment – all lessons – Page 18 • Teacher Checklist of Process Skills – Page 19 • Notebook Assessments – Page 20 – 22 • Vocabulary quiz – Page 23 • Writing prompts • Teacher observations • Collect I notice...I wonder...charts • Poster / Presentation during inquiry

Light Quiz

What happens when light strikes a surface?
(Lesson 4)

1. Draw and explain to what happens to the path of light as it hits a piece of black paper, a glass mirror, and a glass of water. Explain why the light behaves the way it does as it hits each object.

<u>Word Bank</u>		
Absorbed	Opaque	Transparent
Reflected	Refracted	Translucent

1. Light is _____ by the black paper.



Piece of black paper

2. Light is _____ by the mirror.



mirror

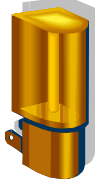
3. Light is _____ by the glass of water.



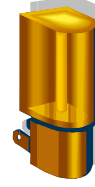
Glass of water

4. Arrange the following materials from most transparent to most opaque.

Materials: frying pan, glass window, paper towel, bubble wrap,



Night Light Design



What happens when light strikes a surface?
(Lesson 4)

Brainstorm with a group – What factors make a “better” night light?
(HINT: Consider the various night light designs you have seen – what makes one “better” than the other?)

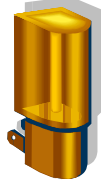
Sketch or draw your night light design. Include captions with relevant scientific vocabulary to explain how your design works and materials make the “best” night light.

What design factors do you like the best? _____
Explain why you chose this design

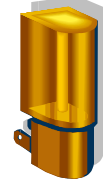
Select one design factor that you did not chose _____
Explain why you did not chose this design factor

What materials do you like the best? _____
Explain why you chose to use these materials

Select one type of material that you did not chose _____
Explain why you did not chose this material



“TEACHER NOTES” Night Light Design



Brainstorm with a group – What factors make a “better” night light?

(HINT: Consider the various night light designs you have seen – what makes one “better” than the other?)

- **Color**
- **Amount of light**
- **Translucent cover**
- **Transparent cover**
- **Opaque cover**
- **Sensor to turn off/on with amount of light**
- **Design – aesthetics**
- **Battery powered vs wall unit**

Sketch or draw your night light design. Include captions with relevant scientific vocabulary to explain how your design works and materials make the “best” night light.

Explanation might include:

- **Reflect / absorb light**
- **Description of cover – translucent, transparent, opaque, reflector**
- **Path of light**

Name _____ Date _____

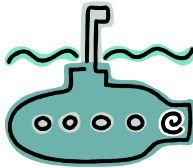
Submarine Periscope Design

How does light travel?

What happens when light strikes a surface?

(Lesson 5)

Your Task: You have been hired by a submarine company to judge different periscope designs. A periscope is an instrument used for conducting observations from a concealed or protected position. For example, a periscope is used in a submarine ship to look above the water for enemy ships.

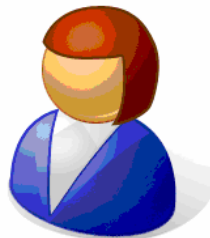
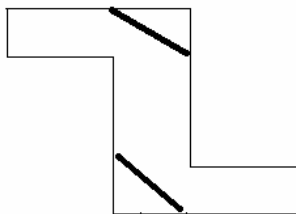


Using what you know about light, decide what periscope design would be the best tool.

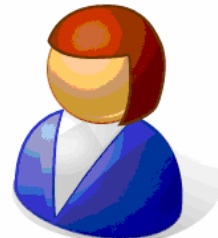
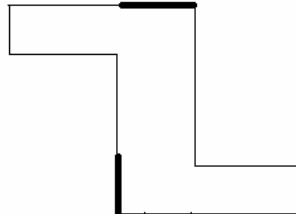
Your proposal to the submarine company should include:

- explain which periscope you recommend and why
- an illustration to show the path of light through your periscope
- an explanation why you didn't recommend the other design
- an illustration as to why the other design does not work and
- describe what the viewer would see in each periscope

A.



B.

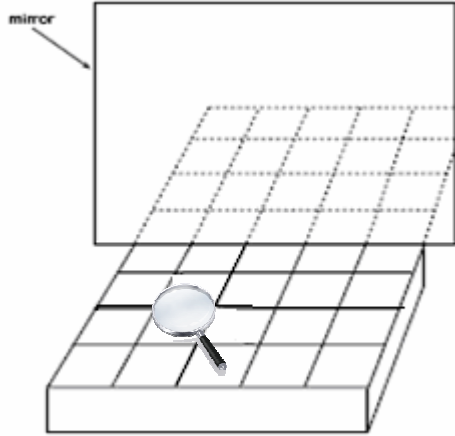


— = Mirrors

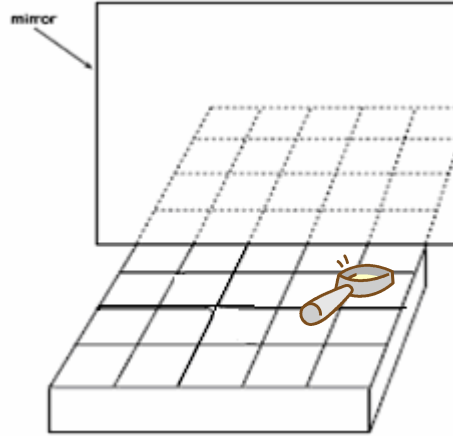
How are Images Reflected in Flat Mirrors?

How does light travel? What happens when light strikes a surface?
(Lesson 5)

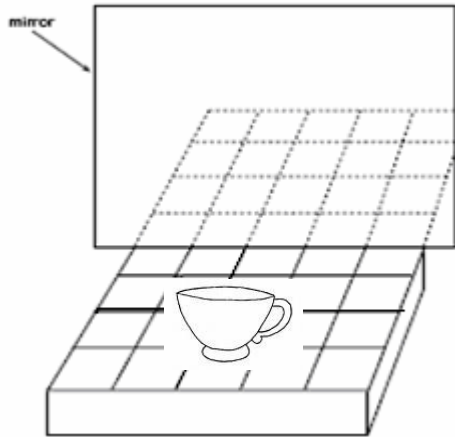
1.



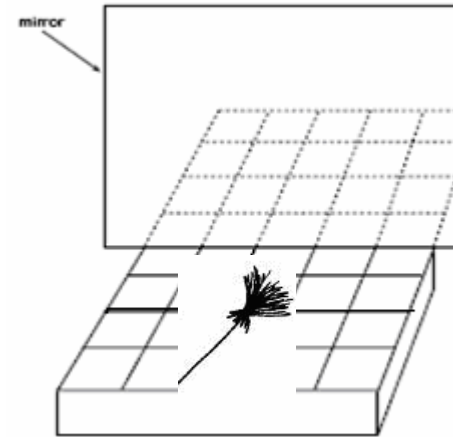
2.



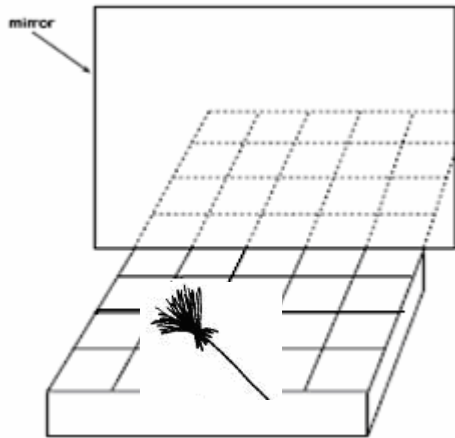
3.



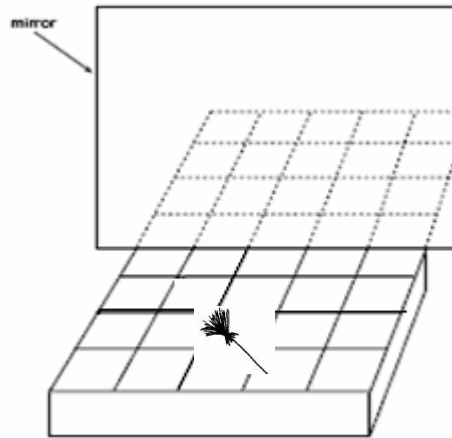
4.



5.



6.



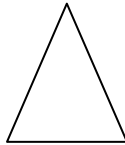
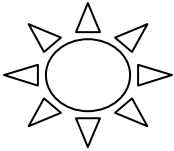
What is White Light?

How does light affect the colors we see?

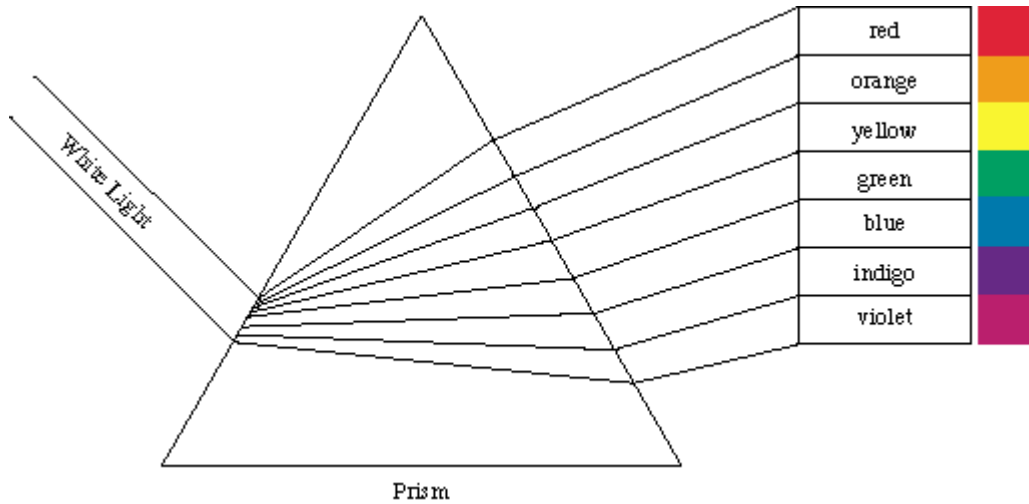
How does light travel?

(Lesson 8)

Illustrate with colored pencils (crayons) what white light is and how it behaves as it strikes a prism.



Answer:



<http://www.quiltwoman.com/images/BlockMonth/Dec98/prism.gif>

Stage Lighting

How does light affect the colors we see?

How does light travel?

(Lesson 8)

Your school is putting on a play but there are problems preventing the show from going on! As a member of the Lighting Crew, you are expected to help solve the two problems that might cause the show to be canceled. You should include a description of your plan for solving each of the problems, as well as an explanation of how the scientific concepts of light are involved in your solutions

Problem #1- In the first scene in which Miss Clark appears, she is supposed to be wearing a BLACK dress. The only available dress that will fit the student playing this role is RED. There is no money in the budget to purchase another dress. What can be done to the lighting on the stage to make the RED dress APPEAR BLACK?

Problem #2- There are certain scenes in the play that require the stage to be lit by white light only. ALL of the white light bulbs in the stage lights have blown out. The white light bulbs are very expensive and there is no money in the budget to purchase new bulbs. The only available replacement light bulbs are red, yellow, blue, purple, green, and orange. Is there some way to make white light using the available bulbs?

Sally's Buckets

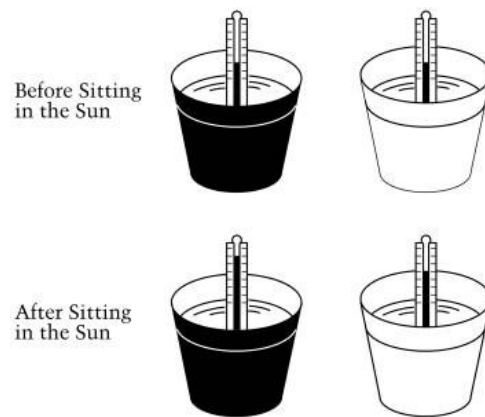
(Lesson 9)

What happens when light strikes a surface?

How does light affect the colors we see?

One hot, sunny day Sally left two buckets of water out in the sun. The two buckets were the same except that one was black and one was white. At the end of the day, Sally noticed that the water in the black bucket felt warmer than the water in the white bucket.

Sally wondered why this happened, so the next day she left the buckets of water out in the hot sun again. She made sure that there was the same amount of water in each bucket. This time she carefully measured the temperature of the water in both buckets at the beginning of the day and at the end of the day. The pictures below show what Sally found.



How does the experiment help explain why people often choose to wear white clothes in hot weather?

Use the Essential Questions to Assess Understanding

- How is inquiry used to investigate the answers to questions we pose?
- How does light travel?
- What happens when light strikes a surface
- How does light affect the colors we see?
- How do we see?
- What are the similarities/ differences between a camera and the human eye?
- How do various instruments improve vision?

Light and the Eye CMT “like” Questions

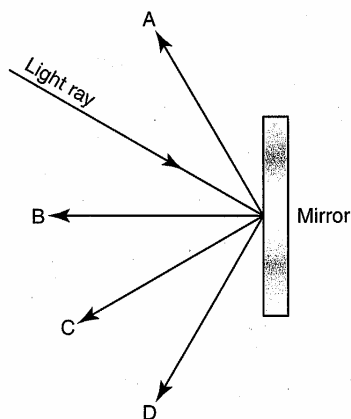
1. When you are riding a bicycle at night, your bicycle’s reflectors help people in cars see your bicycle. How do bicycle reflectors work?

- A) They are made of a special material that gives off its own light.
- B) They are hooked up to batteries that allow them to produce light.
- C) They are covered with paint that glows in the dark.
- D) They bounce light back from other sources.

2. Which of the following choices best explains why grass on a distant hillside appears green?

- A) Grass reflects all colors except green.
- B) Grass reflects green light more than any other color.
- C) Grass absorbs only green light from the sun.
- D) Grass transmits green light in the same way that green-colored cellophane does.

3. A light ray strikes a plane mirror as shown below in the diagram.



Which ray shows the path of the reflected ray?

- A) ray A
- B) ray B
- C) ray C
- D) ray D



4. A student sees a mirror image of a duck in the water of the lake. What causes this mirror image?

- A) Black light coming from under the water
 - B) Refracted light bending through the water
 - C) Reflected light bouncing off the surface of the water
 - D) Absorbed light given off by the water
5. Which of the following would reflect rather than refract light?
- A) magnifying glass in a science set
 - B) mirror in a bathroom
 - C) prism hanging from the rear view mirror
 - D) lens in a pair of eyeglasses
6. A shadow is caused by



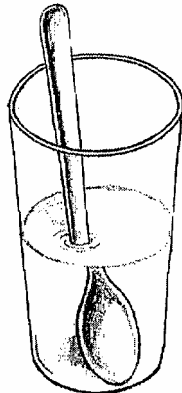
- A) light being blocked by an object
- B) a lack of light in the room
- C) too much light in the room
- D) an object reflecting light

7. At dusk, you often can only make out the shape of objects, not their color. This is because at dusk there is less light, and:

- A) The color in the object is lessened.
- B) People are tired and they can not see colors as well.
- C) The nerves that perceive color need more brightness
- D) The dyes in the object can not reflect the colors.

8. Raul's little sister, Sarah, wants to know why she can see herself in a mirror, but she can see through a window. What should Raul tell his sister to explain the differences between mirrors and windows?

9. The spoon appears to be broken where it enters the water because



- A) The light is reflected by the water.
- B) The light is absorbed by the water.
- C) The light is refracted by the water.
- D) The light is dissolved by the water.

10. As a play begins, white stage lights shine on an actress wearing a red dress. Suddenly the lights go off and a green light is shone on the actress. The dress looks black. Why does the dress look black?

- A) The dress reflects the green part of the light.
- B) The dress absorbs the red part of the light.
- C) The dress absorbs the green part of the light.
- D) The dress reflects the black part of the light.

11. Roddy and Stephanie each make a flashlight using identical batteries and bulbs.



They then add cardboard reflectors to their flashlights as shown below. Roddy's reflector is made of white cardboard and Stephanie's reflector is made of black cardboard.

Roddy's Flashlight
White Reflector



Stephanie's Flashlight
Black Reflector



The flashlights are then switched on.

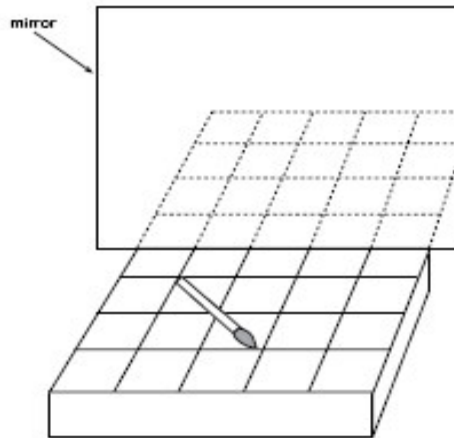
A.) Which flashlight shines more light on a wall two meters away? (check one)

_____ Roddy's (white reflector)

_____ Stephanie (black reflector)

B.) Explain your answer

12. The picture shows a paint brush that is lying on a shelf in front of a mirror. Draw a picture of the paint brush as you would see it in the mirror. Use the patterns of lines on the shelf to help you.



13. Messages are carried from the eyes to the brain by

- A. blood vessels
- B. light
- C. muscles
- D. nerves

14. Light traveling through a pair of eyeglasses is

- A. refracted
- B. transmitted
- C. absorbed
- D. reflected

Answer Key - Light and the Eye CMT “like” Questions

1.	D	B.19	7.	C	B.20	13.	D
2.	B	B.20	8.	**	B.19	14.	A
3.	C	B.19	9.	C	B.19		
4.	C	B.19	10.	C	B.20		
5.	B	B.19	11.	**	B.20		
6.	A	B19	12.	**	B.20		

** Constructed Responses

8. *Raul’s little sister, Sarah, wants to know why she can see herself in a mirror, but she can see through a window. What should Raul tell his sister to explain the differences between mirrors and windows?*

Key Concepts:

- A. Transparent materials let light through without change
- B. Smooth, silvered objects (such as a mirror) reflect light images.
- C. While both mirrors and windows are smooth, only the mirror is silvered/shiny. (Opaque)

Score

- 2. Answer includes A and B with elaboration C
- 1. Answer includes A and B with no elaboration
- 0. Answer is incomplete or wrong

11. *Roddy and Stephanie’s flashlights – Which shines more light on a surface*

Key Concepts:

- A. White and silvered smooth surfaces reflect more light / absorb less light – this flashlight shines more light on the surface
- B. Black surfaces absorb more light and therefore reflect less

Score

- 2. Answer includes A and B with elaboration
- 1. Answer includes A and B with no elaboration
- 0. Answer is incomplete or wrong

12. *Paint brush reflected in a mirror*

Key Performance Elements:

- A. Brush is drawn with brush end aimed right at intersection 3 up and 3 from left
- B. Brush is drawn with stick end at intersection 1 up and 1 from left.

Score:

- 2. Answer includes A and B with elaboration
- 1. Answer includes A and B with no elaboration
- 0. Answer is incomplete or wrong

Light Assessment

1. Describe how light travels from an object to your eye. Explain what we did in our investigations to support this idea.
2. How is your shadow formed at noon on a summer day?
3. A door has a stained glass window. Explain whether this window would be described as transparent or translucent.
4. Draw the path of light when you observe your feet in a full length mirror.



5. White light is shining on a red apple on a blue table cloth. Describe the path of light that allows you to see the red apple and the blue table cloth. You may want to include a colored diagram to help explain your answer.

Teacher Check List of Process Skills

Student Name	Observing	Predicting	Collecting and Organizing Data	Investigating	Interpreting Data	Sharing Results		
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								

Science Notebook Assessment



Name:
Topic: Light
Date:

Assessment Scale
1-Work in Progress
2-Meets Expectations
3-Exceeds Expectations

Process	Rating
1. Organized notebook	
2. Managed time wisely throughout the unit	
3. Communicated efforts with teacher throughout the unit.	
4. Participated during class discussions.	
5. Worked independently during unit.	
6. Worked cooperatively with others during unit.	
7. Portfolio demonstrates knowledge learned during the unit.	

Science Notebook Assessment

Enduring understandings and essential questions _____ (20)

Completion of observations _____ (20)

Accuracy of observations _____ (20)

“What I learned...”reflections _____(30)

Neatness / Organization / Labels _____ (10)

Comments:

Science Notebook Assessment

Enduring understandings and essential questions _____ (20)

Completion of observations _____ (20)

Accuracy of observations _____ (20)

“What I learned...”reflections _____(30)

Neatness / Organization / Labels _____ (10)

Comments:

Science Notebook Journal Response

1. Followed the format of science notebook entry.
 2. Question answered completely with pictures or diagrams labeled.
 3. Response is well organized and clearly communicated
-

Science Notebook Journal Response

1. Followed the format of science notebook entry.
2. Question answered completely with pictures or diagrams labeled.
3. Response is well organized and clearly communicated

Common “Light” Vocabulary

light	absorb/absorption
reflect/reflection	refract/ refraction
convex	concave
plane mirrors	opaque
translucent	transparent
magnifier	lens
iris	pupil
retina	cornea
shutter	aperture
diaphragm	periscope
telescope	color

STAGE 3 – LESSON ACTIVITIES

What will need to be taught and coached, and how should it best be taught, in light of the performance goals in stage one? How will we make learning both engaging and effective, given the goals (stage 1) and needed evidence (stage 2)? Stage 3 helps teachers plan learning experiences that align with stage one and enables students to be successful in stage two. Lesson activities are suggested, however, teachers are encouraged to customize these activities, maintaining alignment with stages one and two.

The suggested lesson activities are not sequenced in any particular order. Teachers may select which lesson activities will best meet the needs of their students and the unit objectives. Each lesson activity is coded with the corresponding knowledge (K) and/or skill (S) objectives that are found in stage one.

- Use the essential questions to start each lesson (keep in mind the unit objectives and enduring understandings). Post the essential questions in your class and close each lesson discussing and posting the big ideas or enduring understanding.
- There may be more than one lesson idea related to the topic. Teachers should formatively assess their students and select those lessons most appropriate for their students.
- It is recommended that students use science notebooks for this unit.

Lesson 1. What is light? Where is light? Organizing Science Notebooks.....	Page 2
Lesson 2. Circus Light	Page 4
Lesson 3. How does light travel?	Page 13
Lesson 4. What happens when light strikes the surface of different objects?	Page 15
Lesson 5. Angle of Reflection – How are images made in flat mirrors?	Page 21
Lesson 6. Different Types of Mirrors	Page 24
Lesson 7. Refraction – The Bending Pencil.....	Page 27
Lesson 8. How does light affect the colors we see?	Page 29
Lesson 9. How do we see different colors?	Page 32
Lesson 10. Parts of the Eye.....	Page 33
Lesson 11. Compare a Camera and the Human Eye.....	Page 40
Lesson 12. How do Various Instruments Enhance our Vision?	Page 43
Lesson 13. Inquiry Investigation	Page 44

1. What is light? Where is light?

Enduring Understanding(s):

- Light is a form of energy.

Essential Question(s):

- What is light?
- Where is light?

Knowledge Objective: K1

Approximate Time: 1 class (40 min) This includes an activity that access prior knowledge and setting up the science notebook.

Suggested Lesson Ideas include:

- Create a class chart of possible sources of light that students see in their world today to keep posted in the classroom
- Do a scavenger hunt in the classroom and at home having students find and record in their science notebook all of the locations they find light and light sources
- Brainstorm everything they know about light using a KWL
- Teacher guided discussion regarding light as a form of energy. Light can be used to power things. Connection to solar powered instruments, calculators, cars, and solar pool cover.
- You could explore different forms of energy using the non-fiction books that are housed in each school library.
- See next lesson *Circus Light*

Teacher's Background Notes.

The purpose of this activity is to access prior knowledge, formatively assess their background knowledge, and lead the discussion towards the essential questions listed above. They will most likely connect electricity to light. Lead the discussion toward the term energy.

Energy is the term scientists use to describe the way we measure the amount of movement that exists in any situation.

In the following activities, students will be encouraged to explore some of the ideas they have related to the essential questions. Students will explore and build a set of observations and some explanations that will help describe the way light behaves. Please recognize that they will be exploring the most common observations – there are other, more limited observations that could be made and may be known by your students. If they want to explore those observations, invite them to explore them and share their findings with the class. You should not feel that you must know the “answer”. Rather you should model the pursuit of understanding of a logical description of what happens that can explain what is observed and predict what would happen under slightly different circumstances.

ORGANIZING SCIENCE NOTEBOOKS

We recommend that the teacher starts 2 posters/charts in the classroom. One poster is for **essential questions** and one poster for **enduring understandings** (or what we learned after each lesson). At the beginning of each lesson the teacher will share the lesson question that will drive inquiry for the lesson. At the end of the lesson the teacher should facilitate the class in identifying the enduring understanding for the lesson. The teacher may want to number or color code the essential question and enduring understanding(s) that are related.

Students should also identify two pages in the beginning of their science notebooks and **copy the essential questions and enduring understandings down daily**. (One page in the notebook is for essential questions and one page is for enduring understandings.) The first question that the class will investigate is “*What is light? Where is light?*”

2. Circus Light (See NSTA Article on next page)

Enduring Understanding(s):

- Light is a form of energy.
- Light travels in a straight line through any material.
- Light can be absorbed by materials, reflected off the surface of materials, and refracted at the surface between two materials when it passes through.
- White light is a blend of all colors of the visible spectrum and can be separated into individual colors.

Essential Question(s):

- How is inquiry used to investigate the answers to questions we pose?
- How does light travel?
- What happens when light strikes a surface?
- How does light affect the colors we see?

Knowledge Objective: K1, K2, K6

Approximate Time: 1 class (90 minutes)

Materials Per Group of Students (2-3 students):

Science notebook

Bouncing Light

- Flashlight, tennis ball, large mirror, chalk eraser w/corn starch

Bending Light

- Pencil, glass cup

Light in the Darkness

- Large cardboard box with cloth drape, flashlight, mirror, piece white paper, small object/figurine

Me and My Shadow

- Lamp (or overhead projector), screen or blank wall, a set of pictures of shadow pictures or shapes to form with their hands – such as a bird, dog, or elephant

Making a Rainbow

- 2 prisms, overhead projector

Note:

- It would be helpful to have an aid or parent volunteer to assist with this lesson.
- Most lessons suggested in this kit can be connected back to these initial stations and observations.
- The first few stations will take about 20 minutes and less time will be needed for subsequent stations.
- Students will need reminders mid way through each station to take observations and notes.
- Allow time at end to finish questions and synthesize as a class.

- If you don't have a larger mirror in your classroom, tape 6 small mirrors together on the back to create one larger mirror.

**Sample student directions can be found on the Wallingford W drive at:
W:\SCIENCE - ELEMENTARY\Light gr 5\Circus Light - lesson 2**



Science and Children

February 2004, p. 50-54

Feature

Circus of Light

Juanita Jo Matkins and Jacqueline McDonnough

Insert Article Here

See W drive

3. How does light travel?

Enduring Understanding(s):

- Light travels in a straight line through any material.
- Light can be absorbed by materials, reflected off the surface of materials, and refracted at the surface between two materials when it passes through.

Essential Question(s):

- How does light travel?
- What happens when light strikes a surface?

Knowledge Objective: K2

Approximate Time: 1 class (40 min)

NOTE: We recommend that the teacher starts 2 posters/charts in the classroom. One poster is for **essential questions** and one poster for **enduring understandings** (or what we learned after each lesson). At the beginning of each lesson the teacher will share the lesson question that will drive inquiry for the lesson. At the end of the lesson the teacher should facilitate the class in identifying the enduring understanding for the lesson.

Students should also identify two pages in the beginning of their science notebooks and **copy the essential questions and enduring understandings down daily**. (One page in the notebook is for essential questions and one page is for enduring understandings.)

Suggested Lesson Ideas include:

Activity 1- How Can Light Travel Through 3 Holes?

Materials Per Group of Students (2-3 students)

- 3 cardboard squares with small hole
- 3 stands (binder clip, clay or acrylic stand) to hold cardboard squares
- 1 flashlight
- Wall or flat surface to shine light on (paper, cardboard, wall, notebook, etc.)
- [See following page for sample data collection table – How Does Light Travel? This can be glued/taped into the science notebook](#)
- Student notebook

Teacher Directions:

1. Explain to students that they will be investigating the essential question, “How does light travel?” Have them copy this into their science notebooks.
2. Introduce students to the materials available. This lesson requires a room that is fairly dark. **If you don’t have shades on your windows, you may need to relocate your class for this lesson.**
3. Have students predict in their science notebook “How do you think light travels?”

4. Challenge them to make the light from the flashlight travel through all 3 holes in the cardboard. Tell them that they need to arrange the holes in a way so that the light is able to shine through to the wall/notebook after traveling through the 3 holes in the cardboard.
5. As they are investigating, have them discuss “How do you think light travels?” Guide students to the following big ideas:
 - *Light travels in a straight line.*
 - *Light travels out in all directions from a light source.*
6. Remind students to record their observations and notes in their science notebook. Encourage them to make labeled diagrams.
7. After this lesson, validate what they learned by reading page 84 (How Does Light Travel?) in the McGraw Hill Book. Have students take additional notes related to this question in their science notebook.

Activity 2- Mirrors and Reflection in Lenses and Mirrors

Directions for this lesson can be found in the *Lenses and Mirrors* DSM II Teacher Guide (this is included in the kit)

Students will shine a flashlight through a narrow slit and observe the behavior of light as they strike a mirror at various angles. They will discover that light is reflected by a mirror at the same angle at which it strikes the mirror.

Materials Per Group of Students (2-3 students)

Activity Sheet 1 Part A and B (see teacher guide for a copy)

Flashlight

1 flat mirror

1 black slit card

Holders for mirror and slit card

Masking Tape

Scissors – provided by teacher

Metric ruler – provided by teacher

Note – you do not need to use the frosted acetate paper to place over flashlight.

Activity 3- Optional Activity – Model the Path of Light with a String

Hold mirror between 2 people and use string to find nose in mirror / Follow the Bouncing light in Macmillan/McGraw-Hill Activity Resources page 239

Activity 4- Optional Activity – Make Periscopes

Have students make periscopes. Students can make mirrors out of aluminum and cardboard. Paper towel tubes or cardboard milk cartons can be used as the body. Various directions to make periscopes can be found on line. Materials are not provided in the kit for this activity.

Name _____ Date _____

How Does Light Travel?

Materials Per Group of Students (2-3 students)

3 cardboard squares with small hole

3 stands to hold cardboard squares (binder clip, clay or acrylic stand)

1 flashlight

Wall or flat surface to shine light on (paper, cardboard, wall, notebook, etc.)

Directions: Record your observations, predictions, and/or explanations related to the question:
How does light travel?

2 holes in a row	3 holes in a row	Any number of holes – not in a row

4. What happens when light strikes the surface of different objects?

Enduring Understanding(s):

- Light travels in a straight line through any material.
- Light can be absorbed by materials, reflected off the surface of materials, and refracted at the surface between two materials when it passes through.

Essential Question(s):

- What happens when light strikes a surface?

Knowledge Objective: K1, K2, K4

Approximate Time: 1-2 classes

Materials Per Group of Students (2-3 students):

Flashlight

Bag of assorted materials such as:

- Transparency film
 - Thick cardboard
 - Cloudy packing foam/plastic or wax paper
 - Thick foam
 - Aluminum foil
 - Playing card
 - Small mirror
 - Tulle / netting
- Each item should be approximately 10 cm x 10 cm to cover the light source
 - You may use other assorted items found in the classroom
 - Darkened room
 - Science notebook

Teacher Directions:

1. After reviewing yesterday's lesson, introduce students to today's essential question: What happens when light strikes a surface?
2. Introduce students to the materials. These materials are pre-packaged in bags for student groups to share. Note: You may want to use additional materials in your room for an assessment after the lesson.
3. Have students make a 4 column chart in their notebook (similar to the hand-out found after this lesson)

Item	Prediction	Observations or I notice...	Science Terms and Explanation

4. Before darkening the room, have students predict what they think will happen when they shine their flashlight on each object.
5. Darken the room and have students investigate what happens when they turn on their flashlight on the object. Students should record observations and their “noticings” in their notebook.
6. Combine groups and have students share their observations and add to their notes.
7. As a class discuss student observations and have students add to their notes in the last column.
8. Big Ideas to reinforce and vocabulary words to draw out of students during this exploration include:
 - When light strikes a surface, it can be **reflected**, **transmitted** (passes through), **absorbed**, or a combination of the three.
 - Some objects **reflect** light (light bounces off the object). Objects like mirrors and shiny objects can reflect light waves that can produce images. Some objects such as painted walls reflect light in all directions and do not produce images; the wall is described as **illuminated**.
 - Some objects **absorb** or block light. (Note: in future lessons students will learn that color is factor in both absorption and reflection of light by objects)
 - When light is absorbed by an object, some of that energy is changed to heat. This is why people wear light colored clothes in the summer, because they would feel hotter than in dark colored clothes.
 - **Shadows** are formed when light is blocked and the surface is not illuminated.
 - **Translucent** – A material is translucent if any light energy passes through it, but one can not make out an image through the materials. Most translucent materials can be described as “more or less” translucent. Examples of translucent materials include frosted glass and wax paper.
 - **Transparent** – A material is transparent if light passes through it and one can make out an image through the material. The better one can make out the image on the other side (the more focused it is), the more transparent the material. The more difficult it is to make out an image on the other side, the less transparent. Examples of transparent materials are glass and clear plastic.
 - **Opaque** – A material is opaque if no light passes through it. Examples of opaque materials are plywood and steel. (Note: Color, thickness, distance from light or eye, brightness of light and type of material can effect how opaque an object is. For example, your hand can be described as opaque; however, if you shine a strong flashlight through your palm you can get a reddish glow on the other side indicating that the hand can be translucent. Conversely, you can combine translucent objects to create a more opaque object. For example, one sheet of paper is translucent, but multiple layers of papers can be more opaque.)

Item	Prediction	Observations or I notice...	Science Terms and Explanation
Transparency			Transparent - image is transmitted through the plastic
Cardboard			Opaque – none of the light comes through – Can make a shadow which is the absence of light
Cloudy plastic or wax paper			Translucent - some light is transmitted through – can make a partial shadow – image is not focused
Foam			Translucent – some light is transmitted through – can make a partial shadow – can be opaque if more than one piece of foam is used or the flashlight is farther away
Aluminum			Light is reflected off of the aluminum – opaque – no light travels through Can create a shadow which is the absence of light
Playing cards			Translucent – some light is transmitted through if the flashlight is close to the playing card – can be opaque if more than one card is used or the flashlight is farther away May notice that light is reflected off the card
Mirror			Light is reflected Opaque – light does not travel through Note- one way mirrors are mirrored on one side so that light travels through one direction but reflects from the other side
Tulle / Netting			Transparent – can see a focused image on the other side Note – if you use multiple pieces it will become more translucent

9. Have students write down their enduring understandings (what they learned) in their science notebook. They should also have working definitions of the bold terms above.
10. Reinforce new learning by reading page 96 in the Macmillan and McGraw-Hill book.
11. Reinforce new learning by reading page 86 and bottom half of transparency page 32 in the Macmillan and McGraw-Hill book.

Other questions:

- Think of several ways to make transparent objects translucent or more opaque. For example, what would happen to glass if it were sandblasted or painted?
- Design ways to make transparent or translucent objects opaque. Why is it important for some materials to be stored in opaque containers? What types of things may be sensitive to light? Think of objects that are packaged in opaque packaging and determine whether it is for a reason.

This is the ideal time to assess the science notebook.

Name _____ Date _____

What Happens When Light Strikes the Surface of Different Objects?

Item	Prediction	Observations or I notice...	Science Terms and Explanation

5. Angle of Reflection – How are images made in flat mirrors?

* Lesson 5 and 6 can be combined

Enduring Understanding(s):

- Light travels in a straight line through any material.
- Light can be absorbed by materials, reflected off the surface of materials, and refracted at the surface between two materials when it passes through.

Essential Question(s):

- How does light travel?
- What happens when light strikes a surface?

Knowledge Objective: K1, K2, K3, K4

Approximate Time: 1 class (40 minutes)

Materials Per Group of Students (2-3 students):

I notice I wonder Chart
Plane (flat) mirror
Small wooden blocks
Small objects like a crayon, glue stick, sticker, etc.
Science notebook

Activities Include:

1. Explore different **angles, positions/distances** and observe your self (or an object) in a plane mirror.
2. Place graph paper on the table in front of the mirror. Challenge students to place an object in front of a mirror and predict what the object will look like in the mirror before looking in the mirror. Then draw the actual object using the graph paper as a grid. Have them repeat this until they can predict the objects position in the mirror.
 - Have a discussion to lead students to understand the big ideas below. Have students generate a definition for organized reflection.
 - Have students create a T-chart in their science notebook. Label one side “Prediction Drawing” and the other side “Actual Drawing”.
 - As assessment for this concept would be to provide them with a different object and have them draw what they expect to see in the mirror (see assessment section).
 - For an advanced assessment, place the mirror on the floor or ceiling and have students accurately predict by drawing the image in the mirror.
3. Each pair of students needs one plane mirror and 4 stickers. Each student in the group should label their left and right ear with a sticker. Have one person view their image in the mirror and have the other person sit next to the mirror facing the first student. Have both students point to the left ear. Students should then

describe in their notebook what they see. Repeat for the right ear and have students exchange positions and again repeat for both ears.

Big Ideas:

- An **organized reflection** reflects the light back into an image of the object. A disorganized reflection (such as light reflecting off a wall) illuminates the object in all directions.
- You see an image in a mirror because light is reflected off an object – that light reflects off the mirror and into your eye.
- The angle between an incoming light ray and a surface equals that angle between the reflected light ray and the surface.
- Light reflects off you and strikes the mirror. Only the light that reflects off the mirror and enters your eyes can be seen. Some of the reflected light enters your eyes.
- Your image appears to be behind the mirror because your brain assumes that the light rays forming the image on your retina traveled in a straight line from the object to your eyes.
- Plane mirrors produce images with a number of distinguishable characteristics. Images formed by plane mirrors are **upright, left-right reversed**, and the **same size as the object**.
 - There is a left-right reversal of the image. That is, if you raise your left hand, you will notice that the image appears to raise its right hand. If you raise your right hand, the image appears to raise its left hand. This is termed **left-right reversal**. This characteristic becomes even more obvious if you wear a shirt with lettering. Try observing a child's image when the child is wearing a shirt with lettering and observe how both the letters and the words are reversed. While there is a left-right reversal of the orientation of the image, there is no top-bottom vertical reversal. If you *stand on your feet* in front of a plane mirror, the image does not *stand on its head*. Similarly, the *ceiling* does not become the *floor*. The image is said to be upright, as opposed to inverted.
 - The dimensions of the image are the same as the dimensions of the object. If a 1.6-meter tall person stands in front of a mirror, he/she will see an image which appears 1.6-meters tall. If a penny with a diameter of 18-mm is placed in front of a plane mirror, the image of the penny appears to have a diameter of 18 mm.

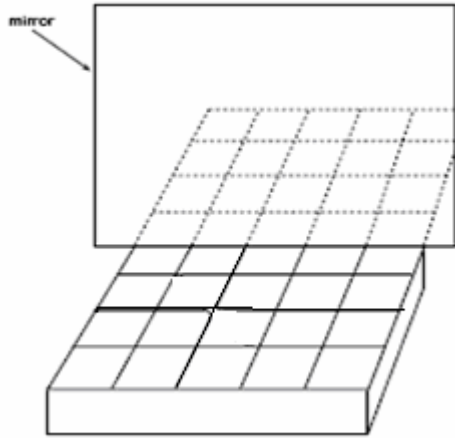
Other Suggested Lesson Ideas include:

- Tennis ball activity (see Circus Light article) or bouncing ball on floor
- Shining flashlight on mirror in dark room and dusting corn starch with the chalk erasers. (see Circus Light article).
- Place a transparency on the mirror and draw what you see in the mirror when you hold up a letter block or piece of paper with a letter on it. Then put the block next to the transparency. The letter on the transparency is backwards but life sized.
- McMillan McGraw Hill book page 89 bottom
- Have three people stand in front of a mirror (you won't all fit – the mirror isn't as wide as the three people) If you are standing on the edge you should be able to see the other two people in the mirror even though the mirror is not as large as the 3 of you are wide. Use a string to show the path from your nose to the other person's nose in the mirror.

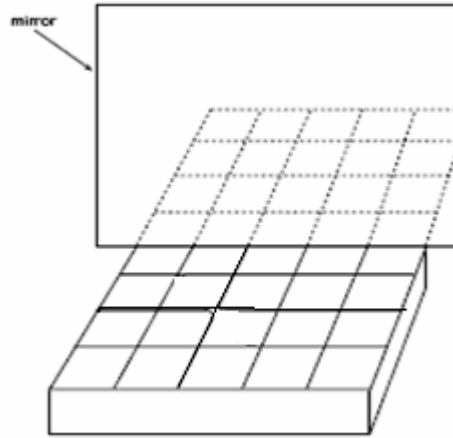
How are Images Reflected in Flat Mirrors?

(Lesson 5)

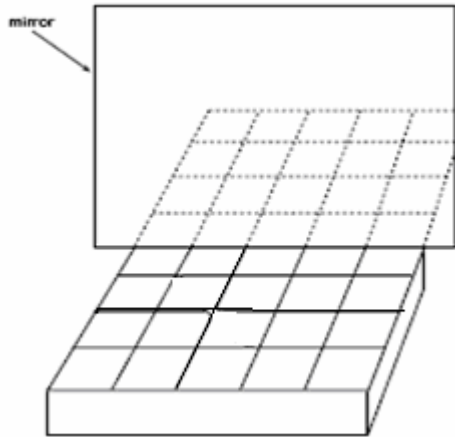
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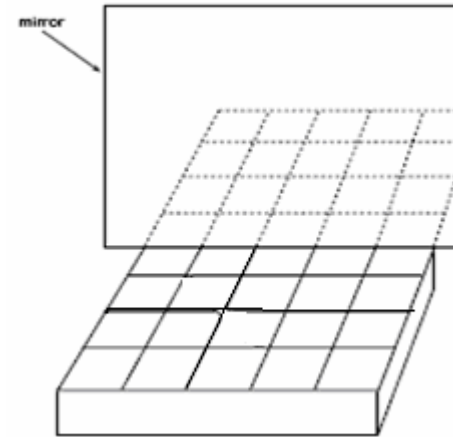
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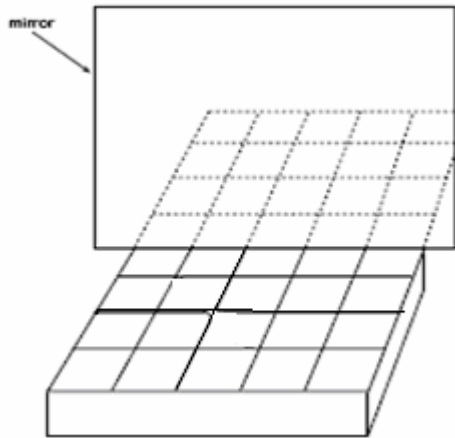
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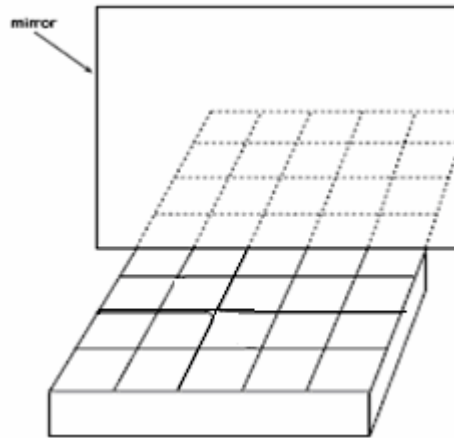
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5.



6.



6. Different Type of Mirrors

* Lesson 5 and 6 can be combined

Enduring Understanding(s):

- Light can be absorbed by materials, reflected off the surface of materials, and refracted at the surface between two materials when it passes through.

Essential Question(s):

- What happens when light strikes a surface?

Knowledge Objective: K12

Approximate Time: 1 class (40 minutes)

Materials Per Group of Students (2-3 students):

- 1 plane mirror
- 1 concave mirror
- 1 convex mirror
- 1 wood block with letter or some type of small object to observe
- Science notebook
- Optional sample worksheet on next page

Teacher Directions:

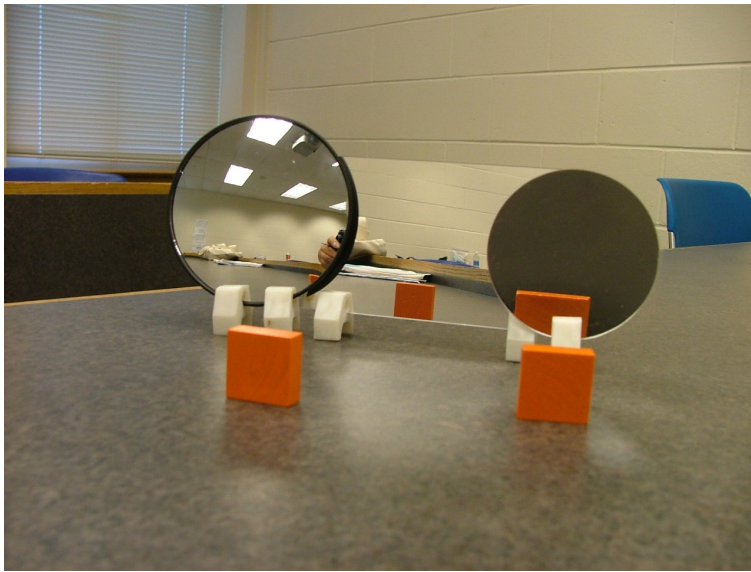
- Students will explore the different types of mirrors, plane, concave, and convex and record observations in a T-chart in notebook or on worksheet (see next page).
- See picture below for sample set-up of mirrors.
- Place a wood block(s) with a letter (or a similar object) in front of the mirrors and record and draw to scale what you see in each of the different mirrors. Students may need a mini lesson on how to draw to scale.
- Discuss different places or purposes for different types of mirrors such as:
 - Grocery stores
 - Fun house at an amusement park
 - Some dressing room mirrors make you appear slimmer
 - End of driveways
 - Rearview mirror on car makes images appear larger than they are
 - Child/baby mirror for car
- Refer to the McMillan McGraw Hill Text book on page 88 for explanation. Additional information can be found in the content background notes.
- Assessment ideas see McMillan McGraw Hill Teacher Resources – Assessment Section page 89

Other Lesson Ideas:

- Have students predict and draw their image as viewed on the back and front of a metal spoon. Explore how their image changes with distance and each side of the spoon.

Big Ideas:

- Different mirrors or shiny images reflect light in different ways. Teachers should note that the intent of this lesson is not to explain how the different mirrors work, but to understand that mirrors are manufactured different ways for different purposes.
- The main intent of lesson is to predict images in flat mirrors - then to explore how different shaped mirrors can change an item
- Light striking a shiny flat surface is reflected in an organized pattern (focused image).
- Light striking a shiny curved surface is reflected in an organized pattern but it is reflected differently allowing for different optical effects such as magnification or inverted images (such as fun house mirrors).



Convex mirror, Plane mirror and Concave mirror (in order)

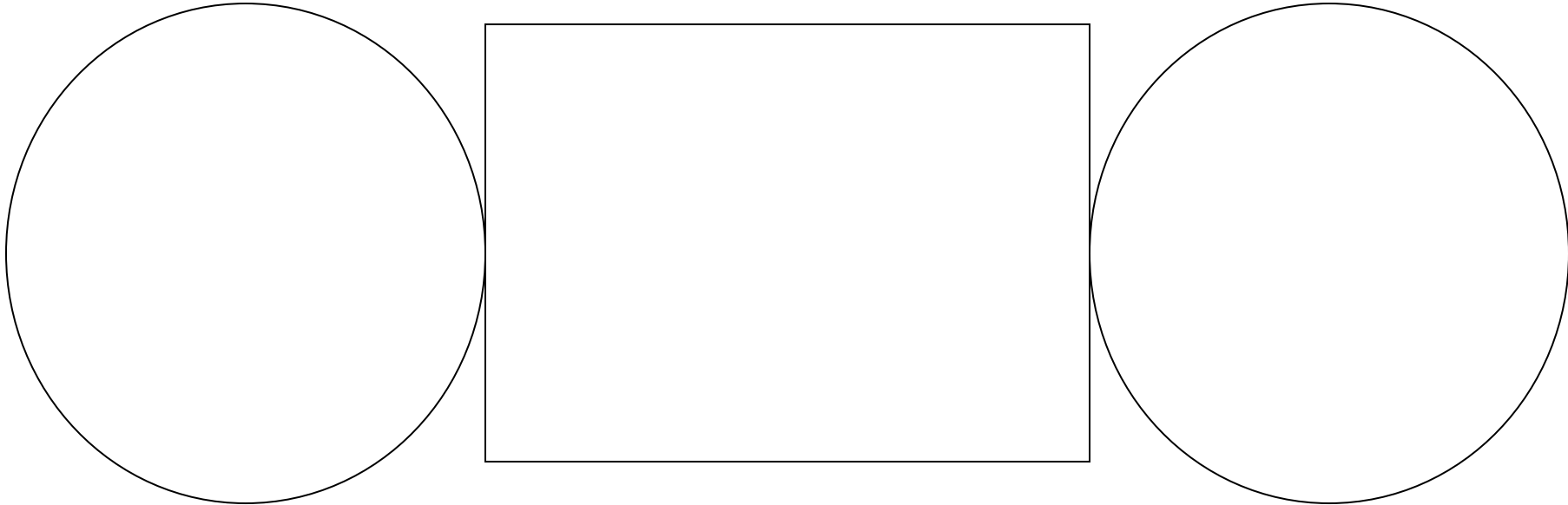
Different Types of Mirrors

Draw what you see . . .

Concave

Plane or Flat Mirror

Convex



Compare and Contrast the images in the 3 mirrors. How are they alike? How are they different?

7. Refraction – The Bending Pencil

Enduring Understanding(s):

- Light travels in a straight line through any material.
- Light can be absorbed by materials, reflected off the surface of materials, and refracted at the surface between two materials when it passes through.

Essential Question(s):

- How does light travel?
- What happens when light strikes a surface?

Knowledge Objective: K3

Approximate Time: 1 class (40 minutes)

Materials Per Group of Students (2-3 students):

Oil

Water

9oz cup filled with oil to about 2-3 cm from the bottom and the same amount of water

1 pencil

Science notebook

In this activity students will first **predict** what will happen to a pencil when put in a cup with equal amounts of water and oil. Students will then record their observations using a “I notice.../I wonder...” T-chart in their science notebook. Teacher should focus on observation skills and how students can communicate what they observe. Have students share their findings. Confirm student learning that refraction is bending light therefore making the object appear to be bending.

Big Ideas:

- Light is refracted at the surface between two transparent materials when a light ray passes through that surface, when the speed of light in those two materials is different. The light ray “bends” due to the different speed of light in the different material.
- The pencil looks like it is “bent more” in the oil than the water. The light travels slower in the oil than the water.

This is the ideal time to assess the science notebook.

Other Lesson Ideas:

- Student groups could observe and compare 3 cups (1 w/water, 1w/oil, and 1w/ oil and water)

Enrichment:

- Use a magnifying lens and a flashlight to demonstrate how lenses (use the hand lens) “bend” light. Place white paper on the table and hold the magnifying lens about 10 cm above the paper. Turn off the lights and shine a flashlight through the lens and slowly move the flashlight away from the lens. Eventually you will see the light focus on a

small spot. This is a demonstration of refraction (bending of light) – the light is bent towards the center focus area. You can also relate this demonstration to how eye glasses work. Light that passes through the eye glasses is focused at different distances by “bending” or refracting the light.

8. How does light affect the colors we see?

Enduring Understanding(s):

- White light is a blend of all colors of the visible spectrum.
- Light can be separated into colors.

Essential Question(s):

- How does light affect the colors we see?
- How does light travel?

Knowledge Objective: K1, K15, K16,

Approximate Time: 1 class (40 minutes)

Materials Per Group of Students (2-3 students):

Red, green and blue yarn

Prism

Colored pencils

Optional student worksheet (see next page)

Activity 1- Prism

Using a prism and a strong light source such as an overhead projector or the sun on a **sunny** day, students will explore what happens to the white light and record observations (using colored pencils) in science notebook. Do not look directly at the sun. What do you notice is happening to the white light when it hits a prism? (rainbow) The prism is **refracting** (bending) the light and the different colors are being separated.

Recommended journal questions:

- Where do you think the colors come from?
- Where in nature or in your world have you seen all of these colors at one time?
- Where do you think colors come from?

Activity 2- Yarn Braid

Follow up the prism activity with a more concrete representation of what is happening to the light. Explain that white light or the light you see from a bulb or the sun is the combination of all colors. Let's look at this yarn (teacher should have red, green, and blue yarn together/braided/or random twist). The yarn represents white light (colors we would see in white light). White light is composed of all the colors (ROY G BIV), for simplicity we are using only 3 colors to represent all the colors.

Have the student's model (or do a teacher demonstration) with the yarn to show what happens to white light as it hits a prism. Students should show that white light is a combination of all colors together and after traveling through the prism it separates into different colors.

Have students diagram and reflect in their notebook.

Diagram should include the following labels:

- light source
- path of white light hitting the prism
- the separation of white light into the various colors that they observe.
- Student Reflection:
 - In your own words explain what is happening to the white light when it hits the prism. (Assess science notebook).

Activity 3- Observe a colored object at dusk or in a room that can be darkened (optional activity)

Observe a colored object such as a house, car, bike, or flowers as the sun is setting. With light students will view vibrant colors. As the amount of light decreases you stop seeing the different colors but can still view the shape of the object. Eventually if there is no “light pollution” you will not be able to see the shape with the absence of light (complete darkness).

You can also do a similar activity using shapes with each side a different color. Have students observe one side (for example a red octagon) as the lights dim and the room gets completely dark. Then turn the shape over (for example a blue octagon) and ask the students to tell you what color the shape is. You can relate this activity to the rods and cones in your eye. You have fewer cones which see color so when there is less light there are fewer cones to transmit the signal for color but more rods to transmit the signal of light grey or dark.

This is the ideal time to assess the science notebook.

Name: _____ Date: _____

How Does Light Effect the Colors We See?

Prism – Lesson 8

1. While experimenting make observations within your Science notebook using the “I Notice” and “I Wonder” chart.
2. Using coloring tools please label what happens to white light when it hits a prism. Make sure you include the light source, the prism, and the white light. Please draw your diagram down below.



3. Using what you know from the observations you made in your investigations and drawing, please explain in your own words, what is happening to the white light when it hits a prism.

9. How do we see different colors?

Enduring Understanding(s):

- White light is a blend of all colors of the visible spectrum and can be separated into individual colors.
- Light can be absorbed by materials, reflected off the surface of materials, and refracted at the surface between two materials when it passes through.

Essential Question(s):

- What happens when light strikes a surface?
- How does light affect the colors we see?

Knowledge Objective: K6, K7, K8

Approximate Time: 1 class (40 minutes)

Suggested Lesson Ideas include:

Materials Per Group of Students (2-3 students):

Colored pencils – not provided in the kit
Red, blue and green yarn
Science notebook

Activity 1- Diagram the Color Reflected to your Eye

- Have students diagram how white light (all colors of the rainbow) hit an object (for example a red apple/apple). Only the red light reflects off the red apple toward your eye. All other colors are absorbed.
- Have students predict how people see blue, black and white and objects. This concept is supported in the student McMillan McGraw Hill books on page 110-112.
- Have students model this concept using the yarn. Use a green, blue, red, black and white object. For example, an object looks red because red light is reflected back to your eye. The red object absorbs all the other colors.

Activity 2- Color Pendant (flashing red, blue and green light that appears white when still)

Observe what happens to the “white light” pendant when you spin it a circle. Use your observations to draw conclusions to explain this toy.

Additional directions are packaged w/ the color pendant.

Teacher Background Notes: When the object is still (at rest) the three colors flash rapidly enough that although the human eye sees the three colors, the brain interprets the three colors coming from the same point essentially at the same time, thus combines it into white light. When the pendant is spun, the different colors are emitted from different locations, so the eye sees the separate colors from different locations and the brain interprets the image as a circle composed of a series of different colored flashes.

10. Parts of the Eye

Enduring Understanding(s):

- Structure and function of the human eye allows us to see.
- Various instruments can be used to enhance vision.

Essential Question(s):

- How do we see?
- What the similarities/differences between a camera and the human eye?
- How do various instruments improve vision?

Knowledge Objective: K9, K10, K11, K12

Approximate Time: Vary

Materials Per Group of Students (2-3 students):

- Diagram of the eye (see following pages and Wallingford's W drive)
- Materials will vary – see activities below

Activity 1- Literature Inquiry

Use non-fiction literature housed in media center to do a literature inquiry focusing on:

- Parts of the eye
- How the eye works
- Comparing the eye to a camera
- Instruments that help enhance our vision

Have students prepare presentations and teach students about the remaining objectives.

Activity 2- Observing Your Own Eye

Students will use their science notebook and a concave mirror to observe their own eyes. Draw what they see in their science notebook. After they complete their first drawing have them close and cover one eye for 30 seconds or longer if needed and observe their eye in the mirror. Make another drawing of what they see. Explain what the difference is between your two pictures. Why do you think this change occurred? (Relate this later to how the eye is similar to the camera)

Activity 3- Parts of the Eye

Give each student a blank copy of the eye diagram. Using the overhead the teacher will display a blank copy of the eye and identify the **parts** of the eye and their **functions** with the class and have the students fill in their diagram.

This will include: the **pupil, iris, cornea, lens, retina and optic nerve.**

- **Cornea** is the outer clear layer that protects the eye.
- **Iris** is the colored part of the eye that opens and closes to regulate the amount of light that passes through the pupil.
- **Pupil** is the open pathway that light goes through.
- **Lens** focuses (refracts) the light into an image on the retina.

- **Retina** absorbs the light and sends the image to the brain.
- **Optic Nerve** carries the message from the retina to the brain where it is interpreted.

Activity 4- See Activity 10 in the *Lenses and Mirrors* DSM Teacher's Guide

Students will:

- Learn the different parts of the eye and how they work together.
- Find the blind spot in their vision and discover what causes it.
- Observe the change in the iris and the pupil when a light shines in the eye

Note: materials are not provided in the kit for part 6 of this lesson.

Materials Per Group of Students (2-3 students):

Activity sheet 10 (see Delta teacher guide)

1 marker

1 pin – do not need this (skip part 6 of lesson)

Flashlight

Black construction paper – teacher will provide

White paper – teacher will provide

Scissors – teacher will provide

Activity 5- Build a Model of the Eye

You may want to provide students with materials (clay, Styrofoam, paper...) to build a model of the eye to reinforce student understanding of the parts of the eye and their functions. If needed, you may request Styrofoam balls, tooth picks, and labels from Science Resource Center/Science Resource Teacher for this purpose.

Activity 6- Web Sites on the Eye

<http://www.bootslearningstore.com/ks2/eyesight.htm>

Cow's Eye Dissection Web Site

http://www.exploratorium.edu/learning_studio/cow_eye/index.html

Exploratorium Cow's Eye Dissection Web site - The site features uses high-resolution video to show how human and cow's eyes function. Step-by-step instructions are accompanied by pictures, video, sound, and written instructions. Try out the interactive eye diagram or hands-on activities. Preview and use with discretion

Activity 7- Video – Science Screen Reports for Kids – A Look into the Human Eye

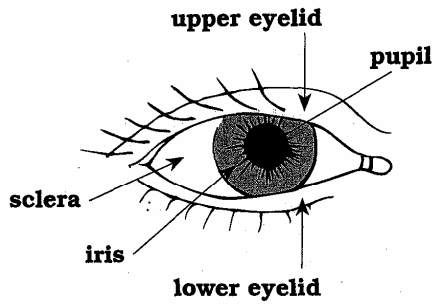
Volume 14 Issue 6

Approximately 16 minutes long

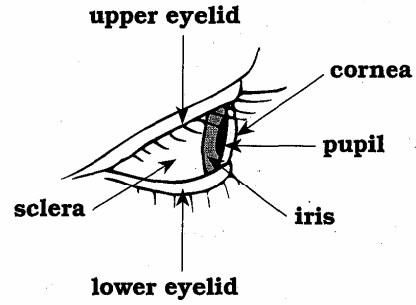
This video is housed in your media center

Seeing Inside Your Eye

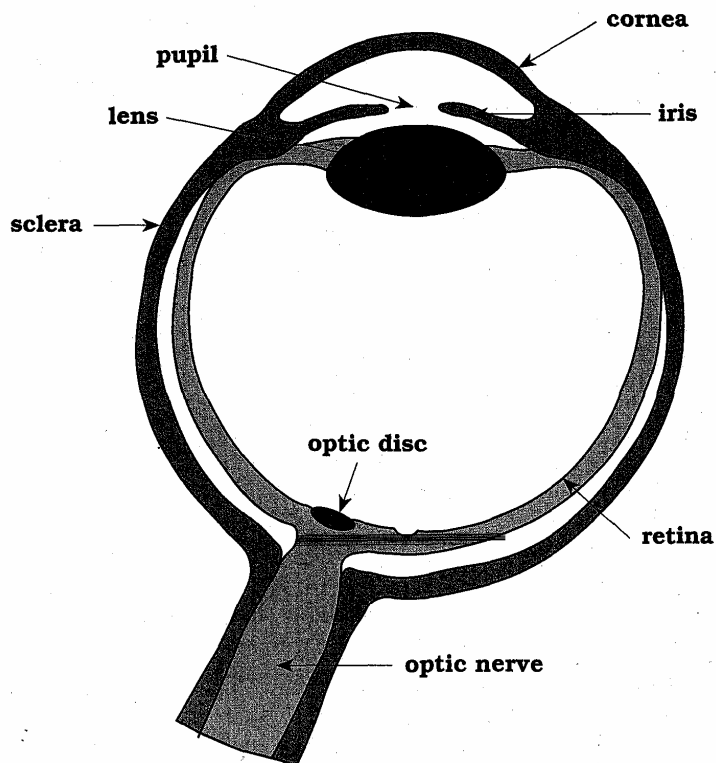
Front view



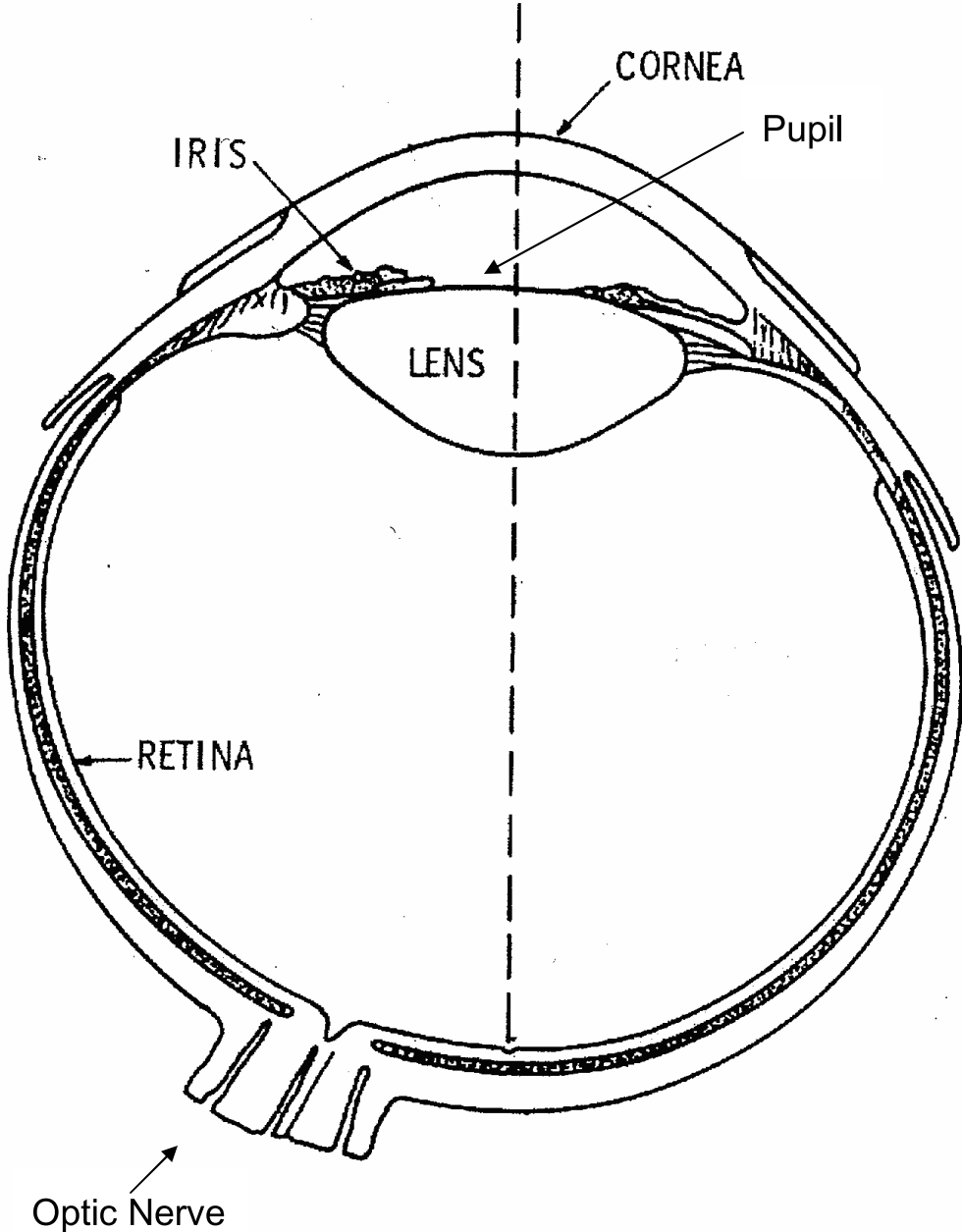
Side view



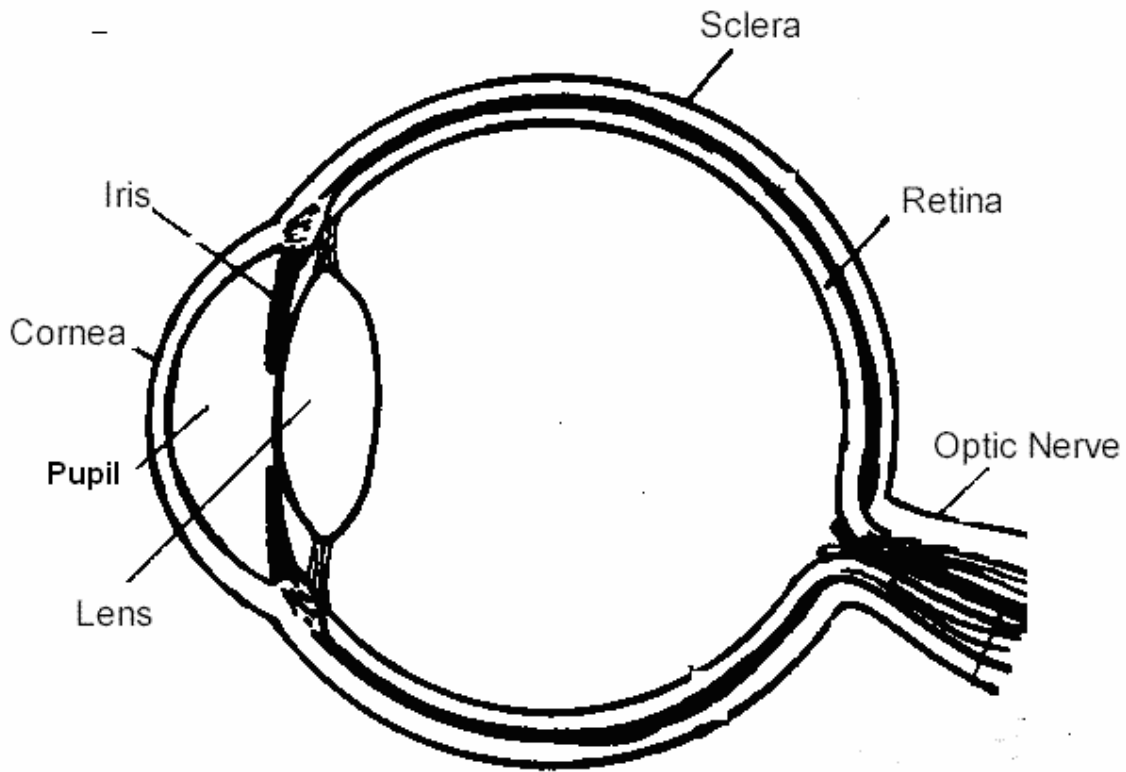
Top view, right eye



The Human Eye

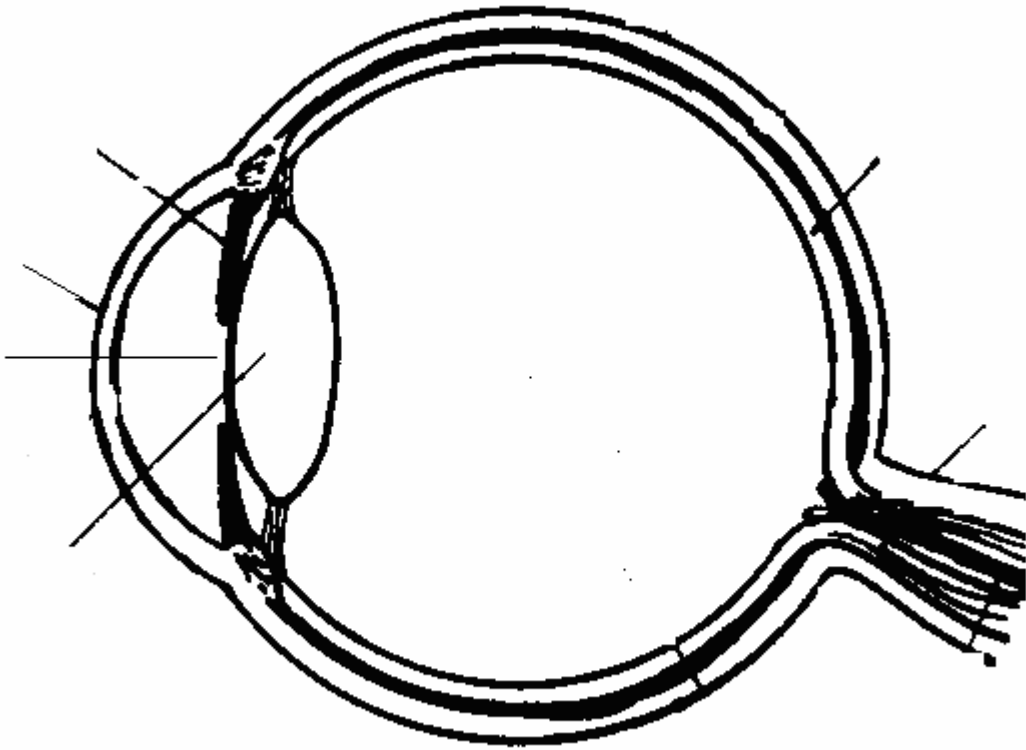


Parts of the Eye



www.vhl.org/gifs/eye.gif

Parts of the Eye



www.vhl.org/gifs/eye.gif

11. Compare a Camera and the Human Eye

Enduring Understanding(s):

- Structure and function of the human eye allows us to see.

Essential Question(s):

- How do we see?
- What are the similarities and differences between a camera and the human eye?

Knowledge Objective: K2, K9, K10, K11

Approximate Time: 1 lesson

Materials Per Group of Students (2-3 students):

Will Vary

Activity 1- Write Analogies

Use the next page to introduce the 4 main parts of a camera. Have students write analogies to compare the parts of the eye to the parts of the camera.

Have students create a labeled diagram of the eye that includes the function of each part in their notebooks and compares it to the camera.

For example:

- Diaphragm controls the amount of light that enters the camera through the aperture like the iris controlling the amount of light that enters the eye through the pupil.
- Blinking of the eye lids is like the rapid opening and closing of the shutter that controls when light enters the eye.
- Images are formed on the retina in the eye just like images are formed on film or a digital card in a camera.
- The optic nerve carries messages to the brain like the wire from the digital card to the computer.

Activity 2- Reinforce with non-fiction texts

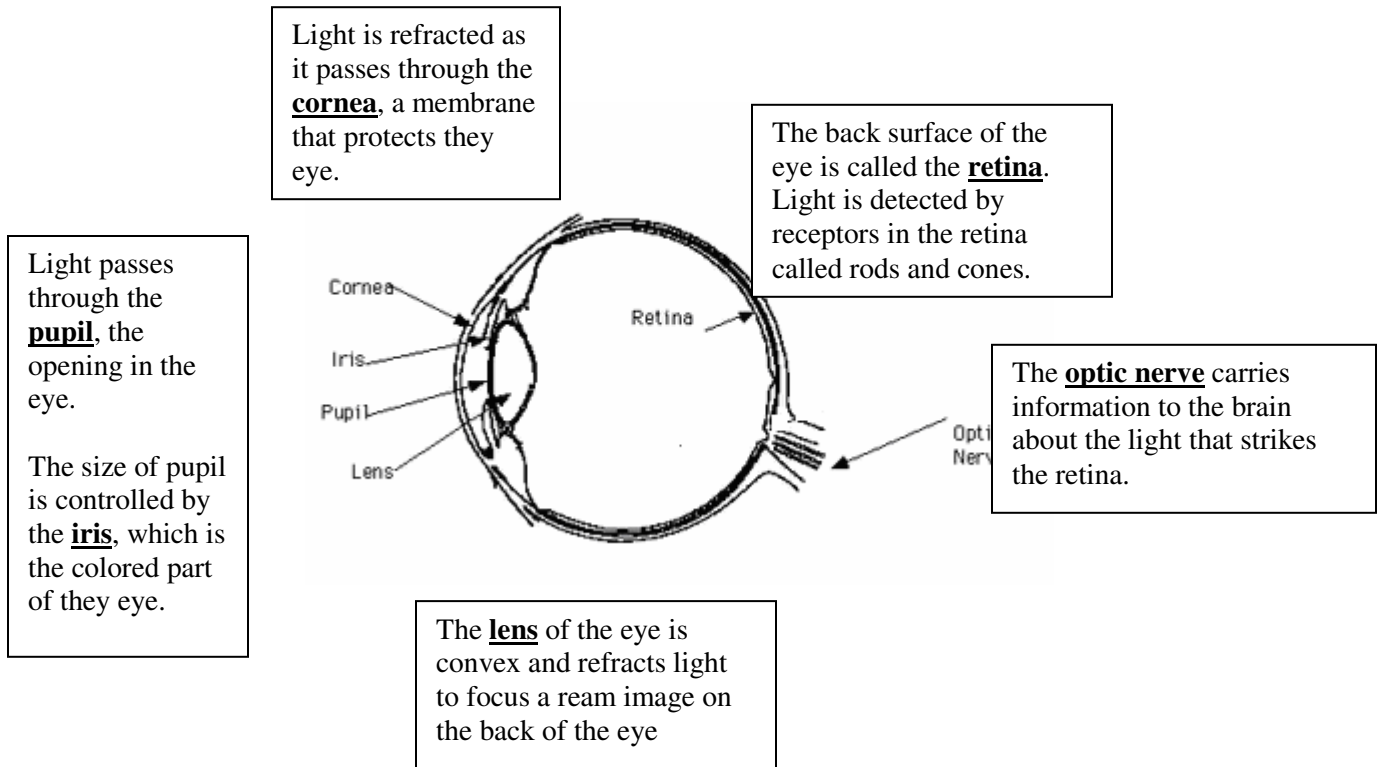
- See list of non-fiction titles purchased and housed in your media center (materials section)

Big Ideas for Students to Understand

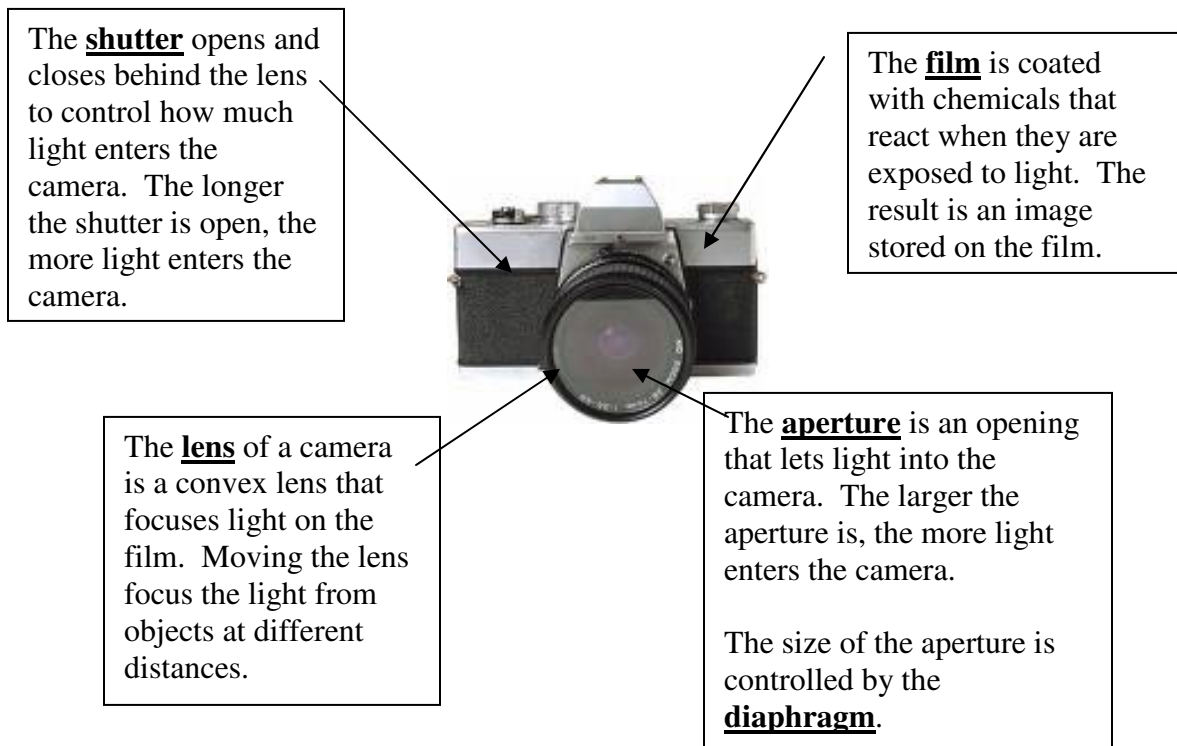
- Both have **lenses** which focus the image by refracting the light. The cornea in the eye also helps refract the light.
- Image is formed on a surface – retina in eye and film or digital receiver (card) in camera.

- In both cases, images are inverted and reversed.
- Both control the amount of light
 - in the eye the **iris** opens and closes the **pupil** to controls amount of light entering eye
 - in the camera the **diaphragm** opens and closes the **aperture** to control the amount of light entering the camera.
- Both produce an image that needs to be interpreted by a “brain” – in animals the **optic nerve** sends a message and the brain interprets the message – in the camera an image is formed either on **film** / paper or sent via a cable to the computer – the computer produces an image. In both cases a person has to interpret the picture.
- The **shutter** in a camera opens and closes to allow any light to enter the camera. Still cameras take single images during the time the shutter is open. Moving picture cameras take a series of pictures in order by opening and closing the shutter, similar to blinking the eyelids. When shown very rapidly, our brain “runs the images together” into a sense of continuous motion of the image, like a movie (moving pictures).

How Your Eye Works



How a Camera Works



12. How do Various Instruments Enhance our Vision?

Enduring Understanding(s):

- Various instruments can be used to enhance vision.

Essential Question(s):

- How do various instruments improve vision?

Knowledge Objective: K12

Approximate Time: 1 class (40 minutes)

Suggested Lesson Ideas include:

Materials:

- 15 hand lens / magnifiers
- 1-2 Periscopes
- 1-2 Eye Charts
- 1 binocular

Activity 1- Explore different instruments using the non-fiction text.

This objective may have been included in the previous literature inquiry. Emphasis should be on **eyeglasses, magnifiers, periscopes and telescopes**. You may also discuss binoculars, microscopes, overhead projector, camera, etc.

See page F101 in Macmillan and McGraw Hill book.

Activity 2- Explore with the hand lens (magnifiers).

In addition to the hand lens found in the kit, a simple magnifier can be made by placing water in a clear container. Students can use this to read small font such as the newspaper.

Encourage students to share instruments they have at home that enhance our vision such as telescopes, binoculars, microscopes, etc.

Activity 3- Activity 11 Testing Your Eyesight in *Lenses and Mirrors DMS*

Teacher's Guide

Students will use the eye chart to test their vision. Discuss how glasses help to correct eye sight.

13. Inquiry Investigation

Combination of Hands-on Materials and Non-Fiction Literature

Description:

Using the materials in the kit allow students to raise questions (or save questions as they arise throughout the unit). Facilitate students toward questions aligned with the content goals of this unit. Have students further their understanding with a combination of hands-on materials and non-fiction resources.

Enduring Understanding(s):

- Light is a form of energy.
- Light travels in a straight line through any material.
- Light can be absorbed by materials, reflected off the surface of materials, and refracted at the surface between two materials when it passes through.
- White light is a blend of all colors of the visible spectrum and can be separated into individual colors.
- Structure and function of the human eye allows us to see.
- Various instruments can be used to enhance vision.

Essential Question(s):

- How is inquiry used to investigate the answers to questions we pose?
- How does light travel?
- What happens when light strikes a surface?
- How does light affect the colors we see?
- How do we see?
- What are the similarities/ differences between a camera and the human eye?
- How do various instruments improve vision?

Knowledge Objective:

Potentially All Objectives – depending on the type of materials provided for students. Teachers should purposefully select materials related to the objects of this inquiry.

Teachers may also select non-fiction resources that are aligned with the following objectives:

K8. Describe how we see different colors in our environments. (EP B20)

- Absorption
- Reflection

K9. Identify the five main parts of the eye. (lens, cornea, iris, pupil, retina) (EP B24)

K10. Explain the function of each part of the eye. (EP B24)

K11. Relate the parts of the camera to the parts of the eye. (compare and contrast) (EP B24)

K12. Describe the uses of different instruments that enhance our vision such as eyeglasses, magnifiers, periscopes and telescopes. (EP B25)

Approximate Time: 3-5 lessons (40 minutes)

Materials:

Hands-on materials will vary depending on the targeted objectives.
Teachers may also select non-fiction resources from the media center.

Day 1

Students will work in groups of 2-3 to explore materials/books and create questions using note cards (one question per card). Students will need to separate questions into two piles, ones that can be investigated with the materials that they have used today (TESTABLE QUESTIONS). The other pile will be questions that can not be investigated – but need to be answered using print resources. Discuss/model the difference between a testable question and a question that need to be answered using books/print resources. Model then have students take a question that is not testable and “turn” it into a question that is testable.

Teacher will want to select questions that are aligned with the content goals of this unit. Students may choose either a testable questions to be investigated **or** research type questions to explore. Before the next lesson, the teacher should remove any questions that are not related to content objectives or if materials are not available to complete the experiment. Teacher may add questions of topics that the students may not have generated.

Day 2

Teacher will model and explain how a Gallery Walk works. Students and teacher walk through room in a quiet and orderly fashion to read all of the various questions that have been posted. Students will then stand next to the topic that they are interested in. Teacher or student may choose partnerships. Each group may consist of no more than three students.

Students will decide as a group what their plan will look like to investigate their question and decide on the necessary materials they will need. If this is the first inquiry investigation of the year, the teacher may need to model a sample procedure. In their science notebooks students will need to record a plan for their investigation, which will include:

- Question
- Hypothesis
- Procedure or plan
- Materials.

[See next page for a sample planning template](#)

Day 3-4

Investigations occur. During this time teacher should be assessing students process skills using the check list (see assessment section). Teacher should also be monitoring for group dynamics, content objectives being met, and helping and assisting groups where needed.

Day 5

Whole group discussion on what should be included in the presentation / science notebook / letter or final product. Ideas may include:

- Name of group members
- Question being investigated

- Original hypothesis
- Plan/procedure
- Materials
- Results/diagrams/data collection chart
- Problems that occurred
- Further Questions that you have

Allow rest of class to prepare the final product.

Day 6

Presentations (3 minutes per group)

Teacher should help students synthesize what they learned from all the groups. This should be copied or glued into the science notebook. ([See end of this section for a sample](#))

Name: _____ Date: _____

Investigation Planning Guide

Group Members:

Question Being Investigated:

Hypothesis (prediction):

Materials Needed:

Plan / Procedure:

Step 1 _____

Step 2 _____

Step 3 _____

Step 4 _____

Step 5 _____

Step 6 _____

Step 7 _____

Step 8 _____

Step 9 _____

Step 10 _____

Results (This includes any diagrams, observations, and graphs):

Problems That We Occurred:

Further Questions That You Have:

Sample Inquiry Synthesis

- Light is a form of energy. Visible light is the part of the electromagnetic spectrum we can see.
- Light travels in a straight line. The path of light can be changed.
 - Light can be **reflected** off of different surfaces.
 - Light can be **refracted** (bent) by some substances.
 - Light can be **absorbed** by some objects and can be changed to heat energy.
- When light is reflected we can predict where it will go. The angle at which light reflects from a flat, smooth surface is the same as the angle at which light strikes the surface.
- Some objects absorb all the light and some only absorb a portion of it.
- Different objects reflect different amounts of light.
- Different types of mirrors will give a different sized image.
- Light travels through some objects and not through others.
 - Opaque objects block light (and images) casting shadows.
 - Translucent objects transmit some of the light (and images).
 - Transparent objects transmit most of the light (and images).
- White light is a combination of red, orange, yellow, green, blue, indigo, and violet (ROY G BIV) and can be separated into this spectrum of colors by a prism.
- Colored objects reflect the color you see and absorb the other colors of white light.
- Different instruments can enhance or change our vision such as eyeglasses, magnifiers, periscopes and telescopes.

<i>Essential Facts and Concepts</i>	<i>Guiding Questions</i>	<i>CSDE Expected Performance</i>	<i>FMWK Code</i>	<i>Explorations/ Applications/ Assessments</i>
Certain objects experiencing a chemical, nuclear or electrical change produce light.	What is light and how does it travel?	Describe how light is absorbed and/or reflected by different surfaces	B 19	Refer to Standards 3.1 & 4.3 for prior exploration of related concepts.
Light reflects or bounces off objects, thus “illuminating” them so that we can see them.				
Light moves in straight lines.				
We can “see” objects when they either give off light of their own or reflect light from their surface.	What happens when light strikes a surface?			
Usually light strikes a surface and is partially absorbed and partially reflected.				
When light is absorbed by a material, the temperature of the material is increased.				
The ratio of how much light is absorbed versus how much light is reflected is affected by the color of the surface and the color of the light.				
Mirrored surfaces reflect almost all the light that strikes them.	How do cameras work?			
Mirrors can produce images (organized reflection), while other objects reflect light in a random manner.				
Images can be intentionally formed using property of light that it travels in straight lines.				
In a pinhole camera the light from a scene travels to the pinhole, passes through the pinhole in a straight line and forms a focused image of the scene at any distance that is reversed and inverted.				
A smaller hole in the pinhole camera creates a more focused but dimmer gray image.				
A larger hole in the pinhole camera creates a less focused but brighter image with more color.				

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Teacher Background Notes

These science content background notes were created for teacher use only. We anticipate that these notes provide you, the teacher, with some useful background as you facilitate inquiry activities for your students. These notes are not meant to be an overview of the unit, but as background information for you that go beyond the content of this particular unit. These notes should not be replicated for your students; however, you may share some of the content when appropriate for the developmental level of your students.

These notes have been prepared by Laura Danielle Riccitelli, Lyman Hall High School and Louise Chapman, Sheehan High School

Essential Question: How does light travel?

A. Ray Model

Light is a form of energy that travels in a straight path. Light can be thought of as traveling in rays from a light source. Each ray moves in a straight path until it strikes something like a mirror.

B. Electromagnetic Waves

Light is an electromagnetic wave. Electromagnetic waves are **transverse waves** (a wave that causes a medium to vibrate at right angles to the direction in which the wave is traveling). A **medium** is the material that the wave travels through. Electromagnetic waves carry energy from place to place. They are produced from changing electric fields (created by electrically charged particles and changing magnetic fields). A magnetic field is created by magnets, changing electric fields, and vibrating charges. **Simplified version:** Moving an electron up and down generates changing magnetic and electric fields. These changing fields cause each other to travel through different mediums.

Figure 1. Transverse wave

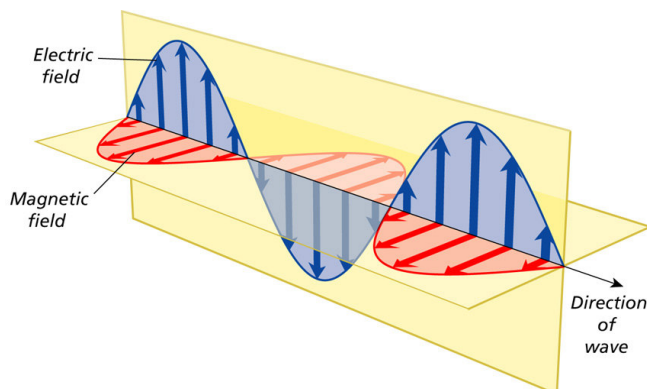


Figure 2. Electron Movement

Wave Length and Frequency

Electromagnetic waves vary in their wave length and frequency therefore creating different speeds at which waves travel. **Wavelength** is the distance between a point on a wave and the same point on the next wave.

Figure 3. Wavelength

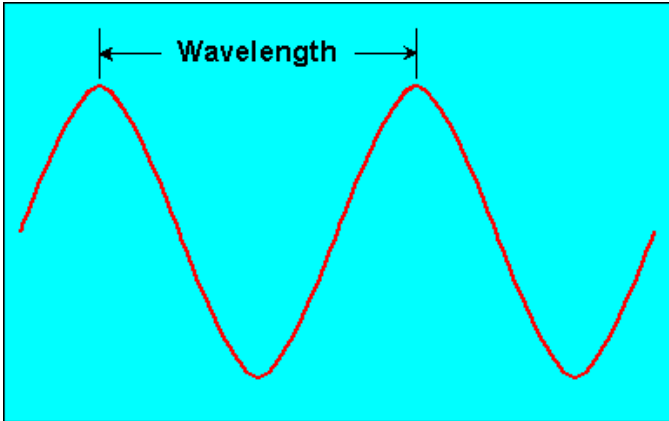
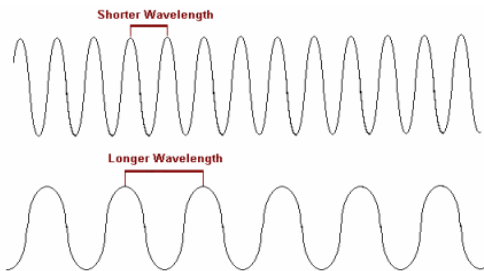


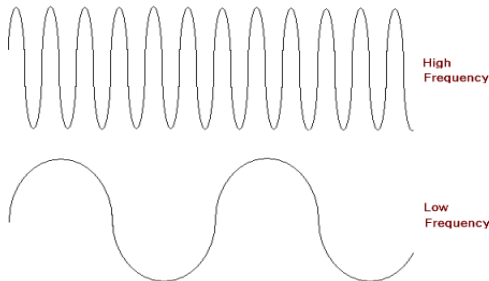
Figure 4. Differences in Wavelengths



<http://www.joot.com/dave/writings/articles/entanglement/wave.shtml>

The **frequency** is the number of waves that pass a point in a given time.

Figure 5. Frequency of Waves



<http://www.joot.com/dave/writings/articles/entanglement/wave.shtml>

The wavelength is inversely proportional to the frequency. As the wavelength increases the frequency decreases.

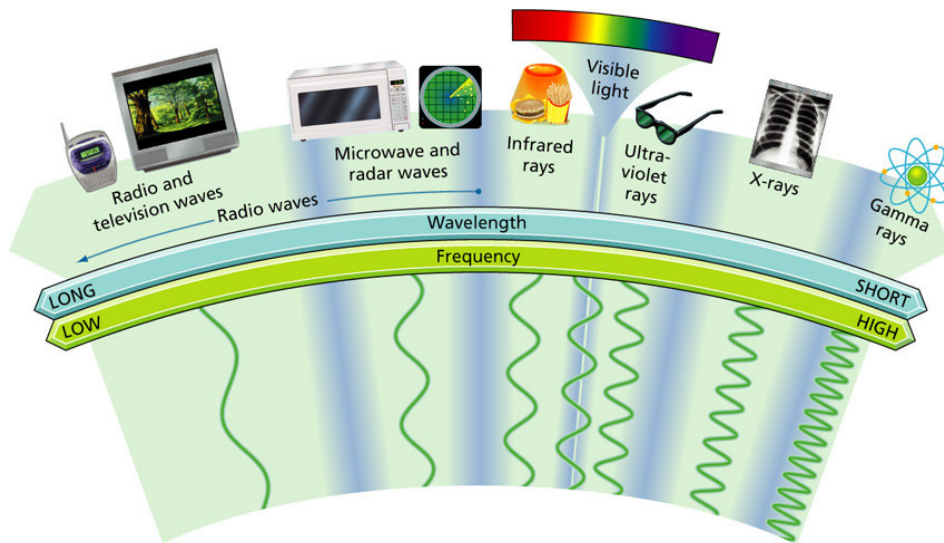
D. Calculating the Frequency

Early experiments confirmed that all electromagnetic waves travel at the same speed when in a vacuum. The speed of an electromagnetic wave is represented as 'c' is 3.00×10^8 meters per second. The frequency of a wave can be calculated by the following formula: Frequency = Speed (c) / wavelength.

E. The Electromagnetic Spectrum

The transfer of energy through electromagnetic waves is called electromagnetic radiation. The full range of electromagnetic radiation is part of the **electromagnetic spectrum**. Visible light is only a small portion of the spectrum, which is the portion of the spectrum the human eye sees as light.

Figure 6- Electromagnetic Spectrum



Essential Question: What happens when light strikes a surface?

A. When Light Strikes and Object

When light strikes an object it can be reflected, absorbed, or transmitted. Objects that absorb or reflect all of the light that strikes it are called **opaque** because no light is able to pass through it. Examples of opaque objects include wood and metal. Materials that are **transparent** allow all light to pass through. Examples of transparent materials are glass and water. **Translucent** materials scatter light as it passes through. Examples of translucent materials include frosted glass and wax paper. (Science Explorer)

When light rays enter a new medium their speed changes. The speed at which light will travel through the new medium is dependent upon what the material is made up of. When light strikes the new medium at an angle the light is **refracted** or bent.

B. Absorption

Absorption of light occurs when light does not pass through or reflect from an object. Different materials absorb different wavelengths (colors) of light. For example a green shirt absorbs all wavelengths of light except for green. A black object absorbs all wavelengths, but a white object reflects all wavelengths.

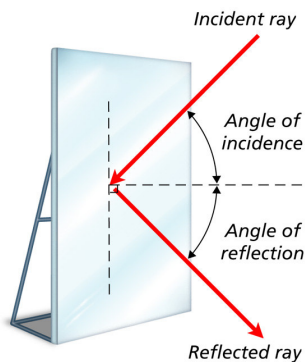
C. Reflection

Many objects can be seen because light reflects, or bounces off of the object, such as a mirror. What is seen however is dependent on the surface of the object that reflects it.

Law of Reflection

Since light is made up of rays that travel in a straight path, the ray that reaches the mirror is called the **incident ray**. The ray reaches the mirror at an angle called the **angle of incidence**. The angle of incidence is an angle created by the incident ray and with a line that is perpendicular to the surface of the mirror. Once the incident ray strikes the mirror the ray is then reflected. The angle at which the ray is reflected, the **angle of reflection**, is created by the **reflected ray** and the line perpendicular to the mirror surface. The **law of reflection** states that the angle of incidence and the angle of reflection are equal to one another.

Figure 7. Law of Reflection



Law of Reflection:

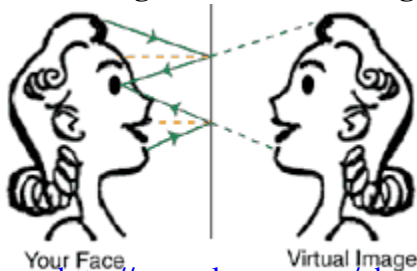
Angle of incidence = Angle of reflection

Types of Mirrors

1. Plane Mirrors

Plane mirrors are mirrors with a flat surface. When you look into a plane mirror the image is **right side up** and the **same size** as the object being reflected. The image created is a **virtual image**, which is an image that can be seen but does not exist and **right side up**. To create the image in the mirror rays of light strike an object and are reflected. The rays that are reflected strike the mirror and are then reflected to your eyes. The reflected rays appear to come from behind the mirror so the image appears to be the same distance behind the mirror as the object is in front of it.

Figure 8. Virtual Image in a Plane Mirror



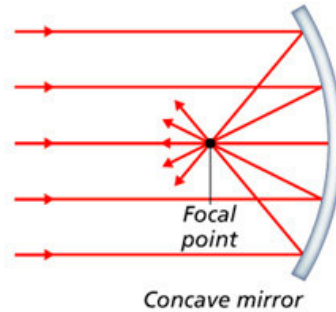
The solid lines represent the path that the light takes from behind the girl. As the light is reflected from her it strikes the mirror and is reflected back to the girl. The dashed lines show where her brain thinks the rays are coming from. The image is the same size as the girl and right side up

<http://www.learner.org/channel/workshops/sheddinglight/highlights/highlights2.html>

2. Concave Mirrors

A **concave mirror** is a mirror with a surface that curves inward. Concave mirrors reflect parallel rays of light so that they meet at a **focal point**. Examples of concave mirror are the inside of a spoon or make up mirrors.

Figure 9. Concave Mirror



Concave mirrors can form **virtual images** as well as a **real image**, which is an image that is a copy of the object that formed at the focal point. A real image can be seen on a surface like a screen. Real images are **upside down** and can be **larger or smaller** than the object.

Figure 10.

If the object is between the focal point and the mirror, then the image appears as if it is behind the mirror, right side up, and larger than the object.

Figure 11.

If the object is farther from the mirror than the focal point then the reflected rays meet in front of the mirror. A real image is created behind the object and inverted.

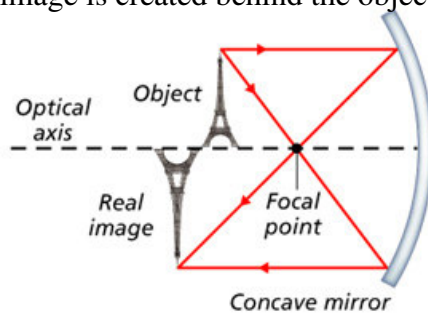
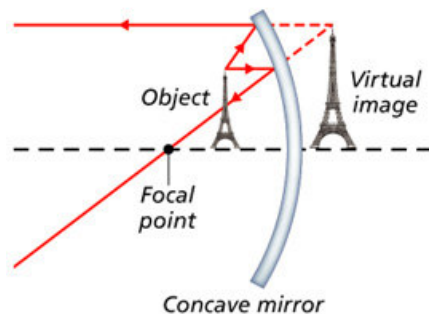


Figure 12.

If the object is closer to the mirror than the focal point then a virtual image is formed. The reflected rays spread out and appear to come from behind the image creating an image that is right side up and appears larger than the object.



3. Convex Mirrors

Convex mirrors are mirrors in which the surface curves outward. The curvature of the mirror causes the light rays to spread out as they strike the surface. The rays appear to come from a point from behind the mirror, which is where the object appears.

Convex mirrors create **virtual images** that are **upright** and **smaller** than the object. The virtual image created by a convex mirror differs from a plane mirror because the image is smaller than the object. Convex mirrors allow for a wide angle view. Examples of convex mirrors are the passenger side view mirrors of cars and in corners of grocery stores.

Figure 13. Convex Mirror

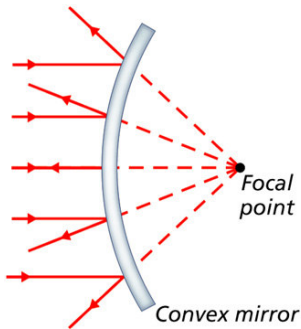
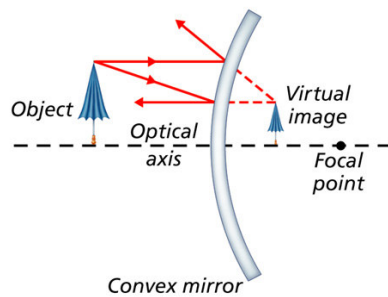


Figure 14. Convex Mirror

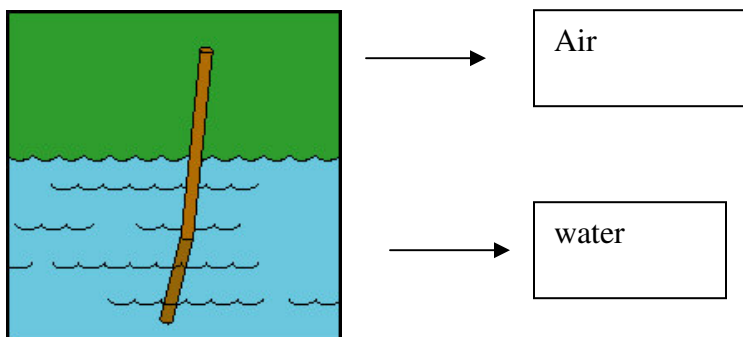


D. Refraction

In a vacuum light travels in a straight line at a speed of 3.00×10^8 m/s. Once light passes from the vacuum into another medium the speed of light will slow down. How much it slows is dependent upon the materials that make up that medium. When the light enters a new medium at an angle, the change in speed causes the light to **refract** or bend.

Figure 15. Refraction

As the stick is placed in water the stick appears to bend. Light travels at a different speed in each medium. Light waves travel at a slower speed in water which cause the image to bend from its normal position.



<http://www.ps.missouri.edu/rickspage/refract/refraction.html>

Index of Refraction

Some mediums cause light to bend more than others because the speed at which the light travels changes. For example in Figure 15 light travels faster in air than in water. As the light hits the water it slows down. The **index of refraction** is a measure of how much a ray of light bends when it reaches a material. The higher the index of refraction the more it bends light. The lower the index the less it bends the light.

Figure 16. Refraction of a Pencil in Water

The pencil looks bent as light is refracted. The speed of the light slows down in the water causing the pencil that is submerged to appear bent.



<http://hyperphysics.phy-astr.gsu.edu/HBASE/geoopt/refr2.html>

Lenses

Lenses are objects made of a transparent material that has one or two curved surfaces that can refract light. The curvature and thickness of the lens affect the way that light is refracted.

Types of Lenses

1. Concave Lenses

Concave lenses are thinner in the center than at the edges. As the parallel rays of light strike the lens they are refracted away from the center of the lens as the medium changes. The light rays never meet so only a **virtual image** (right side up) is produced. The image forms at a point from which the refracted rays appear to come. The image is **smaller** than the object. Concave lenses tend to be used in optical images such as telescopes in combination with mirrors. Concave lenses are also used in eyeglasses for people who are nearsighted so that they can focus and see objects that are far away.

Figure 17. Concave Lens

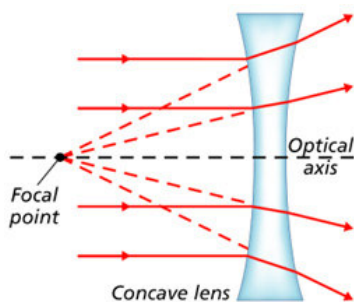
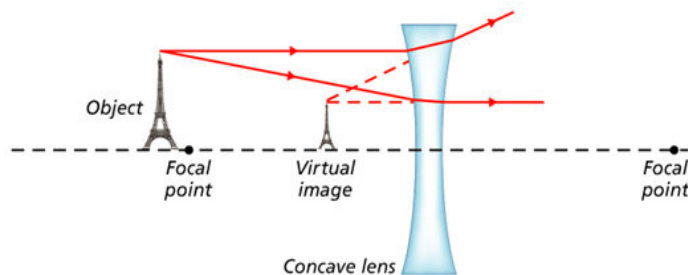


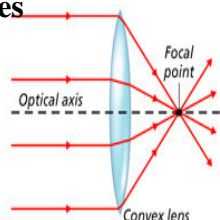
Figure 18. Concave Lens



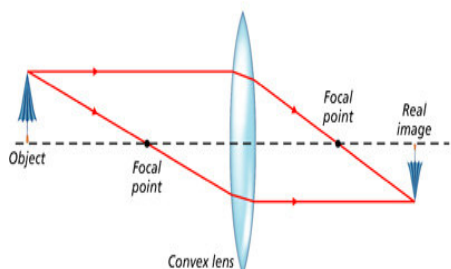
2. Convex Lenses

Convex lenses are lenses that are curved outward from the center and are thinner at the edges. As parallel light rays strike the surface of the lens the light is bent towards the center of the lens. The rays meet at a focal point and continue on. The greater the curvature of the lens the greater the refraction (bending). Like a concave mirror the type of image formed by the lens is dependent on the position of the object in relation to the focal point. Therefore either a real or virtual images is created. Convex lenses are used in slide and movie projectors and cameras. Convex lenses are also used in eyeglasses for people who are farsighted or have difficulty seeing objects that are close to them (ie. reading glasses and magnifiers).

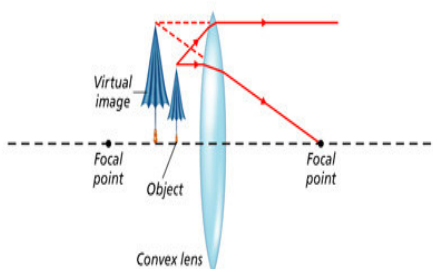
Figure 19. Convex Lenses



The parallel lines strike the lens and refract towards the center of the lens and meet at the focal point.



When the object is beyond the focal point a real image is formed (upside down).



When the object is in front of the focal point a virtual image is formed (right side up).

Works Cited:

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Padilla, Michael. Science Explorer: Investigations in Life, Earth, and Physical Science. New Jersey: Prentice Hall, 2004

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Essential Question: What is the structure and function of the eye?

How your eye works:

“On the back of your eye is a complex layer of [cells](#) known as the **retina**. The retina reacts to [light](#) and conveys that information to the [brain](#). The brain, in turn, translates all that activity into an image. Because the eye is a sphere, the surface of the retina is curved.

When you look at something, three things must happen:

- The image must be reduced in size to fit onto the retina.
- The scattered light must come together -- that is, it must **focus** -- at the surface of the retina.
- The image must be curved to match the curve of the retina.

To do all that, the eye has a lens between the retina and the **pupil** (the "peep hole" in the center of your eye that allows light into the back of the eye) and a transparent covering, or **cornea** (the front window). The lens, which would be classified a "plus" lens because it is thickest toward the center, and the cornea work together to focus the image onto the retina.”

(<http://science.howstuffworks.com/lens7.htm>)

The iris opens and closes to adjust the level of light to what the retina needs to function.

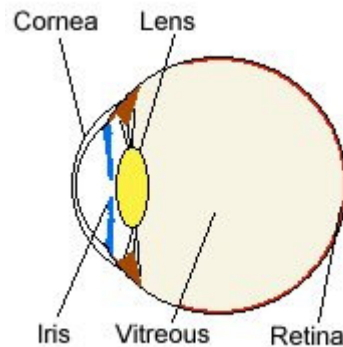


Figure 1. Anatomy of the eye

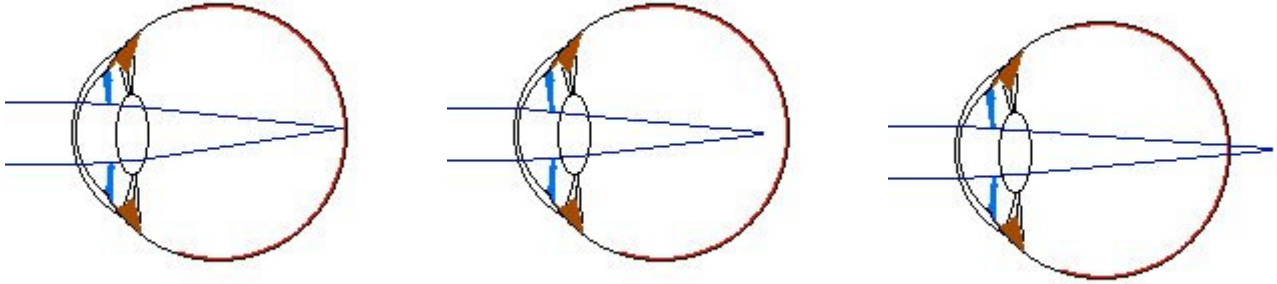


Figure 2. The "perfect" eye

Near-sightedness

Far-sightedness

<http://www.alaskaeyecare.com/visualsystem.cfm>

“How does light let you see these words? Here’s how:

1 Suppose you’re looking out the window on a sunny day and you see a tree. You see that tree because light from the sun hit that tree. Some of that light reflected from the tree—it bounced off the tree like a ball bouncing off a wall.

2 Some of that reflected light hit you right in the eye. That reflected light goes through the clear [cornea](#) of your eye. As it goes through the cornea, it bends a little.

3 The light shines through your [pupil](#), the dark hole in the middle of your eye.

4 The light shines through the [lens](#) of your eye. The lens in your eye bends the light that has reflected from that tree to make a perfect little upside-down picture of the tree on the back of your eyeball.

At the back of your eyeball, there’s a layer of cells that are sensitive to light called the [retina](#). When the picture of the tree shines on the retina, the light-sensitive cells send messages to your brain.

6 Your brain takes the information from your retina and puts it together to make an image of the tree in your mind.

7 Weird, isn’t it? You think you see the tree—but what you see is the light that bounced off the tree and got into your eye. Or if you really want to get picky, what you really see is the fixed-up picture that your brain makes up from the mixed signals it gets from your eye. Amazing!”

http://www.exploratorium.edu/learning_studio/cow_eye/light.html

“Most human beings come equipped with two [eyes](#) and an absolutely amazing **binocular vision** system. For objects up to about 20 feet (6 to 7 meters) away, the binocular vision system lets us easily tell with good accuracy how far away an object is. For example, if there are multiple objects in our field of view, we can automatically tell which ones are farther and which are nearer, and how far away they are. If you look at the world with one eye closed, you can still perceive distance, but your accuracy decreases and you have to rely on visual cues or focusing distances, both of which are slower.

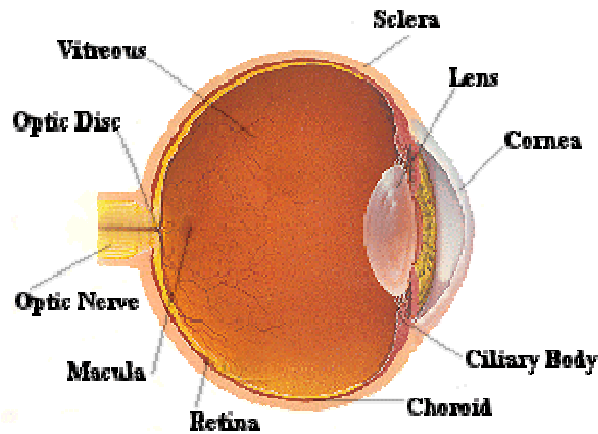
The binocular vision system relies on the fact that our two eyes are spaced about 2 inches (5 cm) apart. Therefore, each eye sees the world from a slightly different perspective, and the binocular vision system in your [brain](#) uses the difference to calculate distance.”

(<http://entertainment.howstuffworks.com/question360.htm>)

How do we see? How does the eye work?

<http://www.pixi.com/~gedwards/eyes/eyeanat.html>

Sight is an amazing process made possible by many parts of the eye working together. Light enters the eye and is bent or refracted by the cornea (the window of the eye) through the pupil (the opening in the iris). This light passes through the lens (located behind the pupil). This completes refraction by fine tuning the focused light onto the retina. The retina changes the light (energy) into electric impulses that are carried through the optic nerve to the vision center (occipital cortex) of the brain where the image is interpreted. A summary of the eye's structures and their functions follows:



Cornea

The cornea is the "window" of the eye (like a watch crystal). It is the clear part of the eye, through which the colored part of the eye is seen. It is the main source of refraction. The cornea is made up of five layers of strong clear tissue. The first layer (epithelium) is made up of rapidly-replaced cells that allow for fast healing (24-48 hrs) of surface injuries. The last four layers add rigidity, provide a barrier against infection and keep the cornea clear.

Sclera

The outer "white part" of an eye is the sclera. This tough structure is the outer wall of the eye that gives protection to the delicate inner structures.

Choroid

This structure, between the sclera and the retina, is made up of blood vessels that provide nourishment to the eye.

Iris

This colored part of the eye has very fine muscles to control the size of the pupil.

Pupil

The pupil is the black-appearing spot in the center of the iris. Its size changes since its function is to control the amount of light reaching the retina. In the dark, it expands allowing more light to enter. It contracts in bright light to keep out excess light.

Lens

This controls 1/3 of the refraction of light that enters the eye (the cornea, the other 2/3). Located just behind the pupil it allows for changing of focus from distance to near objects by altering its shape. This changing focus is called accommodation. As a person ages the lens hardens and accommodation becomes more difficult.

Aqueous Humor

This fluid is produced by the ciliary body and circulates in the front part of the eye. It provides nourishment to the front parts of the eye and maintains the eye pressure.

Retina

This membrane lines the inside wall of the eye. It contains photoreceptors (rods and cones) that change light into sight by converting light into electrical impulses. These electrical messages are sent from the retina to the brain and interpreted as images.

Macula

This tiny part of the retina is the central focusing spot. It is responsible for seeing details (such as reading) and also for color vision.

Optic Nerve

This nerve is the pathway that the light rays take from the retina to the processing center of the brain. It actually is made of about a million tiny nerves bundled together.

Optic Disc

This area is not sensitive to light and it is often referred to as the "blind spot". It is where the retina meets the optic nerve.

The Vitreous Gel

This clear gel fills the central core of the eye. It helps to maintain a spherical shape to the eye.

Essential Question: What are the similarities/differences between a camera and the human eye?

Camera

"A still film camera is made of three basic elements: an optical element (the lens), a chemical element (the film) and a mechanical element (the camera body itself).

The optical component of the camera is the **lens**. At its simplest, a [lens](#) is just a curved piece of glass or plastic. Its job is to take the beams of light bouncing off of an object and redirect them so they come together to form a **real image** -- an image that looks just like the scene in front of the lens.

But how can a piece of glass do this? The process is actually very simple. As [light](#) travels from one medium to another, it changes speed. Light travels more quickly through air than it does through glass, so a lens slows it down.

When light waves enter a piece of glass at an angle, one part of the wave will reach the glass before another and so will start slowing down first. This is something like pushing a shopping cart from pavement to grass, at an angle. The right wheel hits the grass first and so slows down while the left wheel is still on the pavement. Because the left wheel is briefly moving more quickly than the right wheel, the shopping cart turns to the right as it moves onto the grass.

The effect on light is the same -- as it enters the glass at an angle, it **bends** in one direction. It bends again when it exits the glass because parts of the light wave enter the air and speed up before other parts of the wave. In a standard **converging**, or **convex** lens, one or both sides of the glass curves out. This means rays of light passing through will bend toward the center of the lens on entry. In a **double convex lens**, such as a magnifying glass, the light will bend when it exits as well as when it enters.

The chemical component in a traditional camera is **film**. Essentially, when you expose film to a **real image**, it makes a chemical record of the pattern of light.

It does this with a collection of tiny light-sensitive grains, spread out in a chemical suspension on a strip of plastic. When exposed to light, the grains undergo a chemical reaction.

Once the roll is finished, the film is developed -- it is exposed to other chemicals, which react with the light-sensitive grains. In black and white film, the developer chemicals darken the grains that were exposed to light. This produces a negative, where lighter areas appear darker and darker areas appear lighter, which is then converted into a positive image in printing.

Color film has three different layers of light-sensitive materials, which respond, in turn, to red, green and blue. When the film is developed, these layers are exposed to chemicals that dye the layers of film. When you overlay the color information from all three layers, you get a full-color negative.

To increase or decrease the amount of light passing through the lens, you have to change the size of the **aperture** -- the lens opening. This is the job of the **iris diaphragm**, a series of overlapping metal plates that can fold in on each other or expand out. Essentially, this mechanism works the same way as the iris in your eye -- it opens or closes in a circle, to shrink or expand the diameter of the lens. When the lens is smaller, it captures less light, and when it is larger, it captures more light.

The length of exposure is determined by the **shutter speed**. Before you take a picture, the first curtain is closed, so the film won't be exposed to light. When you take the picture, this curtain slides open. After a certain amount of time, the second curtain slides in from the other side, to stop the exposure."

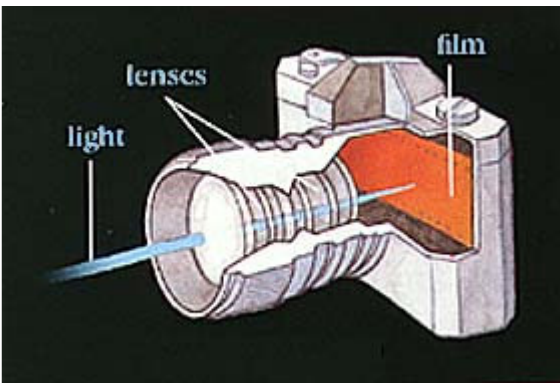
<http://science.howstuffworks.com/camera3.htm>

Comparing the eye to a camera:

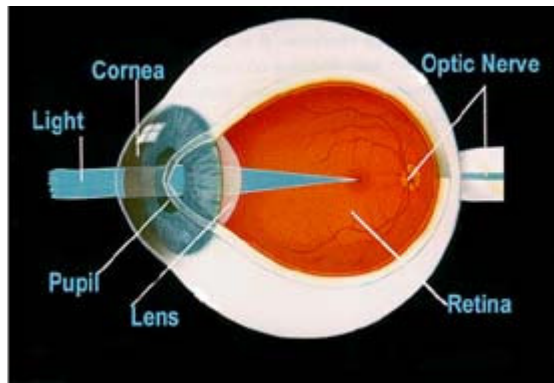
"The individual components of the eye work in a manner similar to a camera. Each part plays a vital role in providing clear vision. So think of the eye as a camera with the cornea, behaving much like a lens cover. As the eye's main focusing element, the cornea takes widely diverging rays of light and bends them through the pupil, the dark, round opening in the center of the colored iris. The iris and pupil act like the aperture of a camera.

Next in line is the lens which acts like the lens in a camera, helping to focus light to the back of

the eye. Note that the lens is the part which becomes cloudy and is removed during cataract surgery to be replaced by an artificial implant nowadays.



The Camera



The Human Eye

The very back of the eye is lined with a layer called the retina which acts very much like the film of the camera. The retina is a membrane containing photoreceptor nerve cells that lines the inside back wall of the eye. The photoreceptor nerve cells of the retina change the light rays into electrical impulses and send them through the optic nerve to the brain where an image is perceived. The center 10% of the retina is called the macula. This is responsible for your sharp vision, your reading vision. The peripheral retina is responsible for the peripheral vision. As with the camera, if the "film" is bad in the eye (i.e. the retina), no matter how good the rest of the eye is, you will not get a good picture.

The human eye is remarkable. It accommodates to changing lighting conditions and focuses light rays originating from various distances from the eye. When all of the components of the eye function properly, light is converted to impulses and conveyed to the brain where an image is perceived.” (http://www.pasadenaeye.com/faq/faq15/faq15_text.html)

Essential Question: How do various instruments improve vision?

The eye has limited size and therefore limited light-gathering power.

1. The eye can only see electromagnetic radiation in the visible wavelengths.
2. The eye distinguishes a new image multiple times a second, so it cannot be used to accumulate light over a long period in order to intensify a faint image.
3. The eye cannot store an image for future reference like a photograph.

Astronomers have developed a variety of instruments and techniques to supplement the human eye and to alleviate these shortcomings

(<http://csep10.phys.utk.edu/astr162/lect/light/limitations.html>)

Different instruments:

1. Telescopes:

There are two types of telescopes which do the same thing but in different ways:

- The refractor telescope, which uses [glass](#) lenses.
- The reflector telescope, which uses mirrors instead of the lenses.

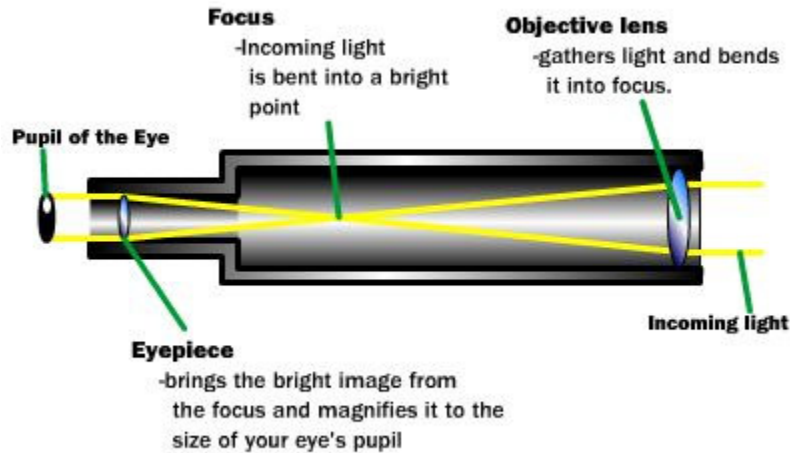
“To understand how telescopes work, let's ask the following question. Why can't you see an object that is far away? For example, why can't you read the writing on a dime when it is 150 feet (55 meters) away with your naked eyes? The answer to this question is simple: the object does not take up much space on your eye's screen (retina).

If you had a "bigger eye," you could collect more light from the object and create a brighter image, and then you could magnify part of that image so it stretches out over more space on your retina. (Animals that are nocturnal need more light so bigger eyes, ie.: owls) Two pieces in a telescope make this possible:

- The **objective lens** (in refractors) or **primary mirror** (in reflectors) collects lots of light from a distant object and brings that light, or image, to a point or **focus**.
- An **eyepiece lens** takes the bright light from the focus of the objective lens or primary mirror and "spreads it out" (magnifies it) to take up a large portion of the retina. This is the same principle that a magnifying glass (lens) uses; it takes a small image on the paper and spreads it out over the retina of your eye so that it looks big.

When you combine the objective lens or primary mirror with the eyepiece, you have a telescope. Again, the basic idea is to collect lots of light to form a bright image inside the telescope, and then use something like a magnifying glass to magnify (enlarge) that bright image so that it takes up a lot of space on your retina.” (<http://science.howstuffworks.com/telescope10.htm>)

Refractor



© 2000 How Stuff Works

This is the simplest telescope design you could have. A big lens gathers the light and directs it to a focal point and a small lens brings the image to your eye.

(<http://science.howstuffworks.com/telescope10.htm>)

The ability of a telescope to collect light is directly related to the diameter of the lens or mirror that is used to collect the light. This is called the aperture. The larger the aperture, the more light that comes in, and therefore the brighter the image. This is the most important feature,

The ability of a telescope to enlarge an image is called the magnification. To determine the magnification, we need to combine the lenses used. The eyepiece performs the actual magnification so different eyepieces can be used to change the magnification.

Refractors:

The parts of the refractor telescope:

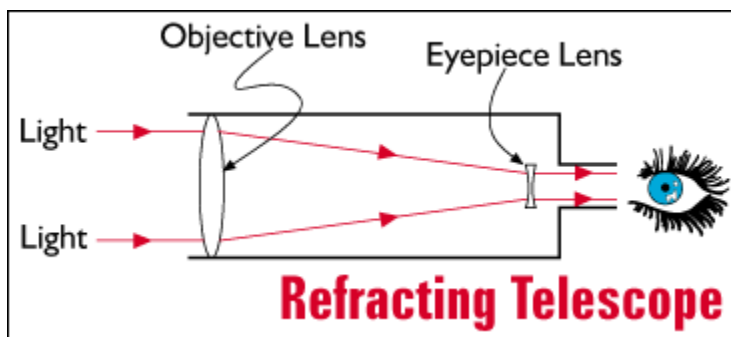
- a long metal, plastic, or wood tube
- a glass combination lens at the front end (objective lens)
- a second glass combination lens (eyepiece)

Refracting telescopes use lenses to gather and bend light making things seem larger. The lenses used in refracting telescopes are called concave and convex. Convex (curved outward) lenses make things bigger, but blurry. Concave (curved inward) lenses make things look clearer, but small. As you can guess, a combination of these two lenses makes things seem bigger and clearer.

“A refracting astronomical telescope makes use of two lenses, one of which works in each of these ways.

The lens in the front of the telescope, called the *objective lens*, produces an upside-down image of the object one is using the telescope to look at.

The lens near the eye, called the *eye lens*, acts as an ordinary magnifying glass to magnify that upside-down image.” (<http://www.hypermaths.org/quadibloc/science/opt01.htm>)



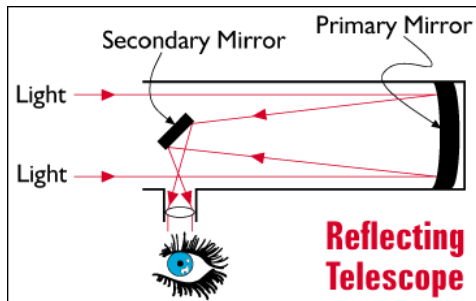
“The tube holds the lenses in place at the correct distance from one another. The tube also helps to keep out dust, moisture and light that would interfere with forming a good image. The objective lens gathers the light, and bends or refracts it to a focus near the back of the tube. The eyepiece brings the image to your eye, and magnifies the image. Eyepieces have much shorter focal lengths than objective lenses.

Refractors have good resolution, high enough to see details in planets and binary stars. However, it is difficult to make large objective lenses (greater than 4 inches or 10 centimeters) for refractors. Refractors are relatively expensive, if you consider the cost per unit of aperture. Because the aperture is limited, a refractor is less useful for observing faint, deep-sky objects, like galaxies and nebulae, than other types of telescopes.” (<http://science.howstuffworks.com/telescope10.htm>)

Reflectors:

“In 1680, Newton used a curved, metal mirror in the back of the tube, instead of a lens, to gather the light and reflect it to a focus point. Mirrors do not have the chromatic aberration problems that lenses do.

Because the mirror reflected light back into the tube, he had to use a small, flat mirror (secondary mirror) in the focal path of the primary mirror to deflect the image out through the side of the tube, to the eyepiece; otherwise, his head would get in the way of incoming light.” (<http://science.howstuffworks.com/telescope10.htm>)



“One disadvantage of reflectors is that you occasionally have to clean and align the mirrors. Also, slight errors in grinding the mirrors can distort the image. Here are some of the common problems:

- Spherical aberration - light reflected from the mirror's edge gets focused to a slightly different point than light reflected from the center.
- [Astigmatism](#) - the mirror is not ground symmetrically about its center (it might be slightly egg-shaped, for example); star images focus to crosses rather than to points.
- Coma - stars near the edge of the field look elongated, like [comets](#), while those in the center are sharp points of light.

In addition, all reflectors are subject to some light loss, for two reasons: First, the secondary mirror obstructs some of the light coming into the telescope; second, no reflective coating for a mirror returns 100 percent of the light striking it -- the best coatings return 90 percent of incoming light.” (<http://science.howstuffworks.com/telescope10.htm>)

Some telescopes are hybrids. They have a mixture of refractor and reflector elements. They are referred to as Compound telescopes

Eyepieces

“An eyepiece is the second lens in a refractor, or the only lens in a reflector. Eyepieces come in many optical designs, and consist of one or more lenses in combination -- they are almost like mini-telescopes themselves.

The purposes of the eyepiece are to:

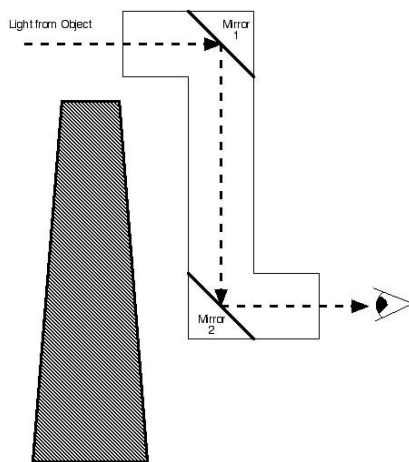
- produce and allow you to change the telescope's magnification
 - produce a sharp image
 - provide comfortable eye relief (the distance between your eye and the eyepiece when the image is in focus)
 - determine the telescope's field of view:
 - apparent - how much of the sky, in degrees, is seen edge-to-edge through the eyepiece alone (specified on the eyepiece)
 - true or real - how much of the sky can be seen when that eyepiece is placed in the telescope (true field = apparent field/magnification)”
- (<http://science.howstuffworks.com/telescope10.htm>)

2. The Periscope

Since light only travels in a straight line, it can't curve around corners. This causes us to not be able to see what is around a corner.

“A periscope, is a optical device for conducting observations from a concealed or protected position. Simple periscopes consist of reflecting mirrors and/or prisms at opposite ends of a tube container. The reflecting surfaces are parallel to each other and at a 45° angle to the axis of the tube.” (<http://inventors.about.com/library/inventors/blperiscope.htm>)

The military often uses periscopes to look at things without putting themselves in danger. The army uses them to see above or around a wall or obstacle, while the navy uses them to see above the surface of the water without surfacing the submarine.



(<http://www.madsci.org/posts/archives/2000-05/959444445.Eg.r.html>)

3. Eyeglasses

“Refracting is a big word that means bending light rays. If a person has vision trouble, it's often a refractive problem. Glasses or contact lenses work so well because they can correct refractive problems. In other words, they bend the light rays in a way that lets you see more clearly. Laser surgery also can correct some vision problems, but it's not recommended for kids because they're still growing.” (http://www.kidshealth.org/kid/feel_better/things/glasses.html)

“Sometimes, for different reasons, the eye doesn't focus quite right:

- The surfaces of the lens or cornea may not be smooth, called **astigmatism**.
- The lens may not be able to change its curve to properly match the image.
- The cornea may not be shaped properly, resulting in blurred vision.

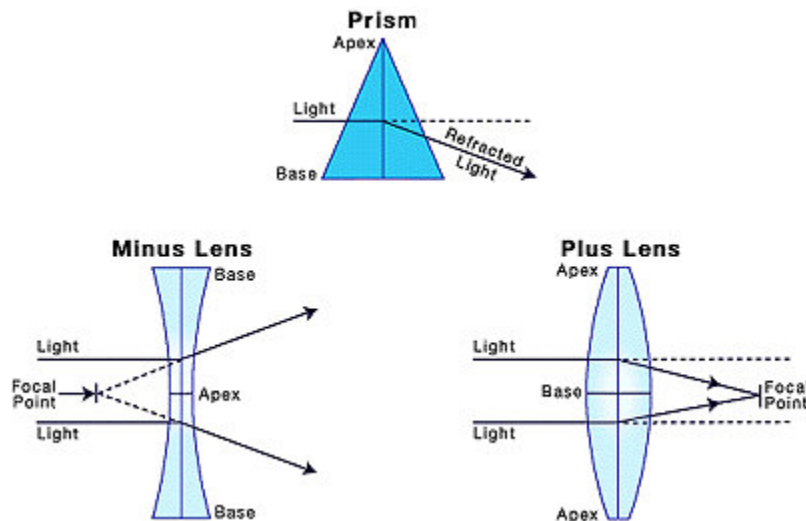
Most vision problems occur when the eye cannot focus the image onto the retina. Here are a few of the most common problems:

- **Myopia** (nearsightedness) occurs when a distant object looks blurred because the image comes into focus before it reaches the retina. Myopia can be corrected with a minus lens, which moves the focus farther back (so it lands on the retina).
- **Hyperopia** (farsightedness) occurs when a close object looks blurred because the image doesn't come into focus before it gets to the retina. Hyperopia, which can also occur as we age, can be corrected with a plus lens. **Bifocal** lenses, which have a small plus segment, can help a farsighted person read or do close work, such as sewing.
- **Astigmatism** is caused by a distortion that results in a second focal point.

In addition, lenses can be made to correct for double vision when the eyes do not work together ("crossed eyes"). The lenses do this by moving the image to match the eye that turns in .

Corrective lenses, then, are prescribed to correct for aberrations, to adjust the focal point onto the retina or to compensate for other abnormalities.

The best way to understand the behavior of light through a curved lens is to relate it to a **prism**. A prism is thicker at one end, and light passing through it is bent (**refracted**) toward the thickest portion. See the diagram below.



A **lens** can be thought of as two rounded prisms joined together. Light passing through the lens is always bent toward the thickest part of the prisms. To make a minus lens (above on the left), the thickest part, the **base**, of the prisms is on the outer edges and the thinnest part, the **apex**, is in the middle. This spreads the light away from the center of the lens and moves the focal point forward. The stronger the lens, the farther the focal point is from the lens.

To make a plus lens (above on the right), the thickest part of the lens is in the middle and the thinnest part on the outer edges. The light is bent toward the center and the focal point moves back. The stronger the lens, the closer the focal point is to the lens.

Placing the correct type and power of lens in front of the eye will adjust the focal point to compensate for the eye's inability to focus the image on the retina.

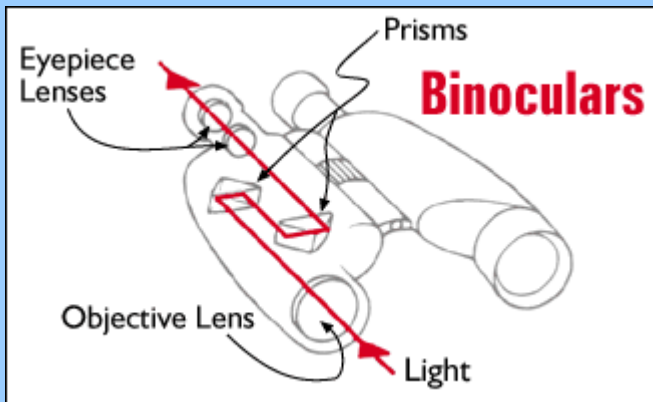
The strength of a lens is determined by the lens material and the angle of the curve that is ground into the lens. Lens strength is expressed as **diopters** (D), which indicates how much the light is bent. The higher the diopter, the stronger the lens. Also, a plus (+) or minus (-) sign before the diopter strength indicates the type of lens.” (<http://science.howstuffworks.com/lens7.htm>)

“**Bifocal lenses** have two parts: the upper part normally used for distance vision and the lower part used for near-vision tasks such as reading.”

(http://www.visionrx.com/Library/enc/enc_prescglasses.asp#work)

Laser eye surgery resurfaces the cornea so that the image is correctly placed on the retina. It is done with computer controlled lasers.

4. Binoculars

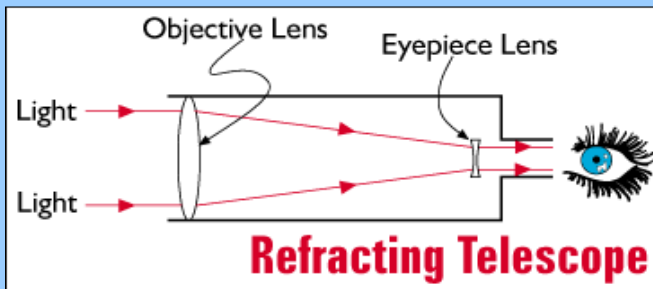


Binoculars are like two telescopes mounted side by side. So, how do telescopes work?

At the front of each telescope is a lens—either an objective or a field lens. This gathers light from whatever it is you're looking at. Let's say you're looking at a bird. The objective or field lens magnifies the image of the bird, but this image is upside-down. Not very useful at this point.

If you're using prism binoculars (and most likely you are—they're the most popular kind), a prism in each tube reverses and inverts the image of the bird. In field glasses, there's a second lens instead of a prism.

The light then travels down the tube, and through a lens in the eyepieces. The bird is magnified even further. Good binoculars will give you an accurate and detailed look at the bird.



<http://www.yesmag.bc.ca/Questions/binoculars.html>

Materials List

Light Energy Grade 5

Revised June 13, 2007

15	3 Inch Prism
15	Convex mirror
15	Concave mirror
20	Plane mirror
45	Stands for mirrors/slit cards
15	Slit cards (for activity 1 in <i>Lenses and Mirrors</i> Delta teacher's guide)
15	Plastic Cafeteria Trays
1 roll of	Red, blue & green yarn
15	Hand lenses
15	Wood blocks 1 inch with letters
45	7cm X 7cm cardboard squares w/hole punch in middle w/ binder clip stands
15	Protractors on oaktag
15 bags	Bags w/assorted objects - lesson 4 <ul style="list-style-type: none"> • Transparency film • Thick cardboard • Cloudy packing foam/plastic or wax paper • Thick foam • Aluminum foil • Playing card • Small mirror • Tulle / netting
1-4	Shiny metal spoons
1	Color Pendant w/ directions

6	Tennis balls
1 bag w/	2-4 Chalk erasers & 1 box corn starch
15	9 oz clear cups
15	Pencils
2 Liter	Vegetable oil
1	Large mirror – not breakable glass
1 roll	Masking tape
15	Flashlights w/ batteries
4	D batteries (extra)
1-2	Periscopes
1-2	Eye Charts
1	Binocular
15	Student books Physical Science MacMillan McGraw Hill
1	Teacher Guide MacMillan McGraw Hill
1	Copy of - Teaching Resources from Macmillan McGraw Hill
1	CD – Teaching Resources from Macmillan McGraw Hill
1	Teacher Guide <i>Lenses and Mirrors</i> DSM Delta
1	Light Energy Curriculum Guide Binder
1	Teacher Resource Book on Light

CATCH IT MATERIALS

10 wood rulers
10 ½ meter sticks
10 plastic rulers

Catch it Curriculum Guide

LITERATURE RESOURCES

These literature resources have been purchased to supplement the kit and are housed in each elementary school library.

Guided Reading sets (6 copies of each)

Sight, A True Book
Experiments with Light, A True Book
Color and Light, Delta Science Readers (23 copies)
Light and Shade, Pearson
Seeing is Not Believing, Pearson I-Openers

Read Aloud (1 copy of each)

Sound and Light-Smart Science, Robert Snedden
Light and Dark-Discovering Science, Rebecca Hunter
My Eyes, Kathy Furgang
Sight, Sue Hurwitz
Light and Dark-It's Science, Sally Hewitt
My Light, Molly Band
Light, Kim Taylor
Light, Stille
Sound and Light, Science Facts and Experiments, David Glover
Light and Color, Straightforward Science
Shifting Perspectives, Rigby

Big Books (1 copy per school)

Light, Berger

Related Materials that May Be Found in Your Library

Additional Teacher Resources That Are Suggested