National Aeronautics and Space Administration

NASA eClips™
Educator Guide

NASA's Our World:
Rose Colored Glasses –
A New Camera for Hubble

Educational Product	
Educators & Students	Grades 5-6

EG-2010-003-LaRC

Rose Colored Glasses – A New Camera for Hubble

National Standards:

National Science Education Standards (NSES)

Science as Inquiry

Abilities necessary to do scientific inquiry

Understanding about scientific inquiry

Physical Science

Light, heat, electricity and magnetism

International Society for Technology in Education: National Educational Technology Standards (ISTE/NETS)

Research and Information Fluency

Students apply digital tools to gather, evaluate, and use information.

Grade Level:
5-6

Subjects:
Elementary science

Teacher Preparation Time:
45 minutes

Lesson Duration:
One and a half 55-minute lessons

Time Management:
This lesson may take longer with younger students or with students who have little prior knowledge about light.

educatorguide

Lesson Overview:

This lesson is developed using a 5E model of learning and utilizes NASA eClips™ video segments. Students learn about visible light, wavelengths of different colored light, and the electromagnetic spectrum through observations and information presented in video segments. Working in teams, students observe images taken by the Hubble Space Telescope through different colored filters and analyze how the filters affect what they can see. This models one of the processes used by Wide Field Camera 3 on board Hubble Space Telescope to collect information about the universe and how NASA scientists use this information to learn more about the universe.

Icons flag five areas of interest or opportunities for teachers.

- **TECHNOLOGY** highlights opportunities to use technology to enhance the lesson.

- **MODIFICATION** denotes opportunities to differentiate the lesson.

- **RESOURCES** relates this lesson to other NASA educator resources that may supplement or extend the lesson.

- **CONNECTIONS** identifies opportunities to relate the lesson to historical references and other topics or disciplines.

- **CHECK FOR UNDERSTANDING** suggests quick, formative assessment opportunities.

Essential Questions

- What is the electromagnetic spectrum?
- How is visible light different from other parts of the electromagnetic spectrum?
- How does technology help us explore beyond the visible light spectrum?

Instructional Objectives

Students will

- explore the visible light spectrum and its place within the electromagnetic spectrum;
- understand that light is a form of electromagnetic energy that travels in waves;
- examine the relationship between wavelength and color of light;
- compare images observed through colored lenses; and
- learn about the Wide-Field Camera 3 installed on the Hubble Space Telescope.

Materials List

Engage

Per student

- Student Guide

Per class

- approximately 500 mL of water
- shallow transparent plastic or glass dish
- overhead projector

Explore

Per group of four

- five paper towel tubes
- five pieces of colored cellophane to cover the end of the paper towel tube
  - one of each color: red, yellow, green, blue, and violet
  - colored cellophane can be obtained from a craft or party store
- five rubber bands
- Hubble images, downloaded from http://hubblesite.org/gallery/

Extend

Per student

- 3D glasses patterns found in the NASA eClips™ Teacher Toolbox
  - red and blue cellophane to create the 3D glasses
  - cardstock to create the 3D glasses

NASA Background

Since its launch in 1990, the powerful gaze of the Hubble Space Telescope, or HST, has helped scientists explore the universe. Far above Earth's surface, HST floats clear of Earth's light-distorting atmosphere, beaming back images capturing details of the universe that are impossible for land-based telescopes to detect.

HST's triumphs have continued to accumulate thanks to a unique design that has allowed astronauts to repair and upgrade the telescope while it remained in orbit.

The Wide-Field Camera 3, or WFC3, was installed on HST during its last servicing mission in May 2009. This camera extends HST's view, allowing it to peer further into the mysteries of the cosmos.

Examples of early images recorded by WFC3 are seen in the following figures 1, 2, and 3.

Figure 1. Barred Spiral Galaxy Centauri. Image credit: NASA

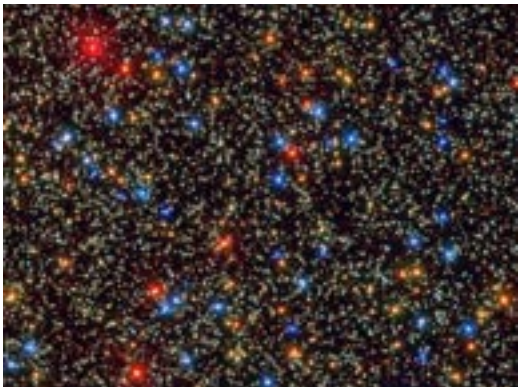


Figure 2. Omega Centauri. Image credit: NASA

Figure 3. Roiling cauldrons of gas Image credit: NASA

Resources

Wide-Field Camera 3:
http://wfc3.gsfc.nasa.gov/index.php

Hubble Space Telescope Servicing Mission 4:
http://www.nasa.gov/mission_pages/hubble/servicing/SM4/main/Summary_FS_HTML.html

Hubble Mission:
http://www.nasa.gov/mission_pages/hubble/main/index.html

Hubble Images:
http://hubblesite.org/gallery/

5E Inquiry Lesson Development

ENGAGE

1. As a class, use a KHWL Chart (Know/How/Want to know/Learned) chart to organize what your students KNOW, HOW they know this information and what they WANT TO KNOW about light.

   These questions can guide the discussion:
   - What do you know about light?
     (Answers will vary. Students may suggest ideas that are incorrect. Do not correct these ideas at this time. Revisit the KHWL chart throughout the lesson to correct any misconceptions and add more facts.)
   - What do you know about rainbows?
     (Answers will vary. Once again, students may suggest ideas that are incorrect. Do not correct these ideas at this time. Revisit the KHWL chart throughout the lesson to correct any misconceptions and add more facts.)
   - Ask students to explain how they have learned the information stated about light and rainbows.
     (Answers will vary. Help students consider the validity of their sources for information.)
   - What do you want to know about light and rainbows?
     (Answers will vary. Encourage students to seek answers to their questions beyond this lesson.)

(MODIFICATION) Students may complete the KHWL chart individually in a science notebook before sharing their thoughts with the class.

2. Set up a demonstration to project a visible light spectrum using this procedure.
   a. Gather these materials: water, shallow and transparent plastic or glass container and overhead projector.

   b. Set the container on the overhead projector.

   c. Fill the container half full with water.

   d. Turn on the overhead projector.

   e. Direct students to look for images near the ceiling. Allow students to discover the images. Students should see rainbow images created as the visible light is refracted. Do not specifically ask students to look for rainbows.

3. Ask students to draw and answer questions about the images they see on page 4 in the Student Guide.

4. **(CHECK FOR UNDERSTANDING)** Ask students to compare the image of the visible light spectrum found on page 1 in the Student Guide to what they see during this activity.

5. **(TECHNOLOGY)** Show the NASA KSNN™ video segment *Why do we see rainbows?* found at: http://ksnn.larc.nasa.gov/webtext.cfm?unit=rainbows. Click on the video tab at the top of the page and select the desired format.

(MODIFICATION) For younger students, use the NASA KSNN™ video segment *What makes a rainbow?* found at: http://ksnn.larc.nasa.gov/k2/s_makeRainbows.html Click on the video tab at the top of the page and select the desired format.

6. **(CHECK FOR UNDERSTANDING)** Ask students to compare what they observed during the ENGAGE activity with information presented in the video segment.
   (Answers may vary, but should include a discussion about light bending, or refracting, as it travels through different materials. Bands within the visible light, or white light, bend in different amounts resulting in the colors of the rainbow. Colors always appear in the same order.)

EXPLORE (20 minutes)

1. **(CHECK FOR UNDERSTANDING)** Ask students to discuss how scientists use light to learn more about the universe. *(Answers may vary. Students may discuss the use of telescopes, light from stars, etc.)*

2. Ask students to read about the Hubble Space Telescope on page 5 in the Student Guide.

3. Divide the class into groups of four. Give each group the following materials:
   - five paper towel tubes
   - five pieces of colored cellophane large enough to cover the end of the tube
     - one of each color: red, yellow, green, blue, violet
   - five rubber bands

4. Direct the students to cover one end of each tube with a piece of colored cellophane and use the rubber band to hold the cellophane in place.

5. Before class, print out color images taken by the Hubble Space Telescope. These images can be found at http://hubblesite.org/gallery/. Print one image per group.

(MODIFICATION) You may choose to project the images instead of printing them.

6. Ask students to look at the Hubble image with each of the tubes.

7. Ask students to rank the clarity of the images when seen through different color lenses in Table 1 on page 5 in the Student Guide.

8. **(MODIFICATION)** Allow students to look at the rainbow demonstration and other light sources in the classroom using the tubes.

EXPLAIN (20 minutes)

1. Ask students to answer question 1 on page 6 in the Student Guide.

2. **(TECHNOLOGY)** Show the NASA eClips™ video segment *Hubble Wide-Field Camera 3 (5:45)* to students. This segment can be found on the NASA eClips™ page of the NASA web site:
   http://www.nasa.gov/audience/foreducators/nasaeclips/search.html?terms="wide%20field%20camera%203"&category=0000

The video may be streamed or downloaded from the nasa.gov web site; a captioned version is also available at the nasa.gov site.

(MODIFICATION) This video may be streamed from the NASA eClips YouTube™ channel:
http://www.youtube.com/watch?v=Vwc8qPuvH-c&feature=PlayList&p=887C1C3BAAD53F17&index=36

3. **(CHECK FOR UNDERSTANDING)** Ask students to discuss what they have learned from the video segment.

   These questions can guide the discussion:

   a. What kind of light is captured by the Wide-Field Camera 3?
      (Answers may vary, but should include a discussion that this camera sees not only visible light, but also detects near infrared and near ultraviolet light.)

   b. What can scientists learn by studying the images created by the Wide-Field Camera 3?
      (Answers may vary, but should include discussions about scientists learning more about very young and very old stars. These images also help scientists learn more about the age of the universe.)

EXTEND (15 minutes)

1. Before class, print 3D glasses patterns on card stock for each student.

   This pattern is found in the Teacher Toolbox at
   http://www.nasa.gov/audience/foreducators/nasaeclips/toolbox/techtools.html

Depending on class time, create the 3D glasses using red and blue cellophane for students or ask the student to create their own glasses.

2. **(TECHNOLOGY)** ask the students to view Wide-Field Camera 3 images found at this site: http://www.nasa.gov/mission_pages/hubble/multimedia/ero/index.html

3. **(CHECK FOR UNDERSTANDING)** Ask students to discuss how the images change using the 3D glasses. These questions can help guide the discussion:

   a. How are the images different when you look at them using the 3D glasses?
   (Answers will vary but may include a discussion that different sections of the image appear to be 3D. Some sections stand out more than other sections.)

   b. What are the benefits in looking at something in 3D?
   (Answers will vary but may include a discussion that the images are more realistic when viewed with 3D glasses.)

   SAFETY CONCERN: ***Warn students NOT to walk around wearing the 3D glasses.***

4. **(CONNECTIONS)** Taking color pictures with the Hubble Space Telescope is much more complex than taking color pictures with a traditional camera. Students can learn more about the color behind the pictures at this web site:
   http://hubblesite.org/gallery/behind_the_pictures/

5. **(RESOURCES)** New tools are being developed to see beyond the realm of the Hubble Space Telescope. The James Webb Space Telescope (JWST) is scheduled for launch in 2014. This telescope will have instruments designed to work primarily in the infrared range of the electromagnetic spectrum. Students can learn more about the JWST through a game about telescopes at this web site:
   http://www.jwst.nasa.gov/game_small.html

6. **(RESOURCES)** An infrared camera records heat rather than light. Challenge your students to try to match infrared images with digital images at this web site: http://spaceplace.nasa.gov/en/kids/aster_do1.shtml

7. **(CONNECTIONS)** Career Clips

   a. Ask students to read the Career Clip found on page 7 in the Student Guide.

   b. Discuss how your students have been thinking and acting like scientists and engineers throughout this lesson. Ask students to respond to the questions on page 7 in the Student Guide to reflect on their work.

EVALUATE (10 minutes)

1. Use questions, discussions and the responses in the Student Guide to assess the students' understanding of the essential questions.

2. Return to the KHWL chart to add more information that students have LEARNED throughout this lesson. Review the information under the KNOW column. With the help of the students, correct any misinformation placed there during the ENGAGE experience.

3. Evaluate your students' understanding of the wavelengths within visible light through this activity:

    a. Give each student a sheet of paper.

    b. Ask students to write their name on the paper so that it stretches the entire length of the paper.

    c. Ask the students to draw a wavelength beginning at the first letter and weaving between each letter of their name.

    d. Based on the number of crests, ask students to determine which color of the visible light spectrum the wavelength most closely resembles.

    e. Ask students to group themselves by color.

    f. Now ask students to arrange themselves to represent the wavelengths within visible light. Students should group themselves according to the spectrum from red to violet.

Rose Colored Glasses – A New Camera for Hubble

Essential Questions

- What is the electromagnetic spectrum?
- How is visible light different from other parts of the electromagnetic spectrum?
- How does technology help us explore beyond the visible light spectrum?

Background

Light is a form of energy. Light is made up of vibrating electric and magnetic energy. This energy travels as a wave. The energy is called electromagnetic radiation. The energy is organized according to wavelengths in the **electromagnetic spectrum**. The human eye can see only a small section of the electromagnetic spectrum. This section is called **visible light**.

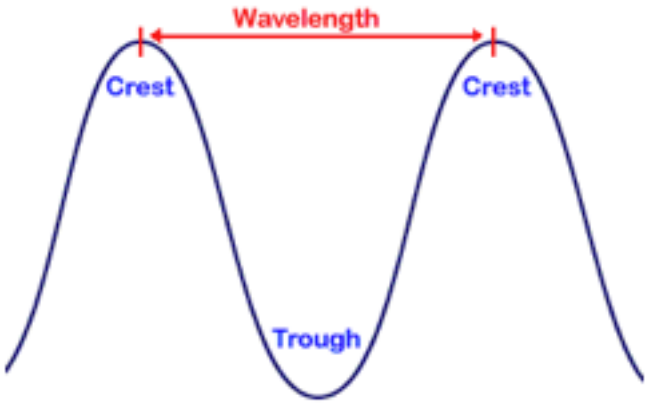
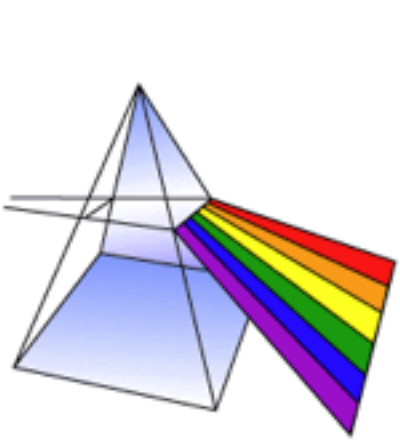


Figure 1: Wavelength of a light wave. Image credit: NASA

Visible light looks like white or yellow light. Visible light can be divided into different **wavelengths**. Wavelengths are measured as the distance from one crest of a light wave to the next crest.

Different wavelengths of light **refract**, or bend, at different angles. A rainbow is formed when sunlight is bent by raindrops in the sky. The light is separated by wavelengths. Visible light waves with longer wavelengths look red. Visible light waves with shorter wavelengths look violet.



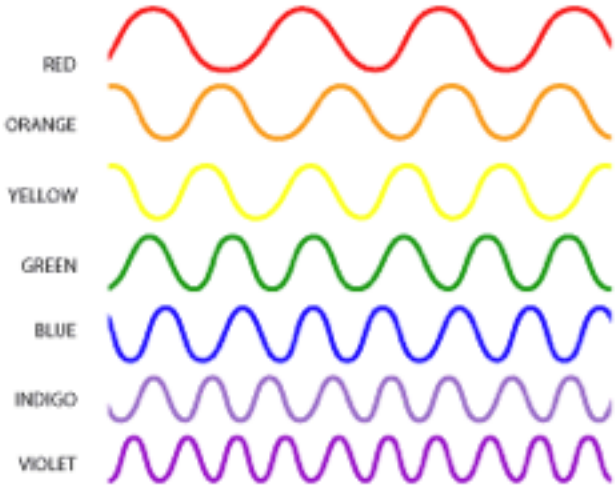


Figure 2: The visible part of the electromagnetic spectrum is made up of the colors seen in a rainbow. Image credit: NASA

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We cannot see most waves in the electromagnetic spectrum. **Ultraviolet**, x rays and gamma rays have wavelengths shorter than visible light.

Infrared, microwaves and radio waves are longer than visible light.

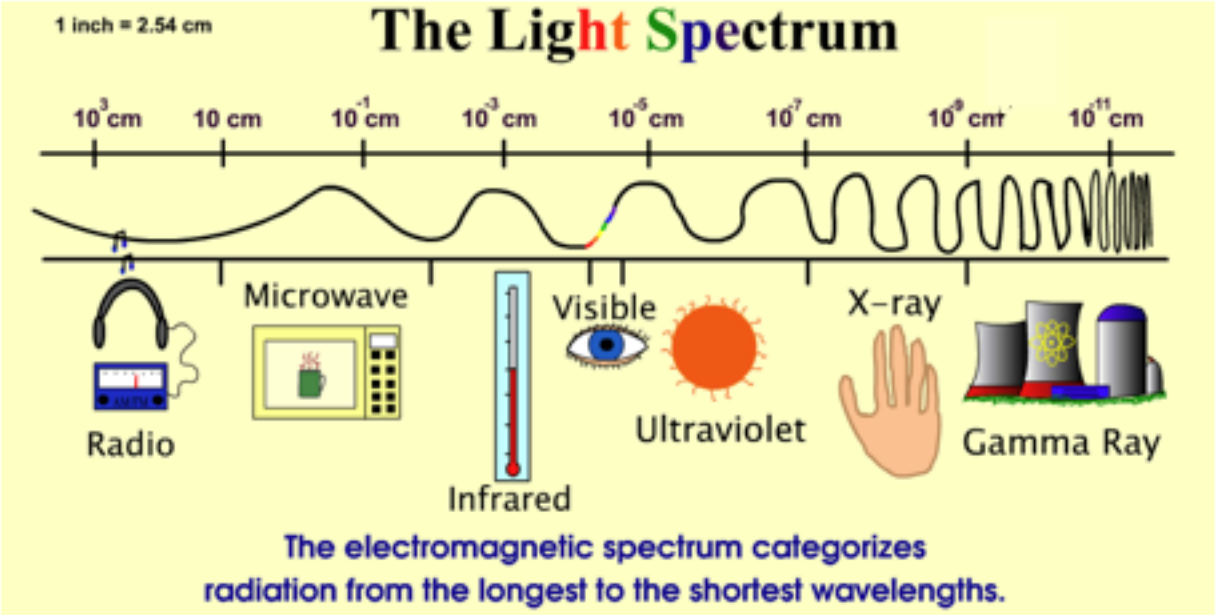

Figure 3: This diagram shows the types of wavelengths in the electromagnetic spectrum from longest to shortest. Image Credit: Aeronomy of Ice in the Mesosphere Satellite Mission

Vocabulary

absorb – **Absorb** means to take in. Light energy that is absorbed is not given off, it is taken in by the object that absorbs the light. As a result, the object may become warmer.

astronomers – An **astronomer** is a person who studies objects in space.

electromagnetic radiation – **Electromagnetic radiation** is energy made up of vibrating electric and magnetic waves.

electromagnetic spectrum – The **electromagnetic spectrum** is the entire range of visible and invisible energy waves organized by wavelengths. Visible light is a small part of the electromagnetic spectrum. Radio waves, ultraviolet waves, infrared waves, and microwaves are also part of this spectrum.

Hubble Space Telescope, HST – The **Hubble Space Telescope** is a large telescope that orbits Earth. It is named after astronomer Edwin P. Hubble (1889-1953).

infrared – **Infrared** wavelengths are longer than visible light and give off heat.

reflect – **Reflected** light is light that hits a surface and bounces off.

refract – When light is **refracted** it is bent. Light refracts when it passes from one material to another.

ultraviolet -- **Ultraviolet** wavelengths are shorter than visible light. Shorter waves have more energy. Ultraviolet radiation can burn and cause skin cancer.

visible light – **Visible light** is the part of the electromagnetic wave that can be seen by the human eye.

wavelength – **Wavelength** is the distance between two crests or two troughs on a wave. Light is classified by its wavelength.

ENGAGE

1. Draw what you see when light travels through the container of water. be sure to include the colors you see in your drawing.

2. Describe what you see. List the colors you see in order.

3. Compare what you see to the information you have learned about light.

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EXPLORE

The **Hubble Space Telescope**, or **HST**, was launched in 1990. HST orbits far above Earth's surface. From this position, HST has a clear view of the universe. HST has helped scientists look deeper into the universe. Tools on the telescope collect information about light. The information is turned into pictures for **astronomers** to study.

A new camera was added to HST in 2009. The Wide-Field Camera 3, or WFC3, is Hubble's most advanced tool. New lenses on this camera separate light into different wavelengths.

Scientists study the pictures taken by the camera. They look carefully at the colors in the pictures. All objects **reflect** and **absorb** different colors based on the material they are made of. Scientists use what they see to learn more about the materials in our universe.

During this EXPLORE and EXPLAIN activity, you will look at some Hubble Space Telescope images through different colored lenses.

Figure 1: Early release observations from WFC3. Image credit: NASA

Table 1. Looking Through Different Colored Lenses

Color of Lens	Rank of Image Clearest (1) to Fuzziest (5)
Red	
Yellow	
Green	
Blue	
Violet	

1. In Table 1, rank the lenses from the one that creates the clearest image (1) to the one that creates the fuzziest image (5).

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EXPLAIN

1. Which color lens gave the clearest image? Which color lens gave the fuzziest image? Is there a pattern between the clearness of the image and the lens color?

EXTEND
CAREER CLIP

1. Throughout this lesson, you have been thinking and acting like a scientist and an engineer. Read this Career Clip to find out more about Russell Werneth, an aerospace engineer at NASA Goddard Space Flight Center.

   a. How is the work that you have been doing during this lesson similar to the work Russell Werneth does every day?

   b. What can you do today that may help you prepare for a future career as a scientist or engineer?

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ENGAGE

1. Draw what you see when light travels through the container of water. be sure to include the colors you see in your drawing.

   Answers will vary but students should draw rainbow images.

2. Describe what you see. List the colors you see in order.

   Answers will vary but students should discuss that they see rainbow images. The light refracts as it travels through the water, creating rainbow images around the room. The colors will be either be ordered red, orange, yellow, green, blue, violet OR violet, blue, green, yellow, orange, red.

3. Compare what you see to the information you have learned about light.

   Student answers will vary depending on their level of prior knowledge. Concepts that students may describe in their own words include: different wavelengths of light refract at different angles, the light is refracted as it travels through the water, the light is separated by wavelengths, visible light waves with longer wavelengths look red, and visible light waves with shorter wavelengths look violet.

EXPLORE

Table 1. Looking Through Different Colored Lenses

Color of Lens	Rank of Image Clearest (1) to Fuzziest (5)
Red	***5***
Yellow	***4***
Green	***3***
Blue	***2***
Violet	***1***

1. In Table 1, rank the lenses from the one that creates the clearest image (1) to the one that creates the fuzziest image (5).

EXPLAIN

1. Which color lens gave the clearest image? Which color lens gave the fuzziest image? Is there a pattern between the clearness of the image and the lens color?

   The filter that creates the clearest image is the violet or purple filter. The filter that creates the fuzziest image is the red filter.

   Red has the longest wavelength and less energy. This filter creates the fuzziest image.
   Violet or purple has the shortest wavelength and the most energy of the colors in the visible spectrum. This filter creates the clearest image.

answerkey

EXTEND
CAREER CLIP

1. Throughout this lesson, you have been thinking and acting like a scientist and an engineer. Read this Career Clip to find out more about Russell Werneth, an aerospace engineer at NASA Goddard Space Flight Center.

   a. How is the work that you have been doing during this lesson similar to the work Russell Werneth does every day?

      Answers may vary, but may include: use scientific knowledge to build new tools to explore the universe and analyze the data collected using those tools.

   b. What can you do today that may help you prepare for a future career as a scientist or engineer?

      Answers may vary, but may include: finding solutions to problems, building special tools to solve problems, modifying equipment just as the Wide-Field Camera 3 was an improvement over previous HST cameras.

answerkey