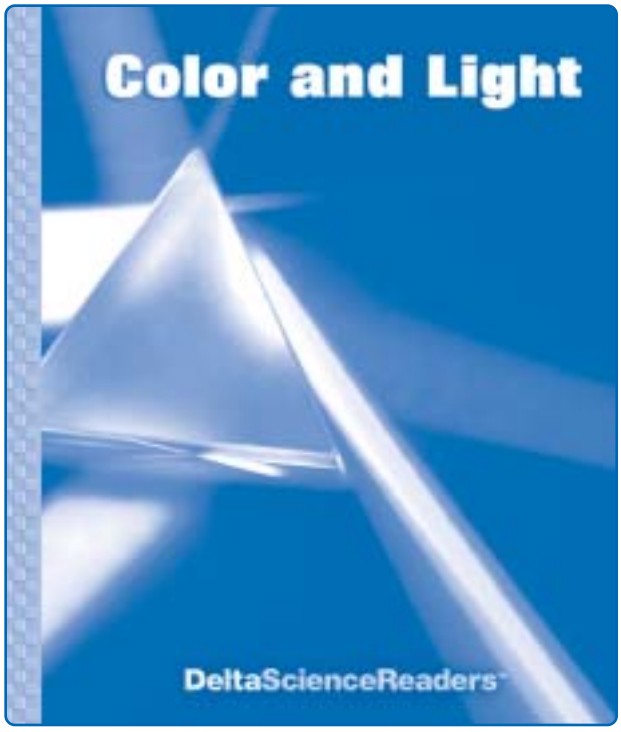
DELTA SCIENCE READER

Color and Light



Delta Science Readers *are nonfiction student books that provide science background and support the experiences of hands-on activities. Every* ***Delta Science Reader*** *has three main sections: Think About . . . , People in Science, and Did You Know?*

Be sure to preview the reader Overview Chart on page 4, the reader itself, and the teaching suggestions on the following pages. This information will help you determine how to plan your schedule for reader selections and activity sessions.

Reading for information is a key literacy skill. Use the following ideas as appropriate for your teaching style and the needs of your students. The After Reading section includes an assessment and writing links.

OVERVIEW

In the Delta Science Reader *Color and Light*, students read about different aspects of light and color. They discover that different surfaces and substances reflect, absorb, and refract light. They learn how we see things in general and how we see color in particular. They also read about a famous astronomer—Annie Jump Cannon—and her work with stellar spectra. Finally, students learn about color blindness.

Students will

- discover what light is, how it travels, and what happens when it strikes an object
- read about the electromagnetic spectrum
- learn how we see objects and color
- read about the primary colors of light
- examine nonfiction text elements such as table of contents, headings, and glossary
- interpret photographs and diagrams to answer questions
- complete a KWL chart

READING IN THE CONTENT AREA SKILLS

- Compare and contrast light waves and other waves; convex and concave lenses; and gamma rays, x-rays, and ultraviolet rays
- Recognize cause-effect relationships related to light and color
- Describe the sequence of events involved in vision
- Draw conclusions about the electromagnetic spectrum
- Identify main ideas and supporting details in text passages
- Demonstrate critical thinking
- Interpret graphic devices
- Summarize

NONFICTION TEXT ELEMENTS

Color and Light includes a table of contents, headings, photographs, illustrations, captions, boldfaced terms, labels, diagrams, and a glossary.

CONTENT VOCABULARY

The following terms are introduced in context and defined in the glossary: *absorb, color filter, concave lens, convex lens, cornea, electromagnetic spectrum, electromagnetic wave, energy, focal point, gamma rays, illuminated, image, infrared rays, iris, lens, light, luminous, microwaves, mirage, opaque, optic nerve, primary colors of light, prism, pupil, radio waves, ray, reflect, refraction, retina, shadow, translucent, transparent, ultraviolet rays, visible spectrum, wave, wavelength, white light, x-rays.*

BEFORE READING

Build Background

Access students' prior knowledge of color and light by displaying and discussing the cover. Ask, *What is the object pictured on the cover?* (a prism) *What is entering the prism?* (a ray of light) *What is leaving the prism?* (a rainbow) *What do you think caused the light to become a rainbow?* (Accept reasonable responses.)

Read the title aloud, and invite students to share what they know about the topic from their personal experiences and hands-on explorations in science. To stimulate discussion, ask questions such as these: *How do we see things? How can we see different colors? What does light have to do with the way we see colors?*

Begin a group KWL chart by recording facts students know about color and light in the K column and questions they have about color and light in the W column. You may want students to copy the KWL chart so they can maintain their own charts as they read.

K What I Know	W What I Want to Know	L What I Learned	+ What I Want to Explore Further

Preview the Book

Explain that when students preview nonfiction, they should look at the title, the table of contents, headings, boldfaced words, photographs, illustrations, charts, graphics, and captions.

Then preview the book with students. Call attention to the various nonfiction text elements and explain how they can help students understand and organize what they read. Ask questions such as these: *How do*

the headings help you predict what you will read about? What do you see in this picture? How do you think it will help you understand the text? Explain that the words in boldface type are important words related to color and light. Point out that these words are defined in the glossary. Choose one word and have students find its definition in the glossary.

Preview the Vocabulary

You may wish to preview some of the vocabulary words before reading, rather than waiting to introduce them in the context of the book. Possibilities include creating a word wall, vocabulary cards, sentence strips, or a concept web.

For example, after helping students define the words, have them find pairs of words that are antonyms—words with opposite meanings. Examples in the glossary include *absorb-reflect, concave lens–convex lens, and opaque-transparent*.

Set a Purpose

Discuss with students what they might expect to find out from the book, based on their preview. Encourage them to use the questions on the KWL chart to set an overall purpose for reading.

GUIDE THE READING

Preview the book yourself to determine the amount of guidance you will need to give for each section. Depending on your schedule and the needs of your class, you may wish to consider the following options:

- **Whole Group Reading** Read the book aloud with a group or the whole class. Encourage students to ask questions and make comments. Pause as necessary to clarify and assess understanding.
- **Shared Reading** Have students work in pairs or small groups to read the book together. Ask students to pause after each text section. Clarify as needed and discuss any questions that arise or have been answered.
- **Independent Reading** Some students may be ready to read independently. Have them rejoin the class for discussion of the book. Check understanding by asking students to explain in their own words what they have read.

Tips for Reading

- If you spread out the reading over several days, begin each session by reviewing the previous day's reading and previewing what will be read in the upcoming session.
- Begin each text section by reading or having a volunteer read aloud the heading. Have students examine any illustrations or graphics and read accompanying captions and labels. Discuss what students expect to learn, based on the heading, illustrations, and captions.
- Help students locate context clues to the meanings of words in boldface type. Remind them that these words are defined in the glossary. Provide help with words that may be difficult to pronounce.
- As appropriate, model reading strategies students may find helpful for nonfiction: adjust reading rate, ask questions, paraphrase, reread, visualize.

Think About . . . (pages 2–13)

Pages 2, 3 *What Is Light?*

- Have students read the text about light. Assess understanding by asking, *What is light?* (a form of energy made of electromagnetic waves) *How does light travel?* (Light travels in a straight line from the source to an object.) *How are light waves different from sound waves and water waves?* (Light waves are faster and can travel through empty space. Other kinds of waves need air or some other kind of material to travel through.)

- Ask students to name some sources of light. (the sun, light bulbs, fire, lasers, fireflies) If students mention the moon, explain that the moon shines because it reflects light from the sun. The moon itself is not a source of light. Ask, *What do we need in order to see objects that are not sources of light?* (a light source)

- If necessary, provide help with the pronunciation of *electromagnetic* (ih-lek-tro-mag-NET-ik).

Pages 4, 5, 6 *Reflection of Light*, *Absorption of Light*, and *Refraction of Light*

- Direct students' attention to the photograph on page 4 and ask, *What do you see in this photograph?* (a reflection of trees in water) Then have students read the text section, "Reflection of Light."

- After reading, ask, *What is the main idea—the most important point—of the first paragraph?* (Light reflects, or bounces back, from some surfaces.) *What details support this main idea?* (You can see an image of yourself in a mirror or a shiny piece of aluminum foil. Trees are reflected in smooth water.) *Why don't images form in shiny surfaces that are rough or wrinkled?* (The light rays are scattered. They reflect in many different directions.)

- Have students study the diagram and read the caption. Ask, *What does the diagram show?* (It shows that light reflects off a surface in a straight line at the same angle that the light hits the surface.) Point out that the reflection is in the opposite direction. *How does the diagram help you understand the text?* (It shows what the text describes.)

Further Facts

- The earliest known mirrors were made of polished bronze or copper. Examples have been found in Egypt dating from about 2900 B.C.E. and in China dating from around 1500 B.C.E. True glass mirrors were developed in the late Roman Empire around the first century.

- During the Han Dynasty (202 B.C.E.–220 C.E.), Chinese experiments with mirrors led to the discovery of the principles of the periscope.

- Mirrors are the key component of reflecting telescopes, which use a system of mirrors to collect light and reflect it to the point of focus. The first working reflecting telescope was built by Sir Isaac Newton (1642–1727) in 1672. Wide-aperture reflecting telescopes are used in many astronomical observatories.

- Have students read the text section, "Absorption of Light." Then ask, *What sometimes happens to light that is not reflected by an object?* (It is absorbed by the object.) *What happens to some of the absorbed light?* (It is changed into heat energy.)

- Remind students that they read on page 3 that light rays travel in a straight line. Explain that this does not mean that light rays do not change direction. Have students read "Refraction of Light" to find out what can cause a light ray to bend.

- After students finish reading, explore causes and effects in the text with them. Ask, *What happens when light hits a new material, such as water?* (It slows down.) *What effect does this have?* (The light wave can bend. It can change direction.) *What is this bending of light called?* (refraction) *What can result when light bends as it passes through air of different temperatures?* (a mirage)

- Call on volunteers to explain what caused the effects that are pictured in the two photographs on page 5. (The turtle's head appears to be in two parts because light reflecting off the turtle at an angle hit the air, sped up, and bent. The mirage was caused by light from the sky hitting a layer of hot air and reflecting off it so that your eyes see a reflected image of the sky, not the road.)

- If necessary, provide help with the pronunciation of *mirage* (mih-RAHZH).

- Before students read about lenses on page 6, ask them to share any knowledge they have about how eyeglasses work. If necessary, explain that the curved piece of glass or plastic in eyeglasses is called a lens. Then have students read the text. Remind them to use the diagram to help them understand what they read.

- After reading, guide students to compare and contrast convex and concave lenses. Ask, *How are convex and concave lenses alike?* (They both refract light.) *How are they different in shape?* (Convex lenses are thicker in the middle than at the edges. Concave lenses are thinner in the middle than at the edges.) *What is the difference in how they refract light?* (Convex lenses refract light so that it comes together at a point. Concave lenses refract light so that it spreads out.) *What different effects does this create?* (Convex lenses make close-up objects appear bigger. Concave lenses help people see distant objects clearly.)

- As appropriate, explain that people who have difficulty seeing close-up objects are called farsighted, and people who have difficulty seeing distant objects are called nearsighted. As people age, some develop problems with both types of vision and need bifocals—lenses in which one part corrects for near vision and a second part corrects for distance vision. Bifocals were invented by Benjamin Franklin in 1784.

- You may wish to challenge students to name as many different things as they can, in addition to eyeglasses, that use lenses. (contact lenses, cameras, binoculars, microscopes, telescopes, projectors, vehicle headlights, flashlights, magnifiers)

Page 7 *What Happens When Light Hits Different Materials?*

- Have students read page 7. Ask, *What is the difference between a luminous object and an illuminated object? Give an example of each.* (A luminous object gives off its own light. An illuminated object reflects light that strikes it. Examples of luminous objects include the sun, a flashlight, a candle, and a light bulb. The moon is an illuminated object.) *Are the stars luminous or illuminated objects?* (luminous) As appropriate, tell students that the planets that sometimes look to us like "stars"—such as Mars, Venus, and Jupiter—are illuminated objects. Like Earth's moon, they shine by reflecting the sun's light.

- Direct attention to the photographs on page 7. Assess comprehension by having students describe the three things that can happen to light when it strikes an object. (Light is blocked by an opaque object, and a shadow forms. Light easily passes through a transparent object, and only a faint shadow may form. Some but not all light passes through a translucent object. Translucent objects make partial shadows.) Invite students to suggest examples of the different kinds of objects.

- Ask students what word part they see in both *transparent* and *translucent*. (trans) Explain that *trans* is a prefix—a word part added to the beginning of a word to make a new word—that comes from a Latin word that means "across, beyond, through." *Transparent* comes from a Latin word that means "to show through," and *translucent* comes from a Latin word that means "to shine through."

- If necessary, provide help with the pronunciation of *translucent* (tranz-LOO-sent).

Pages 8, 9 *Electromagnetic Spectrum*

- Have students study the photograph on page 8 and then read the text to discover how the prism creates a band of colors like a rainbow. Ask, *What is the main idea you learned about white light in the first paragraph?* (White light is made of all colors.) *What is the visible*

spectrum? (the colors red, orange, yellow, green, blue, indigo, and violet) *Why do you think this is called the visible spectrum?* (These are the colors we can see.) *What is the relationship between color and wavelength?* (Each color has a different wavelength.) *What causes white light to separate into its colors when it passes through a prism?* (Each wavelength of light bends at a different angle. This makes the colors separate.)

- Encourage students to draw a conclusion about how rainbows in the sky are formed. If necessary, explain that water droplets in the air act as prisms and separate the colors in sunlight as it passes through them.

- Direct attention to the diagram at the top of pages 8 and 9, and have students read the labels and the caption. Point out the visible light in the diagram. Ask, *What color do you see on the left side of visible light?* (violet) *What did you learn about the wavelength of violet light?* (Violet light has the shortest wavelength of the colors in the visible spectrum and is refracted the least.) *How would you describe the wavelengths to the left of visible light?* (They get shorter, or closer together.) *What color is on the right side of visible light?* (red) *What do you know about the wavelength of red light?* (Red light has the longest wavelength and is refracted the most.) *How would you describe the wavelengths to the right of visible light?* (They get longer, or farther apart.) *What conclusions can you draw from this diagram?* (There are wavelengths of light that are shorter and longer than the wavelengths of light in the visible spectrum. There are wavelengths of light that we cannot see.) Have students read page 9 to find out about the rest of the electromagnetic spectrum. Remind them that the diagram can help them understand the text.

- Check understanding by focusing on details in the text. Ask, *What kinds of electromagnetic waves have shorter wavelengths than the visible spectrum?* (gamma rays, x-rays, and ultraviolet rays) *How are these kinds of rays alike?* (They have high energy, are useful, and can be dangerous.) *What use do gamma rays and ultraviolet rays have in common?* (killing harmful bacteria) *What use do gamma rays and x-rays have in common?* (killing cancer cells) You may wish to tell students that many insects can see near-ultraviolet light. Point out also that ultraviolet rays come from the sun and can cause sunburn and skin cancer. Ultraviolet rays are filtered as sunlight passes through the atmosphere, especially the ozone layer.

- Ask, *What kinds of electromagnetic waves have longer wavelengths than the visible spectrum?* (infrared rays, microwaves, and radio waves) *How are these waves alike?* (They have low energy and are useful.) You may wish to tell students that in a microwave oven the microwaves are absorbed by water and fat in foods and produce heat from the inside.

- Suggest that students work in pairs or small groups to invent mnemonics for remembering the waves in the electromagnetic spectrum in order.

- If necessary, provide help with the pronunciation of *ultraviolet* (ul-truh-VI-uh-let), *infrared* (IN-fruh-red), and *microwave* (MY-kro-wave).

Page 10 *How Do We See Objects?*

- Before students read page 10, invite them to share what they know about how we see things. Ask students to examine the diagram and then read the text. Ask, *What did you learn by studying the diagram and reading the text?* (how our eyes work) Check understanding by having students describe the sequence of events involved in vision. (Light enters the eye by passing through the cornea and the pupil. A lens behind the pupil focuses the light. An upside-down image forms on the retina at the back of the eye. Cells in the retina send signals about the image along the

optic nerve to the brain. The brain turns the image right side up so we see things the right way.)

- Ask, *What kind of lens do we have in our eyes?* (convex) *How is the lens in our eye like a convex lens made of glass? How is it different?* (The lens in our eye and a glass lens both focus light. A glass lens stays the same, but the lens in our eye can change its shape and get thicker or thinner.) *What effect does the lens's ability to change shape have on our vision?* (We can focus on objects that are close up and on objects that are far away.) If necessary, point out that the lens in the eye adjusts so that the focal point of the light entering the eye is on the retina, at the back of the eyeball.

- You may wish to share with students the information that nearsightedness occurs when the shape of the eyeball is too long. The focal point is in front of the retina, not on it. This causes the image of distant objects to be blurred. In farsightedness, the eyeball is too short. The light reaches the retina before it is focused. This blurs the image of nearby objects.

- If necessary, provide help with the pronunciation of *cornea* (KOR-nee-uh) and *retina* (REH-tih-nuh).

Pages 11, 12 *How Do We See Colors?*

- Before having students read page 11, you may wish to review these relevant facts: We see most things because light is reflected off them to our eyes. Different colors of the visible spectrum have different wavelengths. Then have students read to learn how we see color.

- Ask, *What is the main idea of this page?* (The colors that we see depend on the wavelengths of light that are reflected and absorbed by an object.) *What details support this main idea?* (Rose petals look red because they reflect only wavelengths of red light; they absorb all other wavelengths. White objects reflect all the wavelengths of light. Black objects absorb all the wavelengths of light.)

- Have students read page 12 to learn how colored light affects the colors we see. Ask, *How does a color filter change the light that passes through it?* (The filter lets only light of the same color pass through; it absorbs all the other wavelengths of light.) Have students explain how the effect in the bottom photograph was created. (The rose petals absorbed all of the green light and did not reflect any of it. This made the petals look black. The green leaves reflected the green light, so they still look green.)

Page 13 *What Are the Primary Colors of Light?*

- Before students read page 13, invite them to predict what would happen if red, green, and blue light were mixed together. Then have them read page 13 to confirm their predictions.

- After students read, ask, *What are red, green, and blue light called?* (the primary colors of light) *What happens when all three colors are mixed together?* (White light is produced.) *Why does this happen?* (White light is made up of all the colors of light, so a mixture of all the colors looks white.) *What is additive color mixing?* (combining different colors of light to make new colors)

- If necessary, provide help with the pronunciation of *magenta* (muh-JEN-tuh) and *cyan* (SI-an).

People in Science (page 14)

Annie Jump Cannon

- Ask students whether they know what an astronomer is. If necessary, explain that an astronomer is a scientist who studies objects in space. Point out that not all astronomers work with telescopes. Many astronomers study the information gathered from observing the universe

through telescopes and other instruments. Then have students read page 14 to find out about an astronomer who studied stars.

- After students read, ask, *What is one thing that can be learned from studying the spectrum of a star?* (its temperature) As appropriate, tell students that a star's spectrum also gives information about the star's chemical makeup, density, magnetic field strength, and speed of rotation, as well as whether the star is moving toward or away from the viewer.

- Tell students that Cannon finished classifying and cataloging more than 225,000 stars in less than four years. Encourage students to discuss what personal qualities Annie Jump Cannon probably needed to accomplish this monumental task. (Students may mention that she must have been patient, hardworking, efficient, and able to concentrate on a task.)

- Inform students that after 1924 Cannon cataloged tens of thousands of additional stars that were much fainter than the stars she first studied. Ask, *Why do you think she extended her classification?* (Possible responses: She thought it was important; she enjoyed the work; perhaps she thought she would discover something new.)

- Explain that *spectra* is the plural of *spectrum*. Write both words. Tell students that many science words come from Latin and ancient Greek and that their plural forms are different from the plurals of English words. *Spectrum* comes from a Latin word that means "appearance."

Further Facts

- As a child, Annie Jump Cannon had a makeshift observatory in the attic of her home.

- Cannon added subdivisions to the main spectral classes to make the scheme more precise. In this system, Earth's sun is classified G2, which means it is two-tenths of the way between types G and K. (An unknown person came up with the mnemonic that generations of astronomy students have used to remember the sequence: Oh, Be A Fine Girl, Kiss Me.)

- The results of Cannon's work were published in nine volumes from 1918 to 1924. The books contain classified spectra for more than 225,000 stars. Her extended work was published in two volumes in 1925 and 1949.

- In 1938 Cannon was named William Cranch Bond Professor of Astronomy at Harvard. Although she retired officially in 1940, she continued her research until her death the following year.

Did You Know? (page 15)

About Color Blindness

- Direct students' attention to the circles at the bottom of the page. Call on volunteers to identify the numbers they see in the circles. Explain that pictures like these are used to test people's ability to tell the difference between colors.

- Have students read to learn about color blindness. Ask, *What part of the eye lets us see colors?* (the cones in the retina) *How do the cones work?* (They absorb different wavelengths of light.) *What are two causes of color blindness?* (The cones may not pick up all the color signals, or the cones may not send signals to the brain.)

- Ask students whether they have ever noticed that in dim light colors are hard to identify. Explain that cones work only when the light is bright. In dim light, cells called rods take over. Rods do not let us see colors.

- Ask, *What is one problem people with color blindness may have?* (recognizing the colors of traffic lights) *What other problems might a person with color blindness have?* (Students may mention

choosing clothing colors, doing an art assignment in school, or telling some foods apart.) Invite students to suggest ways that a person with color blindness might deal with not being able to distinguish some colors.

Further Facts

- The most common cause of color blindness is genetic. Color blindness is linked to the X chromosome and is almost always passed from a mother to her son.
- Birds are extremely sensitive to color. Instead of just three cone pigments, birds have four or more. This enables birds to distinguish among colors more accurately than humans can, to see more shades, and to see into the ultraviolet range.
- Many animals do not have color vision. Dogs have just two types of cones. Dogs appear to have vision similar to that of a person who is red-green color blind.

AFTER READING

Summarize

Complete the KWL chart you began with students before reading by asking them to share the answers to their questions. Call on volunteers to retell each text section. Then have students use the information in the KWL chart to write brief summary statements.

Discuss with students how using the KWL strategy helped them understand and appreciate the book. Encourage them to share any other reading strategies that helped them understand what they read.

Direct attention to the fourth column in the chart and ask, *What questions do you still have about color and light? What would you like to explore further?* Record students' responses. Then ask, *Where do you think you might be able to find this information?* (Students might mention an encyclopedia, science books, and the Internet.) Encourage students to conduct further research.

Review/Assess

Use the questions that follow as the basis for a discussion of the book or for a written or oral assessment.

1. What are light waves, and how do they travel? (Light waves are electromagnetic waves. They travel in a straight line from a light source until they strike an object.)

2. What are the four things that can happen when light strikes an object? (Light can reflect off the object, be absorbed by it, pass through it, or be refracted [bent] by it.)

3. What is the electromagnetic spectrum? (The electromagnetic spectrum is all the wavelengths of light.) Name the parts of the electromagnetic spectrum. (gamma rays, x-rays, ultraviolet rays, visible light, infrared rays, microwaves, radio waves)

Writing Links/Critical Thinking

Present the following as writing assignments.

1. What is the connection among our eyes, wavelengths of light, and our ability to see color? (Different colors of light have different wavelengths. Objects that appear colored do so because they reflect certain wavelengths and absorb others. The wavelengths that are reflected reach our eyes, enter through the pupil, and are focused by the lens. Our eyes have three types of special cells, called cones, in the retina. Each type of cone absorbs different wavelengths, or colors, of light. This lets us see different colors.)

2. Which part of the electromagnetic spectrum and the way it is used do you think is most important? Why? (Responses will vary.)

Science Journals: You may wish to have students keep the writing activities related to the Delta Science Reader in their science journals.

References and Resources

For trade book suggestions and Internet sites, see the References and Resources section of this teacher's guide.