Students read about the properties of two major kinds of waves: sound and light. The nature of these waves, the role of media in their propagation, and their speed in going through various media are described. Finally, they read about ways that humans have extended their sensory capabilities through devices that exploit waves they normally would not see or hear.

KEY CONCEPTS AND PROCESS SKILLS

(with correlation to NSE 5–8 Content Standards)
1. Energy is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. (PhysSci: 3)
2. Energy is transferred in many ways. (PhysSci: 3)
3. Technology influences society through its products and processes. (Persp: 5)

KEY VOCABULARY

longitudinal wave
media, medium
transverse wave
wave speed
MATERIALS AND ADVANCE PREPARATION

For the teacher
1 Scoring Guide: UNDERSTANDING CONCEPTS (UC)

For each student
1 Scoring Guide: UNDERSTANDING CONCEPTS (UC) (optional)

Masters for all Scoring Guides can be found in Teacher Resources III: Assessment.

TEACHING SUMMARY

Getting Started
1. Review the previous activities on waves.

Doing the Activity
2. (LITERACY) Students work either as a class or in small groups to complete the reading.

Follow-Up
3. (UC ASSESSMENT) Compare and contrast sound waves to light waves.

BACKGROUND INFORMATION

Mechanical Waves
Mechanical waves must have a medium through which to travel. The particles of the medium are what vibrate when the wave passes through it. Without particles there is nothing to transfer the energy of the wave. Mechanical waves are transverse or longitudinal. Sound is an example of a longitudinal mechanical wave. Since it is a mechanical wave sound cannot travel through a vacuum. A water wave is an example of a transverse mechanical wave. Obviously, without the water the wave cannot travel.

Electromagnetic Waves
Electromagnetic waves do not require a medium and can, therefore, travel through a vacuum. Electromagnetic waves are produced when there is a change in velocity of an electric charge. Electromagnetic waves consist of varying electric and magnetic fields that are perpendicular to one another. Light is an example of an electromagnetic wave. For more on electromagnetic waves, see Background Information in Activity 96, “The Electromagnetic Spectrum.”

Speed of Sound
In general, the propagation speed of a wave motion depends on the elastic and inertial properties of the medium. Elastic properties relate to the tendency of a material to resist deformation when a force is applied to it. Steel is an example of a material with high elasticity, and a rubber band is considered to have low elasticity. The scientific term for the degree of elasticity of an object or substance is the elastic modulus. For a
sound wave, the speed is faster in a more elastic medium. In general, solids are most
elastic, allowing relatively high-speed transmission. This is followed by liquids and
then gases. This means that the medium’s phase of matter significantly affects the
elastic properties of the medium.

Inertial properties also influence the speed of sound in a medium, but with less effect
than the elastic properties. Inertial properties are related to the material’s internal
inertia, or its tendency to be sluggish to changes in its state of motion. An example is a
medium’s density; a denser medium has more inertia. Thus, a denser medium results
in slower propagation, even if the phase of matter is the same. For example, because
helium is much lighter than air sound will travel faster in the less dense environment
of helium.

For air, which is nearly an ideal gas, the speed of sound is
\[ v_{s(\text{air})} = 331.4 + 0.5T_c, \]
where
\[ T_c \] is the air temperature (Celsius).

This equation is an approximation because it does not have any theoretical basis.
Instead, it is the result of analysis of measured speed data for temperatures of
0°–100°C. There are more theoretical equations that provide more accuracy for all
temperatures, but they are not generally introduced in a basic physics class.

**Speed of Light**

The speed of light in a vacuum, \( c \), is 299,792,458 m/s and is a physical constant. It is
the maximum speed in the universe for all energy and matter, regardless of the frame
of reference. It is the speed at which all electromagnetic radiations, including those
outside the visible spectrum, travel through a vacuum. The speed at which electro-
 magnetic energy propagates through transparent media, such as glass or air, is less
than \( c \). The ratio between the speed of light in a vacuum and the speed at which it
travels in a medium is called the index of refraction. It is given as

\[ n = \frac{c}{v} \]

where
\( n \) is the index of refraction for the medium,
\( c \) is the speed of light in a vacuum (m/s), and
\( v \) is the speed of light in the medium (m/s).

For example, the index of refraction for glass is about 1.5, and so light in glass travels at

\[ v = \frac{c}{1.5} \text{ m/s}, \]

\[ \approx 200,000,000 \text{ m/s} \]
TEACHING SUGGESTIONS

GETTING STARTED

1. Review the previous activities on waves.

This activity synthesizes what students have already learned about transverse and longitudinal waves. Before they begin the Reading, ask the class to name as many different types of waves as they can. Record their suggestions on chart paper, a board, or smartboard. Students may suggest water waves, waves on a string or spring, sound, light, microwaves, radio waves, and seismic waves. After reviewing the definition of transverse and longitudinal waves, label each wave they suggested as longitudinal or transverse. Accept incomplete examples at this point, and consider returning to the list at the end of the activity.

DOING THE ACTIVITY

2. (LITERACY) Students work either as a class or in small groups to complete the reading.

The Reading is supported with a strategy called Stopping to Think, which helps students process the information they read. In this activity, Stopping to Think questions focus students’ attention on important ideas they encounter in the text. These questions do not require a written response and are different than the Analysis questions found at the end of the activity. Sample responses for Stopping to Think sections are shown below. For more information on this strategy, see the Literacy section of Teacher Resources II: Diverse Learners.

Stopping to Think 1

What is the medium for an ocean wave? Provide evidence that the medium is not transferred when a water wave moves on a lake.

The medium for an ocean wave is the water. This is seen when a buoy or moored boat bobs up and down as waves pass under it. If there is no current or wind, the water under a ship moves up and down while the ship stays in about the same place.

Stopping to Think 2

How is a transverse wave different from a longitudinal wave?

The difference is in the orientation of the direction of motion of the wave medium compared to the direction of travel of the wave. Longitudinal waves move back and forth in the same direction as the wave travels. Transverse waves move back and forth in a way that is perpendicular to the direction of wave travel.

Stopping to Think 3

What does it mean if you hear thunder and see lightning at almost the same time?

It means the lightning was close by. We normally hear thunder some time after we see lightning because it takes much longer for sound to travel to us than it does light. However, the closer we are to the source of the thunder and lightning the less difference in time there will be. The speed of the sound of the thunder will vary depending on temperature, wind, and other factors.

Teacher’s Note: In general it takes thunder about three seconds to travel 1 km. For example if thunder is heard 6 sec after seeing the lightning that caused it, the lightning was about 2 km away.

Stopping to Think 4

What is another example of a device that uses waves to extend our senses?

Stopping to Think 4 is an open question that invites students to think about devices that they use to detect signals that we cannot see or feel. Answers might include televisions that receive on-air signals through antennae, radios, satellite TV receivers, infrared cameras, GPS units, and cell phones.
3. **(UC Assessment)** Compare and contrast sound waves and electromagnetic waves, such as light.

Analysis Questions 1 and 2 help the class summarize the main points in the reading. Students’ written work from Analysis Question 3 may be scored with the **Understanding Concepts (UC) Scoring Guide.** A complete and correct response is shown in Suggested Answers to Analysis Questions.

The focus of the next series of activities is on light and other forms of electromagnetic radiation. In those activities, students will learn more about the properties of light and the electromagnetic spectrum.

### Suggested Answers to Questions

1. **Create a larger version of the Venn diagram below. Record the characteristics of sound and light waves in the circle with that label. In the spaces that overlap, record common features.**

   ![Venn Diagram]

   - **Sound**
     - Longitudinal
     - Medium required
     - ~340 m/s
     - Used in sonar
     - Wave transmits energy
     - Frequency
     - Wavelength speed
     - Changes speed in different mediums

   - **Light**
     - Transverse
     - No medium needed
     - 300,000,000 m/s
     - Used in radar, astronomy

2. **Explain why a satellite orbiting Earth could use radar but not sonar.**

   Sonar uses sound waves. Sound waves are mechanical waves and, therefore, require a medium. Since the satellite is in space sound waves would not be able to travel to and from the satellite. Radar uses electromagnetic waves, which do not require a medium and can, therefore, travel through space.

3. **(UC Assessment)** If you started the motor of a boat in the middle of a lake, who would detect the sound of the motor first: a friend sitting on the shore of the lake, or a friend snorkeling just below the surface of the water along the same shore? Explain your answer.

   Students’ responses may vary. Some students may point out that the friend in the water might be closer to the motor than the friend on the shore. Look for evidence of understanding that the sound that travels through the water will arrive faster than the sound traveling through the air.

   **Level-3 Response**

   The friend who is snorkeling should hear the sound first. The sound will reach the friend who is underwater first because sound travels more quickly through water than it does through air.

4. **Dolphins and whales communicate with other dolphins and whales, respectively, by making low-frequency sounds. They navigate by making high-frequency sounds that echo back to them. Military sonar systems on ships produce sounds as loud as 200 dB, and these sounds travel great distances across oceans. Describe how such systems might affect whales and dolphins.**

   One way that the sound waves from the sonar could cause problems for whales and dolphins is by interfering with their communication and navigation. For example, these animals might not be able to find one another to mate, they might get lost, or they could even swim into objects, such as a beach. We learned that for humans a sound of 130 dB is at the threshold of pain, so a sound of 200 dB will probably have so much energy that it could be very harmful to animals nearby. Another problem is that the sound waves travel quickly through water and the waves from some sonar systems travel great distances. This means that it would be very difficult for some animals to move far enough away from the sonar waves to be safe.
ACTIVITY OVERVIEW

Students explore light by investigating the colors of the visible spectrum. They first observe how a diffraction grating splits white light into its component colors. Then they investigate the energy levels of the different colors of white light through the use of a phosphorescent material.

KEY CONCEPTS AND PROCESS SKILLS

(with correlation to NSE 5–8 Content Standards)

1. Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. (PhysSci: 3)

2. Energy is transferred in many ways. (PhysSci: 3)

3. The sun’s energy arrives as light with a range of wavelengths, consisting of visible light, infrared, and ultraviolet radiation. (PhysSci: 3)

4. Scientists use appropriate tools and techniques to gather, analyze, and interpret data. (Inquiry: 1)

KEY VOCABULARY

evidence

frequency

visible light spectrum
Activity 94 · Comparing Colors

MATERIALS AND ADVANCE PREPARATION

For the teacher

1 Scoring Guide: ANALYZING DATA (AD)
1 Scoring Guide: EVIDENCE AND TRADE-OFFS (ET)
1 diffraction grating
* 1 flashlight
* 1 white surface or wall

For each pair of students

1 Phospho-box
1 card with star-shaped cutout
1 colored-film card
1 timer
* 1 set of colored pencils (red, orange, yellow, green, blue, and purple) (optional)

For each student

1 Scoring Guide: ANALYZING DATA (AD) (optional)
1 Scoring Guide: EVIDENCE AND TRADE-OFFS (ET) (optional)

*Not supplied in kit

Masters for all Scoring Guides can be found in Teacher Resources III: Assessment.

Practice using diffraction grating to diffract white light into the visible spectrum for the demonstration described in Step 1 of the Teaching Suggestions.

For best results, conduct this activity inside.

TEACHING SUMMARY

Getting Started
1. Introduce colors of the visible spectrum.

Doing the Activity
2. Investigate the frequencies of visible light colors.
3. Review the definition of evidence.

Follow-Up
4. Introduce the relationship between color and frequency.
5. (AD ASSESSMENT) Students analyze transmission graphs.
6. (ET ASSESSMENT) Identify the trade-offs of different lenses.
BACKGROUND INFORMATION

Refraction

Refraction occurs when a wave propagating through one medium (or through a vacuum, in the case of light) encounters the interface of another media at an angle. This results in a change in the angle of propagation of the wave as it travels across the interface. For example, the frequency of a wave is determined at the source and is fixed after the wave has left the source. However, the speed and the wavelength can change depending on the medium through which the wave travels. There is, as a result, a differential slowing of the wavefront that causes the light to refract, or change direction. In the case of white light, different frequencies of the light are redirected at slightly different angles, producing the light spectrum that we observe as a rainbow.

Diffraction Grating

A diffraction grating is a tool that diffracts the light that passes through it. It has a similar effect on light as a prism that refracts white light into the visible spectrum, although the sequence of the spectrum is reversed. The mechanism for the separation of light into a spectrum via diffraction is different from that when light is refracted; in diffraction, the light bends around small obstacles that are roughly the same size as the wavelength of the light. A diffraction grating is a transparent or reflective film with parallel thin rulings on it, which cause this bending or dispersion of light. The direction in which the grating disperses light depends on the spacing of the grating and the wavelength of light. Diffraction gratings are commonly found in spectrometers and monochromators. Likewise, the tracks of a CD are separated by the distance of an ordinary lab diffraction grating and will produce a separation of white light.

Visible Light Spectrum

The visible light spectrum is that portion of the electromagnetic spectrum that is visible to the human eye and is perceived as color. It ranges in wavelength from about 400 nm (violet) to 700 nm (red). The boundaries are somewhat hard to distinguish as the colors blend and the outermost regions blend into ultraviolet and infrared. The table below shows the approximate range for each color. It also shows that the bandwidth for each color is not evenly distributed, with red having the widest wavelength range and yellow the thinnest.

<table>
<thead>
<tr>
<th>Color</th>
<th>Wavelength (nm)</th>
<th>Wavelength range (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Violet</td>
<td>380–450</td>
<td>70</td>
</tr>
<tr>
<td>Blue</td>
<td>450–495</td>
<td>45</td>
</tr>
<tr>
<td>Green</td>
<td>495–570</td>
<td>75</td>
</tr>
<tr>
<td>Yellow</td>
<td>570–590</td>
<td>20</td>
</tr>
<tr>
<td>Orange</td>
<td>590–620</td>
<td>30</td>
</tr>
<tr>
<td>Red</td>
<td>620–750</td>
<td>130</td>
</tr>
</tbody>
</table>
TEACHING SUGGESTIONS

1. **Introduce the colors of the visible spectrum.**

Introduce the activity by asking, *Who has ever seen a rainbow?* It is likely that all of your students have seen one. Next ask, *What causes the colors of a rainbow?* Record their suggestions on chart paper, a board, or smartboard. Make sure students are aware that for a rainbow to form, there must be water droplets in the air and sunlight to pass through the water droplets. This phenomenon is called refraction.

Hold up the diffraction grating up and explain that this film with grating on it can also make a rainbow by splitting up the white light that passes through it. Point out that the grating works by a different mechanism than a prism. Whereas refraction is a result of the different frequencies of light being redirected through the glass, diffraction is a result of white light being spread out when it is transmitted through very fine slits. Conduct a demonstration that shows the visible light spectrum by holding the grating about 6” in front of a light source, such as a flashlight. Move the grating around a bit until the diffracted light is projected onto a white surface, such as a wall or paper.

Point out that the rainbow is not formed directly in front of the grating, but is instead angled upward or to the side of it. Ask students, *What does this tell you about the light that goes through the grating?* If necessary, explain that this is evidence that the grating splits up the white light. Then explain that due to the shape of a grating, the incoming white light is separated into its component colors and it appears in its various colors.

**Procedure Step 2**

Students should list the following colors in either ascending or descending order: red, orange, yellow, green, blue, violet. They might also mention the color indigo. Scientists no longer classify indigo as a color in the visible light spectrum because it is a relatively narrow band of color that is transitional between blue and violet. The brightest colors are often seen in the middle of the spectrum, in the yellow area where our eyes are most sensitive.

In reviewing responses to Procedure Step 2, emphasize that the order of the visible light spectrum always shows in the same order of red, orange, yellow, green, blue, violet or vice versa, regardless of how it is diffracted or refracted. Students may surmise that this is because each color has some unchanging characteristic that provides the rank.

**Procedure Step 3**

**Sample Student Response**

The colors blend from one to the next with a smooth transition between them.

In reviewing responses to Procedure Step 3, reinforce the idea that the visible spectrum is continuous from red to violet. Although students are not familiar with the entire electromagnetic spectrum at this point, the evidence for answering this question foreshadows later activities where students learn about the continuous nature of the electromagnetic spectrum.

**Procedure Step 4**

**Sample Student Response**

Yellow appears the brightest, with the colors on the outside of it, orange and green, the next brightest. Closely followed is red, with blue and violet the least bright.

Explain to students that the sun does not give off more yellow light and less red or violet (in fact, it gives off more green than any other color), but rather, our eyes are more sensitive to the color yellow than to the other colors. These observations provide some evidence to students that sunlight has unequal intensity of different colors, that our eyes are sensitive to those colors, or both.

To prepare students for Part B: “Colored Light,” ask *Do you think that each color of light contains the same amount of energy?* A common response is that yellow contains the most energy because it looks the brightest. Do not tell students at this time that this is
incorrect, but do ask a follow-up question, such as, What other observations or measurements could help answer the question of what color contains the most energy? Students tend to suggest taking the temperature of the colors. Explain that Part B of this activity should provide some additional evidence to help answer the question of which color has relatively more energy.

### DOING THE ACTIVITY

2. **Investigate the frequencies of visible light colors.**

   Review how the colored-film card works before starting Part B. In this investigation, each colored film isolates a single color of light. Explain that colored film doesn't refract light like a refraction grating or a water drop to separate the colors in white light. Instead, it only allows one color to be transmitted through the film and come out the other side.

   A common student misconception is that color is transferred to the light from the colored film, much like paint is put onto an object. Make it clear to students that the films do not add any color to white light.

   With the Phospho-box, students should observe that only blue and violet light cause the phosphorescent strip to glow, even when they double the exposure time. Since the phosphorescence in the strip is triggered by a threshold energy, this is evidence that the blue and violet lights have more energy than the other colors. For improved results, students should hold the boxes closer to the light source when exposing them.

   **Procedure Step 10**
   
   **Sample Student Response**
   
   Violet was the brightest, then blue. The other colors did not trigger the phosphorescent strip. The violet seemed equally as bright as when the card was not used.

   Next ask, Why don't all of the colors make the strip glow? Some students may suggest that not all colors of light carry energy. Make it clear that all colors carry energy, but each color carries a different amount. Each color is due to a wave with a slightly different frequency. Only some frequencies carry enough energy to cause the phosphorescent material in the strip to glow. Point out that the colors that make the strip glow (blue and violet) are found right next to each other in the rainbow. This gives some evidence that higher frequencies (and, therefore, energy) of a light wave are related to its position in the spectrum. For visible light, violet has the highest frequency, and red has the lowest. The rest of the colors are in between, according to their position in the rainbow. The phosphorescent strip has a threshold energy. Any energy equal to or greater than the threshold will make the strip glow. The threshold energy corresponds to the frequency delivered to the strip by blue light.

   In Procedure Step 15, students should find that when they double the time duration, the results are similar. This indicates that the phosphorous strip is sensitive to the frequency of the light and not the total exposure.

3. **Review the definition of evidence.**

   Although the term evidence is used previously in the unit, Analysis Question 4 provides an opportunity to formally present what is and isn't scientific evidence. Review the definition of evidence provided in the Student Book. Explain that scientists collect information (data) with various tools and strategies, including observation and experimentation. Tell students that they will now use the data they collected from the film experiment to decide if it gives information about what is damaging Tía Ana’s eyes. The consideration of evidence is a key step in scientific reasoning and decision-making. Throughout this unit, and throughout *Issues and Physical Science*, students will collect and analyze information, which may become evidence to support or refute claims.

   It is important that students be able to distinguish evidence from opinion. Evidence is information that supports a claim. Opinion is the view someone takes about a certain issue based on his or her own judgment, often without the support of factual evidence. An informed opinion may be based on evidence; however, another person may have a
different opinion based on the same evidence. To distinguish evidence from opinion it is helpful to determine if the information is reproducible, meaning could someone else gather similar information under similar circumstances? If the answer is yes, the information is not opinion and is likely to be evidence.

Students should also learn to distinguish supposition from inference. A supposition is a claim based on an incomplete set of evidence. In contrast, an inference is a logical conclusion arrived at by an examination of a complete set of evidence.

When making a decision based on evidence, one must be critical of the source, quality, and quantity of evidence available. Review with students that scientific conclusions are based on evidence, and biased or insufficient evidence compromises the validity of these conclusions. The criteria for quality evidence may vary among the scientific disciplines. However, evidence is generally considered of higher quality if it is obtained through systematic investigation and is reproducible, meaning another investigation under the same set of circumstances would obtain similar data. Additionally, the greater the quantity of high-quality evidence that can be provided the stronger a case is in support of, or against, a claim. Criteria for quantity also vary, but might include the sample size or number of trials in an experiment, the number of observations that support a conclusion, or the availability of multiple lines of evidence that lead to the same conclusion. Scientific conclusions should logically follow the evidence collected, and should not be overly generalized beyond the context of the investigation.

**FOLLOW-UP**

4. Introduce the relationship between color and frequency.

To relate the results of the Phospho-box procedure to the story of Tía Ana, ask students which color of visible light is more likely to damage eyes due to its higher energy. Students should respond that the violet light is most likely to be damaging. In fact, it is not the violet light that is damaging but ultraviolet just beyond the violet frequencies. Students will be introduced to ultraviolet in subsequent activities, and so use this discussion of higher and lower energies to explore the frequencies of the various colors. It may be helpful to present a diagram like the one below that shows the relative frequencies through the visible spectrum. For the same intensity of light, those light waves that are higher frequency will also have higher energy than light waves of lower frequency. Student’s evidence from the activity supports this idea. Let students know that in the next activity, they will consider waves that are of a frequency higher than violet light, such as those that could damage Tía Ana’s eyes.

5. (AD ASSESSMENT) Students analyze transmission graphs.

Review Analysis Question 6a in which students are asked to identify the lenses that block out high-energy wavelengths. Model how to read one of the graphs, and describe how it shows transmission at different wavelengths and also provides an overall sunlight percentage that is transmitted. This question is a good opportunity for assessing student’s ability to not only read the graphs, but to apply the concept of selective transmission introduced by the colored films. Selective transmission is further investigated in the next activity.

Students’ written work from Analysis Questions 6a may be scored with the ANALYZING DATA (AD) Scoring Guide. A complete and correct response is shown in Suggested Answers to Analysis Questions.
6. (ET ASSESSMENT) Identify the trade-offs of different lenses.

Analysis Question 6b introduces the concept of a trade-off. This concept is emphasized in the unit’s last activity, Activity 99, “Personal Protection Plan,” but is introduced here as part of the Evidence and Trade-offs assessment. Provide all students with an EVIDENCE AND TRADE-OFF (ET) Scoring Guide, and ask them to keep it with their science notebooks, as they will refer to it several times in this unit, and throughout Issues and Physical Science. Explain to the class that you will apply the ET Scoring Guide to provide feedback on the quality of their work. As a class, discuss what a Level-3 response would include. In this case students’ responses should include a clear understanding of each lens based on the graphs and a discussion of the trade-offs of making their choice. You may develop a Level-3 exemplar with the class or share the students the Level-3 response shown in the Suggested Answers to Questions section. Point out the elements that make the example a Level-3 response, and discuss how a Level 1 and a Level 2 differ. Ask students for ideas about how to improve the Level-3 response to make it a Level 4. For more information see Teacher Resources III: Assessment.

As a class, discuss what a Level-3 response would include. In this case it should include a discussion on the benefits and trade-offs of different sunglass lenses.

One of the goals of Issues and Physical Science is to teach students that

- decisions often involve trade-offs.
- identifying trade-offs involves analyzing evidence.

Explain to students that in this unit they will make several decisions about what types of protective materials or equipment to use in various situations. In a decision involving trade-offs something is given up to gain something else. Since many decisions involve trade-offs, students should understand that a perfect choice is often not possible. It is possible, however, to recognize and analyze the trade-offs associated with each decision. For example, when asked, “Paper or plastic?” at a store checkout counter, most shoppers make the choice quickly. But there are several trade-offs attached to choosing paper or plastic. A shopper who chooses paper over plastic may do so to avoid generating plastic waste or using up petroleum resources. In requesting the paper bag, though, they are contributing to other environmental problems, such as increased water and energy use, and the higher amounts of solid waste and CO₂ emissions associated with making paper bags. Neither choice is particularly beneficial for the environment, and both choices have a downside. Identifying the trade-offs helps clarify the reasoning that is being applied to make a decision.

To further explore trade-offs, brainstorm with the class a list of decisions they make every day that involve trade-offs. Choose one and talk through the associated trade-offs of deciding one way or another. This practice will familiarize students with ways of identifying and considering trade-offs in this and subsequent activities.

SUGGESTED ANSWERS TO QUESTIONS

1. What is the purpose of the card with the star-shaped cutout?

   The star-shaped cutouts provide a control so that we can see what white light, which contains all of the colors, does to the strip in the Phospho-box. Then we can compare the effects of each color to the effect of white light.

2. How do you think the colored-film card changes the white light into colored light?

   Answers will vary. Even though you discussed this earlier, some students will indicate that the color is transferred to the light from the colored film. Although it is hard to provide convincing evidence to the contrary, make clear that this is not what is happening, and that instead, each film is acting as a filter and letting only one color through and is blocking the rest of the colors. Transmission, reflection, and absorption will be further investigated in the next activity.
3. **Why do you think only some colors make the strip on the bottom of the Phospho-box glow? Explain.**

   Answers will vary. Lead students to the understanding that light carries energy, and when it is absorbed by a material that energy is transferred to the material. In the case of the material that makes up the strip on the box, if light with enough energy is absorbed, the energy is then reemitted as the glowing light. Point out that glow-in-the-dark toys are made of a similar kind of material.

4. **Is there enough evidence, or information that supports or refutes a claim, that supports the idea that the higher-energy colors of white light are damaging Tía Ana’s eyes?**

   There is evidence that there is a range of energy carried by white light, with some colors (blue, violet) having more energy than others (red, orange). However, there is no evidence that supports the idea that the relatively higher energy in some colors is enough to damage Tía Ana’s eyes.

5. **Using the graph below, why do you think sunlight is yellow instead of purple?**

   The graph shows that the largest percentage of color in the visible light spectrum is in the middle of the spectrum or near the yellow frequency.

6. **Sunglass lenses are an example of a material that blocks some white light and some other high-frequency light that is harmful to the eyes. Examine the transmission graphs about three pairs of sunglasses below.**

   a. **(AD ASSESSMENT) Which lens has the best high-energy protection for the eyes? Explain how you decided.**

      Answers will vary. Students could make their choices on price and/or ultraviolet protection, but many may be more concerned with the style and color of the frames and lenses. Encourage students to be clear about what is influencing their choice. Look for responses that specifically identify the data on the graphs as influencing their choice.

      **Level 3 Response**

      Lens 1 provides the best protection. This can be determined because its graph goes down close to zero for the ultraviolet wavelengths. Lens 3 is nearly as good because it lets only a little more of the UV through, and most of the light is transmitted more evenly (except it blocks more blue and violet). So Lens 1 must look red and Lens 3 looks blue. All three of the lenses provide a lot of blocking in the UV frequencies. In fact, both lenses 1 and 3 transmit only 30% of the light. They are all better protection than if you were not wearing sunglasses.

   b. **(ET ASSESSMENT) The price for each pair of sunglasses is shown below. Which pair would you buy and why? Describe any trade-offs you made in your choice.**

      **Lens 1:** $80
      **Lens 2:** $10
      **Lens 3:** $20

      Answers will vary. Students could make their choices on price and/or ultraviolet protection, but some may be more concerned with the style and how dark the lenses appear. Encourage students to be clear about what is influencing their choice. Look for responses that specifically identify the trade-off being made, such as higher cost for effectiveness.

      **Level-3 Response**

      Although Lens 1 is the best protection, I wouldn’t buy it because it is the most expensive one. Lens 2 provides nearly as much UV protection and is only 1/8th the cost. I would choose this lens because it is cheaper than both of the other lenses and has similar protection to Lens 1. In fact, the cheaper Lens 2 has better protection than Lens 3. The trade-off is that it is a very light lens with 60% of the light going through it, and I prefer a dark lens. It is a better trade-off than selecting Lens 3, however, because I would not like to wear a red lens at all.
Selective Transmission

1-2

ACTIVITY OVERVIEW

Students learn more about the properties of light by investigating transmission, absorption, and reflection of waves outside the visible spectrum. They investigate how three thin films, which all transmit visible light, selectively transmit waves that are not visible to the human eye, such as ultraviolet.

KEY CONCEPTS AND PROCESS SKILLS

(with correlation to NSE 5–8 Content Standards)

1. Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. (PhysSci: 3)

2. Energy is transferred in many ways. (PhysSci: 3)

3. The sun’s energy arrives as light with a range of wavelengths, consisting of visible light, infrared, and ultraviolet radiation. (PhysSci: 3)

4. Scientists use appropriate tools and techniques to gather, analyze, and interpret data. (Inquiry: 1)

KEY VOCABULARY

absorption
reflection
transmission
trade-off
-MATERIALS AND ADVANCE PREPARATION

For the teacher
1 Scoring Guide: ORGANIZING DATA (OD)

For each group of four students
3 thermometers
3 Phospho-Boxes
1 film A
1 film B
1 film C
* about 40 cm masking tape
1 timer

For each student
1 Scoring Guide: ORGANIZING DATA (OD) (optional)

*Not supplied in kit

Masters for all Scoring Guides can be found in Teacher Resources III: Assessment.

This investigation works best if it is done outside during midday of a clear, sunny day. It is the most sun-dependent activity in the module. Make sure to check the weather, and try out the Procedure first. If there is not enough sun to show a significant temperature difference, provide students with the sample data from the activity, and have them complete the activity as it is written.

The procedure instructs students to hold or prop up the three boxes for 5 minutes. If opting to allow them to prop up the boxes, prepare a way in which students can do this, or provide time in class for them to come up with a design.

TEACHING SUMMARY

Getting Started
1. Review the concept of selective transmission.

Doing the Activity
2. Investigate the transmission properties of different films.
3. (OD ASSESSMENT) Students collect more transmission data.

Follow-Up
4. Discuss the trade-offs of different window films.
**BACKGROUND INFORMATION**

**Selective transmission and reflection**

When light hits an object, it is reflected, transmitted, or absorbed. When a light wave of a given frequency strikes a material that has electrons of the same natural frequency of vibration as the light, the electrons absorb the energy of the light wave and transform it into vibrational motion. The vibrating electrons interact with other atoms and convert its vibrational energy into thermal energy. The light wave has been absorbed by the object and never again is released in the form of light. Because different atoms and molecules have different natural frequencies of vibration, they will selectively absorb different frequencies of visible light.

Reflection and transmission of light waves occur because the frequencies of the light waves do not match the natural frequencies of vibration of the objects. In this case, when the light waves of these frequencies strike an object, the electrons in the atoms of the object vibrate only briefly and at reduced amplitude. Then the energy is reemitted as a light wave. If the object is transparent, the vibrations of the electrons are passed on to neighboring atoms through the bulk of the material and reemitted on the opposite side of the object, which is called transmission. If the object is opaque, the electrons vibrate for short periods of time but are then reemitted on the side in which they were admitted, which is reflection.

In many cases, the object causes the light to do more than one of these things if the light contains a variety of frequencies. For example, an everyday opaque object, such as a dark shirt, will absorb some energy, as indicated by its warming up in the sun, but it will simultaneously reflect the visible light frequencies into our eyes. Another example is a mirrored sunglass lens where some visible light is transmitted through and some is reflected by the mirror. A smaller portion of the light energy is absorbed by the lens itself.
TEACHING SUGGESTIONS

■ GETTING STARTED

1. Review the concept of selective transmission.

   Review with students the setup of the previous activity, “Comparing Colors,” where films of different colors transmitted some parts of white light but not others. Ask students, What happens to the colors of light that do not pass through the colored films? Students often use such terms as “bounces back,” “goes into,” and “warms up,” as well as the more technical terms transmit, reflect, and absorb, to describe selective transmission.

   Let students know that for this activity they will test materials for the materials’ ability to transmit sunlight. Sunlight that is not transmitted is blocked either by reflection or absorption.

■ DOING THE ACTIVITY

2. Explore the transmission properties of different films.

   Each of the films has different transmission properties. Film A does not block out either ultraviolet (UV) or infrared (IR), film B blocks both UV and IR, and film C blocks UV but not IR. These films are commonly placed on windows and used in other applications to block the wavelengths appropriate for the application.

   After students finish Part A, have groups share the data they collected and come to consensus about the ranking of the films for blocking ability. A sample data set is provided below. Results may significantly differ, depending on the light conditions, but the film rankings should be the same. Students should be able to see from the data that film B is preventing full transmission of whatever in sunlight results in the heating of the air in the box.

<table>
<thead>
<tr>
<th>Film</th>
<th>Initial temperature (°C)</th>
<th>Final temperature (°C)</th>
<th>Change in temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>28.5</td>
<td>42</td>
<td>13.5</td>
</tr>
<tr>
<td>B</td>
<td>29</td>
<td>35</td>
<td>6</td>
</tr>
<tr>
<td>C</td>
<td>28</td>
<td>40</td>
<td>12</td>
</tr>
</tbody>
</table>

3. (OD ASSESSMENT) Students collect more transmission data.

   At the conclusion of Part A, there is evidence of selective transmission although it is not obvious whether what is being transmitted is part of the visible spectrum or some invisible frequencies of sunlight. In Part B, students go a step further by using a UV card, which detects only invisible ultraviolet light. The results give evidence that the films selectively transmit UV frequencies of sunlight since the card behind film A is much darker than the other two. This provides convincing evidence that some nonvisible light waves can be selectively transmitted.

   Since the the results of Part B do not correspond with the Part A results in that film B blocked out energy in Part A and both film B and C blocked energy in Part B, students can conclude that the films are selectively transmitting at least two different kind of waves.

   Students’ written work from Procedure Step 9 may be scored with the Organizing Data (OD) Scoring Guide. A complete and correct response is shown below.

   Procedure Step 9
   Level-3 Response
   Part B: UV Detector Data for Films

<table>
<thead>
<tr>
<th>Film</th>
<th>Initial color</th>
<th>Final color</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>white</td>
<td>Dark purple</td>
</tr>
<tr>
<td>B</td>
<td>white</td>
<td>light purple</td>
</tr>
<tr>
<td>C</td>
<td>white</td>
<td>light purple</td>
</tr>
</tbody>
</table>
When students have completed the Procedure, ask them to surmise whether the light that is not selectively transmitted is reflected or absorbed. Students should be able to conjecture that it is likely to be absorbed, as the films are not a shiny mirror-like surface. It they looked like reflective lenses, it would be logical to assume the majority of light was reflected of the surface.

**FOLLOW-UP**

4. **Discuss the trade-offs of different window films.**

Analysis Question 4 is similar to Analysis Question 6 in the previous activity, although it is not scored with a Scoring Guide. When reviewing students’ responses, make sure they have identified the trade-offs that they made in their choices. For example, for the snowy mountainous region, both films B and C would be appropriate, but C would be the better choice based on cost.

**SUGGESTED ANSWERS TO QUESTIONS**

1. **Which film transmits the most energy? What is your evidence?**

   Film A transmitted the most energy. The evidence for this was that the temperature change behind the film was the highest, and the UV level was also the greatest. A was also the clearest film, which means the most visible light was transmitted through it. This combined evidence showed that film A had the most transmission of sunlight.

2. **What evidence from this investigation supports the idea that sunlight contains invisible waves that behave similarly, but not identically, to visible light waves?**

   The light waves that transmitted through the films carried heat energy to the other side of the film, as indicated by the increased temperature. This could be because some visible light in the sunlight heated up the box, but it could also be from light that we cannot see. The fact that the UV cards were darkened behind the films in varying degrees shows that the invisible ultraviolet was present inside the box and was selectively transmitted through the films.

3. **Films, like the ones used in this activity, are commonly put on glass windows as energy-saving devices and to prevent sun damage. If the costs of the films A, B, and C from this activity are those listed below, which material would you choose to put on**
   
   a. **your car windows?**

   Film B would be the best choice because it would keep the interior of the car from warming up but would also provide ultraviolet protection. Since the total area of the windows is small, the extra cost may be acceptable.

   b. **windows in a home located in a desert?**

   Film B would be a good choice in summer because it would keep the interior cooler in the summer. But it would also prevent any benefits from the transmission of wavelengths that would warm the interior in the winter.

   c. **windows in a home located in a snowy mountainous region?**

   Film C would be the best choice because it would block out the ultraviolet but would allow transmission of wavelengths that would warm the interior of the house in cooler weather. It is less expensive than B and would provide adequate protection.
SEPUP SCORING GUIDES AND ASSESSMENT COMPONENTS

1. Designing Investigations (DI)
2. Organizing Data (OD)
3. Analyzing Data (AD)
4. Understanding Concepts (UC)
5. Recognizing Evidence (RE)
6. Evidence and Trade-offs (ET)
7. Communication Skills (CS)
8. Organizing Scientific Ideas (SI)
9. Group Interaction (GI)
3. ANALYZING DATA (AD) ASSESSMENT COMPONENTS

What to look for:
- Response accurately summarizes data, detects patterns and trends, and draws valid conclusions based on the data used.

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>INDICATOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Characteristics of data</td>
<td>a. Source of data is objective and reliable.</td>
</tr>
<tr>
<td></td>
<td>b. Data are free of inconsistencies or inconsistencies are identified.</td>
</tr>
<tr>
<td></td>
<td>c. Student identifies potential sources of error and, where appropriate, estimates the relative importance of such errors.</td>
</tr>
<tr>
<td>2. Trends and relationships</td>
<td>a. Interpretation of data is accurate.</td>
</tr>
<tr>
<td></td>
<td>b. Identification and description of trends and relationships between variables are correct.</td>
</tr>
<tr>
<td>3. Inferences and conclusions</td>
<td>a. Conclusion is compatible with analysis of data.</td>
</tr>
<tr>
<td></td>
<td>b. Student recognizes the need for additional data where appropriate.</td>
</tr>
<tr>
<td></td>
<td>c. Analysis is mathematically correct.</td>
</tr>
</tbody>
</table>

4. UNDERSTANDING CONCEPTS (UC)

What to look for:
- Student's response identifies and describes scientific concepts relevant to a particular problem or issue.

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 4 Above and beyond</td>
<td>Student accomplishes Level 3 AND goes beyond in some significant way, such as: using relevant information not provided in class to elaborate on your response. using a diagram to clarify scientific concepts. relating the response to other scientific concepts.</td>
</tr>
<tr>
<td>Level 3 Complete and correct</td>
<td>Student accurately and completely explains or uses relevant scientific concepts.</td>
</tr>
<tr>
<td>Level 2 Almost there</td>
<td>Student explains or uses scientific concepts BUT has some omissions or errors.</td>
</tr>
<tr>
<td>Level 1 On your way</td>
<td>Student incorrectly explains or uses scientific concepts.</td>
</tr>
<tr>
<td>Level 0</td>
<td>Student's response is missing, illegible, or irrelevant.</td>
</tr>
<tr>
<td>X</td>
<td>Student had no opportunity to respond.</td>
</tr>
</tbody>
</table>
5. RECOGNIZING RELEVANT EVIDENCE (RE)

What to look for:
- Response states correct and relevant evidence such as facts, data and observations.

### Scoring Guide

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 4 Above and beyond</td>
<td>Student accomplishes Level 3 and goes beyond in some significant way, such as: • questioning or justifying the source, validity, and/or quantity of evidence.</td>
</tr>
<tr>
<td>Level 3 Complete and correct</td>
<td>Student identifies key evidence with the appropriate facts, data and observations.</td>
</tr>
<tr>
<td>Level 2 Almost there</td>
<td>Student includes some, but not all, relevant evidence BUT student omits key evidence OR provides an insufficient number of facts, data, and observations.</td>
</tr>
<tr>
<td>Level 1 On your way</td>
<td>Student states opinion as facts OR student uses incorrect or irrelevant evidence.</td>
</tr>
<tr>
<td>Level 0</td>
<td>Student’s response is missing, illegible, or irrelevant.</td>
</tr>
<tr>
<td>X</td>
<td>Student had no opportunity to respond.</td>
</tr>
</tbody>
</table>

6. EVIDENCE AND TRADE-OFFS (ET)

What to look for:
- Response uses relevant evidence to compare multiple options in order to make a choice.
- Response takes a position supported by evidence and describes what is given up (traded off) for the chosen option.

### Scoring Guide

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 4 Above and beyond</td>
<td>Student accomplishes Level 3 and goes beyond in some significant way, such as: • including relevant evidence that was not studied in class. • evaluating the source, quality, or quantity of evidence. • proposing relevant experiments or research. • including a diagram or other visual aid to clarify his or her ideas.</td>
</tr>
<tr>
<td>Level 3 Complete and correct</td>
<td>Student compares options using accurate and relevant evidence AND takes a position supported by the evidence AND student describes trade-offs of his/her decision.</td>
</tr>
<tr>
<td>Level 2 Almost there</td>
<td>Student discusses one or more options using accurate and relevant evidence, and takes a position supported by the evidence, BUT reasoning is incomplete or part of evidence is missing.</td>
</tr>
<tr>
<td>Level 1 On your way</td>
<td>Student’s response is missing, illegible, or irrelevant.</td>
</tr>
<tr>
<td>X</td>
<td>Student had no opportunity to respond.</td>
</tr>
</tbody>
</table>

### Assessment Components

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>INDICATOR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>b. Student distinguishes relevant evidence from irrelevant information.</td>
</tr>
<tr>
<td></td>
<td>c. Student evaluates source, quality, and quantity of evidence.</td>
</tr>
<tr>
<td>2. Examining options and perspectives</td>
<td>a. Student considers multiple options or perspectives.</td>
</tr>
<tr>
<td></td>
<td>b. Student examines evidence associated with each option or perspective.</td>
</tr>
<tr>
<td></td>
<td>c. Student applies suitable criteria to weigh options and perspectives and make a fair comparison.</td>
</tr>
<tr>
<td></td>
<td>b. Student identifies and describes trade-offs.</td>
</tr>
<tr>
<td></td>
<td>c. Student applies objective reasoning.</td>
</tr>
</tbody>
</table>
1. DESIGNING INVESTIGATIONS (DI)

What to look for:
- Response states a design and specifies data to be collected for the investigation.
- Procedures are described completely and accurately.

### Assessment Components

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>INDICATOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Reason for investigation</td>
<td>a. States goals and objectives of the investigation clearly.</td>
</tr>
<tr>
<td></td>
<td>b. The question (in those circumstances where the student chooses the question to investigate) that the student seeks to answer is one that can be investigated scientifically in a typical classroom situation.</td>
</tr>
<tr>
<td>2. Design of investigation</td>
<td>a. States hypothesis or prediction clearly.</td>
</tr>
<tr>
<td></td>
<td>b. Design is appropriate for the investigation.</td>
</tr>
<tr>
<td></td>
<td>c. Procedures are clear, reproducible, and list specific data to be collected.</td>
</tr>
<tr>
<td></td>
<td>d. Variables are identified and controlled as necessary.</td>
</tr>
<tr>
<td>3. Conducting an investigation</td>
<td>a. Data are accurate and precise.</td>
</tr>
<tr>
<td></td>
<td>b. Data set is complete with no unnecessary gaps.</td>
</tr>
<tr>
<td></td>
<td>c. Data are consistent and reproducible.</td>
</tr>
</tbody>
</table>

### Scoring Guide

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| Level 4 Above and beyond  | Student accomplishes Level 3 and goes beyond in some significant way, such as:  
|                           | • identifying alternate procedures.  
|                           | • suggesting improved materials.  
|                           | • relating clearly to scientific principles and approaches.                                                                                 |
| Level 3 Complete and correct | Student's design is appropriate and has a reproducible procedure, if required.                                                               |
| Level 2 Almost there      | Student's design or procedure is incomplete and/or has significant errors.                                                                   |
| Level 1 On your way       | Student's design or procedure is incorrect or demonstrates a lack of understanding of the goals of the investigation.                        |
| Level 0                   | Student's design or procedure is missing, illegible, or irrelevant.                                                                       |
| X                         | Student had no opportunity to respond.                                                                                                     |

2. ORGANIZING DATA (OD)

What to look for:
- Response accurately records and logically displays data.

### Assessment Components

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>INDICATOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Table of results</td>
<td>a. Data table has appropriate columns in correct sequence (e.g. independent variable in first column).</td>
</tr>
<tr>
<td></td>
<td>b. Columns have appropriate headings that include measurement units.</td>
</tr>
<tr>
<td></td>
<td>c. Data are in ascending or descending order.</td>
</tr>
<tr>
<td>2. Graph of results</td>
<td>a. Type of graph is appropriate for representing the data.</td>
</tr>
<tr>
<td></td>
<td>b. Data are arranged on appropriate axes (e.g. independent variable is on x-axis).</td>
</tr>
<tr>
<td></td>
<td>c. Scales used are the most appropriate for the data.</td>
</tr>
<tr>
<td></td>
<td>d. Axes are labeled with names of variables and units.</td>
</tr>
<tr>
<td></td>
<td>e. Data points are plotted correctly.</td>
</tr>
</tbody>
</table>

### Scoring Guide

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>DESCRIPTION</th>
</tr>
</thead>
</table>
| Level 4 Above and beyond  | Student accomplishes Level 3 and goes beyond in some significant way, such as:  
|                           | • using innovation in the organization or display of data.                                                                                 |
| Level 3 Complete and correct | Student logically presents complete and accurate data.                                                                                   |
| Level 2 Almost there      | Student reports data logically BUT records are incomplete.                                                                                 |
| Level 1 On your way       | Student reports data BUT records are illogical OR records contain major errors in the data.                                                 |
| Level 0                   | Student's data is missing, illegible, or irrelevant.                                                                                    |
| X                         | Student had no opportunity to respond.                                                                                                    |
## UNIT F: WAVES

Listed below is a summary of the activities in this unit. Note that the total teaching time as listed is 11–15 periods (approximately 3 weeks if you teach the activities as recommended every day).

<table>
<thead>
<tr>
<th>ACTIVITY DESCRIPTION</th>
<th>KEY CONCEPTS AND PROCESSES</th>
<th>ADVANCE PREPARATION</th>
<th>ASSESSMENT</th>
<th>TEACHING PERIODS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>89</strong> INVESTIGATION: It's a Noisy World  &lt;br&gt;This activity introduces sound intensity and the decibel scale. Students examine cards that represent the relative intensity of various sounds and learn that an increase of 10 dB is equivalent to a 10-fold increase in sound intensity.</td>
<td>Sound intensity, decibel scale  &lt;br&gt;MATHEMATICS, LITERACY</td>
<td>Wave frequency, amplitude, wavelength, audiograms</td>
<td>Q 4: UC</td>
<td>1</td>
</tr>
<tr>
<td><strong>90</strong> LABORATORY: The Frequency of Sound  &lt;br&gt;Students make a pendulum to create a wave in yarn attached to the bottom of the pendulum. By varying the length of the pendulum, students change the frequency of the wave. They measure the wavelength associated with each frequency.</td>
<td>Wave frequency, amplitude, wavelength, audiograms</td>
<td>Gather objects that make different pitches</td>
<td>Proc: GI  &lt;br&gt;Q 5: AD</td>
<td>1</td>
</tr>
<tr>
<td><strong>91</strong> LABORATORY: Longitudinal and Transverse Waves  &lt;br&gt;Using a long metal spring, students investigate transverse and longitudinal waves. They investigate such properties of the waves as wavelength and amplitude.</td>
<td>Longitudinal waves, transverse waves, energy transmission through a medium, frequency, amplitude, wavelength</td>
<td>Decibel scale, effects of intense sounds on hearing, risk evaluation</td>
<td>Q 1: UC</td>
<td>1–2</td>
</tr>
<tr>
<td><strong>92</strong> INVESTIGATION: Noise-Induced Hearing Loss  &lt;br&gt;Students are introduced to the concept of noise-induced hearing loss. They analyze fictitious profiles and develop a list of strategies to reduce the risk of noise-induced hearing loss.</td>
<td>Decibel scale, effects of intense sounds on hearing, risk evaluation</td>
<td>Prepare self case study</td>
<td>Proc: OD  &lt;br&gt;Proc: AD</td>
<td>1</td>
</tr>
<tr>
<td><strong>93</strong> READING: The Nature of Waves  &lt;br&gt;Students read about the properties of two major kinds of waves, sound and light. The nature of these waves, the role of media in their propagation, and their speed in various media are described.</td>
<td>Longitudinal waves, transverse waves, energy transmission through a medium, speed of sound, speed of light, using waves to extend the senses  &lt;br&gt;LITERACY</td>
<td>Visible light spectrum, transmission of energy, evidence</td>
<td>Q 3: UC</td>
<td>1</td>
</tr>
<tr>
<td><strong>94</strong> LABORATORY: Comparing Colors  &lt;br&gt;Students explore of light by investigating the colors of the visible spectrum. Students first observe how a diffraction grating splits white light into its component colors. Then they investigate the frequency of the different colors of white light through the use of a phosphorescent material.</td>
<td>Visible light spectrum, transmission of energy, evidence</td>
<td>Gather flashlight</td>
<td>Q 6a: AD  &lt;br&gt;Q 6b: ET</td>
<td>1</td>
</tr>
<tr>
<td>ACTIVITY DESCRIPTION</td>
<td>KEY CONCEPTS AND PROCESSES</td>
<td>ADVANCE PREPARATION</td>
<td>ASSESSMENT</td>
<td>TEACHING PERIODS</td>
</tr>
<tr>
<td>---------------------</td>
<td>-----------------------------</td>
<td>---------------------</td>
<td>------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>95 <strong>LABORATORY: Selective Transmission</strong></td>
<td>Transmission, reflection, absorption, selective transmission</td>
<td>Sunshine needed</td>
<td>Proc: OD</td>
<td>1-2</td>
</tr>
<tr>
<td>Students learn more about the properties of light by investigating transmission, absorption, and reflection of waves outside the visible spectrum. Students investigate how three thin films, which all transmit visible light, selectively transmit waves that are not visible, such as ultraviolet.</td>
<td>Electromagnetic spectrum, radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, gamma rays, solar spectrum, using electromagnetic waves to extend the senses.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Evidence, absorption, reflection, health risk due to ultraviolet exposure, law of reflection</td>
<td>Sunlight needed, gather covering cloth</td>
<td>Q 4: AD</td>
<td>1-2</td>
</tr>
<tr>
<td>96 <strong>LABORATORY: Reflection and Absorption</strong></td>
<td>Students compare the reflection and absorption of sunlight off a dark surface and reflective surface. Then they consider the increased health risks due to sunlight that is reflected onto the skin and eyes from sand, snow, or water.</td>
<td>Properties of UV, skin cancer and cataracts, vitamin D deficiency, increased risk,</td>
<td>Proc: DI</td>
<td>1-2</td>
</tr>
<tr>
<td>Students design an experiment that compares the effects of sunblock lotion and moisturizing lotion for their ability to transmit, reflect or absorb ultraviolet. They relate the results to the sun's effects on human health and actual use of sunscreens.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>98 <strong>TALKING IT OVER: Personal Protection Plan</strong></td>
<td>Health risks of ultraviolet exposure, benefits and trade-offs, risk evaluation</td>
<td></td>
<td>Q 5: ET</td>
<td>1</td>
</tr>
<tr>
<td>Students analyze a series of fictitious profiles to determine the relative risk of cataracts and skin cancer for each case. After analyzing these narratives, each student determines his or her own relative exposure risk from ultraviolet, and then creates a personal protection plan.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>