# MYSTERIES OF THE UNSEEN WORLD

## Museum Educator Guide

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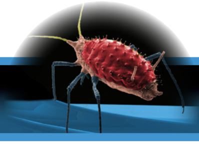

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## Mysteries of the Unseen World Museum Educator Guide

This guide is designed to provide museum educators with resources to promote and help augment guest experiences before or after viewing the film *Mysteries of the Unseen World*. Inside the guide you will find informational text about the film, text to include in newsletters for event promotion, and a suite of activities to use with visiting groups of children. Activities vary from those that last 5 minutes to those designed to be used during an overnight, day camp, or other extended experience.

### Information about the Film

*Mysteries of the Unseen World* will transport audiences to places on this planet they have never been before, to see things that are beyond their normal vision, yet are literally right in front of their eyes.

High-speed and time-lapse photography, electron microscopy, and nanotechnology are just a few of the advancements in science that allow us to see a whole new universe of things, events, creatures, and processes we never knew existed. These technologies now give us “super powers” to see beyond what is in front of us.

Visually stunning and rooted in cutting-edge research, *Mysteries of the Unseen World* will enthrall audiences as they begin to understand the enormity of the world they can’t see, a world that exists in the air they breathe, on their own bodies, and in all of the events that occur around them minute-by-minute—and nanosecond-by-nanosecond. With this understanding comes a new appreciation of the wonder and possibilities of science.

### Sample Text for Event Promotion

Existing and emerging technologies are giving science exciting new images of long-hidden worlds—allowing viewers to see things not visible to the naked eye. Using high-speed and time-lapse photography, electron microscopy, and nanotechnology, you can peer into these invisible realms of things too fast, too slow, and too small to see. Bring your [school or boy scout troop etc..] group to [insert museum or science center] to view National Geographic’s educational and visually stunning film *Mysteries of the Unseen World*.

To enrich your group’s experience at the [museum or science center], we are offering a suite of engaging hands-on activities that range from 5 minutes to over an hour in length. Activities are aligned with Next Generation Science Standards, allowing you to meet your instructional demands while students are having fun and learning. Check out the museum-focused activities as well as classroom resources at www.natgeoed.org/mysteriesoftheunseenworld.

Please contact [coordinator’s name and contact information] to schedule your journey into the unseen world.



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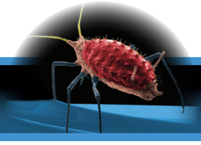

These activities for students in grades 3-5 and 6-8 extend some of the concepts introduced in the *Mysteries of the Unseen World* film. This section of the guide includes brief, 5- to 15-minute activities that can be used with museum visitors, as well as longer activities that can be offered as a museum class. Activities of various lengths are also included for use with museum overnight stays.

## Grades 3-5

### Activity 1: Playing with Perspective

**Grades: 3-5**
**Time: 5 to 15 minutes**

**Objective:** Students will understand that objects look different at different magnifications.
**Next Generation Science Standards:** DCI: PS1.A; CC: Scale, Proportion, and Quantity

**Materials:**
- Sample of coffee grounds
- Sample of writing paper
- Electron microscope images of coffee grounds and paper
- Prepared microscope slides of coffee grounds and paper
- Microscope
- Magnifying glass
- Ruler
- Comic strip templates and pencils

**Preparation:**
Set up a cart with all the listed materials. Group the electron microscope images with prepared slides and samples of the same material.

**Activity:**
1. Invite students to observe the electron microscope image of either the paper or the coffee grounds. Then have them look at the slide of the same item under the microscope. Ask students:
   - *Do you think you were looking at the same thing each time? Why or why not?*
   - *What do you think you were looking at?*
2. Tell students what they were looking at (paper or coffee grounds), and then have them look at the same object with a magnifying glass and then with their naked eye. Ask:
   - *How do these look similar to the magnified object you saw before? How do they look different?*
   - *All of these things that you looked at are the same thing (paper or coffee grounds). What makes them look so different?*
3. Explain that each time they looked at the object, they saw it at a different magnification. The higher the magnification, the closer up they are seeing the object. Ask:
   - *Which view do you think had the highest magnification (the most close-up view)?* (The first one – the electron microscope image)
   - *Which view do you think had the lowest magnification?* (The actual object, which isn't magnified at all)



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4. Give students the ruler and ask them to measure the real object. Ask them to find a 1 millimeter (mm) length of the object. Explain that the piece of the object in the electron microscope image is so small it is measured in nanometers (nm) and that there are one million nanometers in a millimeter. So, the object in the electron microscope image is actually so small they couldn't see it just using their eyes, but it looks bigger to them because it is magnified.
5. Have students look at the other object (paper or coffee grounds) with their naked eye and then with the magnifying glass, microscope, and finally, the electron microscope image. Ask them to draw what they see at each magnification level in one frame of the comic strip template. Beneath the comic strip, have them write a sentence explaining why the images they drew look different even though they are of the same object.

## Activity 2: Electron Microscope Image Scavenger Hunt

**Grades: 3-5**
**Time: 15 minutes**

**Objective:** Students will understand that magnifying objects allows them to be seen in more detail.
**Next Generation Science Standards:** DCI: PS1.A; CC: Scale, Proportion, and Quantity

**Materials:**
- One copy of the Electron Microscope Images worksheet
- One copy of the Scavenger Hunt Answer Key worksheet
- One copy of the Scavenger Hunt worksheet for each small group or individual
- One pencil for each small group or individual

**Preparation:**
Place images from the Electron Microscope Images worksheet around the room.

**Activity:**
1. Give individuals or groups of students a copy of the scavenger hunt list and a pencil.
2. Have students look at the images and try to match an image with each clue. Have them write the number of the image beside the clue they think it matches.
3. Challenge students to find as many images from the list as they can in seven minutes.
4. After seven minutes, go to each image and ask students to share which clue they thought the image matched. Then reveal the correct clue and what the object is.
5. Allow students time to discuss which images they found surprising and why.
6. To modify this activity for independent use by museum visitors, make an answer key available for visitors when they complete the scavenger hunt.


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## Electron Microscope Images

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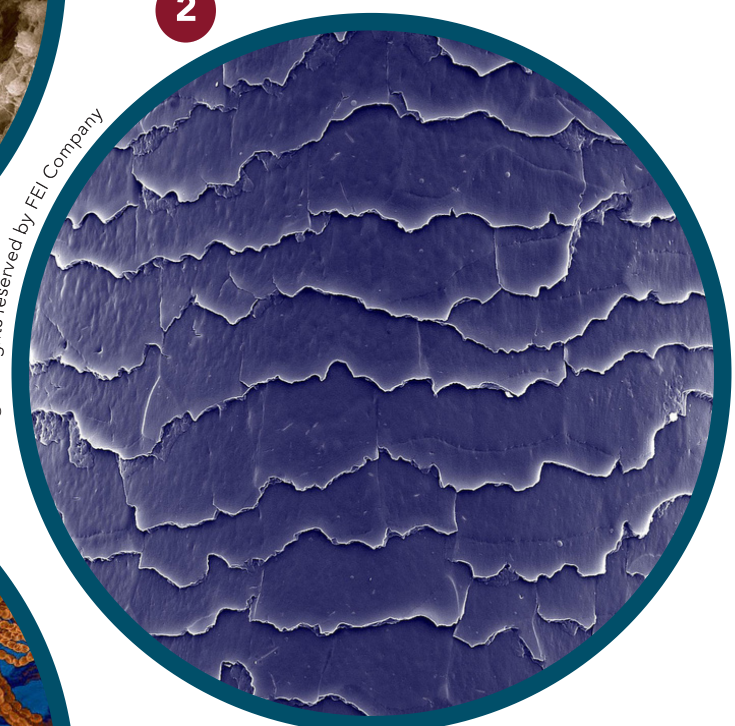



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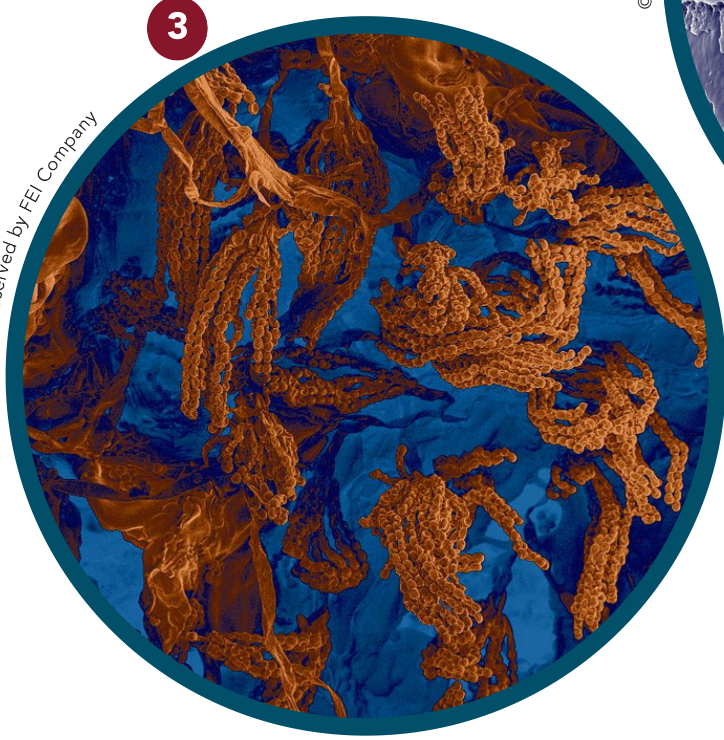





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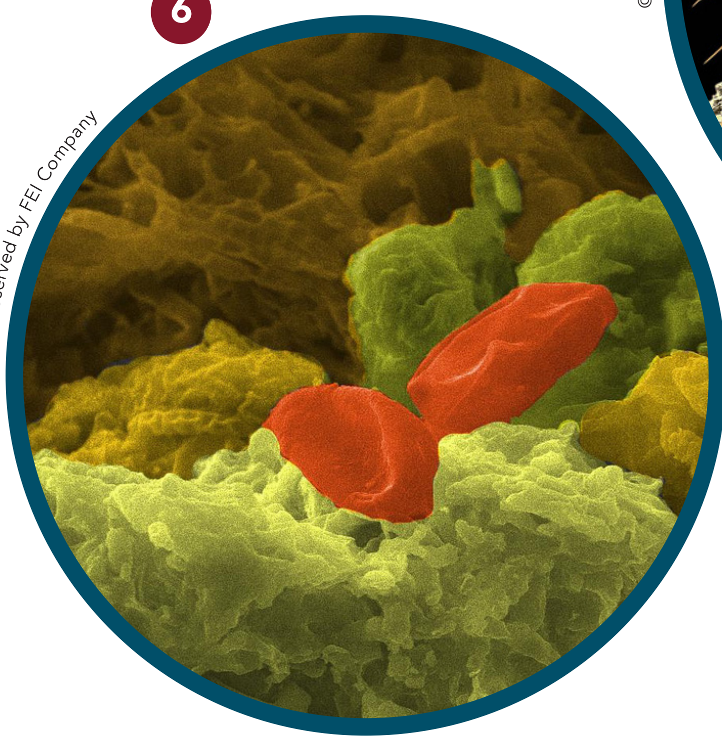





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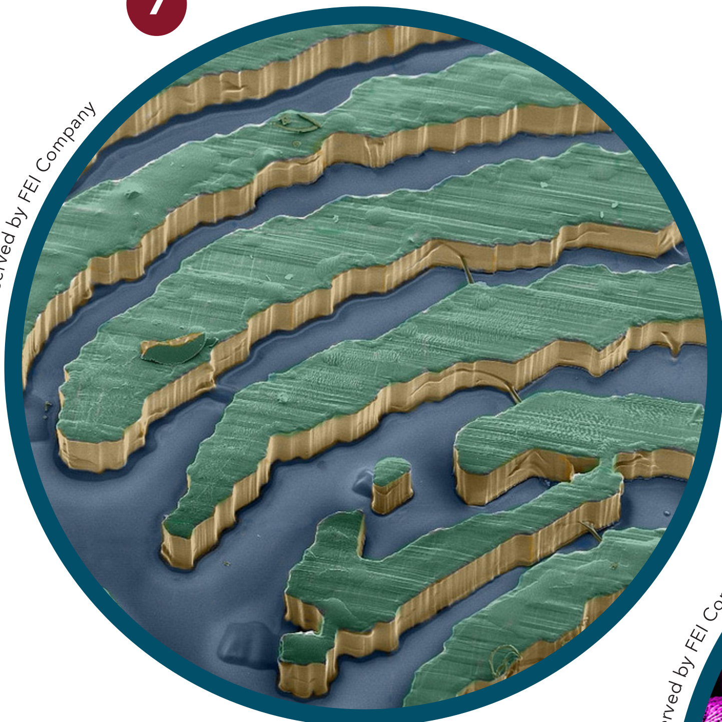



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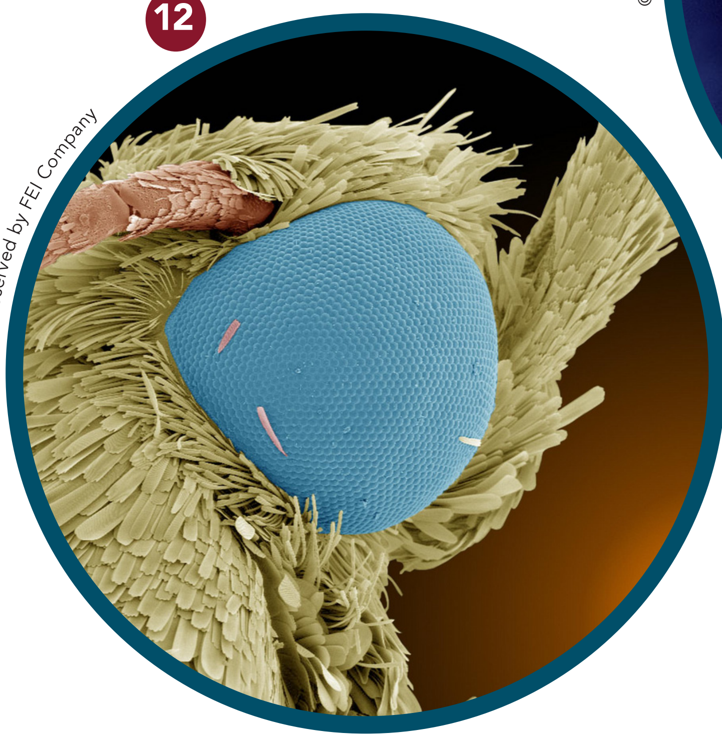



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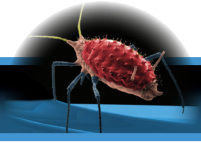

## Scavenger Hunt

Your challenge: Find the image that matches each clue. See how many you can guess correctly in five minutes.

1. You probably brushed yours this morning. ______________________
2. These can make you sneeze in the spring. ______________________
3. This feeds on your old skin. ______________________
4. It is a tree's armor. ______________________
5. It's part of the write stuff. ______________________
6. This can be used to identify people because no two are alike. ______________________
7. They run through your veins. ______________________
8. Your dentist may ask how often you use this. ______________________
9. This could be called a butterfly of the night. ______________________
10. This is a member of one of the largest orders of insects. ______________________
11. No one eats bread with this on it! ______________________
12. This protects the thing Little Miss Muffet fears. ______________________



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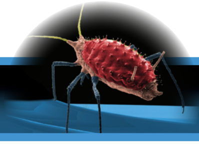

## Scavenger Hunt Answer Key

Your challenge: Find the image that matches each clue. See how many you can guess correctly in five minutes.

1. You probably brushed yours this morning. *2 – Human Hair*
2. These can make you sneeze in the spring. *8 – Pollens on a Leaf*
3. This feeds on your old skin. *5 – Dust Mite*
4. It is a tree's armor. *6 – Tree Bark*
5. It's part of the write stuff. *4 – Mechanical Pencil Lead*
6. This can be used to identify people because no two are alike. *7 – Fingerprint*
7. They run through your veins. *1 – Blood Cells*
8. Your dentist may ask how often you use this. *10 – Dental Floss*
9. This could be called a butterfly of the night. *12 – Head of a Moth*
10. This is a member of one of the largest orders of insects. *11 - Myrmecophilous Beetle Head*
11. No one eats bread with this on it! *3 - Bread Mold*
12. This protects the thing Little Miss Muffet fears. *9 – Spider Skin*



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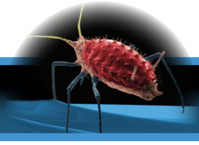

# Activity 3: Making Waves

**Grades: 3-5**
**Time: 45 minutes to 1 hour**

**Objective:** Students will understand parts of a wave.
**Next Generation Science Standards:** PE: 4-PS4-1; CC: Patterns; DCI: PS4.A; SEP: Developing and Using Models

## Materials:

- Rope at least 1.5 meters (5 feet) long for each pair of students. Jump ropes work well.
- Meter stick for each small groupPaper or notebook for each small group
- Pencils for each small group

**Preparation:** None

## Warm Up:

1. Bring about ten students to the front of the room and have them do a "stadium wave" by raising and then lowering their hands one by one.
2. Ask the other students to describe what they see. Encourage them to describe it in terms of what individuals are doing and what the group as a whole is doing. Ask students to name what they see. If necessary, remind them that they may have done this or seen others do it at a sporting event.
3. Explain that a wave carries energy through space or matter. Allow a few minutes for students to share what they know about waves. Ask:
   - *What are some things that we describe as traveling in waves?*
   - *How would you describe the movement of a wave?*
   - *What are some parts of a wave?*

## Explore:

1. Divide students into pairs and give each pair a rope. Each student should hold one end of the rope while one of them raises and lowers their end slowly and steadily to make transverse waves.
2. Have students experiment with the waves they are creating by moving their hand more quickly, slowing down the movement of their hand, making the waves go higher, faster, etc. Walk around the room encouraging students to vary their movements and observe what happens to the wave.
3. Bring students back together and ask them to describe what they observed as they made waves. Ask:
   - *What are some things that changed about the waves as you changed your movements?*
   - *How was the wave different when you made bigger hand motions? Smaller hand motions?*
   - *How was the wave different when you increased the speed of your hand motions from very slow to very fast?*
   - *In which cases do you think you applied more energy to the wave? Why?*
4. Bring two students to the front and have them create a wave as the other students observe. Ask them to keep the wave slow and constant. Point out the crest and trough of the wave. Explain that the crest is the highest point of the wave and the trough is the lowest point of the wave.
5. Use a meter stick to show that the wavelength is the distance from one crest to the next. Do not introduce an actual measurement at this point.



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6. Use the meter stick to show the amplitude of the wave. Explain that the amplitude is the height of the wave from trough to crest. Again, do not introduce an actual measurement at this point.

7. Combine two pairs of students to make small groups of four students. Within each group, have two students create a wave. Make sure they keep the wave slow and steady. The other two students in the group should identify the crest and trough of the wave and work together to measure and record the wavelength and amplitude of the wave. They should measure in more than one place to show that the wavelength and amplitude is the same throughout the wave.

8. Ask the students making waves to alter their movements to try to create a new wave with a longer wavelength but about the same amplitude. Have the other two students measure and record the wavelength and amplitude of the new wave.

9. Ask the students making waves to alter their movements to try to create a new wave with a shorter wavelength but about the same amplitude. Have the other two students measure and record the wavelength and amplitude of the new wave.

**Debrief:**

1. Discuss the activity with students. Ask:
   - *What started the disturbance in the rope that created the wave?* (The movement of students' hands)
   - *What happened to the energy from the movement of your hand?* (It was transferred along the wave to the hand of the student holding the other end.)
   - *You made waves with long wavelengths and short wavelengths. Which one required you to apply more energy with your hand?* (Short wavelengths)

2. As a group, brainstorm some ways students encounter waves in their life. Encourage students to name as many as they can. If necessary, prompt them to think about things that travel in waves and about unseen waves such as sound and light. Some examples of ways they encounter waves are seeing (light waves), hearing (sound waves), cooking (microwaves), listening to the radio (radio waves), getting a sunburn (ultraviolet waves), using a TV remote (infrared waves), or getting an x-ray (x-ray waves).

3. As an extension activity, provide students with various materials (paper, clay, string, wire, markers and pencils, etc.) and have them work in small groups to create a model of a wave and label the crest, trough, wavelength, and amplitude.



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Grades 6-8

## Activity 1: Zoom

**Grades: 6-8**
**Time: 5 to 10 minutes**

**Objective:** Students will understand that objects look different at different magnifications.
**Next Generation Science Standards:** CC: Scale, Proportion, and Quantity

### Materials:

- One copy of the Magnified Images - Electron Microscope handout, laminated if possible
- Prepared microscope slides of mechanical pencil lead, tree bark, and a fingerprint
- Sample of mechanical pencil lead, tree bark, and a fingerprint
- Three small boxes, large enough to cover the sample items

### Preparation:

- Organize the items into three sets, each containing an electron microscope image, microscope with slide set at highest magnification, and sample of the same object.
- Arrange these sets on a cart in order from most magnified view to least magnified view.
- Turn the electron microscope images face down and use a box to cover up the samples.

### Activity:

1, Show students the electron microscope image from a set and explain that it is a highly magnified image of something common. Explain that there are three more views of the same object, each with increasingly less magnification, so that each gets closer to actual size.

2. Challenge students to correctly name the object in as few views as possible. Ask them to predict how many views it will take for them to get it right before they begin.

3. Have students take a guess about what the object is based on the electron microscope image. If they are incorrect, have them look through the microscope at the slide of the same object on the highest possible magnification.

4. If students still haven't guessed the item correctly, have them adjust the microscope to the lowest possible magnification and look again. If they are still unable to correctly identify the object, have them lift the box to see the sample of the object. Allow students three educated guesses per view.

5. When students get to the sample of the actual object, discuss what they saw. Ask:
   - *Each time you looked at the object, you saw it at a different magnification. What does that mean?* (Magnification allows you to look at an object more closely than you could see it with your eye alone.)
   - *Which view in the set was at the highest magnification? (The first) Which was at the lowest magnification?* (The last)

6. Explain that the first image was taken with an electron microscope and that the piece of the object in that image is so small it is measured in nanometers (nm). There are one million nanometers in a millimeter. Have students find a 1 millimeter (mm) length on the ruler and imagine that length divided up into a million smaller lengths. The object in the electron microscope image is actually so small they couldn't see it just using their eyes, but it looks bigger to them because it is magnified.



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## Magnified Images – Electron Microscope

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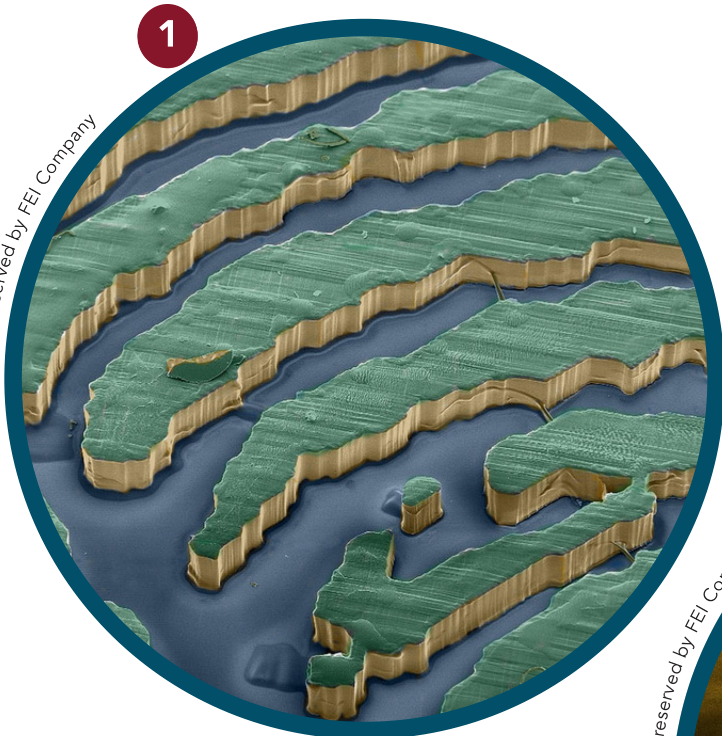

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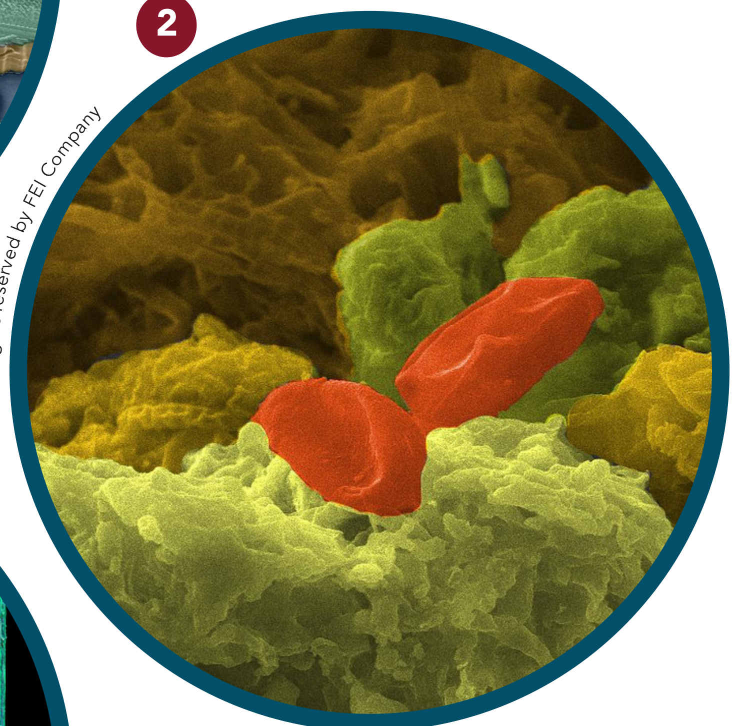

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## Activity 2: Faster, Slower

**Grades: 6-8**
**Time: 10 to 15 minutes**

**Objective:** Students will understand that technology can enable more detailed observations.
**Next Generation Science Standards:** SEP: Asking Questions and Defining Problems; CC: Influence of Science, Engineering, and Technology on Society and the Natural World

### Materials:

- Three or four devices, such as iPhones, iPads, iPods, or tablets, that can take video (Alternatively, one such device per small group)

### Preparation:

- Download an app to the video device that will allow videos to be sped up or slowed down. A number of free apps are available, including Givit (https://itunes.apple.com/us/app/givit-video-editor/id560803488?mt=8).
- Familiarize yourself with how to use the app on your device to speed up and slow down video.
- Make the video devices available on a cart. Alternatively, to use as a large group activity, provide one device for each small group.

### Activity:

1. Have one student record video of another student running in slow motion.
2. Demonstrate how to use the app to speed up the video so students can see the slow-motion run in "real" time. Discuss whether or not the student actually looks like he or she is running. Ask students to record specific observations and note what seems wrong with the movement. Observations might include the position of arms, legs, head, and hands, the length of the stride, etc.
3. Have the running student run a short distance in real time as the other students observe. Ask students to describe and record the running student's movement in as much detail as possible. Encourage them to notice details like the position of arms, legs, head, and hands, noting how these change in relation to each other as the student runs. The running student should run back and forth a few times, allowing the other students an opportunity to make detailed observations.
4. Have students watch the sped-up video of the student running in slow motion again. Again, have them make specific notes about what is wrong with the movement.
5. Ask one student to record video of the running student running in real time. This time, students should use the app to slow down the video. Ask students to describe the running student's movements in as much detail as possible.
6. Give students a few minutes to look over their notes and observations and give the running student specific instructions about what to change in his or her slow-motion run to make it look more realistic. Allow the running student time to practice, with other students' input.
7. Have a student make another recording of the running student running in slow motion. Once again, have students use the app to speed up the video.
8. Discuss the new video. Ask:
   - *Does this run look more realistic? Why or why not?*


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- *You made observations about the student running in real time and about using technology to slow down the motion. How were these different? In which case was it easier to make observations? Why?*
- *How did your observations change when you used technology? Why do you think they changed?*
- *Discuss practical uses for this type of digital technology. How could this technology be used by people in day-to-day life? Can you think of applications for use by scientists? Doctors? Athletes? Artists?*

## Activity 3: Playing with Light

**Grades: 6-8**
**Time: 45 minutes to 1 hour**

**Objective:** Students will understand that colors in visible light are caused by different wavelengths and that light is refracted, reflected, transmitted, or absorbed by different materials.
**Next Generation Science Standards:** PE: MS-PS4-2; DCI: PS4.B. CC: Patterns; SEP: Developing and Using Models

### Materials:

- Jump rope or piece of rope at least 1.5 meters (5 feet) long
- Rope at least 6 meters (20 feet) long
- String at least 0.5 meters (about 2 feet) long for each small group
- Ruler for each small group
- Flashlight for each small group
- Rubber bands or tape
- Red, blue, and green lighting gels or plastic wrap (enough to fit over all the flashlights)
- Diffraction grating
- Slide projector or overhead projector
- Diagram of the electromagnetic spectrum, printed or projected

### Preparation:

- Use rubber bands or tape to secure lighting gel or plastic wrap over the light end of several flashlights. Use only one color for each flashlight and prepare enough flashlights for each small group of students to have one. If using plastic wrap, use several layers so the color is strong.
- Place the diffraction grating in a slide projector or overhead projector to create a rainbow in the room. If you are using an overhead projector, use books or other objects to block all but the small area beneath the diffraction grating.

### Warm Up:

1. Recruit a student volunteer to create a wave in a length of rope by moving one end up and down while another student holds the other end. Briefly review the crest, trough, wavelength, and frequency of the wave.

2. Show students a diagram of the electromagnetic spectrum. Explain that this spectrum shows the range of electromagnetic radiation, from radio waves to gamma waves. Ask:

   - *What is a major difference you notice about the waves across the spectrum?* (The wavelength and/or frequency)
   - *Which end of the spectrum would you predict has more energy?* (Gamma rays; the shorter the wavelength the more energy)



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3. Explain that radio waves have the longest wavelengths in the spectrum and the least energy. Have student volunteers demonstrate a range of wavelengths in radio waves by using a long rope to create a wave with a wavelength spanning the room and a wave with wavelengths about the size of a football. Point out that radio waves can actually have wavelengths as long as a football field.

4. Pass out lengths of string and rulers to students and have them work together to use the string to demonstrate a range of wavelengths in a microwave. These wavelengths range from a few centimeters up to about 0.3 meters (1 foot). Ask:

   - *Why can't we demonstrate the wavelengths of visible light, infrared light, gamma waves, or any other part of the spectrum? (These wavelengths are too small to see with our eyes.)*

5. Point out a colorful object in the room and ask students if they know what wavelengths or frequency have to do with how we see that color. Allow students to share their ideas and explain that we see different wavelengths of visible light as different colors.

**Explore:**

1. Turn on an overhead or slide projector and ask students what color the light from the projector is. Explain that white light, like that in a slide projector, is actually the colors of the visible light spectrum combined. Ask students to predict what will happen if you refract or bend that light so it separates out into different wavelengths. If they readily say you will see the colors of the rainbow, press them for more detail, like in what order the colors will appear.

2. Place a diffraction grating over the projector to create a rainbow in the room. Adjust the lights in the room so the rainbow is easily visible.

3. Ask students to observe the colors they see in the rainbow. Introduce them to the mnemonic "Roy G. Biv" to order the colors (red, orange, yellow, green, blue, indigo, violet), and explain that though these are the colors we most easily see, the rainbow is actually a continuum of colors in the visible light spectrum. Ask:

   - *Which colors do you think have longer wavelengths?* (Red) *Which have shorter wavelengths?* (Violet)
   - *Could you put these colors in order by their wavelength?* (They would be in the same order as seen in the rainbow, with red as the longest wavelength and violet as the shortest.)
   - *Why are we able to see these colors distinctly with the diffraction grating?* (The diffraction grating refracts or bends the light by wavelength.)

4. Give students flashlights with red, green, and blue plastic wrap over them. Shine an uncovered flashlight and ask students why the light is white. (It is a combination of different wavelengths/colors of light.) Have students turn their flashlights on and observe the color of the light. Ask students to explain why the color they see is not white. (The filters on their flashlights absorb all the colors except the one they see. That color is the only one transmitted through the filter.)

5, Ask students to predict what will happen if they shine each of the colors onto the rainbow. Then have them shine their colored lights onto the rainbow one color at a time and observe what happens.

6. Ask students to predict what would happen if they shine their colored light on different objects in the room. Then have them shine their light around the room and make observations.

7. Ask students to predict what will happen if they shine different combinations of the colored lights on a white wall. Turn off the projector. Have students experiment with shining their lights on a white wall in different combinations and observing what happens.



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**Debrief:**

1. Discuss students' observation and how they compared to their predictions. Relate what they observed to the refraction, reflection, absorption, and transmission of light waves. Ask:

    - *What did you predict would happen when you shined your light on the rainbow? What actually happened?* (When the lights are shined on a similar color on the rainbow [i.e. red light on the red band] the color is visible. But when the lights are shined on a different color [i.e. red light on the green band] the color appears black. Note that there may be some variation because the plastic wrap is not a perfect filter. Colors may appear altered rather than black.)
    - *What did you predict would happen when you shined your colored light on different objects in the room? What actually happened?* (As with the rainbow, when the lights are shined on an object that is the same color as the light, the color is unchanged. When the light is shined on an object that is a different color, the object appears black [or the color is altered].)
    - *How can you explain what you observed when you shined your light on the rainbow and on objects in the room?* (When light strikes an object, certain wavelengths of light are absorbed, while others are reflected back to our eyes. We see the color of the wavelength that is reflected. The filter on the flashlight only transmits certain colors. If the color that it transmits is not the one reflected by the object, the object will appear black. If it is the one reflected by the object, the object will appear its normal color. If the filter lets through more than one color of light, as many do, the color of the object can appear altered.)
    - *What did you predict would happen when you shined different colors of light at the same spot on the wall? What actually happened?* (If lights of two different colors are shined on the same spot, they will form a new color. If lights of red, green, and blue are shined on the same spot, they will appear white.)
    - *How can you explain what happened? (*White light is a combination of different wavelengths of light, specifically those of red, green, and blue, which are the primary colors of light. Since each filtered flashlight lets through only one color, the light appears that color. But if you shine lights with all three of the colors, it will appear white because all three primary colors of light are combined.)
    - *What does it mean for light to be refracted? What is an example of this?* (When light is refracted, it is slowed down or bent. An example is when the white light of the projector is passed through the diffusion grating.)
    - *What does it mean for light to be absorbed? What is an example of this?* (When light is absorbed, it strikes an object and is not transmitted through the material or reflected from the material. An example is the filter on the flashlight, which absorbed some wavelengths of light.)
    - *What does it mean for light to be reflected? What is an example of this?* (When light is reflected, the waves strike an object and are returned. An example is shining a light on a red object. The wavelengths of light that we see as red are reflected off the object.)

2. Give each small group a scrap of colored paper. Ask students to draw a diagram showing why they see that paper as a certain color, even though the light that is hitting that paper is white.



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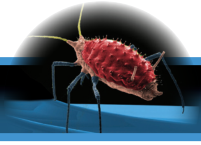

## Grades 4-6 Overnight Adventure Activities

## Activity 1: Too Slow

**Grades: 4-6**
**Time: 20 minutes, plus one minute every 15 minutes throughout evening**

**Objective:** Students will understand that technology can aid in observing processes too slow to be seen with the naked eye.
**Next Generation Science Standards:** CC: Influence of Science, Engineering, and Technology on Society and the Natural World

### Materials:

- 10 to 30 ice cubes per small group
- One container for each small group. Containers should have flat bottoms and be big enough to hold the water from the ice cubes when they melt. The lower the sides, the better, as students will need to observe and photograph the ice cubes as they melt.
- One digital camera per small group. If you do not have enough cameras for each group to have one, cameras can be shared among the groups.
- One meter stick per small group
- Paper and pencil for each small group
- One roll of masking tape

### Preparation:

- Just before beginning the activity, place the ice cubes in the containers.

### Activity:

1. Divide students into small groups and provide each group with ice cubes and a container. Invite each group to construct a sculpture out of their ice cubes inside the container.
2. Once a group's sculpture is complete, have them photograph it. They should take the photograph from as close to the sculpture as possible, using the masking tape to mark where they are standing. They should use a meter stick to measure and record the height at which they are holding the camera.
3. Give each group paper and pencil and have them draw a comic strip predicting how their sculpture will melt. Each pane of the comic strip should show the sculpture at a different point in time as it melts.
4. Throughout the evening, have each group return to their sculpture every 15 minutes and take a photograph. Be sure students stand in the same place and hold the camera at the same height each time. Students should continue to photograph their sculpture every 15 minutes until it melts. Students should also write down their observations each time they photograph the sculpture.
5. Once the sculptures have melted, print out the images for students or download them to a computer.
6. If you printed the images, have students compile them into a flip book. They can flip through the pages to "watch" the ice sculpture melt. If you downloaded the images to a computer, students can view them as a slide show with the speed set high or click through them quickly to watch the ice sculpture melt.
7. Have each group compare the photographic evidence of the ice sculpture melting to their predictions. Ask:
   - *How close was your prediction to what actually happened?*



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- *Which do you think is a more effective way to communicate how the ice melted – the photographic evidence or your written observations? Why?*
- *How can technology aid scientists in making observations?*

## Activity 2: Too Fast

**Grades: 4-6**
**Time: 30 minutes**

**Objective:** Students will understand that technology can aid in observing processes too fast to be seen with the naked eye.
**Next Generation Science Standards:** CC: Influence of Science, Engineering, and Technology on Society and the Natural World; SEP: Asking Questions and Defining Problems

### Materials:

- Slinky
- Small pitcher of water for each small group
- Beaker or other container for each small group
- Plate for each small group
- Eyedropper for each small group
- Paper towel for each small group
- Computer with Internet access
- Projector and screen for use with a computer

### Preparation:

- Set up a computer, projector, and screen to show videos from the Internet.
- Bookmark the following YouTube videos from the Slo Mo Guys:
    - How a Slinky Falls in Slow Motion: http://www.youtube.com/watch?v=rCw5JXD18y4 (actual slinky drop from 0:54 to 1:20)
    - Surface Tension Droplets at 2500 fps: http://www.youtube.com/watch?v=ynk4vJa-VaQ (actual water drop from 1:08 to 2:00)

### Activity:

1. Ask students to predict what will happen if you drop a slinky from waist level onto the ground. Challenge them to describe the motion of the slinky in as much detail as possible.

2. Drop a slinky and have students observe its motion. Have students describe in detail what they saw. Repeat as necessary until students have made all the observations they can.

3. Next, show students the video "How a Slinky Falls in Slow Motion." Again, have them describe in detail what they observed.

4. Discuss the differences and similarities in students' predictions, real-time observations, and slow-motion observations. Ask:

    - *Did your prediction match what you observed? Why or why not?*
    - *You observed the slinky falling in real time and in slow motion. In which were you able to see the most detail? Why?*
    - *How accurate were your observations of the slinky falling in real time when compared to your observations of the slow motion video? What were some examples of details you thought you saw that weren't exactly right?*


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5. Divide students into small groups and give each group a pitcher of water, paper towels, an eyedropper, and a small beaker or other container with a plate underneath.

6. Instruct students to slowly fill the small container until the water is just spilling over the top. Have students predict what will happen to a drop of water if they drop it onto the top of the water in the container.

7. Have students add a drop of water and observe what happens to the drop. Ask them to describe what they observe in detail. They can add drops as needed until they are satisfied with their observations.

8. Next, show students the video "Surface Tension Droplets at 2500 fps." Ask them to describe in detail what they observe.

9. Discuss the differences and similarities in students' predictions, real-time observations, and slow-motion observations using the same questions you used after watching the slinky video.

## Activity 3: Too Small

**Grades: 4-6**
**Time: 20 minutes**

**Objective:** Students will understand that technology can aid in observing processes too fast to be seen with the naked eye.
**Next Generation Science Standards:** DCI: PS1.A - Structure and Properties of Matter

### Materials:

- Two sets of the Too Small Cards
- Timer, stopwatch, or clock
- Ruler

### Preparation:

- Print two sets of the Too Small Cards, cut them out, and separate them into the two sets. If possible, laminate them for durability.
- Print two copies of the answer key.

### Activity:

1 Ask students how we measure objects we can see. Show them a ruler and point out one meter, then one centimeter. Ask them how a centimeter relates to a meter. (There are 100 centimeters in a meter.) Show them a millimeter and ask how it relates to a meter. (There are 1,000 millimeters in a meter.) Ask how a millimeter relates to a centimeter. (There are 10 millimeters in a centimeter.) Explain that objects on the nanoscale (those too small to be seen by the human eye) can also be measured. Though we can't actually see the measurements used, we can understand them by relating them to measurements we can see. Introduce the micrometer and the nanometer as measurements used for things that are too small for us to see. Show students the millimeter again and explain that there are 1,000 micrometers in a millimeter and 1,000 nanometers in a micrometer. Give students some examples of things measured in nanometers and micrometers. For example, a strand of hair is 100 micrometers wide and a buckyball, a spherical carbon molecule, is 4 nanometers wide.

2. Explain to students that they are going to play a game to challenge their concept of nanosize.

3. Arrange students into two teams, and assign one student as a host for each team. Place one set of statement cards and its corresponding set of number cards face down in front of each team. Supply the hosts with a list of correct answers.



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4. Explain to students that each statement card matches a number card. They will have two minutes to match as many statements and numbers correctly as they can. They can ask their host to check and tell them how many they have correct at any point during the two minutes, but the host cannot otherwise help. They can continue to make changes up until the two-minute point. The team that gets the most right the fastest wins.
5. Call out "go." Students can turn over the cards and start matching them. Call "stop" at two minutes or when one team has matched all the cards correctly.
6. After the game, discuss the cards with students. Ask:
   - *Was it challenging to think about such small sizes?*
   - *Would this game have been easier if all the items were things big enough to see?*
7. Note: This activity can be used as a station with about 10 students at a time.


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## Too Small Cards

| | |
|---|---|
| The number of buckyballs that could fit in the width of a human hair. | 1,000,000 |
| The number of strands of DNA that would fit down the length of a bacterium if they were laid side by side. | 2,500 |
| The number of buckyballs that would fit down the length of an ant. | 40 |
| The number of nanotubes that would fit across the diameter of a raindrop if they were laid side by side. | 1,000 |
| The number of bacteria that would fit across the width of a human hair if they were laid end to end. | 2,500,000 |



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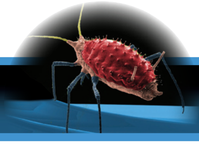

## Too Small Cards Answer Key

1. The number of buckyballs that could fit in the width of a human hair. 2,500
2. The number of strands of DNA that would fit down the length of a bacterium if they were laid side by side. 1,000
3. The number of buckyballs that would fit down the length of an ant. 100,000
4. The number of nanotubes that would fit across the diameter of a raindrop if they were laid side by side. 2,500,000
5. The number of bacteria that would fit across the width of a human hair if they were laid end to end. 40

## Activity 4: Invisible

**Grades: 4-6**
**Time: 1 hour to 90 minutes**

**Objective:** Students will understand that light is reflected, absorbed, or transmitted through an object depending on its color.
**Next Generation Science Standards:** DCI: PS4.B; CC: Patterns

### Materials:

- One flashlight per pair of students
- One prism per pair of students
- One rubber band or tape for each pair of students
- One square of lighting gel or 2-3 squares of colored plastic wrap in red, blue, and green for each pair of students
- Markers and paper for each small group of students
- Large image with various colors, including red, green, and blue
- Optional: red, green, and blue t-shirts or sports pinnies

### Preparation:

- Test shining a flashlight through the prism and shining a flashlight covered with lighting gel or colored plastic wrap around the room to see how dark the room will need to be for this activity.

### Activity:

1. Divide students into pairs and give each pair a flashlight and a prism. Turn the lights down in the room and have students shine the flashlight through the prism and observe what happens. Ask students to record the colors they see.
2. Explain that the white light from the flashlight is actually made up of many colors of light together. Explain that the prism refracts or bends light, separating out the different wavelengths or colors of light and allowing us to see them separately.
3. Give students different colors of lighting gel or plastic wrap (red, green, and blue) and have them explore covering their flashlight with different colors, shining it around the room, and observing what they see. Students should note that some colors look different, some even black, under different colors of lights.



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4. Have students work together to combine the light from different-colored flashlights and observe what happens.

5. Bring students back together to discuss what they observed. Ask:

   - *Why do we see a certain color when light strikes an object?* (The object absorbs the other wavelengths of visible light and reflects back the ones we see.)
   - *How do the filters change the white light of the flashlight into light of one color?* (Each colored filter transmits one color and absorbs the others.)
   - *What did you notice about the colors of objects when you shined your lights around the room?* (Students should have noticed that objects that are the same color as their light look the same, while others look black or have an altered color.)
   - *What happened when you shined different colors of light on the same spot?* (Two different colors shined on the same spot would result in a new color. All three shined on the same spot would appear white.)

6. Bring up an image with red, green, blue, and other colors in it. Have students observe what happens when you shine a red light on it, then a green light, then a blue light. Ask:

   - *What pattern did you notice in how the colors in the image changed when different lights were shined on them?* (Colors the same as the color of the light didn't change. Colors that were different from the color of light did.)
   - *Why did the color change when a different colored light was shined on it and stay the same when the same color of light was shined on it?* (When light strikes an object, certain wavelengths of light are absorbed, while others are reflected back to our eyes. We see the color of the wavelength that is reflected back to our eyes. The filter on the flashlight only transmits certain colors. If the color that it transmits is not the one reflected by the object, the object will appear black. If the color is the one reflected by the object, the object will appear its normal color. If the filter lets through more than one color of light, as many do, the color of the object can appear altered.)

7. Divide students into small groups and give each group pencils, markers, and paper. Challenge them to use what they have learned about how light is transmitted, reflected, and absorbed to create a drawing with elements that they can make appear or disappear using the colored lights. Give groups about 20 minutes to work on their drawings. Encourage them to experiment and test out their ideas with their colored lights.

8. When students have finished, hang their drawings around the room. Turn the lights down, and give students time to walk around and use their colored flashlights to make elements in the images appear and disappear. After five minutes, bring students back together to discuss what they saw and give them an opportunity to point out their favorite effects.

9. Extension: Divide students into three teams and have each team wear a different color of t-shirt or sports pinny (red, green, blue). Have students play flashlight freeze tag with their colored flashlights. Students are only frozen if another team lands a "black dot" on them and they are only unfrozen if their team lands a brighter spot the same color as their shirt..



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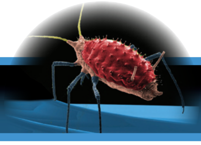


# Activity 5: Mosquito Maze

**Grades: 4-6**
**Time: 5 minutes per student**

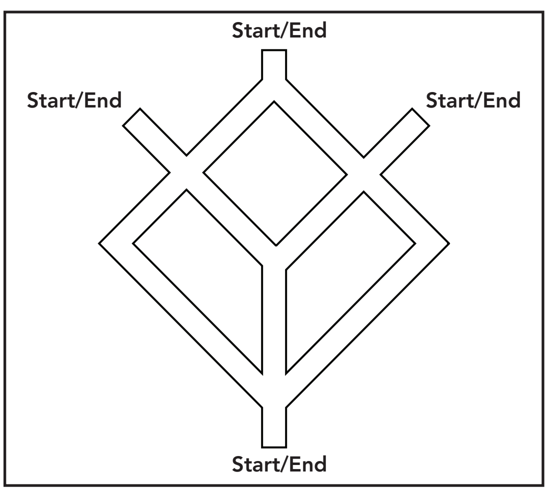
**Objective:** Students will understand how some animals, like mosquitoes, are guided by their sense of smell.
**Next Generation Science Standards:** DCI: PS1.A - Structure and Properties of Matter

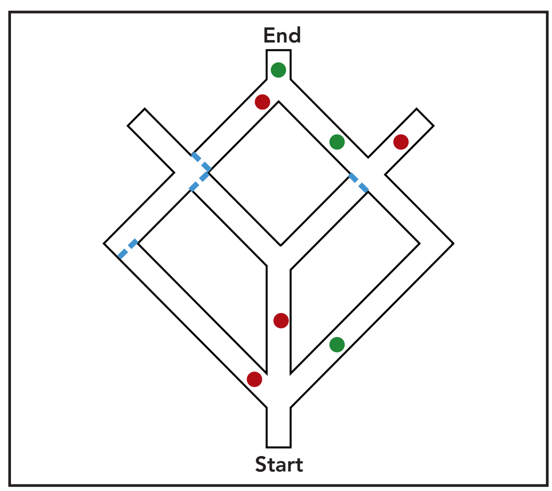
Materials:

- Brown masking tape
- Blue masking tape
- Blindfold
- 5 pungent items, such as:
  - lemon
  - onion
  - garlic
  - perfume
  - air freshener
  - various bottles of essential oil
  - vinegar

## Preparation:

- Use brown masking tape to mark out a maze on the floor, as shown below. Use blue masking tape to block off at least three or four of the forks in the maze. (See example.) The blue masking tape can be moved to different places between turns so students can watch each other without memorizing the maze. Students can also start or end in any of the four places marked below. An example is shown below, with green dots as the placement of students with the target smell, and red dots as the placement of students with distractor smells.




- If you are using pungent items that are normally sprayed, like air freshener and perfume, spray these onto a cloth or paper towel just before beginning the activity.
- If you are using pungent items that are normally in a bottle, such as vinegar, pour them onto a cloth or into a wide-mouth container.



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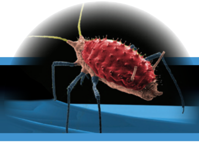

**Activity:**

1. Ask if students have ever been bitten by a mosquito. Explain that mosquitos use a variety of senses, including infrared vision and a sense of smell, to locate the blood in your veins. Explain that you are going to play a game where students will use only their sense of smell to travel through a maze.
2. Blindfold one student and assign that student a guide. Sit that student off to the side briefly while the maze is prepared.
3. Choose one "pungent" item to be the target smell and give that item to three students. Place each of these students about 0.3 meters (1 foot) from a fork in the correct direction to solve the maze.
4. Give four students other "pungent" items to be distractor smells. Place them about 0.3 meters (1 foot) away from each fork in the wrong direction to solve the maze. There should then be a choice between the target smell and one or two distractor smells at each fork in the maze.
5. Let the blindfolded student smell the target smell that will guide them correctly through the maze. Then place the blindfolded student and the guide at the start of the maze.
6. Have the guide hold the arm of the blindfolded student and guide him or her along the maze until they reach a fork. At each fork, the blindfolded student should choose a direction based on smell. The guide should then lead the blindfolded student in that direction along the maze until they reach another fork. If the student makes a wrong choice and gets to a dead end, the guide can turn them around and lead them back to the last fork.
7. Allow students to take turns going through the maze, being a guide, holding the target smell, and holding distractor smells.
8. Note: This activity can be used as a station with about 10 students at a time.

## Activity 6: Perspective

**Grades: 4-6**
**Time: 30 to 45 minutes**

**Objective:** Students will understand how tools aid scientists in making observations.
**Next Generation Science Standards:** CC: Influence of Science, Engineering, and Technology on Society and the Natural World

**Materials:**

- One Milky Way candy bar per group of students
- One paper plate per group of students
- One plastic knife per group of students
- Paper and pencil for each student
- Enough binoculars, telescopes, magnifying glasses, and microscopes so there is at least one tool available for every pair of students at the same time
- Prepared slides for the microscopes. Slides can be of anything, including human hair, paper, insect wings, sugar or salt crystals, yarn, newspaper, or a leaf.

**Preparation:**

- Prepare a place outside or in a planetarium for students to observe the Milky Way galaxy, if possible.




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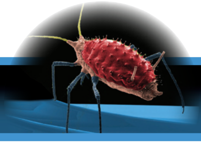

**Activity:**

1. Divide students into small groups and give each group a paper plate, plastic knife, and Milky Way bar. Give each student paper and a pencil. Ask students to examine the Milky Way bar and write down their observations. Invite them to cut open the bar to observe it more closely. Then have students draw what they think the Milky Way bar might look like if it were magnified to the nano level.
2. If possible, have the students go outside (or into a planetarium) and observe the Milky Way galaxy in the night sky. Ask students to draw what they think the Milky Way would look like if they could get close to it.
3. Discuss the concept of perspective with students. Objects look different when we view them from different perspectives. The Milky Way bar would look very different if we could see it magnified by an electron microscope, and if we saw it from far enough away, it might just look like a speck.
4. Show students a pair of binoculars, a telescope, a magnifying glass, and a microscope, and ask them to identify what these tools have in common. (They each magnify objects.)
5. Provide students with binoculars, telescopes, magnifying glasses, and microscopes and invite them to use the tools freely to make observations of objects that are close up and far away. Have them record their observations. Encourage students to use as many of the tools as possible.
6. After about 15 minutes of exploration, bring students back together in their small groups and have a few students share their observations. Ask:
   - *How did each of these tools change your perspective?*
   - *Which do you think changed your perspective the most? The least? Why?*
7. Ask students to work within their groups to sort the tools based on any criteria they choose. Ask a few groups to share how they sorted the tools. Then have each group put the tools in order in terms of their magnification of objects from the highest magnification to the lowest.
8. Challenge students to work with their groups to put together a series of related things that go from micro to macro, similar to the Milky Way exercise from the beginning of the activity.

## Activity 7: Careers

**Grades: 4-6**
**Time: 30 to 45 minutes**

**Objective:** Students will understand that there are a variety of STEM careers.
**Next Generation Science Standards:** CC: Science is a Human Endeavor

**Materials:**
- Paper, pencil, and other drawing supplies for each student
- Computer with Internet access
- Projector and screen for use with the computer



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**Preparation:**

- Set up a computer, projector, and screen to show videos from the Internet.
- Bookmark the following videos:
  - Brendan Mullan video
  - Engineering Design Takes Flight: http://education.nationalgeographic.com/preview/education/media/robert-ruszkowski/?ar_a=1
  - http://education.nationalgeographic.com/preview/education/media/kingsley-fregene/?ar_a=1

**Activity:**

1. Ask students if they have ever thought about what kind of career they would like to have when they are adults. Have them draw a picture showing what they think they will be doing in their career in twenty years. Invite a few volunteers to share their drawings. Then ask students to share ideas about ways people choose their careers.

2. Ask students to name something from *Mysteries of the Unseen World* that they found interesting. Write a few items of interest and have all students brainstorm some careers that could involve or relate to these items.

3. Show students the three videos, each of which highlights a STEM career.

4. After each video, discuss the following:

   - *How would you summarize this person's career?*
   - *How might this person's career relate to the unseen world as described in the film?*
   - *How was this person's work inspired by the natural world?*
   - *What skills do you think you would need to do the job this person does? Why?*
   - *What do you think is the most exciting or interesting thing about this person's career?*
   - *What made the person want to have this career?*

5. After watching all three videos, ask:

   - *Which of these careers was most appealing to you? Why?*
   - *How important do you think it is to have a career that is based on your interests? Why?*
   - *How important do you think it is to have a career based on something you are good at? Why?*

6. Have each student write a list of five or six things he or she is good at and/or interested in. Students can also ask each other to suggest things they are good at. Then have students get into small groups and brainstorm careers that might match each item on their list. Finally, have students revise their earlier drawing to show at least two more career possibilities for themselves. Again, invite students to share their drawings with the whole group.


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# Notes



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