WAVE WISDOM

TEACHER GUIDE

ACCELERATE

PLANNING

Here's a suggested schedule for this kit! The activities should be completed in order, but you can choose when the lessons take place over time.
Note: *The day before starting Activity 1 with the student, soak the water beads as explained at the beginning of Activity 1.*

ACTIVITY INFORMATION	SECTION (S)	TIME REQUIRED	DAY/ LESSON
ACTIVITY 1: WACKY WAVY WATER Can you trust your eyes about water and light? **Time required: 1 h**	☐ Bend the Truth	60 minutes	Day 1
ACTIVITY 2: LIGHT BEHAVIOR Find out what light is like and how it interacts with objects – like gummy candy! **Time required: 2 h**	☐ What Does Light Do?	60 minutes	Day 2
	☐ A Light Snack	60 minutes	Day 3
ACTIVITY 3: WAVE PROPERTIES Explore the secret colors hiding in plain sight and learn about the structure of a wave **Time required: 2 h**	☐ Fe[illegible]		

Full schedule available with purchase

activity 1

WACKY WAVY WATER

Can your student trust the information their eyes provide about how water and light interact? In these four experiments, your student will see the wild things that happen when light hits water.

BEND THE TRUTH

WARNING: Do not eat the water beads.
CHOKING HAZARD - Small parts. Not for children under 3 years.

☑ PREPARATION AND SUPERVISION Sneaky Spheres

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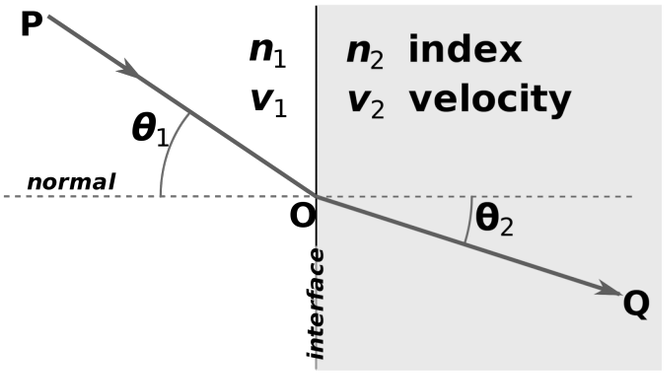
- This is the first of four experiments your student will do to explore the interaction between light and water.
- If possible, have your student do Steps 1–3 the night before starting the experiment so that the water beads have the maximum possible time to expand.
- When the beads are fully grown, they will have a smooth, round appearance. If they are not yet ready, they will have a bumpy, irregular surface.
- You can use more beads if you like, but the results will not necessarily be more impressive. Also, one of the optional extensions provides ideas for using the rest of the unused beads, so that may be a better use of them.
- Your student can do the other 3 experiments while waiting for the beads to expand. You could also do the other 3 experiments on one day and finish Sneaky Spheres and the Think About It questions on the following day.
- In terms of results, your student should observe that the water beads seem to disappear when in water.
- Don't share this with your student yet, but here's an explanation for you:

• Refraction is the bending of light when it changes what material it's going through.
• Refraction happens when light goes through air and then water.
• Each substance of material has a different index of refraction, or the way it interacts with light and how much the light bends when it goes through it.
• The water beads have a similar index of refraction to water, so light doesn't bend much when going from water into the beads and vice versa.



This diagram shows the refraction, or changing of speed and direction, of light at the interface (boundary) between two media (materials through which light travels). In this example, the speed of light is great in the medium on the left, so when the light reaches the medium on the right, it goes slower. The angle at which it leaves the interface is then less than the angle at which it approached. If the index of refraction were instead the same, then the velocity and the angle would be the same.

• The beads may be mostly water when they expand, but the beads themselves are made of sodium polyacrylate, a plastic and polymer that easily accepts water molecules into the spaces between its repeating subunits.
• Sodium polyacrylate is the same substance found in fake snow and baby diapers. It can absorb hundreds of times its own weight in water.

REFLECT

Question: For each of the experiments from Activity 1, write if you think reflection, transmittance, and absorption are happening, and explain why you think that. If light was being transmitted, write about what kind of refraction was happening. Use words and diagrams in your explanations.

1. Water beads "disappearing"

Answer:

• Absorption was happening minimally if at all.
• Reflection was happening a little on the surface of the water.
• The light was transmitting through the air, then the cup, then the water, then the water beads, then the water, then the cup, then the air to the observer's eyes.
• Refraction was happening minimally between each boundary (as far as could be observed).

How to Help:

• Have the student point to evidence of these processes.
• Ask them what they should see if light reflects (some sort of mirror image), transmits (light going through to the other side), absorption (light heating up the objects), and refraction (when transmitted, the light changes direction or angle).
• The water beads seemed to disappear in the water because the index of refraction of the water and water beads is so similar (see details in Activity 1).

2. Straw appearing broken

Answer:

• Absorption was happening minimally if at all.
• Reflection was happening a little on the surface of the water.
• Light was being transmitted through the water and cup, but not through the straw.
• Refraction between the air and water made the light change direction when going into the water, and the change in angle made the straw look like it was in a different place.

3. Writing looking reversed

Answer:

• Absorption was happening minimally if at all.
• Reflection was happening a little on the surface of the water.
• Light was being transmitted through the water and cup.
• Refraction was happening between the water, cup, and air outside the cup, causing the angle of light to change and make the rays of light meet in a way that made the writing look backwards.

4. Metal washer appearing in the water

Answer:

• Absorption was happening minimally if at all.
• Reflection was happening a little on the surface of the water and a lot more on the washer.
• Light was being transmitted the water and cup, but not through the washer.
• Refraction between the water and air made it seem that the washer was in a different place than it was.

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Wavelengths and Colors

- This part details the connection between wavelength and color for visible light.
- You may want to go back to the diffraction grating experiments and have your student see if they can match up the color with the wavelength around the diffraction grating.

THINK ABOUT IT!

Question 1: What wavelength range would be emitted by an orange light bulb? Explain.
Answer: The orange wavelength range is about 590 to 620 nm, and it might also include some red just above 620 or some yellow just under 590.
How to Help: *Point your student to the color wavelength diagram or the diffraction grating labels.*

Question 2: What wavelength range would be emitted by a white light bulb? Explain.
Answer: This should include all visible light, so about 380 to 750 nm.
How to Help: *White light includes all colors' wavelengths.*

Question 3: A toy ball is blue. What wavelengths of light is the ball absorbing and reflecting? Explain.
Answer: The ball is reflecting blue and absorbing the rest of the colors, so it is reflecting about 450 to 495 nm and it is absorbing 380 to 450 nm as well as 495 to 750 nm.

Question 4: Do you think the results of the experiments in Activity 1 would have been different if the water was colored? Explain.
Answer: The index of refraction would probably have been similar, so the results would not have been very different unless there was so much color that the objects could not be seen in the water at all.
How to Help: *Your student can try this modified version of the experiment if they want to.*

Question 5: Do you think diffraction was occurring in those experiments? Explain.
Answer: Diffraction was occurring somewhat; there were some minor separating qualities at the water's surface. But it did not contribute very much to the observed effects.

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PREPARATION AND SUPERVISION Wave Action

- In this part, your student will explore a string model of wave action and wave properties.
- They should come to realize (based on observation) that when frequency increases, wavelength decreases, and when frequency decreases, wavelength increases.
- In addition, more energy put in should result in a higher frequency, and more vertical movement should result in a greater amplitude.

MULTIPLE AGES AND ABILITIES:

To engage two students at once, instead of tying the string to an object, have each student hold one end and take turns moving the string. They can also challenge each other to meet certain requirements, such as controlling the wavelength or frequency.

ACCELERATE

SCIENCE UNLOCKED

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Kit	SU-WAVWIS
Instructions	IN-WAVWIST
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