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Section 2. Life, Earth, and Space Science Probes

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Section 1
Physical Science Probes

Concept Matrix for Probes #1–#15

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GRADE LEVEL USE →	**3–12**	**3–12**	**3–8**	**3–8**	**3–12**	**3–12**	**K–5**	**6–12**	**3–8**	**3–12**	**6–12**	**6–12**	**3–12**	**3–12**	**6–12**
RELATED CONCEPTS ↓															
Atoms											X				
Change in state					X				X						
Chemical change								X				X			
Closed system					X			X							
Color		X													
Conservation of matter					X	X	X	X							
Corrosion												X			
Dissolving						X			X						
Energy														X	X
Energy transfer														X	
Gravity													X		
Heat									X					X	
Insulator														X	
Light	X	X	X												
Light source			X												
Light transmission			X												
Mass					X	X		X				X			
Matter					X	X				X	X				
Melting									X						
Molecules											X				
Open system												X			
Oxidation												X			
Physical change					X	X	X		X						
Reflection	X	X													
Rusting												X			
Sound				X											
Temperature														X	X
Thermal energy														X	X
Thermal equilibrium															X
Vibration				X											
Vision	X	X	X												
Waves				X											
Weight						X	X								

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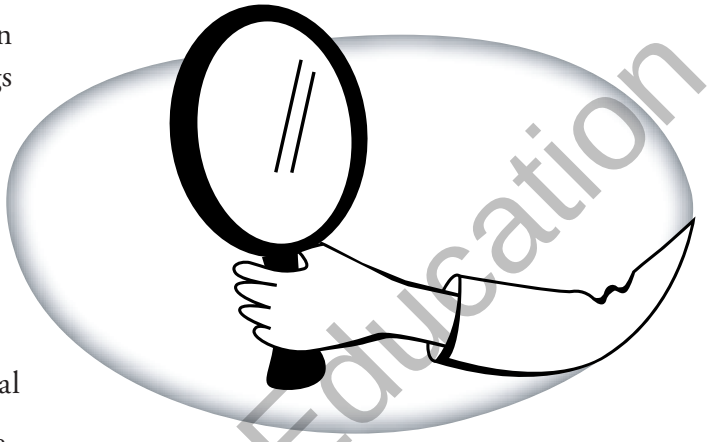
Can It Reflect Light?



What types of objects or materials can reflect light? Put an X next to the things you think can reflect light.

___ water
___ gray rock
___ leaf
___ mirror
___ glass
___ sand
___ potato skin
___ wax paper
___ tomato soup
___ crumpled paper
___ shiny metal
___ dull metal
___ red apple
___ rough cardboard
___ the Moon
___ rusty nail
___ clouds
___ soil
___ wood
___ milk
___ bark on a tree
___ brand new penny
___ old tarnished penny
___ smooth sheet of aluminum foil

Explain your thinking. Describe the "rule" or the reasoning you used to decide if something can reflect light.

_____
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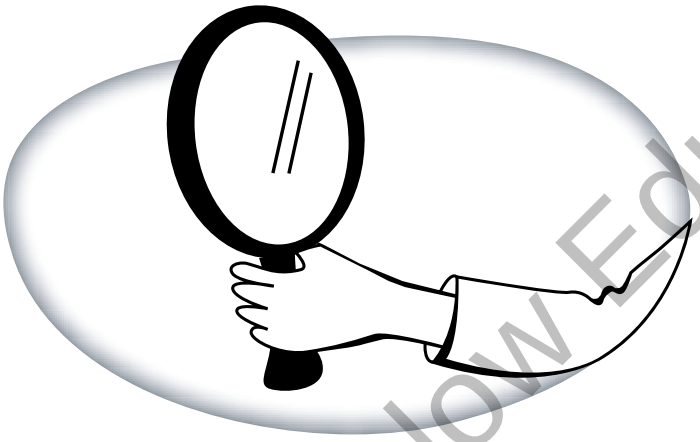
Can It Reflect Light?

Teacher Notes



Purpose
The purpose of this assessment probe is to elicit students' ideas about reflection. The probe is designed to find out if students recognize that all objects we can see reflect some light.

Type of Probe
Justified list

Related Concepts
Light, reflection, vision

Explanation
Assuming all of the objects on the list are visible to the observer, the best answer is all of the objects and materials on the list can reflect light. Since we can see each of these objects and materials, we know they reflect light. An object or material can be seen when light is reflected from the object or material and enters our eye. If light were not reflected from an object or material, we would not be able to see it. Most materials will absorb some wavelengths of light and reflect the rest. This explains why we see different colors. When we see white, all colors have been reflected. Black is the absence of light. Black objects in which you can actually see the features of the object do not absorb all light—some reflection of light at the surface allows you to see the features of an object that appears to be black. Materials reflect light differently. For example, light from a mirror or smooth object reflects at a definite angle while light from a rough object is reflected more diffusely and scatters the rays. This scattering makes some objects appear dull.

Curricular and Instructional Considerations

Elementary Students
In the early elementary grades, students learn that objects can be seen only when light is available to illuminate them. They engage in instructional opportunities to observe properties

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of materials they can see such as color and shape. They observe properties of materials including how light passes through some materials, is blocked by some materials, and bounces (reflects) off other materials. By the end of grade 5 their ideas about light expand to include the role of light in explaining how we see objects. Students become familiar with terminology such as reflection, and draw models to show how an object can be seen when light reflects off the object and enters the eye.

Middle School Students

By the end of middle school, students expand their knowledge of how light travels to include reflection, refraction, and absorption. They trace the path of light as it interacts with different materials and objects including mirrors and lenses. They learn about frequency and wavelengths of light and can use these ideas to explain how we see white or color.

High School Students

Students develop more sophisticated ideas about light and optics in high school. They use both a wave and a particle model of light to explain features of electromagnetic radiation. They connect ideas about heat and temperature to electromagnetic radiation. Even though students at this level learn more advanced ideas about the electromagnetic spectrum and the behavior of visible light, they still hold on to intuitive preconceptions about light reflection.

Administering the Probe

This probe can be used with students in grades 3–12 who are learning about light and reflection. Before using the probe, make sure students are familiar with each object on the list. Cross out any unfamiliar objects. Some students may ask for clarity on the objects listed. For example, they might want to know if they are certain colors. Color does not matter for this probe but you may choose to designate colors if you wish. This probe can be used with the card sort or claim cards strategy. Picture cards for English language learners or emerging readers are available for this probe on the *Uncovering Student Ideas* website at *www.uncoveringstudentideas.org* under "Resources." You can also display some of the actual objects for students to look at as they respond to the probe or set them up as stations where students decide whether each object can or cannot reflect light.

Related Disciplinary Core Ideas From the *Framework* (NRC 2012)

K–2 PS4.B: Electromagnetic Radiation

- Objects can be seen if light is available to illuminate them or if they give off their own light.

3–5 PS4.B: Electromagnetic Radiation

- An object can be seen when light reflected from its surface enters the eyes.

6–8 PS4.B: Electromagnetic Radiation

- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.

Related *NGSS* Performance Expectation (NGSS Lead States 2013)

Grade 4: Structure, Function, and Information Processing

- 4-PS4-2. Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen.

Related Research

- Most studies on children's conception of light reflection were conducted in the 1980s and early 1990s, yet are still relevant today. Guesne (1985) and Ramadas and

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Driver (1989) revealed that middle school students will accept the idea that mirrors reflect light but may not accept the idea that ordinary objects reflect light (AAAS 2009).

- Students' ideas about light reflection may be limited by the context in which they learned about the reflection of light. If their experiences have been mostly with mirrors, then students are apt to think that only things that are smooth or shiny like a mirror can reflect light (Driver et al. 1994).
- A study by Anderson and Smith (1983) revealed that students could describe light as bouncing off mirrors but not off other objects. A few students even lacked a conception of light bouncing or reflecting off any objects. The researchers also found that 61% of the children they questioned thought color to be a property of an object without realizing that it results from light being reflected from the object.
- Piaget's classic studies (1974) included young children's ideas about light. He found that very young children often made no connection between an object and the eye.
- Featherstonhaugh and Treagust (1990) found that many children assume we see not by light being reflected to our eye, but rather by looking, as if a visual ray emanated from the eye.
- Shapiro (1989) describes an interview in which a student describes light as being necessary to see a building because it illuminates it. However, the student did not connect the idea that light traveled from the building to the eye.
- When drawing light rays to show how light travels to the eye, some students think the light ray is actually a material part of the light rather than a way to represent the light's path (Galili and Hazan 2000).

Related NSTA Resources

NSTA Journal Articles

Keeley, P. 2012. Formative assessment probes: Seeing the light. *Science and Children* 49 (6): 28–31.

Matkins, J. and J. McDonnough. 2004. Circus of light. *Science and Children* 41 (5): 50–54.

NSTA Press Books

Fortus, D., and J. Krajcik. 2017. Core idea PS4: Waves and their applications in technologies for information transfer. In *Disciplinary core ideas: Reshaping teaching and learning,* ed. R. Duncan, J. Krajcik, and A. Rivet, 75–94. Arlington, VA: NSTA Press.

Keeley, P. 2014. Seeing the light. In *What are they thinking: Promoting elementary learning through formative assessment,* 105–112. Arlington, VA: NSTA Press.

Konicek, R., and P. Keeley. 2015. A sample lesson framework for uncovering and addressing students' ideas. In *Teaching for conceptual understanding in science,* 205–210. Arlington, VA: NSTA Press.

National Science Teachers Association. 2015. *Nature of light: Enhanced e-book.* Arlington, VA: NSTA Press.

Robertson, W. 2003. *Light: Stop faking it! Finally understanding science so you can teach it.* Arlington, VA: NSTA Press.

NSTA Learning Center Resources

NSTA Science Object

Nature of Light: Characteristics of Light
www.nsta.org/store/product_detail.aspx?id=10.2505/7/SCB-NOL.1.1

NSTA Webinar

NGSS Core Ideas: Waves and Their Applications in Technologies for Information Transfer
http://learningcenter.nsta.org/products/symposia_seminars/NGSS/webseminar30.aspx

Concept Matrix for Probes #16–#25

PROBES	#16 Is It an Animal?	#17 Is It Living?	#18 Is It Made of Cells?	#19 Human Body Basics	#20 Functions of Living Things	#21 Wet Jeans	#22 Beach Sand	#23 Mountain Age	#24 Gazing at the Moon	#25 Going Through a Phase
GRADE LEVEL USE →	**K–12**	**K–12**	**6–12**	**6–12**	**6–12**	**3–12**	**5–12**	**5–12**	**6–12**	**5–12**
RELATED CONCEPTS ↓										
Animal	X									
Beach							X			
Biomolecules			X							
Cells			X	X						
Characteristics of life		X								
Classification	X									
Deposition							X			
Earth-Sun-Moon System									X	X
Erosion							X	X		
Evaporation						X				
Function				X						
Human body				X						
Levels of organization				X						
Life processes		X			X					
Living		X								
Moon phases									X	X
Mountain formation								X		
Nonliving		X								
Once living		X								
Organs				X						
Organ systems				X						
Structure				X						
Tissues				X						
Uplift								X		
Water cycle						X				
Water vapor						X				
Weathering							X	X		

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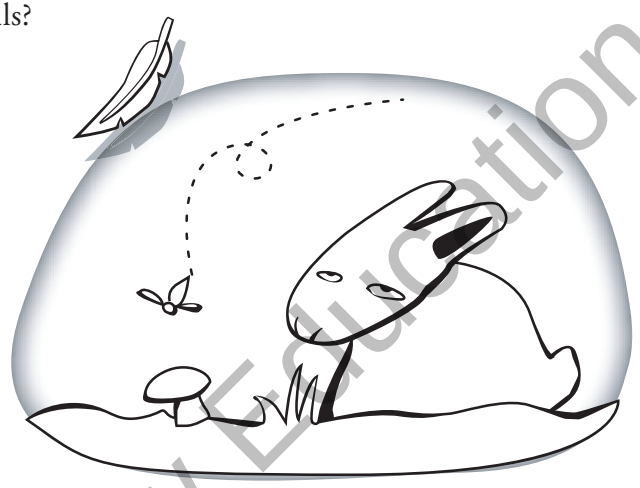
Is It an Animal?

Which of the organisms listed are animals? Put an X next to each organism that is considered to be an animal.



___ cow	___ spider	
___ tree	___ snail	
___ mushroom	___ flower	
___ human	___ monkey	
___ worm	___ beetle	
___ tiger	___ whale	
___ shark	___ frog	___ butterfly
___ starfish	___ chicken	___ snake

Explain your thinking. Describe the "rule" or reasoning you used to decide if something is an animal.

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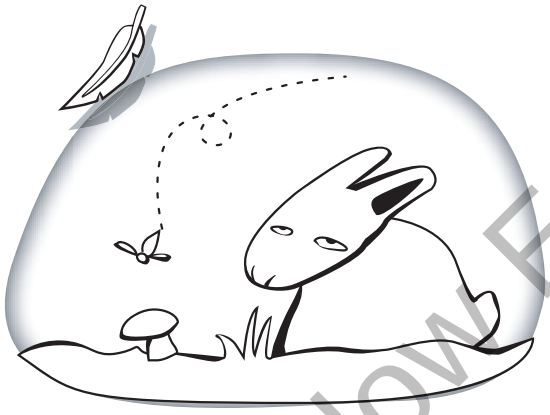
Is It an Animal?

Teacher Notes



Purpose
The purpose of this assessment probe is to elicit students' ideas about animals. The probe is designed to find out what characteristics students use to determine whether an organism is classified as an animal.

Type of Probe
Justified list

Related Concepts
Animal, classification

Explanation
The best response is cow, human, worm, tiger, shark, starfish, spider, snail, monkey, beetle, whale, frog, chicken, butterfly, and snake. The tree and flower are classified as plants, and the mushroom is classified as a fungus. Biological classification places more emphasis on cellular details (including molecular details), anatomical details (internal and external structures), and embryology than on general appearance or behavior. Animals have body plans and internal structures that enable them to obtain their food from an external source, making them consumers (or heterotrophs). All animals are consumers; however, not all consumers are animals (e.g., amoeba). Animals are multicellular and their cells do not contain cell walls. Their embryonic development starts with a diploid zygote (product of the union of egg and sperm), and a defining characteristic of all animals that differentiates them from other heterotrophs is that they develop from a blastula (this is a complex idea that isn't developed until later in high school or college). The animal kingdom contains a vast variety of life forms, including diverse examples from phyla such as sponges, coelenterates (e.g., jellyfish), mollusks (e.g., snails and clams), worms, arthropods (e.g., insects and spiders), echinoderms (e.g., starfish and sea urchins), and vertebrates (including the classes of fish, amphibians, reptiles, birds, and mammals).