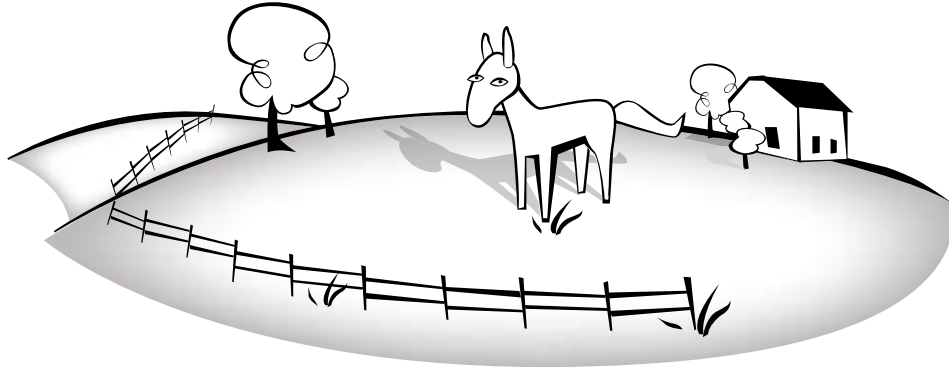


Respiration



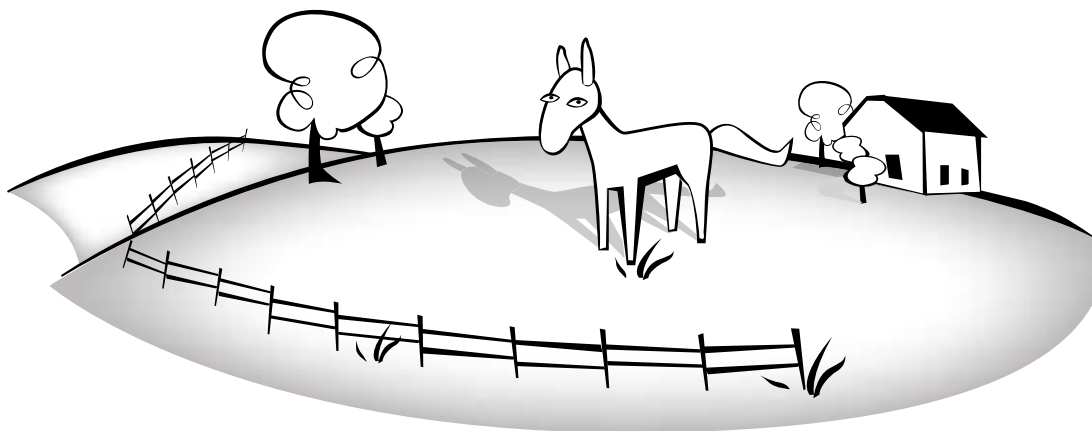
Put an X next to the organisms on the list that use the process of respiration.

- | | | |
|--|--|--|
| <input type="checkbox"/> human | <input type="checkbox"/> grass | <input type="checkbox"/> duck |
| <input type="checkbox"/> frog eggs | <input type="checkbox"/> mushroom | <input type="checkbox"/> tomato plant |
| <input type="checkbox"/> fish | <input type="checkbox"/> chick inside an egg | <input type="checkbox"/> human body cell |
| <input type="checkbox"/> germinating seed | <input type="checkbox"/> horse | <input type="checkbox"/> apple tree |
| <input type="checkbox"/> worm | <input type="checkbox"/> single-celled pond organism | <input type="checkbox"/> honeybee |
| <input type="checkbox"/> bacteria | | |
| <input type="checkbox"/> butterfly larvae inside a chrysalis | | |

Explain your thinking. How did you decide whether an organism uses the process of respiration?

Respiration

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about respiration. The probe is designed to find out whether students recognize respiration as a process that all living things use in order to obtain energy or whether they have a restricted macroscopic meaning of respiration.

Related Concepts

cellular respiration, respiratory system

Explanation

Everything on the list uses the process of respiration. Respiration is an essential life process carried out by all living organisms—from single-celled to multicelled—to provide the energy that organisms need to function. Aerobic respiration happens at two levels. At

the organism level, it generally involves taking in the air that contains the oxygen needed by cells and eliminating carbon dioxide from the body. At the cellular level, the oxygen is used to break down molecules of food in order to release the energy needed by cells to function. Carbon dioxide is released by the cell as a waste product.

Most people, including students, commonly understand that animals with some form of a respiratory system breathe in oxygen from the air through their respiratory systems and breathe out carbon dioxide. They usually equate the gas exchange during aerobic respiration with breathing rather than a cellular process. All animals respire, but they are not the only organisms to do so. Because every living organism is composed of at least one cell, and all cells need energy to function, then every

organism must carry out some form of cellular respiration regardless of whether it has a respiratory system that includes organs such as lungs or gills.

While different types of organisms may perform respiration in different ways, all organisms use respiration to release energy through the breakdown of molecules within a cell. Aerobic respiration involves an interchange of gases between an organism and its environment. Sometimes this interchange involves multi-celled structures (e.g., organs) in an organism that take in oxygen and make it available to the cells. For example, plants take in oxygen through their leaves and animals take in oxygen through their lungs or gills where it is sent to and used within their cells to break down sugars (food) to release energy. Single-celled organisms can absorb oxygen into a cell directly from the environment. Respiration can also occur in the absence of oxygen. This type of anaerobic respiration occurs with some types of bacteria and fungi as well as in the muscle cells of animals when there is a lack of oxygen.

Organisms in an immature stage of development, such as the butterfly larvae in a chrysalis, frog eggs, and a chick developing inside an egg, also respire by taking oxygen, making it available to their cells, and releasing energy from food molecules. They are all living things that need energy to develop. Under the right conditions of temperature and moisture, seeds respire by taking in oxygen, although they can be dormant for long periods of time before germination. Plants utilize oxygen in the process of respiration. They also take in carbon

dioxide and release oxygen in the process of photosynthesis. However, these two processes are not opposites nor are they mutually exclusive. Respiration in plants also happens during photosynthesis.

Curricular and Instructional Considerations

Elementary Students

At the elementary school level, students distinguish between living and nonliving things and learn that most living things need air. Respiration at this level is usually equated with breathing and focuses on familiar structures of animals and plants that take in oxygen, such as lungs, gills, and leaves. As students investigate single-celled organisms, they learn that these simple organisms also need air.

Middle School Students

In middle school, students continue to learn about various structures that take in oxygen and make it available to cells, including the structures of insects and aquatic organisms. At this level, they begin to connect the taking in of oxygen to the needs of cells, developing a basic understanding of cellular respiration without going into the details of cell structure and biochemical processes. Students connect the need of cells for oxygen to their growing understanding of oxidation as a process that releases energy from food within cells. At this stage, students should begin to develop the generalization that all organisms respire, since energy is needed by all living things.

High School Students

In high school biology class, students build on their basic middle school understanding of cellular respiration to examine the process at the cellular and molecular level, including the eukaryotic structures involved, such as mitochondria as well as prokaryotic cellular respiration. They learn about and distinguish between the processes of aerobic respiration and anaerobic respiration. However, at this level, as students learn about the process of photosynthesis in more detail, some may believe that only animals respire and that photosynthesis is the opposite process in plants.

Administering the Probe

Eliminate items from the list that students may not be familiar with, or explain each one, showing pictures if they are unsure as to what the organism is. For elementary school students who are not expected to know about cellular respiration, consider adapting this probe by using familiar language, such as, “Does it use air?” and reducing the number of choices. For high school students, consider adding other nonanimal choices, such as “algae” and “virus,” and replace “human body cell” with specific types of cells.

Related Ideas in *National Science Education Standards (NRC 1996)*

K–4 The Characteristics of Organisms

- ★ Organisms have basic needs. For example, animals need air, water, and food; plants require air, water, nutrients, and light.

5–8 Structure and Function in Living Systems

- ★ Cells carry out the many functions needed to sustain life. They grow and divide, thereby producing more cells. This requires that they take in nutrients, which they use to provide energy for the work that cells do and to make the materials that a cell or organism needs.

9–12 The Cell

- Cells have particular structures that underlie their functions. Inside the cell is a concentrated mixture of thousands of different molecules that form a variety of different structures that carry out such cell functions as energy production.

9–12 Matter, Energy, and Organization in Living Systems

- Living systems require a continuous input of energy to maintain their chemical and physical organizations.
- The chemical bonds of food molecules contain energy. Energy is released when the bonds of food molecules are broken down and new compounds with lower energy bonds are formed.

Related Ideas in *Benchmarks for Science Literacy (AAAS 1993)*

K–2 The Cell

- ★ Most living things need water, food, and air.

★ Indicates a strong match between the ideas elicited by the probe and a national standard’s learning goal.

3–5 The Cell

- ★ Some living things consist of a single cell. Like familiar organisms, they need food, water, and air; a way to dispose of waste; and an environment they can live in.

3–5 The Human Organism

- By breathing, people take in the oxygen they need to live.

6–8 The Cell

- Within cells, many of the basic functions of organisms, such as extracting energy from food and getting rid of waste, are carried out. The way in which cells function is similar in all living organisms.

6–8 Flow of Matter and Energy

- ★ Animals get energy from oxidizing their food, releasing some of its energy as heat.

6–8 The Human Organism

- ★ To burn food for the release of energy stored in it, oxygen must be supplied to cells and carbon dioxide must be removed. Lungs take in oxygen for the combustion of food and they eliminate the carbon dioxide produced.

9–12 The Cell

- Within every cell are specialized parts for the transport of materials, energy transfer, protein building, waste disposal, information feedback, and even movement.

Related Research

- Although students have ideas about gas exchange and usually equate it with breathing, few students at any age have a complete understanding of respiration (Driver et al. 1994).
- In a study by Haslam and Treagust (1987), most students thought respiration and breathing were synonymous.
- Studies have found that although young children recognize air as being necessary for life, they have limited understanding of what happens to air once it is inhaled. Many think only organisms with lungs use air. Few students, all the way through high school, connect food with the use of oxygen (Driver et al. 1994).
- Some students think oxygen is the gas needed by animals and carbon dioxide is the gas needed by plants. Some students think photosynthesis is the plant version of energy release or that respiration only happens in animals (Driver et al. 1994).
- Some students think plants only use oxygen (respire) in the dark (Driver et al. 1994).

Suggestions for Instruction and Assessment

- When teaching students the idea that organisms need air (or oxygen), explicitly address the variety of ways that organisms take in air (or oxygen) so that students do not equate exchange of gases only with animals that have lungs. Furthermore, when students learn about various structures that allow multicellular organisms to take

★ Indicates a strong match between the ideas elicited by the probe and a national standard's learning goal.

- in oxygen, be sure to address how single-celled organisms also take in oxygen.
- Photosynthesis is not the opposite of respiration. The intake and release of gases in the two processes is opposite, but the processes themselves are not opposites. Teaching this idea of opposites may perpetuate the notion that animals use oxygen (and thus respire) and plants do not and that gas flow in plants always happens in opposite directions.
 - For students in middle school, explicitly connect the idea of cells taking in oxygen to the need to release energy from food.
 - Be careful when using a burning analogy to describe how energy is released from food. Oxidation reactions involving food are not combustion reactions.
 - The idea that seeds, frog's eggs, and the chrysalis of a butterfly do not respire or use air may be connected to students' ideas about living or nonliving. In order to accept the idea that these stages in an organism's life respire or need air, they need to accept that they are living stages. It may be useful to combine this probe with the probe from Volume 1 of this series, "Is It Living?" (Keeley, Eberle, and Farrin 2005).

Related NSTA Science Store Publications and Journal Articles

- American Association for the Advancement of Science (AAAS). 1993. *Benchmarks for science literacy*. New York: Oxford University Press.
- Driver, R., A. Squires, P. Rushworth, and V. Wood-Robinson. 1994. *Making sense of secondary sci-*

ence: Research into children's ideas. London and New York: RoutledgeFalmer.

- Keeley, P. 2005. *Science curriculum topic study: Bridging the gap between standards and practice*. Thousand Oaks, CA: Corwin Press.
- Littlejohn, P. 2007. Building leaves and an understanding of photosynthesis. *Science Scope* 8 (30): 22–25.
- National Research Council (NRC). 1996. *National science education standards*. Washington, DC: National Academy Press.

Related Curriculum Topic Study Guide

(Keeley 2005)

"Photosynthesis and Respiration"

References

- American Association for the Advancement of Science (AAAS). 1993. *Benchmarks for science literacy*. New York: Oxford University Press.
- Driver, R., A. Squires, P. Rushworth, and V. Wood-Robinson. 1994. *Making sense of secondary science: Research into children's ideas*. London and New York: RoutledgeFalmer.
- Haslam, F., and D. Treagust. 1987. Diagnosing secondary students' misconceptions of photosynthesis and respiration in plants using a two-tier multiple choice instrument. *Journal of Biological Education* 21 (3): 203–211.
- Keeley, P. 2005. *Science curriculum topic study: Bridging the gap between standards and practice*. Thousand Oaks, CA: Corwin Press.
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National Research Council (NRC). 1996. *National science education standards*. Washington, DC: National Academy Press.

