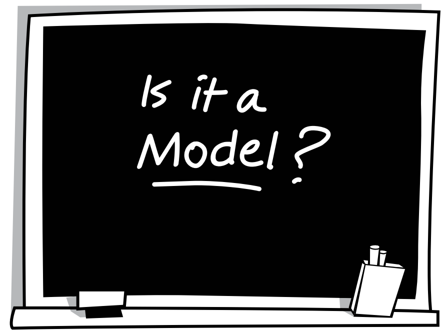
Is It a Model?



Below are listed things that students might do in a science class. Check off the things that are examples of using a model.

_____ **A** building a paper airplane

_____ **B** making an analogy (for example, the heart is like a pump)

_____ **C** observing a bird's behavior at a bird feeder

_____ **D** developing a mathematical equation to solve a science problem

_____ **E** making a plant cell out of household materials

_____ **F** analyzing whale migration patterns with a computer program

_____ **G** building and testing a bridge made of toothpicks

_____ **H** drawing an electrical circuit

_____ **I** forming a mental image of molecules in the liquid state

_____ **J** demonstrating the day/night cycle with a globe and flashlight

_____ **K** dissecting a cow's bone

_____ **L** watching a computer simulation of a hurricane

_____ **M** going on a field trip to the Grand Canyon

_____ **N** graphing the speed of a car

_____ **O** watching a live video of an active volcano

_____ **P** making a replica of a human heart out of clay

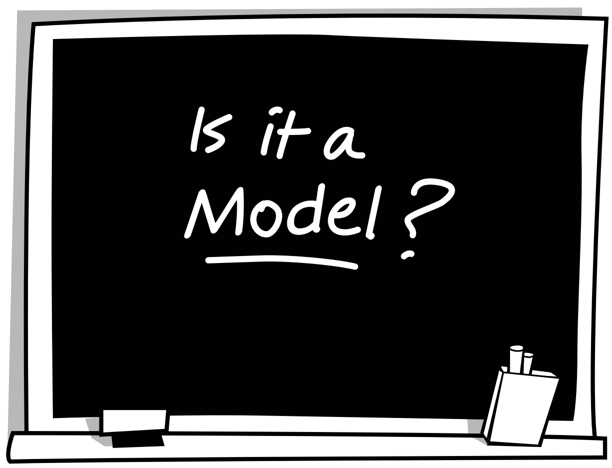
_____ **Q** looking at blood cells under a microscope

Explain your thinking. How did you decide whether something is a model?

____

Is It a Model?

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about models. The probe is designed to find out whether students recognize that models can take a variety of forms besides physical replicas.

Related Concepts

model

Explanation

The best answer is that all but C, K, M, O, and Q are examples of using models. Models are representations of objects, processes, or phenomena that look like, function like, describe, or explain the real thing. They are often simplified versions of the real object and help us to understand how things work. C, K, M, O, and Q all involve the real object or process being studied and thus are not models.

There are many types of models. Physical models can be made from similar or different materials and be smaller or larger in size with the same proportional scale (paper airplane, cell made from household materials, toothpick bridge, globe and flashlight to show day/night cycle, clay heart). Drawings and illustrations are models that help us understand real objects, places, or processes (electrical circuit drawing). Conceptual models help us make sense of an unfamiliar, complex, or abstract idea (mental image, analogy). Drawings are also used to represent conceptual models, such as drawing how one thinks molecules are arranged in water. Mathematical models use a relationship that represents the behavior or properties of an object or system (e.g., mathematical equation to solve a problem, graph). Computers can be used for simulating or mathematically representing a system that may be difficult to observe and analyze in real time (e.g., analyzing migration patterns, hurricane simulation). Models play a crucial role in science. Scientists use models as thinking tools to develop explanations for phenomena and to make predictions about phenomena. Because models are so important to scientists, they evaluate them on an ongoing basis. They consider how well models explain or predict past observations, and they look at new observations that have been collected. They evaluate models to make sure they are consistent with what is understood about nature. They look to determine how well models make predictions, and they test their accuracy. Scientists also are well aware of the limitations of their models. They may be appropriate only under certain conditions. Scientists also frequently revise their models if they fail to explain or predict well.

Curricular and Instructional Considerations

Elementary Students

In the elementary grades, students talk about how the things they play with relate to real-world objects. As they progress, students begin to talk about limitations and make changes to their physical models (e.g., modify wheels, use different materials). They discuss how mathematical concepts can be used to represent natural phenomena and use analogies to make sense of complex ideas. Students compare their models with the real thing, formulate their own models to explain things they can not observe directly, and test their models as more information is obtained, thus building an understanding of how science works.

Middle School Students

In the middle grades, students have a greater general knowledge of mathematics, objects, and processes. Students become familiar with phenomena and systems in the world around them through a variety of direct experiences, and models are used explicitly to build scientific understanding. Computers are used for graphing and simulations that calculate and depict what happens when variables are changed. Students use conceptual models to pose hypothetical questions, and changes in spatial or temporal scale of physical models become increasingly sophisticated. Models that reveal patterns or trends are used to develop generalizations, and the process of evaluating models strengthens justification skills.

High School Students

Students at the high school level learn how to create and use models in a variety of contexts, and much emphasis is placed on mathematical modeling. Students continue to develop generalizations through discussion of models and use the graphic capabilities of computers to design and test models that simulate complicated processes. Students encounter the ideas that there is no one “true” model and that scientists may not have the best model because not enough information is available. Students test models by comparing predictions with actual observations.

Administering the Probe

This probe is best used as is at the middle and high school level, particularly if students have been previously exposed to the word *model* or its use. Remove any answer choices students might not be familiar with. The probe can also be modified as a simpler version for students in grades 3–5 by reducing the number of choices, specifically leaving out some of the more complex and unfamiliar choices.

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

K–12 Unifying Concepts and Processes—Evidence, Models, and Explanation

- Models are tentative schemes or structures that correspond to real objects, events, or classes of events and that have explanatory power.
- Models help scientists and engineers understand how things work.
- ★ Models take many forms, including physical objects, plans, mental constructs, mathematical equations, and computer simulations.

Related Ideas in *Benchmarks for Science Literacy* (AAAS 1993 and 2008)

Note: Benchmarks revised in 2008 are indicated by (R). New benchmarks added in 2008 are indicated by (N).

K–2 Models

- Many of the toys children play with are like real things only in some ways. They are not the same size, are missing many details, or are not able to do all of the same things.
- A model of something is different from the real thing but can be used to learn something about the real thing.
- One way to describe something is to say how it is like something else.

3–5 Models

- A model of something is similar to, but not exactly like, the thing being modeled. Some models are physically similar to what they are representing, but others are not. (N)
- ★ Geometric figures, number sequences, graphs, diagrams, sketches, number lines, maps, and stories can be used to represent objects, events, and processes in the real world, although such representations can never be exact in every detail. (R)
- Models are very useful for communicating ideas about objects, events, and processes. When using a model to communicate about something, it is important to keep in mind how it is different from the thing being modeled. (N)

6–8 Models

- Models are often used to think about processes that happen too slowly, too quickly, or on too small a scale to observe directly,

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

or that are too vast to be changed deliberately, or that are potentially dangerous.

- ★ Mathematical models can be displayed on a computer and then modified to see what happens.
- Different models can be used to represent the same thing. What kind of a model to use and how complex it should be depends on its purpose. The usefulness of a model may be limited if it is too simple or if it is needlessly complicated. Choosing a useful model is one of the instances in which intuition and creativity come into play in science, mathematics, and engineering.

9–12 Models

- ★ A mathematical model uses rules and relationships to describe and predict objects and events in the real world. (R)
- Computers have greatly improved the power and use of mathematical models by performing computations that are very long, very complicated, or repetitive. Therefore computers can show the consequences of applying complex rules or of changing the rules. The graphic capabilities of computers make them useful in the design and testing of devices and structures and in the simulation of complicated processes.
- The behavior of a physical model cannot ever be expected to represent the full-scale phenomenon with complete accuracy, not even in the limited set of characteristics being studied. The inappropriateness of a model may be related to differences between the model and what is being modeled. (N)

Related Research

- Students may think that models are physical copies of the real thing, failing to recognize models as conceptual representations (AAAS 1993).
- In the lower elementary grades, students have some understanding of how models are used, but when developing a model or evaluating one, they tend to focus on perceptual similarities between the actual model and what it is designed to represent (AAAS 2007).
- Middle and high school students are more apt to view visual representations such as maps and diagrams as models than they are ideas or abstract models (AAAS 2007).
- Students may lack the notion of the usefulness of a model as being tested against actual observations. They know models can be changed, but at the high school level they may be limited by thinking that a change in a model means adding new information or at the middle school level by thinking that changing a model means replacing a part that was wrong (AAAS 1993).
- Many high school students recognize that models can help them understand the natural world, but they don't believe models can duplicate reality (AAAS 1993).
- Students are more apt to accept the explanatory role of models if many of the material features of the model are similar to the

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

phenomenon. The more abstract a model is, the less apt students are to recognize its explanatory power (AAAS 1993).

- Middle and high school students tend to think that everything they learn in science is factual. They have difficulty distinguishing between observation and the use of a model to explain a theory (AAAS 1993).
- Students find the idea of multiple models confusing. When multiple models exist, they think that each one represents different aspects of what is being modeled. When multiple models are presented, they tend to think there is one "right one" (AAAS 2007).

Suggestions for Instruction and Assessment

- For younger students, provide opportunities for them to play with toys. Talk about how the toys are like real things only in some ways. They are not the same size, are missing many details, or are not able to do all of the same things.
- Elementary students may need many cycles of reflection and evaluation to overcome their focus on perceptual similarities between the actual model and what it is designed to represent. Have students build a model of a familiar object such as an elbow. If their model looks like but does not act like the real thing, have them talk about this limitation of their model and redesign their model to better represent the function of the item.
- Provide students the opportunity to examine a variety of examples of two- and three-dimensional physical models of the same thing. Analyze and discuss what each model represents and what it doesn't represent. Compare strengths, weaknesses, and limitations of the various models, paying particular attention to scale (relative size, distances), focusing on the proportionality when they are much larger or smaller rather than on the actual number. Propose changes to these models and consider how those changes may better reflect the real thing.
- Provide students the opportunity to examine examples of a physical, conceptual, and mathematical model of the same thing. Compare and contrast what each kind of model can convey and discuss the value of using a variety of kinds of models.
- When models such as atomic/molecular models are used to explain atomic theory, be explicit that the model explains a theory, not an actual observation of atoms and molecules. Point out irrelevant aspects of concrete physical models that can distract from the abstract idea.
- Integrate the unifying theme of models into content domains in a variety of contexts. Use models to examine a variety of real-world phenomena from the living world, physical setting, and technological world.
- Use available online representations (drawings, diagrams, graphs, simulations, and analogies) to help clarify key ideas in science. A collection of reviewed online representations that can be used for science

instruction are found at PRISMS (Phenomena and Representations for Instruction of Science in Middle Schools). To access this collection, go to *http://prisms.mmsa.org*.

- Connect ideas about models to systems thinking. Make models of large systems, such as a watershed, and discuss the boundaries, inputs, outputs, interactions, and consequences as a drop of dye is used to represent a pollutant leaking into a stream.
- Models are important to instruction as a means to make students' thinking visible (Michaels, Shouse, and Schweingruber 2008).

Related NSTA Science Store Publications, NSTA Journal Articles, NSTA SciGuides, NSTA SciPacks, and NSTA Science Objects

Ebert, J. R., N. A. Elliott, and A. Schulz. 2004. Modeling convection. *The Science Teacher* (Sept.): 48–50.

Eichinger, J. 2005. Methods and strategies: Using models effectively. *Science & Children* (Apr.): 43–45.

Finson, K., and J. Beaver. 2007. Time on your hands: Modeling time. *Science Scope* (Jul.): 33–37.

Frazier, R. 2003. Rethinking models. *Science & Children* (Jan.): 29–33.

Gilbert, S. W., and S. W. Ireton. 2003. *Understanding models in Earth and space science.* Arlington, VA: NSTA Press.

Goodwyn, L., and S. Saim. 2007. Modeling muscles. *The Science Teacher* (Dec.): 49–52.

Hitt, A., and J. S. Townsend. 2004. Models that matter. *The Science Teacher* (Mar.): 29–31.

Jones, M. G., M. R. Falvo, A. R. Taylor, and B. P. Broadwell. 2007. *Nanoscale science: Activities for grades 6–12.* Arlington, VA: NSTA Press.

Kane, J. 2004. Geology on a sand budget. *The Science Teacher* (Sept.): 36–39.

Laney, E., and S. Mattox. 2007. Using clay models to understand volcanic mudflows. *Science Scope* (Mar.): 22–25.

Leager, C. R. 2007. Making models. *Science & Children* (Feb.): 50–52.

Littlejohn, P. 2007. Building leaves and an understanding of photosynthesis. *Science Scope* (Apr./May): 22–25.

Michaels, S., A. Shouse, and H. Schweingruber, H. 2008. *Ready, set, science! Putting research to work in K-8 classrooms.* Washington, DC: National Academies Press.

Related Curriculum Topic Study Guide

(Keeley 2005)

"Models"

References

American Association for the Advancement of Science (AAAS). 1993. *Benchmarks for science literacy.* New York: Oxford University Press.

American Association for the Advancement of Science (AAAS). 2007. *Atlas of science literacy.* Vol. 2. (See "Models," pp. 92–93.) Washington, DC: AAAS.

American Association for the Advancement of Science (AAAS). 2008. Benchmarks for science literacy online. *www.project2061.org/publications/bsl/online*

Keeley, P. 2005. *Science curriculum topic study: Bridging the gap between standards and practice.* Thousand Oaks, CA: Corwin Press.

Michaels, S., A. Shouse, and H. Schweingruber. 2008. *Ready, set, science! Putting research to work in K-8 classrooms.* Washington, DC: National Academies Press.

National Research Council (NRC). 1996. *National science education standards.* Washington, DC: National Academy Press.