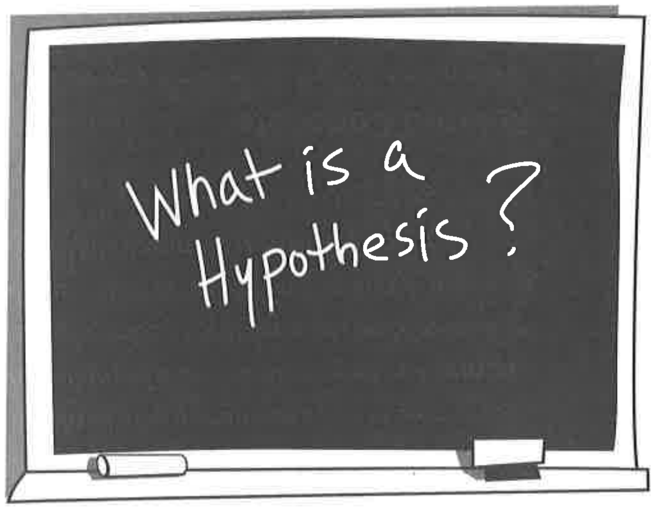
What Is a Hypothesis?

Hypotheses are used widely in science. Put an X next to the statements that describe a hypothesis.



_____ **A** A tentative explanation

_____ **B** A statement that can be tested

_____ **C** An educated guess

_____ **D** An investigative question

_____ **E** A prediction about the outcome of an investigation

_____ **F** A question asked at the beginning of an investigation

_____ **G** A statement that may lead to a prediction

_____ **H** Included as a part of all scientific investigations

_____ **I** Used to prove whether something is true

_____ **J** Eventually becomes a theory, then a law

_____ **K** May guide an investigation

_____ **L** Used to decide what data to pay attention to and seek

_____ **M** Developed from imagination and creativity

_____ **N** Must be in the form of "if…then…"

Describe what a hypothesis is in science. Include your own definition of the word *hypothesis* and explain how you learned what it is.

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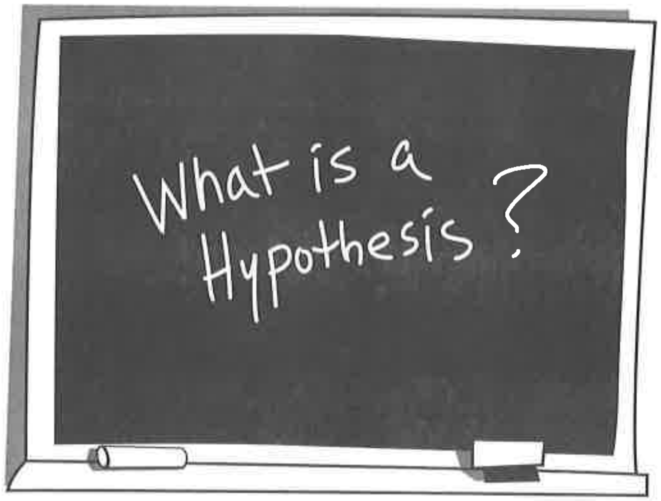
What Is a Hypothesis?

Teacher Notes



Purpose

The purpose of this assessment probe is to elicit students' ideas about hypotheses. The probe is designed to find out if students understand what a hypothesis is, when it is used, and how it is developed.

Related Concepts

hypothesis, nature of science, scientific inquiry, scientific method

Explanation

The best choices are A, B, G, K, L, and M. However, other possible answers open up discussions to contrast with the provided definition. A hypothesis is a tentative explanation that can be tested and is based on observation and/or scientific knowledge such as that that has been gained from doing background research. Hypotheses are used to investigate a scientific question. Hypotheses can be tested through experimentation or further observation, but contrary to how some students are taught to use the "scientific method," hypotheses are not proved true or correct. Students will often state their conclusions as "My hypothesis is correct because my data prove...," thereby equating positive results with proof (McLaughlin 2006, p. 61). In essence, experimentation as well as other means of scientific investigation never *prove* a hypothesis—the hypothesis gains credibility from the evidence obtained from data that support it. Data either support or negate a hypothesis but never prove something to be 100% true or correct.

Hypotheses are often confused with questions. A hypothesis is not framed as a question but rather provides a tentative explanation in response to the scientific question that leads the investigation. Sometimes the word *hypothesis* is oversimplified by being defined as "an educated guess." This terminology fails to convey the explanatory or predictive nature of scientific hypotheses and omits what is most important about hypotheses: their purpose. Hypotheses are developed to explain observations, such as notable patterns in nature; predict the outcome of an experiment based on observations or prior scientific knowledge; and guide the investigator in seeking and paying attention to the right data. Calling a hypothesis a "guess" undermines the explanation that underscores a hypothesis.

Predictions and hypotheses are not the same. A hypothesis, which is a tentative explanation, can lead to a prediction. Predictions forecast the outcome of an experiment but do not include an explanation. Predictions often use if-then statements, just as hypotheses do, but this does not make a prediction a hypothesis. For example, a prediction might take the form of, "If I do [X], then [Y] will happen." The prediction describes the outcome but it does not provide an explanation of why that outcome might result or describe any relationship between variables.

Sometimes the words *hypothesis, theory,* and *law* are inaccurately portrayed in science textbooks as a hierarchy of scientific knowledge, with the hypothesis being the first step on the way to becoming a theory and then a law. These concepts do not form a sequence for the development of scientific knowledge because each represents a different type of knowledge.

Not every investigation requires a hypothesis. Some types of investigations do not lend themselves to hypothesis testing through experimentation. A good deal of science is observational and descriptive—the study of biodiversity, for example, usually involves looking at a wide variety of specimens and maybe sketching and recording their unique characteristics. A biologist studying biodiversity might wonder, "What types of birds are found on island X?" The biologist would observe sightings of birds and perhaps sketch them and record their bird calls but would not be guided by a specific hypothesis. Many of the great discoveries in science did not begin with a hypothesis in mind. For example, Charles Darwin did not begin his observations of species in the Galapagos with a hypothesis in mind.

Contrary to the way hypotheses are often stated by students as an unimaginative response to a question posed at the beginning of an experiment, particularly those of the "cookbook" type, the generation of hypotheses by scientists is actually a creative and imaginative process, combined with the logic of scientific thought. "The process of formulating and testing hypotheses is one of the core activities of scientists. To be useful, a hypothesis should suggest what evidence would support it and what evidence would refute it. A hypothesis that cannot in principle be put to the test of evidence may be interesting, but it is not likely to be scientifically useful" (AAAS 1988, p. 5).

Curricular and Instructional Considerations

Elementary Students

In the elementary school grades, students typically engage in inquiry to begin to construct an understanding of the natural world. Their inquiries are initiated by a question. If students have a great deal of knowledge or have made prior observations, they might propose a hypothesis; in most cases, however, their knowledge and observations are too incomplete for them to hypothesize. If elementary school students are required to develop a hypothesis, it is often just a guess, which does little to contribute to an understanding of the purpose of a hypothesis. At this grade level, it is usually sufficient for students to focus on their questions, instead of hypotheses (Pine 1999).

Middle School Students

At the middle school level, students develop an understanding of what a hypothesis is and when one is used. The notion of a testable hypothesis through experimentation that involves variables is introduced and practiced at this grade level. However, there is a danger that students will think every investigation must include a hypothesis. Hypothesizing as a skill is important to develop at this grade level but it is also important to develop the understandings of what a hypothesis is and why and how it is developed.

High School Students

At this level, students have acquired more scientific knowledge and experiences and so are able to propose tentative explanations. They can formulate a testable hypothesis and demonstrate the logical connections between the scientific concepts guiding a hypothesis and the design of an experiment (NRC 1996).

Administering the Probe

This probe is best used as is at the middle school and high school levels, particularly if students have been previously exposed to the word *hypothesis* or its use. Remove any answer choices students might not be familiar with. For example, if they have not encountered if-then reasoning, eliminate this distracter. The probe can also be modified as a simpler version for students in grades 3–5 by leaving out some of the choices and simplifying the descriptions.

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

K–4 Understandings About Scientific Inquiry

- Scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.
- Scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge).

5–8 Understandings About Scientific Inquiry

- Different kinds of questions suggest different kinds of investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiments; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models.
- Current scientific knowledge and understanding guide scientific investigations. Different scientific domains employ different methods, core theories, and standards to advance scientific knowledge and understanding.

5–8 Science as a Human Endeavor

- Science is very much a human endeavor, and the work of science relies on basic human qualities such as reasoning, insight, energy, skill, and creativity.

9–12 Abilities Necessary to Do Scientific Inquiry

★ Identify questions and concepts that guide scientific investigations.

9–12 Understandings About Scientific Inquiry

- Scientists usually inquire about how physical, living, or designed systems function. Conceptual principles and knowledge guide scientific inquiries. Historical and current scientific knowledge influence the design and interpretation of investigations and the evaluation of proposed explanations made by other scientists.

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

K–2 Scientific Inquiry

- People can often learn about things around them by just observing those things carefully, but sometimes they can learn more by doing something to the things and noting what happens.

3–5 Scientific Inquiry

- Scientists' explanations about what happens in the world come partly from what they observe and partly from what they think. Sometimes scientists have different explanations for the same set of observations. That usually leads to their making more observations to resolve the differences.

6–8 Scientific Inquiry

★ Scientists differ greatly in what phenomena they study and how they go about their work. Although there is no fixed set of steps that all scientists follow, scientific investigations usually involve the collection of relevant evidence, the use of logical reasoning, and the application of imagination in devising hypotheses and explanations to make sense of the collected evidence.

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

6–8 Values and Attitudes

★ Even if they turn out not to be true, hypotheses are valuable if they lead to fruitful investigations.

9–12 Scientific Inquiry

★ Hypotheses are widely used in science for choosing what data to pay attention to and what additional data to seek and for guiding the interpretation of the data (both new and previously available).

Related Research

- Students generally have difficulty with explaining how science is conducted because they have had little contact with real scientists. Their familiarity with doing science, even at older ages, is "school science," which is often not how science is generally conducted in the scientific community (Driver et al. 1996).
- Despite over 10 years of reform efforts in science education, research still shows that students typically have inadequate conceptions of what science is and what scientists do (Schwartz 2007).
- Upper elementary school and middle school students may not understand experimentation as a method of testing ideas, but rather as a method of trying things out or producing a desired outcome (AAAS 1993).
- Middle school students tend to invoke personal experiences as evidence to justify their hypothesis. They seem to think of evidence as selected from what is already known or from personal experience or secondhand sources, not as information produced through experiment (AAAS 1993).

Suggestions for Instruction and Assessment

- The "scientific method" is often the first topic students encounter when using textbooks and this can erroneously imply that there is a rigid set of steps that all scientists follow, including the development of a hypothesis. Often the scientific method described in textbooks applies to experimentation, which is only one of many ways scientists conduct their work. Embedding explicit instruction of the various ways to do science in the actual investigations students do throughout the year as well as in their studies of investigations done by scientists is a better approach to understanding how science is done than starting off the year with the scientific method in a way that is devoid of a context through which students can learn the content and process of science.
- Students often participate in science fairs that may follow a textbook scientific method of posing a question, developing a hypothesis, and so on, that incorrectly results in students "proving" their hypothesis. Make sure students understand that a hypothesis can be disproven, but it is never proven, which implies 100% certainty.
- Help students understand that science begins with a question. The structure of some school lab reports may lead students

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

to believe that all investigations begin with a hypothesis. While some investigations do begin with a hypothesis, in most cases, they begin with a question. Sometimes it is just a general question.

- A technique to help students maintain a consistent image of science as inquiry throughout the year by paying more careful attention to the words they use is to create a "caution words" poster or bulletin board (Schwartz 2007). Important words that have specific meanings in science but are often used inappropriately in the science classroom and through everyday language can be posted in the room as a reminder to pay careful attention to how students are using these words. For example, words like *hypothesis* and *scientific method* can be posted here. Words that are banned when referring to hypotheses include *prove, correct,* and *true.*
- Use caution when asking students to write lab reports that use the same format regardless of the type of investigation conducted. The format used in writing about an investigation may imply a rigid, fixed process or erroneously misrepresent aspects of science, such as that hypotheses are developed for every scientific investigation.
- Avoid using hypotheses with younger children when they result in guesses. It is better to start with a question and have students make a prediction about what they think will happen and why. As they acquire more conceptual understanding and experience a variety of observations, they will be better prepared to develop hypotheses that reflect the way science is done.
- Avoid using "educated guess" as a description for *hypothesis*. The common meaning of the word *guess* implies no prior knowledge, experience, or observations.
- Scaffold hypothesis writing for students by initially having them use words like *may* in their statements and then formalizing them with if-then statements. For example, students may start with the statement, "The growth of algae may be affected by temperature." The next step would be to extend this statement to include a testable relationship, such as, "If the temperature of the water increases, then the algae population will increase." Encourage students to propose a tentative explanation and then consider how they would go about testing the statement.

Related NSTA Science Store Publications and NSTA Journal Articles

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

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

McLaughlin, J. 2006. A gentle reminder that a hypothesis is never proven correct, nor is a theory ever proven true. *Journal of College Science Teaching* 36 (1): 60–62.

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Schwartz, R. 2007. What's in a word? How word choice can develop (mis)conceptions about the nature of science. *Science Scope* 31 (2): 42–47.

VanDorn, K., M. Mavita, L. Montes, B. Ackerson, and M. Rockley. 2004. Hypothesis-based learning. *Science Scope* 27: 24–25.

Related Curriculum Topic Study Guides

(Keeley 2005)

"Inquiry Skills and Dispositions"

"Understandings About Scientific Inquiry"

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