Is It Science?

Students review essential criteria of science then sort and classify statements as scientific, proto-science, pseudoscience, or non-science.

What you'll need:

- Student Worksheets and Backgrounder
- NOTTUS Table
- Examples of misconception statements to classify

Before the Activity

1. Have students watch and discuss the Nature of Science video in the "Engage" portion of UCAR Center for Science Education's Nature of Science Teaching Box. (See URL below.)
2. In pairs (or small groups) have students read and review the Student Backgrounder regarding criteria to determine what is and isn't science.
3. Give examples of what is and is not science, and discuss collectively or in small groups using the NOTTUS criteria. Encourage questions and discussion.
4. Distribute *Is It Science?* statements or let students choose their own to evaluate and classify.

Directions During the Activity

1. Give each student a copy of the Student Worksheet and each pair a copy of the NOTTUS Grid.
2. Each student is then given a statement selected from the Sample Sheet.
3. Next, the student classifies the statement as either science, protoscience, psuedoscience, or nonscience, and determines the NOTTUS criteria that can or cannot be applied.
4. Once each student has read his/her statement and classified it as directed, group members form two lines and share their classification with the person across from them. Pairs should strive to obtain consensus.
5. Move one of the lines so students are able to share and defend their classification a number of times with a classmate.
6. Have students record their classification justification on the student form at the end of the lesson.

Reflection and Assessment

Ask students the following questions:

- Which statements if any were the most difficult to classify? Why?
- If a statement is not classified as science, does that mean that it isn't true?
- Besides knowing something scientifically, what other ways of knowing are there? (e.g. faith, gut instinct, intuition, memory, hunch, research, values)
- Can you think of an example when two "ways of knowing" have been in conflict? How might someone decide which one to trust, believe, or rely upon?
- Physicist Richard Feyneman used to say, "Science is a way of trying not to fool yourself." Do you agree or disagree with this statement?

Learn More!

- Understanding Science, http://undsci.berkeley.edu/
- Teaching About Evolution and the Nature of Science, NAS free download, www.nap.edu/openbook.php?record_id=5787
- Science for All Americans: Project 2061, www.project2061.org/tools/sfaaol/ch1.htm
- Nature of Science Teaching Box, SciEd.ucar.edu/teaching-science/nature-science

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For Teachers:

Student Learning Objectives

- Students will learn that science is a particular way of knowing and learning about the natural world.
- Students learn that science is observable, testable, tentative, predictable, and consistent.

Class time

- One 45 min. - 50 min. class period

Grades

- 5th - 8th grade

Next Generation Science Standards

NGSS Appendix H. Nature of Science

NGSS Science and Engineering Practices:

- Constructing Explanations and Designing Solutions;
- Obtaining, Evaluating, and Communicating Information.

NGSS Crosscutting Concepts:

- Influence of Science on Society and the Natural World
- Sorting and Classifying
- Patterns

Common Core:

- ELA Reading Anchor #1, 6-12
- ELA Speaking & Listening Anchor #1 & #4, 5-12

For upper elementary and/or middle school students:

Student Backgrounder: What Is and Is Not Science? Don't be Fooled

Certain characteristics exist that can help determine what is and is not science. The acronym **"NOTTUS"** can be used as a memory hook for these six characteristics: **Natural, Observable, Testable, Tentative, Uncertain,** and **Social.**

The first of these, **Natural,** refers to the fact that science seeks to explain the things found in the universe. Sometimes science uses chemicals or resources to create human-made products. This is especially true in engineering. Examples include the creation and use of plastics and polymers.

Science must also be **Observable** through human senses or through tools that help us observe what cannot be observed with our senses alone. Tools such as a radar, telescope, microscope, or cameras and sensors on satellites are good examples.

These Natural and Observable phenomena must also be **Testable.** We can make predictions about how they will behave, change, or react and then test these predictions using science methods. Tests in science must be repeatable and predictable.

Scientific findings are **Tentative and Temporary.** Over time, corrections, additional evidence, or contrary evidence may change what we know. When science findings have been tested repeatedly over a period of time, then that knowledge becomes scientific theory.

Even theories in science remain tentative, although they are less likely to be proven wrong.

Science is also **Uncertain.** As evidence grows over time, science becomes more certain but it never attains 100 percent certainty. Being 99 percent certain is still 1 percent uncertain. Weather forecasts are a good examples of uncertainty. Weather forecasts are reliable but the forecasts are nearly always uncertain to a greater or lesser extent. The forecast may call for 90 percent chance of rain, but there is still a 10 percent chance it won't.

And finally, science is **Social.** It requires collaboration with other scientists, communication of results with one's peers, and presenting findings in journals, presentations, and scientific conferences. It may at times require solitary work but eventually it must be a social in nature and involve sharing the science with the scientific community.

If It's Not Science, What Is It? **The prefix "pseudo" mean "false" and "proto" means "before."**

Pseudoscience: Pseudoscience is false science that is positioned as science. Good examples of a pseudoscience include astrology, many weight loss pills, and unscientific means for determining the age of the Earth.

Protoscience: Protoscience is science that is emerging or near science in terms of conforming to "NOTTUS", however, it falls short in one or more ways. For example, mental telepathy is an area of study where information is transmitted directly from one brain to another. It is actively being researched but it is not yet confirmed. It is thought by some to be worthy of scientific consideration. Some scientists are researching if electricity throughout Earth's atmosphere might have connections to Earth's climate system and help us identify trends. Both of these examples then, could be considered as examples of "protoscience."

Nonscience: Non-science events do not meet the NOTTUS characteristics of science. Examples include belief systems, e.g., religious beliefs, philosophy, personal opinions or attitudes. Non-science events or phenomena can be very logical and even true, however, they are simply unobservable, untestable, unpredictable, inconsistent, or often fall outside of the natural world. They cannot be tested and verified as either true or false.

Adapted from its original version by Iowa State Educators by Teri Eastburn

For secondary students:

Student Backgrounder: Criteria for Determining What Is and Is Not Science

Criteria exist that can help in differentiating what is and is not science. The acronym **"NOTTUS"** can be used as a memory hook for these six criteria: **Natural, Observable, Testable, Tentative, Uncertain,** and **Social.**

The first of these, **Natural,** refers to the fact that science seeks to explain the natural phenomena found in the universe in which we live.

These natural phenomena or events must also be **Observable** through basic human senses or through tools that enhance human senses such as a radar, thermometers, microscopes, or instruments and cameras on satellites.

These Natural and Observable phenomena must also be **Testable.** We can make predictions about how they will behave, change, or react and then test these predictions through scientific processes. Results in science must be consistent.

Scientific findings or conclusions, however, are always **Tentative and Temporary.** They are subject to revisions and corrections whenever evidence can prove them wrong. When a natural phenomena has been tested and reaffirmed repeatedly over an extensive period of time, those phenomena are called scientific theories. However, scientific theories, are also considered tentative, although unlikely to be proven wrong.

Science is also **Uncertain.** 99 percent certainty is still 1 percent uncertain. 100 percent certainty is not attainable with scientific ways of knowing; not even those scientific phenomena we're really certain about. Weather forecasts are a good example. They rarely are 100 percent certain. Like weather forecasts, the science of forecasting is reliable but the forecasts always have a degree of uncertainty – sometimes more, sometimes less.

And finally, science is **Social.** It requires collaboration with other scientists, communication of results with one's peers, and presenting findings in journals, presentations, and scientific conferences. It is always a social endeavor involving the scientific community.

If It's Not Science, What Is It?

The prefix "pseudo" mean "false" and "proto" means "before."

Pseudoscience: Pseudoscience is false science that may be portrayed and advertised as a legitimate science by its followers and supporters. Good examples of a pseudoscience include astrology, some weight loss pills or diets, and nonscientific means for determining the age of the Earth.

Protoscience: Protoscience is science that is emerging or near science in terms of conforming to "NOTTUS", however, it falls short in one or more of the criteria. A protoscience differs from a science in that consistent observation and prediction may be limited by knowledge and/or technology. For example, mental telepathy (thought transmission directly from one brain to another), might be worthy of scientific consideration. Another example is research looking for connections between patterns of electricity in our atmosphere and Earth's climate system. Both of these examples could be considered "protoscience."

Nonscience: Non-science events or phenomena simply do not meet the NOTTUS criteria, and therefore, fall outside the realm of science. They would include any belief system, e.g., religious beliefs, philosophy, personal opinions or attitudes, a sense of esthetics, or ethics. Non-science events or phenomena can be very logical and even true, however, they are simply unobservable, untestable, unpredictable, inconsistent, or often fall outside of the natural world.

Is It Science? (NOTTUS)

Adapted from Iowa Science Educators by Teri Eastburn

Criteria	Within the Realm of Science	Outside the Realm of Science
Natural	A naturally occurring cause or mechanism is used to explain how or why an event or phenomenon happens (i.e. uneven heating of Earth's surface causes temperature differences.)	A natural cause or mechanism cannot be, or is not used to explain how or why an event or phenomenon happens.
Observable	A phenomenon, event, or evidence that can be observed by the human senses or with a tool that makes observation possible, i.e. a thermometer.	The phenomenon, event, or evidence that cannot be observed by the human senses or their extension/tools.
Testable	Experiments can be designed to test the natural cause of the phenomenon/ event. Science can be verified or falsified. When tests are repeated with consistent and predictable results, verification grows.	Experiments cannot be designed to test the natural cause of the phenomenon or event. They cannot be verified.
Tentative	Explanations of the phenomenon/event or its cause/behavior are subject to change as new evidence emerges.	Explanations of the cause of the event or phenomenon in question are not subject to change.
Uncertain	Uncertainty is the norm in science with findings often yielding a percentage of certainty, *i.e. the chance of rain is 80 percent.*	100 percent certainty is the norm.
Social	Collaboration, argumentation, sharing, replication, and peer review are necessary parts of the science process.	Individual endeavors are fine and no verification of any kind from others is needed.

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Is It Science?

Student Worksheet: **Is It Science?**

Name: _____

Statement to analyze and classify as science, protoscience, pseudoscience, or non-science. The statement I classified is:

_____

_____

Explain how each of the criterion applies or does not apply to the statement you chose, then check the box at the bottom of the worksheet to classify the statement as either science, protoscience, pseudoscience or non-science. Share your criteria with a classmate and try to defend your point-of-view to obtain a mutually agreed upon classification if you are not in agreement.

CRITERIA	EXPLANATION
Natural	
Observable	
Testable	
Tentative	
Uncertain	
Social	

Based on the NOTTUS criteria, I believe my statement is:

_____science _____non-science _____protoscience _____pseudoscience

Is It Science?
Examples of Statements to Classify

- The Sun warms the Earth unevenly. (science)
- I'm 100 percent safe from lightning in my home. (pseudoscience)
- My birthday falls under the sign of Aquarius so I am creative & loyal. - (pseudoscience)
- There is life somewhere in the universe. (protoscience)
- Snow occurs in temperatures that are 32 degrees F or below. (science)
- Moses parted the sea with his rod so his people could cross to the other side. (non-science)
- Cloud seeding can be used successfully to improve a ski resort's snowfall. (science)
- The meaning of life can be determined and verified. (non-science)
- Scientists decide that Pluto should be classified as a dwarf planet instead of a planet. (science)
- It's predicted that the weather on Friday will be a high of 40 degrees F. and rainy. (science)
- Windows should always be opened before a tornado hits. (pseudoscience)
- If you place an inflated balloon at room temperature into a freezer, it will shrink in size. (science)
- I am definitely going to be rich. (non-science)
- It's always sunny in Southern California. (pseudoscience)
- Jack planted the seeds and a beanstalk grew. (science — don't assume that Jack is *Jack in the Beanstalk*. That is an example of bias.)
- Atmospheric electricity might give us clues to climate change. (protoscience)