

NATURE OF SCIENCE - INTRODUCTION

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WHAT IS SCIENCE?

SCIENCE DEFINED:

Concept: Science is limited to studying only the problems of the natural world that can be understood by using the processes of science.

Sub-concept:

1. Scientists deal with natural phenomena (events) which can be observed, measured, and tested by scientific methods; they must be able to use their senses to observe (directly and/or indirectly) and evaluate.
2. The processes of science are very successful in dealing with problems within the limits of science.
3. Scientific study is based upon the assumption that the universe is orderly, reasonable, and testable.
4. A valid scientific theory offers a well-defined naturally occurring cause (mechanism) which explains why or how a natural event (phenomenon) occurs.
5. Scientific theories are always subject to change (tentative, uncertain).
6. Science does not have the answers to all of the questions in the universe, or the solutions to all human problems.

HOW CAN WE TELL SCIENCE FROM NON-SCIENCE?

Concept: Following the discussion of "CONPTT", the student will be able to distinguish between scientific and non-scientific statements.

Introduction: To summarize our previous discussions and today's ideas, let's list some criteria that might help us recognize the difference between what is science and what is not science, criteria that will enable us to recognize a scientific statement and a non-scientific statement.

The following criteria were developed by science educators in Iowa and found acceptable by several midwestern high school biology teachers.

SCIENCE IDENTIFICATION CRITERIA or THE CHARACTERISTICS OF SCIENCE

Six Criteria of Science: **C**onsistent, **O**bservable, **N**atural, **P**redictable, **T**estable, and **T**entative. The sequence is not important, but the acronym "CONPTT" makes a good long term memory hook.

1. Consistency: The results of repeated observations and/or experiments concerning a naturally occurring event (phenomenon) are reasonably the same when performed and repeated by competent investigators. The event is also free from self-

contradiction: it is consistent in its applications. The weight of the evidence is also compatible with well established observations and limits.

REALITY CHECK #1: which of the following is a scientific statement, and which one is not a scientific statement?

1. Green plants will grow towards a light source.
2. Walking under a ladder will cause bad luck.

Using the idea of "Consistency", how can we determine which statement above is a scientific one?

2. **O**bservability: The event under study, or evidence of the occurrence of the event, can be observed and explained. The observations are limited to the basic human senses or to extensions of the senses by such things as electron microscopes, Geiger counters, etc. If the phenomenon cannot be reproduced through controlled conditions, natural evidence of the event's occurrence must be available for investigation.

REALITY CHECK #2: which of the following is a scientific statement, and which one is not a scientific statement?

1. Some plants eat meat.
2. Extraterrestrial beings have visited Earth.

Using the idea of "Observability", how can we determine which statement above is a scientific one?

3. **N**atural: A natural cause (mechanism) must be used to explain why or how the naturally occurring event happens. Scientists may not use supernatural explanations as to why or how naturally occurring events happen because reference to the supernatural is outside of the realm of science. Scientists cannot conduct controlled experiments in which they have designed the intervention of a supreme being into the test.

REALITY CHECK #3: which of the following is a scientific statement, and which one is not a scientific statement?

1. Green plants convert sunlight into energy.
2. With a rod, Moses parted the sea so his people could cross to the other side..

Using the idea of "Natural", how can we determine which statement above is a scientific one?

4. **P**redictability: The natural cause (mechanism) of the naturally occurring event can be used to make specific predictions. Each prediction can be tested to determine if the prediction is true or false.

REALITY CHECK #4: which of the following is a scientific statement, and which one is not a scientific statement?

1. Without sunlight (or comparable artificial light), green plants will die.
2. If you are a "Scorpio", your horoscope for today is "You'll be saying 'I feel rich !' Lunar position highlights back pay, refunds, correction of accounting error."

Using the idea of "Predictability", how can we determine which statement above is a scientific one?

5. Testability: The natural cause (mechanism) of the naturally occurring event must be testable through the processes of science, controlled experimentation being only one of these. Reference to supernatural events or causes are not relevant tests.

REALITY CHECK #5: which of the following is a scientific statement, and which one is not a scientific statement?

1. The Bermuda Triangle causes ships and planes to sink and disappear.
2. Life comes from life and cannot come from non-life.

Using the idea of "Testability", how can we determine which statement above is a scientific one?

6. Tentativeness: Scientific theories are subject to revision and correction, even to the point of the theory being proven wrong. Scientific theories have been modified and will continue to be modified to consistently explain observations of naturally occurring events.

REALITY CHECK #6: which of the following is a scientific statement, and which one is not a scientific statement?

1. The number of human chromosomes was once "known" to be 48, but is now considered to be 46.
2. Living things were once grouped into 2 major groups, then 3, then 4, and now 5, because the criteria used for classifying living things have changed.
3. We know that the world began about 6000 years ago, and nothing will change that.
4. At one time, it was thought the heart pumped blood out of a large container as an "open system", but now it is known that blood "circulates" in a closed system.

Using the idea of "Tentativeness", how can we determine which statement above is a scientific one?

WHAT IS "EMERGING SCIENCE"?

Emerging Science Defined: Emerging science (or "protoscience") may be defined as a "near science". A protoscience tends to conform to most of the CONPTT criteria but typically falls short in one or more of the criteria. A protoscience differs from a science in that consistent observations and predictions may be limited by knowledge and/or technology.

For example, let's look at parapsychology. This includes such phenomena as clairvoyance, precognition, and psychokinesis. Scientists generally consider parapsychology a pseudoscience because its phenomena conflict with known physical laws. However, at least one member of the parapsychology family, mental telepathy (thought transmission directly from one brain to another), might be worthy of scientific consideration. Mental telepathy, then, could be considered as a "protoscience".

NOTE: See Arthur Strahler, Science and Earth History (1987), page 55 regarding mental telepathy as a protoscience; pages 46-47 for more information about extraterrestrial visitors; and pages 47-49 for more information about UFOs and UFOlogy.

WHAT IS "NON-SCIENCE"?

Non-Science Defined: Non-science may be defined as an area of knowledge which does not meet the criteria of science (CONPTT). Non-science topic areas may be very logical and based on good reasoning, but simply do not fall within 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.

WHAT IS "FALSE SCIENCE"?

False Science Defined: False science ("pseudoscience") may be defined as a non-science which is portrayed and advertised as a legitimate science by its followers and supporters. Good examples of a pseudoscience would include "astrology" (as presented by some of its supporters), and "creation science". (See Strahler, page 525).

SUMMARY

Science is a limited discipline that studies only naturally occurring events, while offering natural explanations for the phenomenon under study. The data must be consistent, observable, predictable, and testable, while any conclusions or theories must be tentative.

[Distribute "The Nature of Science - CONPTT" grid

CAUTION NOTE TO TEACHER: Attempting to disqualify one statement as non-scientific on the basis of one CONPTT characteristic may not be possible. Reviewing each CONPTT criterion individually may confuse the students more and they may fail to see that it is all of the criteria that must be satisfied for a statement to be validated as scientific.

After the quick attempt to create awareness for all six criteria, it might prove more helpful to return to one of the statements classified as non-scientific, and attempt to qualify it as a scientific or non-scientific statement using the entire set of CONPTT criteria.

THE NATURE OF SCIENCE -- "CONPTT" GRID
IS IT REALLY SCIENCE?
Prepared by Iowa Science Educators

CRITERIA	WITHIN THE REALM OF SCIENCE	OUTSIDE THE REALM OF SCIENCE
CONSISTENT	Experimental results and observations are the same.	Experimental results and observations are <u>NOT</u> the same
OBSERVABLE	The phenomenon (event) or evidence for the event can be observed by the human senses or by extensions of those senses.	The phenomenon (event) or evidence for the event can <u>NOT</u> be observed by the human senses or by extensions of those senses.
NATURAL	A natural cause or naturally occurring mechanism is used to explain how or why an event happens.	A natural cause or naturally occurring mechanism <u>CANNOT</u> be, or <u>IS NOT</u> used to explain how or why an event happens.
PREDICTABLE	Accurate predictions and conclusions are based on natural causes <u>NOT</u> on presupposed or assumed information.	Accurate predictions and conclusions are <u>NOT</u> based on natural causes but usually on presupposed or assumed information.
TESTABLE	Controlled experiments can be designed to test the natural cause of the event (phenomenon).	Controlled experiments <u>CANNOT</u> be designed to test the natural cause of the event (phenomenon).
TENTATIVE	Explanations (laws, theories, hypotheses) of the cause (mechanism) for the event are subject to change as evidence shows the need.	Explanations of the cause of the event in question are <u>NOT</u> subject to change.

STUDENT ACTIVITY
IS IT SCIENCE? IS IT A SCIENTIFIC STATEMENT?

During the quick review of the six criteria that determine whether something is science or not science, or whether a statement is scientific or not scientific, only one criterion was applied to each statement. To qualify as science or as a scientific statement, all six criteria must be used and all must be satisfied. Remember: If most but not all are satisfied, then one may have identified a protoscience. If none are satisfied, then one may have identified a non-science or a pseudoscience.

Take one of the statements made in class, or you may find another one on your own, and qualify it as scientific or non-scientific, based on the six CONPTT criteria. You may wish to use the THE NATURE OF SCIENCE -- "CONPTT" GRID -- IS IT REALLY SCIENCE? for reference (above). Do this assignment on the special worksheet provided.

P REDICTABLE	 <input type="checkbox"/> Within <input type="checkbox"/> Outside the realm of science
T ESTABLE	 <input type="checkbox"/> Within <input type="checkbox"/> Outside the realm of science
T ENTATIVE	 <input type="checkbox"/> Within <input type="checkbox"/> Outside the realm of science

On the basis of the CONPTT criteria, I now consider my statement to be....

scientific
 proto-scientific
 pseudoscientific
 non-scientific

Just because a statement is non-scientific, does it mean that the statement is not true?_____.

Explain your answer: