

**Goals:** Explore the nature of science to develop a deeper understanding of what science is and what it is not.

**Today's Learning Objectives:** By the end of this lesson, students will be able to:

- Justify the expert response for a range of statements on the nature of science, exemplifying a balanced view of the nature of science. (even if they don't agree with some of these expert answers yet).
- Differentiate between the 6 views of the Nature of science (Theoretical, Empirical, Anti-science, Scientism, Cultural, Balance).
- Explain, with specific examples, how science is dynamic and uncertain yet reliable, striving for objectivity yet inherently subjective, and powerful yet limited. *[students will not fully be able to do this yet, this objective continues into the next class]*

**Materials:**

NoS quiz x 31 (print)

NoS cards x 200 [not part of the ALA]

Nos card categories (post on Omnivox after class)

On board: Numbers 1-18 with spaces for me to write Agree or Disagree later

On other side of board facing away from students: card categories #1-6 with corresponding card numbers and space for students to put ticks beside

**Overview:**

**Nature of Science Quiz (20 mins):** Sitting in groups of 2-3, students individually complete quiz: A for agree, D for disagree. 10 minutes max for individual portion. When everyone in group is done, they can discuss and change any answers as they wish. While they work, I sort the NoS cards into piles of 6 per student aiming for a reasonable mix of colours.

**Card game (40):** Every student gets 6 cards. Exchanging with others, they try to make a hand of 6 that agrees with their view of science. They then pair up and combine to create a hand of 8 that they both agree on. They discard the remaining four cards. They then pair with another pair. Each group of 4 negotiates to create a hand of 6-8. When teams are finished, I expose the categories and have one student from each group come up and tally how many cards they have in each category. Discuss as a class the patterns we see on the board and what each category represents. Focus on why the balanced view is what we are striving for in our class.

**Back to Quiz (20):** Write on board my EXPERT agree/disagrees to the quiz statements. Easiest just to show the Agrees and say I disagree with the rest. Have students come up and put a mark beside my two responses that are the most contentious for them. Sit in a circle and discuss! End by writing the following on the board, to be discussed more tomorrow.

Science is...	Yet science is also...
Powerful	Limited
Dynamic and never certain	Reliable
Human and therefore subjective	Striving for objectivity
Empirical	Theoretical

**Homework:** Sometime today, post on Visual Classrooms about what new things you have learned about the nature of science and which of the quiz statements are still bugging you and why. If none of the statements are still bugging you, then instead write about which one you found the most surprising and why. Respond to at least two of your classmates' posts as well as comments on your own, before next class.

Lesson on NOS around which the quiz activity is wrapped.



## The Nature of Science Quiz

Mark **A** for agree or **D** for disagree

- \_\_\_\_\_ 1. Science is primarily a search for truth.
- \_\_\_\_\_ 2. Science can solve any problem or answer any question.
- \_\_\_\_\_ 3. Science is primarily concerned with understanding how the natural world works.
- \_\_\_\_\_ 4. Science can use supernatural explanations if necessary.
- \_\_\_\_\_ 5. A "hypothesis" is an "educated guess" about anything.
- \_\_\_\_\_ 6. Science requires a lot of creative activity.
- \_\_\_\_\_ 7. Astrology (predicting your future from the arrangement of stars and planets) is a science.
- \_\_\_\_\_ 8. Scientists can believe in God or a supernatural being and still do good science.
- \_\_\_\_\_ 9. Science is most concerned with collecting facts.
- \_\_\_\_\_ 10. A scientific fact is absolute, fixed, and permanent.
- \_\_\_\_\_ 11. Science can be done poorly.
- \_\_\_\_\_ 12. A scientific theory is merely a guess.
- \_\_\_\_\_ 13. Scientists have solved most of the major mysteries of nature.
- \_\_\_\_\_ 14. Anything done scientifically is always accurate and reliable.
- \_\_\_\_\_ 15. Scientists conduct experiments to prove hypotheses and/or theories.
- \_\_\_\_\_ 16. Science can be influenced by the race, gender, nationality, or religion of the scientists.
- \_\_\_\_\_ 17. All scientific problems must be studied with The Scientific Method.
- \_\_\_\_\_ 18. Disagreement between scientists is one of the weaknesses of science.

## EXPERT ANSWERS TO The Nature of Science Quiz

Mark **A** for agree or **D** for disagree

- D** 1. Science is primarily a search for truth.\*
- D** 2. Science can solve any problem or answer any question.
- A** 3. Science is primarily concerned with understanding how the natural world works.
- D** 4. Science can use supernatural explanations if necessary.
- D** 5. A "hypothesis" is an "educated guess" about anything.
- A** 6. Science requires a lot of creative activity.
- D** 7. Astrology (predicting your future from the arrangement of stars and planets) is a science.
- A** 8. Scientists can believe in God or a supernatural being and still do good science.
- D** 9. Science is most concerned with collecting facts.
- D** 10. A scientific fact is absolute, fixed, and permanent.
- A** 11. Science can be done poorly.
- D** 12. A scientific theory is merely a guess.
- D** 13. Scientists have solved most of the major mysteries of nature.
- D** 14. Anything done scientifically is always accurate and reliable.
- D** 15. Scientists conduct experiments to prove hypotheses and/or theories.
- A** 16. Science can be influenced by the race, gender, nationality, or religion of the scientists.
- D** 17. All scientific problems must be studied with The Scientific Method.
- D** 18. Disagreement between scientists is one of the weaknesses of science.

\*This one is very controversial amongst students and I don't push them too hard on it. I just ask them to consider that since we never know if our scientific explanations are the best (real) explanations, if we can really think we are finding the "truth." At another point in the course we do the Mystery Tube demo, which drives home the point that we can never know if our models/explanations are the real ones – it helps to refer to this if it has already been done, or when you do it, to remind students of it here.

### Card Categories

(color does not completely correspond to sections so go by the card numbers instead)

**Theoretical Emphasis:** Science is primarily a rational, theory-driven endeavor

1. Science is open-ended, but scientists operate with expectations based on the predictions of theory.
2. A theory is what scientists strive for: a large body of continually refined observations, inferences, and testable hypotheses.
3. Theories help scientists interpret their observations: facts do not speak for themselves.
4. In general, scientists plan investigations by working along the lines suggested by theories, which in turn are based on previous knowledge. Theories serve to give direction to observations, i.e., they tell one where to look.
5. A theory is a logical construct of facts and hypotheses that attempts to explain a range of natural phenomena and that can be tested in the natural world.
6. Good science cannot be done without good theories.

**Empirical Emphasis:** Science is primarily and a data-gathering, experimental endeavor in pursuit of physical evidence

7. Observation is central to all of science, i.e., seeing is believing.
8. A scientist should not allow preconceived theoretical ideas to influence observation and experimentation.
9. Unless an idea is testable it is of little or no use; thus, scientists attempt to convert possible explanations into testable predictions.
10. Careful, repeatable observation and experiment give the facts about the world around us.
11. Good science always begins with observations.
12. Science is never dogmatic; it is pragmatic-always subject to adjustment in the light of solid, new observations.
13. A phrase such as "Many scientists believe. ." misrepresents scientific inquiry because scientists deal in evidence.

**Anti-Science View:** Science is overrated. One should not give much credence to the aims, methods or results of science

14. Science is always changing and therefore is not very reliable.
15. Scientists should be held responsible for harm their discoveries have caused, e.g., pollution, nuclear weapons.
16. Earning recognition from other scientists is really the main motivation of more scientists.
17. Most of what scientists do will never be of much practical value.
18. Money spent on projects such as NASA space flights would be better spent on healthcare for the needy.
19. Science destroys values and morality by disparaging the unique nature of men and women.
20. Science and religion are fundamentally at odds.

**Scientism:** Science is THE way of knowing; it is the perfect discipline.

21. The scientific method should be followed in all fields of study.
22. Scientists and engineers should make the decisions about things like types of energy to use because they know the facts best.
23. Science is the most important way of gaining knowledge open to humanity.
24. Science knowledge is of much greater value than any other type of knowledge.
25. Only science can tell us what is really true about the world.
26. Science knowledge is always objective and self-correcting.
27. Credit for our advanced way of life must go to science and scientific progress.

**Cultural View:** Science is embedded in a social, historical, and psychological context which affects all that goes on in science

28. Funding influences the direction of science by virtue of the decisions that are made on which research to support.
29. The scientific enterprise is situated in specific historical, political, cultural, and social settings; thus, scientific questions, methods, and results vary according to time, place, and purpose.
30. The predominance of men in the sciences has led to bias in the choice and definition of the problems scientists have addressed. This male bias is also one factor in the under representation of women in science.
31. Scientific facts are manufactured through social negotiations. Nature has nothing to say on its own behalf.
32. Scientists in one research group tend to see things alike, so even groups of scientists may have trouble being entirely objective.
33. The Early Egyptians, Greeks, Chinese, Hindu and Arabic cultures are responsible for many scientific and mathematical ideas and technological inventions.
34. Until recently, some racial minorities, because of restrictions on their education and employment opportunities, were essentially left out of the formal work of the science establishment. The remarkable few who overcame these obstacles were even then likely to have their work disregarded by the science establishment because of their race.

**Balanced View:** science is a complicated affair that cannot easily be reduced to one or even a few simple descriptions – the other viewpoints have some merit but should not be taken to extremes when understanding science.

35. Science is one of several powerful ways of knowing and understanding the natural world, however, some matters cannot be examined usefully in a scientific way.
36. Science leads to generalizations based on observations or theories. Science always aims to be testable, objective and consistent.
37. As with all human endeavors science is subject to many influences both good and bad.
38. Science builds on what has gone on before and refines its conclusions, but scientific work does not result in infallible propositions, such as the word “proof” implies to a nonscientist.
39. Scientific progress has made possible some of the best things in life and some of the worst.
40. Theory and observation interact. Each contributes to the other: If theory without observation is empty, then observation without theory is blind.