# Philosophy of Science Survey

Week 3

PHIL 2160. Ohio University. Spring 2021.

# Chapter 3: Empirical Facts and Conceptual Facts

# Philosophy of Science Vocabulary

- By the end of this chapter, our philosophy of science vocabulary will have the following terms:

1. Worldviews
2. Direct and Indirect Evidence
3. Truth
4. Empirical Facts
5. Conceptual Facts

- These are *technical terms*, which we will use to analyze how science works and how it changes over time. So don't assume that they mean what they mean in an everyday context.

# Philosophy of Science Vocabulary

- What is a technical term? Why do we need it?
- Example: “line”
  - In everyday contexts, by a line, we mean a long, narrow mark.
  - In geometry, the term “line” does not have the same meaning. Rather, it has a technical meaning.
    - In Euclidean geometry, a line means a length without any width.
- We need technical terms in order to study a subject more precisely than everyday vocabulary permits. Any specialized discipline, like philosophy of science, has its own technical terms, so we need to learn them in order to understand a discipline.

# Philosophy of Science Vocabulary

Let's review

1. A worldview – an interconnected system of beliefs
2. Evidence
    1. Direct evidence – support for a believe that depends directly on sensory experience
    2. Indirect evidence – support for a belief that depends on its coherence with a worldview
3. Truth – means different things depending on theories of truth

**[Top Hat Question]**

   a. Correspondence theory
   b. Coherence theory (individualistic and group versions)

# Facts

- Remember *facts* will be our technical term. It will not mean what we mean in everyday contexts!
- Everyday (dictionary) meaning:

fact. n. “A thing that has actually happened or that is really true; the state of things as they are; reality; actuality; truth [fact as distinct from fancy]”

# Facts

Our technical meaning:

A fact is a belief that is *deeply held and well-justified* in a given context of time.

Note:

1. A fact is a kind of belief.
2. A fact is not the same as truth (in our technical sense): A fact is a belief, so it can be true or false.

# Facts

- Why should we recognize facts as a kind of belief?
- Because scientists don’t hold all beliefs in a worldview in the same degree.
  - Recall core and peripheral beliefs
  - Scientists hold core beliefs more deeply than peripheral beliefs.

# Facts

- Example:
    1. (Core) The Earth is stationary.
    2. (Peripheral) There are five planets.
- Note:

a. Each belief was well-justified in the past.
b. But scientists held the core belief much more strongly than the peripheral one.
c. Each belief turned out to be false.

- To adequately describe (a)-(c), we need a technical term.

# Facts

- To adequately describe (a)-(c), we need a technical term.
- Our desired technical term can't be the same as *truth*
  - because we want to recognize the fact that these beliefs turned out to be false. (see point c)
- Our term can't also be just *belief*
  - because we want to recognize the fact that scientists held some beliefs more strongly than others. (see point b)
- Our term can't also be just *assumption* or *opinion*
  - because we want to recognize the fact that scientists were well-justified to hold these beliefs. (see point a). (An assumption means a hypothesis, something for which we don't yet have strong evidence.)

# Facts

- DeWitt's proposal is to use a *fact* as a technical term that refers to *a belief that is deeply held and well-justified in a given context of time*.
- A fact understood in this sense is well-justified, deeply held, but can turn out to be false. So this term captures all of the points we want about our example.

# Facts

- Example:
  1. (Core) The Earth is stationary.
  2. (Peripheral) There are five planets.
- Note:

a. Each belief was well-justified in the past.

b. But scientists held the core belief much more strongly than the peripheral one.

c. Each belief turned out to be false.

- **With the technical term *facts*, we can now say that in the Aristotelian worldview, it was a fact that the Earth is stationary.**

# Empirical and Conceptual Facts

Our technical meaning (review):

A fact is a belief that is *deeply held and well-justified* in a given context of time.

- A belief is well-justified if it has good evidence for it.
- We have recognized direct and indirect evidence, so we can recognize varieties of facts based on the source of evidence.

# Empirical and Conceptual Facts

- An *empirical fact* – a belief that is deeply held and well-justified in a given context of time, and the primary source of justification is direct evidence.
- A *conceptual fact* – a belief that is deeply held and well-justified in a given context of time, and the primary source of justification is indirect evidence, that is, the belief's coherence with other beliefs of a worldview.

# Empirical and Conceptual Facts

- The pencil example 1
- You are holding a pencil in your hand, and you strongly believe that there is a pencil in your hand.
- Your belief is an example of an **empirical fact**, because:

1. Your belief is strongly held and well-justified. (That is, it is a fact.)
2. The primary source of justification is your direct sensory experience. (That is, your evidence is direct.)

# Empirical and Conceptual Facts

- The pencil example 2
- You place a pencil in a drawer and close it, and you strongly believe that there is a pencil in the drawer.
- Your belief is an example of a **conceptual fact**, because:

1. Your belief is strongly held and well-justified. (That is, it is a fact.)
2. The primary source of justification is not your sensory experience but your belief's coherence with other beliefs of your worldview, such as *the belief that we live in a world where things don't suddenly go out of existence*. (That is, your evidence is indirect.)

# Empirical and Conceptual Facts

- A note on the two examples.
- Remember that indirect evidence does not mean it's weak and that a fact is a strongly held, well-justified belief.
- So to say that a fact is conceptual rather than empirical is not to say that it is unjustified or weak.
  - You do have very good evidence that there is a pencil in the drawer. It's just that the evidence is indirect.

# Empirical and Conceptual Facts

- “Calling a fact a philosophical/conceptual fact is not to suggest that it is incorrect. . . . The distinction between empirical facts and philosophical/conceptual facts is not based on whether the facts turn out to be correct; rather, the distinction is based on the type of reasons we have for believing the fact.” (DeWitt, Ch. 3)

# Empirical and Conceptual Facts

- DeWitt also notes that the empirical/conceptual facts are not clear-cut categories. Why?
- Because a belief can be justified by both direct and indirect evidence.
- Example: “Nothing travels faster than speed of light.”
  - This is a core belief of relativistic physics. (In fact, it’s contrary to the Newtonian worldview.)
  - The belief is strongly held and well-justified.
  - The evidence is both direct (there has been no observation of faster-than-light objects) and indirect (the belief coheres very strongly with relativity theory).

# Empirical and Conceptual Facts

- There are two reasons why it's important to recognize varieties of facts (empirical and conceptual) in our technical sense of the term *facts*.

1. We can analyze a worldview in more detail by identifying the facts and seeing which facts are (primarily) empirical, and which are (primarily) conceptual.
2. We can say more precisely why the popular view about science is misleading. (see next)

# Empirical and Conceptual Facts

- Recall the popular view about science:
- "It seems to be a fairly widespread belief that the accumulation of facts is a relatively straightforward process, and that science is, in large part at least, geared toward generating true theories that account for such facts" (DeWitt, Ch. 2).
- Last week, we noted that one way in which this view is misleading is that the accumulation of facts is *not straightforward*.

# Empirical and Conceptual Facts

- We can now say why the accumulation of facts cannot be straightforward:
  1. Because there are different varieties of facts.
  2. In the popular view, “facts” presumably have the everyday meaning (i.e., same as truth). In that sense, the popular view is simply false because science doesn’t accumulate facts in the everyday sense very much. Many worldviews, including ones we are raised in, are or can be overturned.
  3. But given our technical sense of facts, we could say that within a given worldview, scientists accumulate facts (deeply held and well-justified beliefs). (We will study the historical examples of these points as we go.)

# Chapter 4: Confirmation and Disconfirmation

# Understanding Scientific Methods

- Until now, we talked about philosophical concepts (technical terms) to understand science, especially its interconnected system of beliefs.
- In the next few chapters, we will talk about philosophical concepts to understand scientific *methods*, especially how science produces and justifies beliefs and the nature of justification.

# Understanding Scientific Methods

- What is the benefit of studying scientific methods—how science produces and justifies beliefs? Is it not enough to understand those beliefs that are scientifically well-justified?
- Analogy: What is the benefit of studying methods of making beer? Is it not enough to know which beers are good or which beers you like?

# Understanding Scientific Methods

- There is nothing wrong with just knowing which beers you like.
- But when you study how beers are made, you are likely to appreciate beer more, notice subtle differences, and judge which beers are in fact worthy of praise even if you don’t like the taste.
- Similarly, there is nothing wrong with just having scientifically well-justified beliefs.
- But when you study how science produces and justifies beliefs, you are likely to appreciate scientific beliefs more, notice subtle differences among beliefs, and judge which beliefs are worth taking seriously even if you don’t like them.

# Reasoning in Science

- Scientists use reasoning to support (confirm) or reject (disconfirm) beliefs and hypotheses.
- For convenience, we'll focus on:
  - A theory (think of some interconnected set of beliefs), which we symbolize as **T**.
  - One or more observations predicted by T. We symbolize them as **O**.

# Confirmation Reasoning

- Basic Scheme (DeWitt uses a more simplified one)

1. If **T** is true, then we should be able to observe **O**.
2. We do observe **O**.
3. Therefore, **T** is *probably* true.

- (1) and (2) are called *premises*. They are the starting points of reasoning.
- (3) is called a *conclusion*. It is the end point of reasoning.

# Confirmation Reasoning

- Basic Scheme (DeWitt uses a more simplified one)

1. If **T** is true, then we should be able to observe **O**.
2. We do observe **O**.
3. Therefore, **T** is *probably* true.

- This reasoning is *inductive*, because the premises can at most increase the *probability* that the conclusion is true. (Note "probably" in the scheme.)
- We'll return to the importance of inductive nature.

# Disconfirmation Reasoning

- Basic Scheme (DeWitt uses a more simplified one)

1. If **T** is true, then we should be able to observe **O**.
2. We do not observe **O**.
3. Therefore, **T** is false.

- This reasoning is *deductive*, because in this scheme, the premises *guarantee* the truth of the conclusion (i.e., they guarantee that T is false).

# Confirmation and Disconfirmation Reasoning

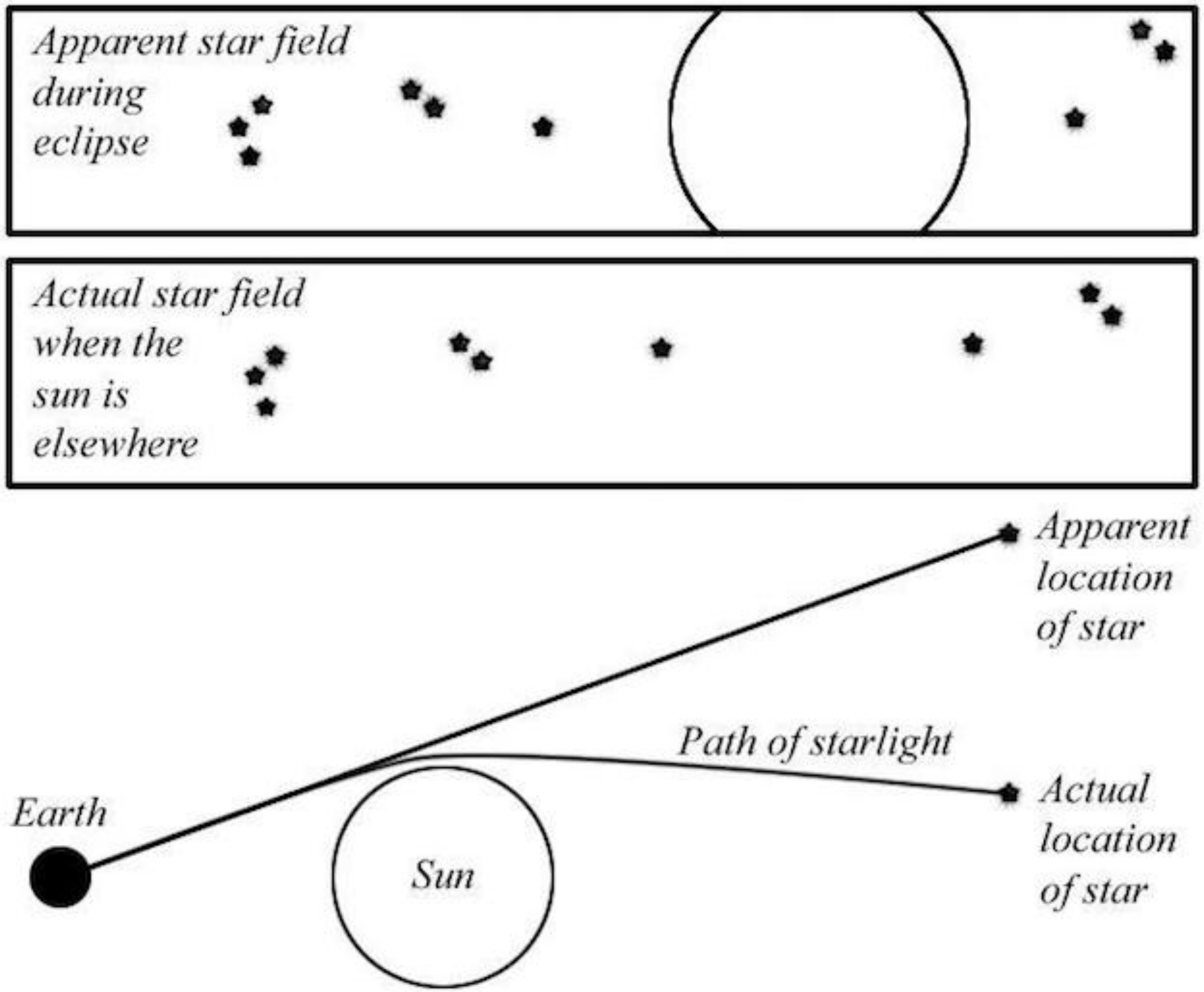
| Confirmation (Inductive) | Disconfirmation (Deductive) |
|---|---|
| If T, then O | If T, then O |
| O | Not O |
| So, probably T | So, not T |

# Quiz 1

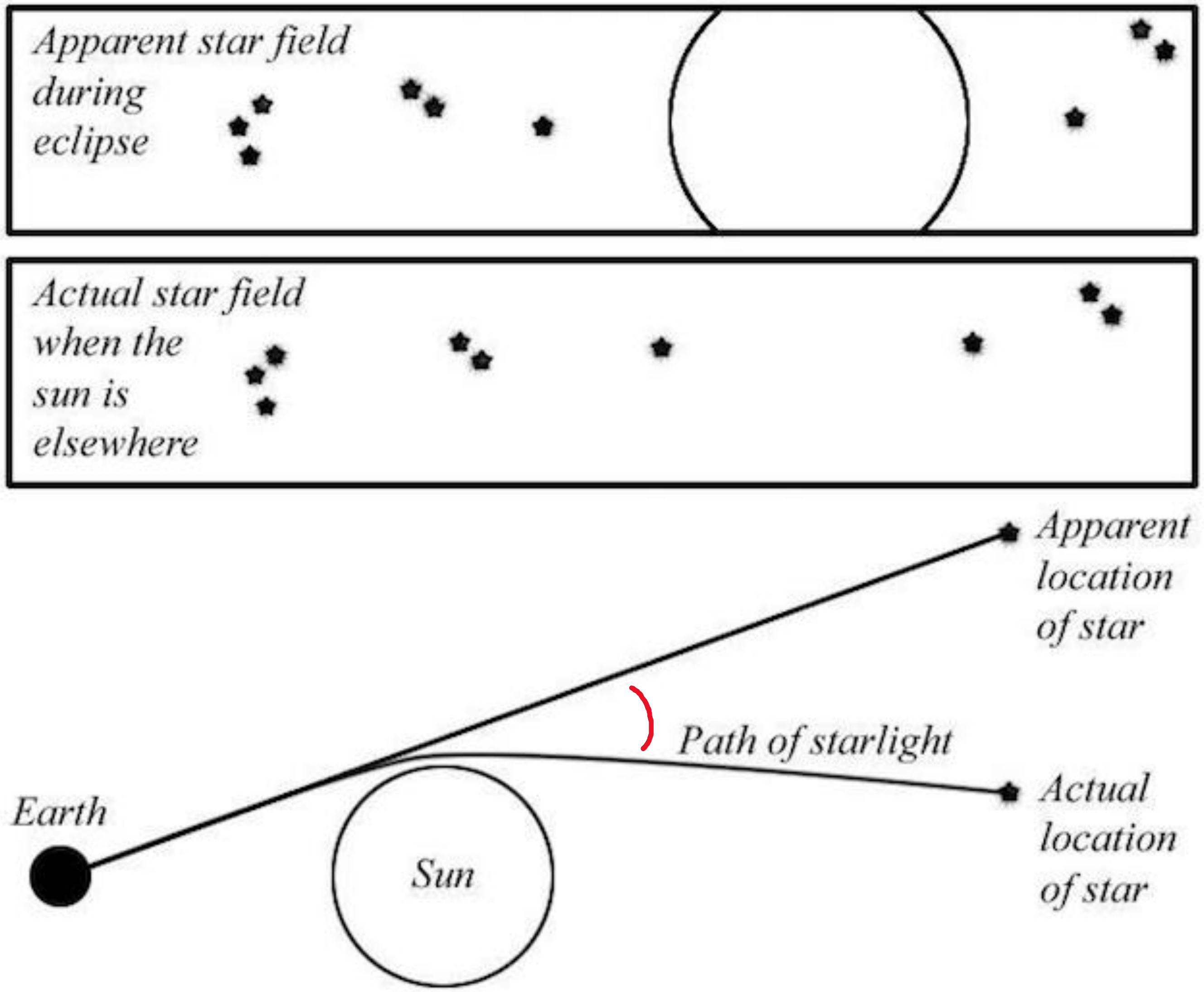
- Before looking at the examples of reasoning, let’s do a quiz.

# Prediction of Light Bending

- *Both* Newton's theory and Einstein's theory predict bending of light. (See next slide)

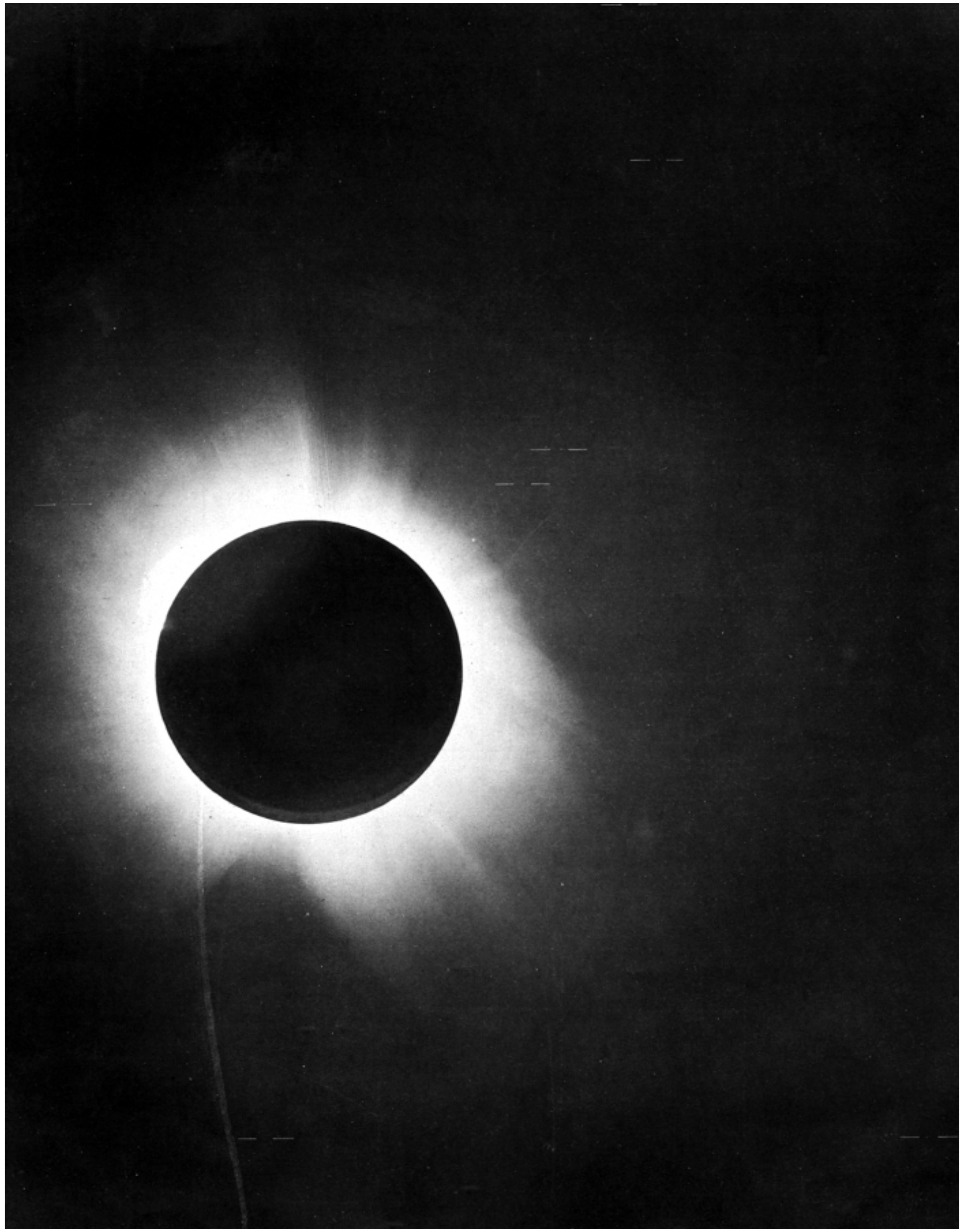



https://imagine.gsfc.nasa.gov/educators/programs/cosmictimes/online_edition/1919/gravity.html




But Einstein's theory predicted that the light bends twice more than predicted by Newton's theory. (See the angle of deflection in red.)

https://imagine.gsfc.nasa.gov/educators/programs/cosmictimes/online_edition/1919/gravity.html



Read more here:
https://www.nytimes.com/2017/07/31/science/eclipse-einstein-general-relativity.html

# LIGHTS ALL ASKEW IN THE HEAVENS

## Men of Science More or Less Agog Over Results of Eclipse Observations.

## EINSTEIN THEORY TRIUMPHS

## Stars Not Where They Seemed or Were Calculated to be, but Nobody Need Worry.

## A BOOK FOR 12 WISE MEN

No More in All the World Could Comprehend It, Said Einstein When His Daring Publishers Accepted It.

*New York Times*, Nov. 10, 1919

# Confirmation Reasoning (Example)

1. If Einstein's theory is true, the angle of deflection should be twice more than predicted by Newton's theory.
2. The angle of deflection is twice more than predicted by Newton's theory.
3. So Einstein's theory is *probably* true.

- This reasoning is inductive, so even if the premises are true, the conclusion can turn out to be false.
- But inductive reasoning can be strong (as in many cases in science) and the conclusion is worthy of taking seriously.

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Updated online: 23 September 2011

News

## Particles break light-speed limit

**Neutrino results challenge cornerstone of modern physics.**

Geoff Brumfiel

An Italian experiment has unveiled evidence that fundamental particles known as neutrinos can travel faster than light. Other researchers are cautious about the result, but if it stands further scrutiny, the finding would overturn the most fundamental rule of modern physics — that nothing travels faster than 299,792,458 metres per second.

Has OPERA found super-speedy neutrinos?
*CERN*

The experiment is called OPERA (Oscillation Project with Emulsion-tRacking Apparatus), and lies 1,400 metres underground in the Gran Sasso National Laboratory in Italy. It is designed to study a beam of neutrinos coming from CERN, Europe's premier

**Stories by subject**

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**Stories by keywords**

- Neutrinos
- OPERA
- MINOS
- Superluminal particles
- Special relativity
- Einstein
- Speed of light

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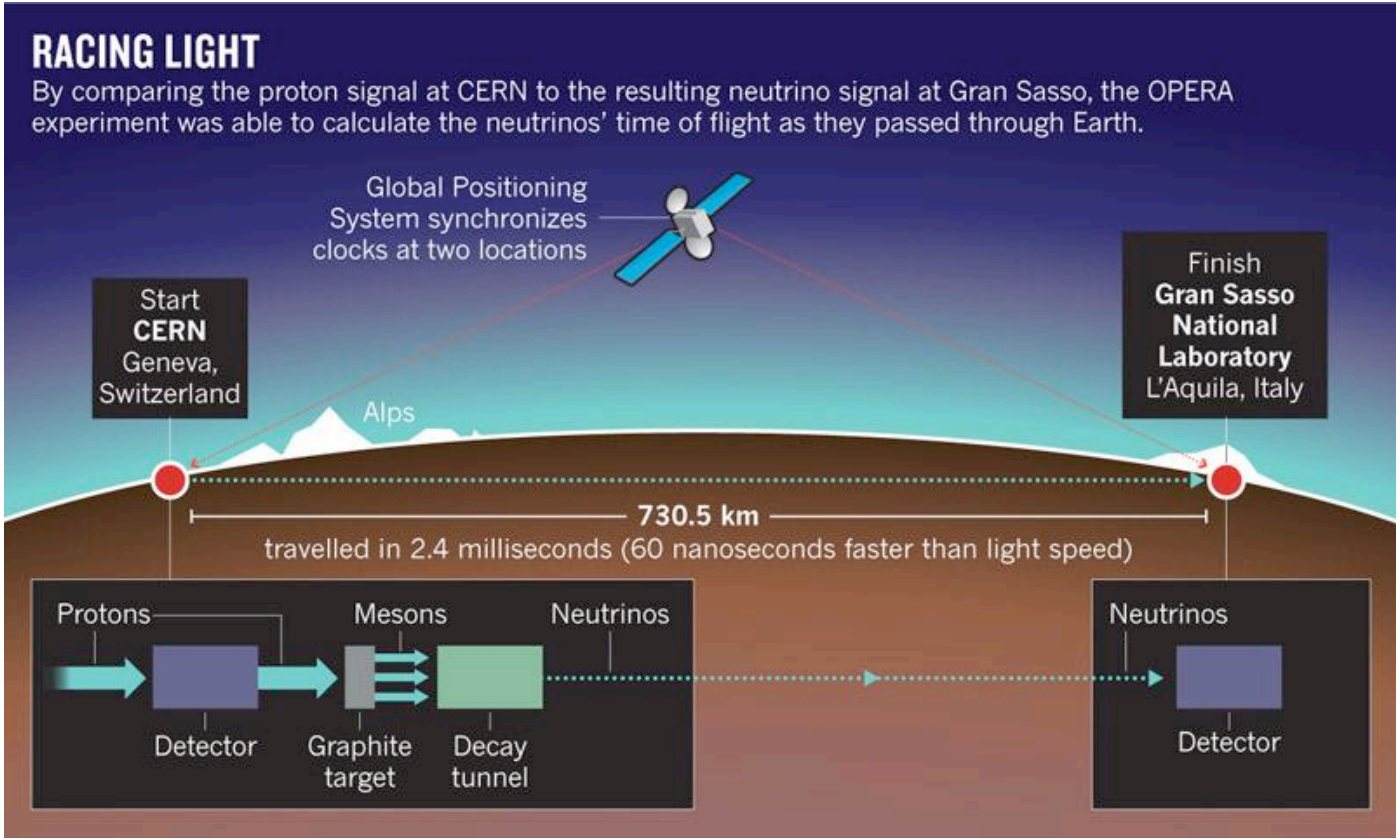
In September 2011, the scientists running the OPERA experiment (in Italy) announced that they detected neutrinos that travel faster than light.




60 nanoseconds = 60 billionths of a second = 0.00000006 s

http://www.nature.com/news/2011/110927/full/477520a.html

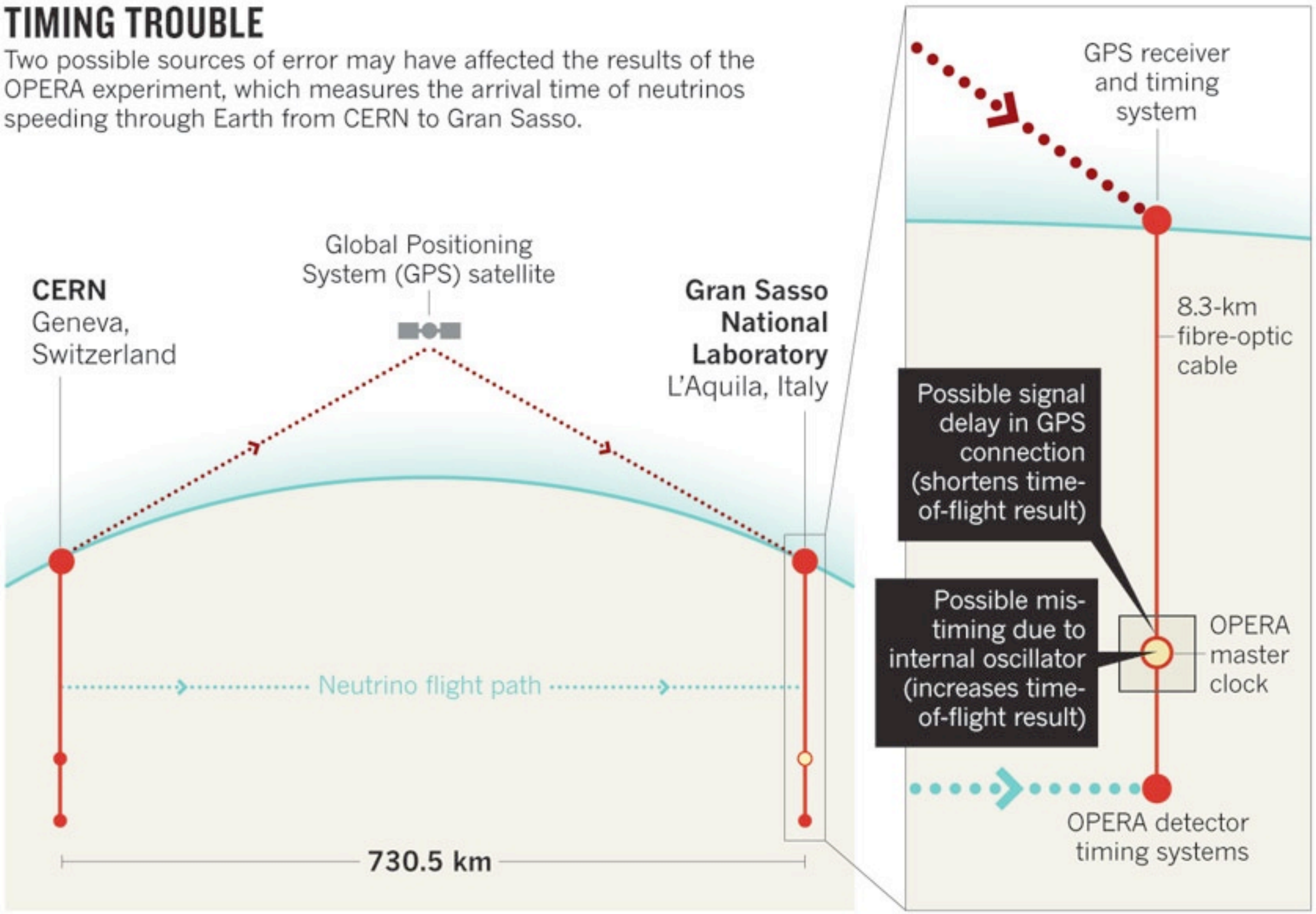
# Disconfirmation Reasoning (Example – Simplistic Version)

1. If the special theory of relativity is true, nothing travels faster than light.
2. Neutrinos travel faster than light.
3. So the special theory of relativity is false.

- Did scientists find this reasoning convincing? (No!)
- Instead of immediately rejecting the relativity theory, scientists began reexamining the experiment.
- Reexamination took several months.

# Disconfirmation Reasoning (Example – Simplistic Version)

- In February 2012, the OPERA group announced that they found two potential sources of error.
- One was a faulty connection of a fiber-optic cable that brings a synchronizing GPS signal into the master clock.
- The other was a faulty oscillator in the master clock.




http://www.nature.com/news/timing-glitches-dog-neutrino-claim-1.10123

# Auxiliary Hypotheses

- To better understand this episode, we need to recognize the role of *auxiliary hypotheses*.
- Auxiliary hypotheses are any additional assumptions needed to draw a prediction from a theory.
- In our basic schema of confirmation and disconfirmation reasoning, the first premise is *If T, then O*.
- But it's often not enough to assume only T to predict O. More assumptions are needed.

# Disconfirmation Reasoning (Refined)

1. If **T** and $A_1, \ldots, A_n$, then **O**.
2. Not **O**.
3. So, not **T**, or not $A_1, \ldots,$ or not $A_n$.

- Note that the conclusion does not say that **T** is definitively false.
- It only says, "T is false, and/or any one or more of the auxiliary hypotheses are false."

# Auxiliary Hypotheses

- Now we can better understand the OPERA case.
- The scientists reexamined their auxiliary hypotheses and found some mistaken assumptions.
- One auxiliary hypothesis was that the GPS signal is properly brought to the master clock.
    - This was wrong because of the faulty connection in the fiber-optic cable.
- Another was that the master clock is running properly.
    - This was wrong because of the faulty internal oscillator.

# Concluding Thoughts

- Scientists use both confirmation (inductive) and disconfirmation(deductive) reasoning.
- Some of you wondered why confirmation reasoning is used, since by its inductive nature, the reasoning is weaker than deductive reasoning.
- This is a good question, and we can better understand why confirmation reasoning is used if we consider what each type of reasoning allows us to conclude.

# Concluding Thoughts

- Imagine you can only use disconfirmation reasoning.
- What conclusions can you reach by this reasoning?
- You can only conclude that this or that theory (or relevant auxiliary hypotheses) is false.
- That is, you can only conclude what the world is *not* like.

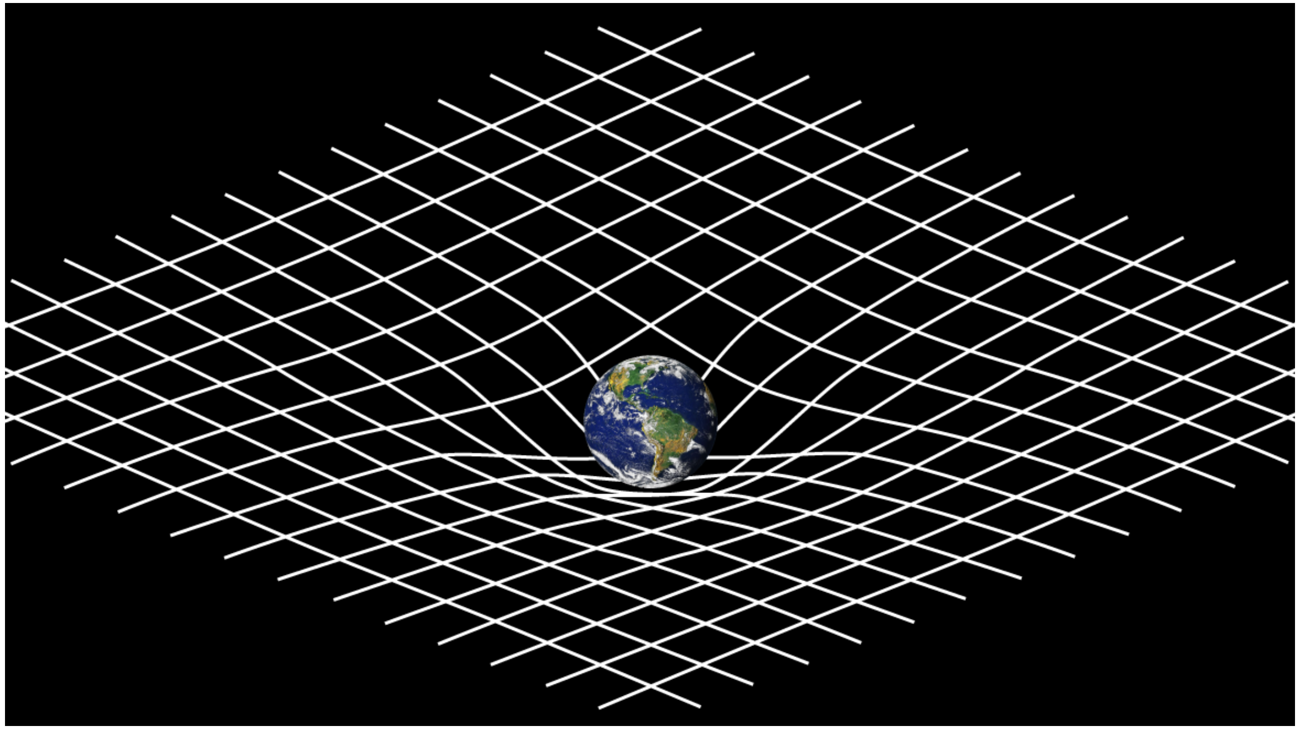
# Concluding Thoughts

- But scientists also study what the world *is* like.
- Now imagine you cannot still use confirmation reasoning but want to reach conclusions about what the world is like.
- How do you go about?
- You can use your direct sensory observations (direct evidence).

# Concluding Thoughts

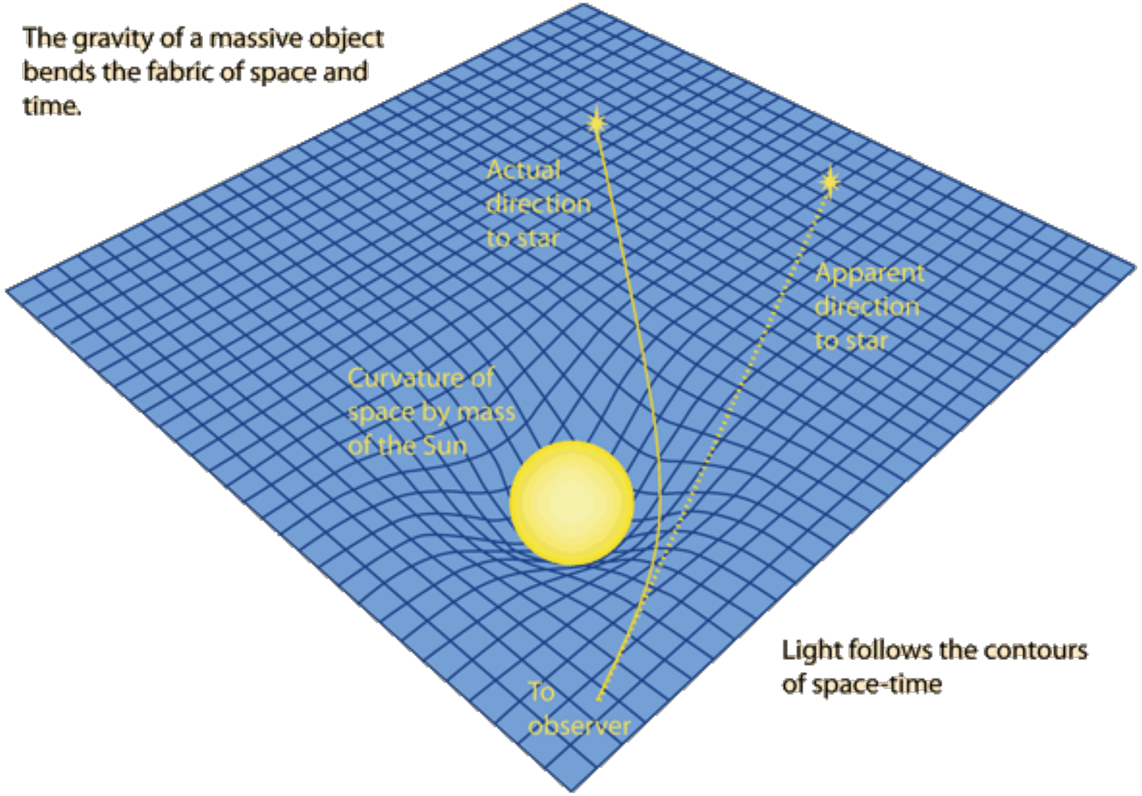
- We noted that direct evidence is limited (because our senses are limited).
- And if we can only use direct evidence, we can only study the observable parts of the world.
- But scientific theories also describe what the *unobservable* parts of the world are like.
- To do this, they have to rely on confirmation reasoning.

# Concluding Thoughts



- Revisit the eclipse example.
- Einstein’s theory describes the curved structure of spacetime.
- But we cannot directly observe curved space.

# Concluding Thoughts




- But if the spacetime is curved, light will bend in a predictable way.
- And light bending has a consequence on our observation of positions of stars.
- This observation is of course what Eddington aimed to check.

# Concluding Thoughts

- As DeWitt says (and some of you noted), a popular view is that because confirmation reasoning is inductive, scientific theories are not *proven*.
  - “Not proven” in the sense of absolutely certain.
- It is true that inductive reasoning does not provide a proof in this strong sense.
- But “not proven” does *not* mean “have no support or justification”!

# Concluding Thoughts

- "The fact that theories in science cannot be shown without a doubt to be correct is no flaw of such theories, nor is it any defect in science itself." (DeWitt, Ch. 4)
- The popular view expects that science must be in the business of providing proofs.
- When we learn that science does not meet this expectation, the conclusion to draw is that the popular view does not characterize the nature of science accurately.