A Glossary of Precise Scientific Terms

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This presentation is freely available from www.sticksandshadows.com. Contact the author at heafnerj@sticksandshadows.com.

2

This presentation was created in conjunction with the LCTTA textbook project.

3

The purpose of this presentation is to present a glossary to accompany LCTTA.

4

I include an abstract.

Abstract

A glossary is presented within the context of a new astronomy textbook designed around critical thinking. Though intended for astronomy, the glossary should be applicable to any introductory science textbook.

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Purpose?

- to emphasize awareness of the importance of terminology
- not to write a treatise on the philosophy of science

I'm not trying to rewrite philosophy or psychology here. I'm not qualified to do either! I'm trying to emphasize that scientists' refusal to use terms consistently both within and outside of the scientific community causes avoidable problems for students and laypersons. These problems aid the public in undermining science.

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accept

- to treat a claim or argument as true based on supporting evidence; synonym of know
- compare with believe

7

I have advocated a distinction between “believing” and “accepting.” The latter is based on evidence and the former is not.

argument

- a premise followed by a conclusion

8

This is very simplistic and not intended to overrule more precise definitions from formal logic. I want to emphasize the difference between a “claim,” which contains no logic, and an “argument,” which may be proposed as an explanation.

argument

- premise indicators: because, given that, since, assuming that, as indicated by, inasmuch as, in view of the fact that
- conclusion indicators: therefore, thus, consequently, as a result, it follows that, we can conclude that, so, hence

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There are many indicators that signal a premise or a conclusion. This list is by no means exhaustive. Indicators are not required and are frequently omitted.

argument

- Most scientists are atheists. Therefore, Joe is an atheist.
- I do not understand quantum physics. Therefore, it must be wrong.

10

Notice that there is a premise and a conclusion. The idea is to ascertain whether or not the conclusion follows logically from the conclusion.

belief

- similar to an opinion, but not necessarily formed by the individual; possibly created by **another person or group of persons**

11

Again I used the OED for help here, with the emphasis on creation by other people. This is especially true of religious beliefs.

believe

- to treat a claim or argument as true without any supporting or contradictory evidence
- compare with accept

12

I have advocated a distinction between “believing” and “accepting.” The latter is based on evidence and the former is not.

claim

- a statement or judgement

13

It's that simple.

claim

- Einstein got general relativity wrong.
- Protons may someday travel at superluminal speeds.

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In science, a claim isn't evaluated on whether it is true or false. Notice that there is no logic included in a claim since there is no conclusion to be drawn.

critical thinking

- the set of skills necessary to evaluate the validity of evidence and the resulting conclusions based on that evidence
- no universal definition (AFAIK)

15

I've not found a universally accepted definition of critical thinking, so I attempted to formulate my own.

doubt

- refusal to accept for fear of being wrong
- refusal to accept with the intent to discredit

16

To be precise, doubt must not be confused with, or equated to, uncertainty. The former is frequently used as a tactic to discredit science. The latter is present in all scientific endeavors, and is not inherently a reason to discredit science. The phrase “exact science” must be avoided because there is no such thing.

evidence

- information that either supports or contradicts a claim or argument
- evidence can sometimes support an invalid or faulty claim or argument

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This was difficult to define. I welcome suggestions for improvement. The second point is intended to flag situations such as a “meteor shower umbrella.” You can show statistically that an umbrella will protect you from meteorite strikes, but the probability of being struck by a meteorite is small to begin with.

fact

- evidence that is repeatable and reliable to the extent that it is taken as general knowledge

18

This was especially difficult to define. I am not convinced I got it correct. I welcome suggestions for improvement.

fallacy

- an error in reasoning or an error in logic that may or may not lead to an incorrect conclusion

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Defining this word is not a problem. The problem is that very few if any introductory science students ever get exposure fallacies and how they are used to subvert science.

fallacy

- Dr. Smith is a bad scientist because he's not a Christian.
- I saw a meteor just before moonrise. Therefore, the meteor caused moonrise.
- too many to list!

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Here are examples of common fallacies. The Baloney Detection Kit provides many more.

falsifiable

- having one possible outcome of experiment or observation that conclusively shows an argument to be false
- a argument that can only be shown to be true is a **tautology**

21

This definition is straightforward. Note that falsification has nothing to do with whether the claim is correct or incorrect (I deliberately do not use "true" and "false" here to avoid associating "falsifiable" with "false").

falsifiable

- A pen falls in agreement with Newtonian physics.
- Physical laws may be different in different parts of the Universe.

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Examples of falsifiable and unfalsifiable claims.

framework

- rules defined both explicitly and implicitly by a set of scientifically valid hypotheses, models, and theories
- defines what questions can and cannot be asked, and therefore, answered

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Students have difficulty understanding this term. I've begun using chess analogies, remembering that all analogies are imperfect. Each chess piece can move on the board according to certain rules. These rules form a framework that allows us to ask questions like, "Can the knight capture the pawn two squares up and one square to the right?". This same framework disallows questions like, "Can the knight capture the pawn three squares up?" The second question is disallowed because the framework formed by the various pieces' movement rules do not permit it. Therefore, all questions about moving a knight three squares in a row are disallowed by the framework.

hypothesis

- a claim or argument put forth in a form that makes it testable and falsifiable

24

Testability and falsifiability form the cornerstone of scientific validity. Both criteria must be met.

hypothesis

- Humans will never set foot on Moon. (Hewitt)
- There may be laws that scientists can't discover. (Hewitt)
- Carl Sagan was an atheist. Therefore, his scientific work is invalid.

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Examples of valid and invalid claims and an argument.

indoctrination

- education without supporting evidence

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Education without supporting evidence is indoctrination at best, and propaganda at worst.

laws of nature

- the collection of internally consistent models, supported by observational and experimental evidence, forming a conceptual framework that allows us to describe everything we currently understand about a subset of naturally occurring phenomena and allows us to make testable predictions about the remaining naturally occurring phenomena we do not yet understand, but are likely to eventually understand

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This definition is designed to address the issue of which questions are allowed and which are not. I thought long and hard about this definition.

laws of nature

- By this definition, the laws of nature are mutable and ever better approximated as models are improved.
- Scientists don't know the ultimate laws of nature. We only find better and better approximations to them based on our understanding.
- The framework defines which questions are acceptable and which are not.

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Here are some important qualifications to the previous definition. Note that Quinn asserts that the laws of nature are immutable and everlasting. I think what she calls the "laws of nature" are what I refer to as the "ultimate laws of nature."

misconception

- conclusion(s) based on incorrect reasoning or faulty evidence

29

This word gets bandied about in educational circles but I have yet to see it properly defined.

misconception

- lunar phases caused by Earth's shadow
- seasons caused by variations in Earth-Sun distance

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Here are examples of misconceptions that any introductory astronomy course should eliminate.

model

- a collection of one or more internally consistent hypotheses that constitutes an explanation for some observed natural phenomenon and that generates testable predictions about that phenomenon
- models may have limited scope and may be replaced by better models over time
- "better" is subjective

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Models may also provide a description (as opposed to an explanation) for a natural phenomenon. The qualifier "better" could mean "more efficient", "more expedient", or "more accurate" or even something else.

model

- Ptolemaic model of solar system
- Copernican model of solar system

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Here are two examples of scientific models.

natural phenomenon

- an event, occurrence, or process that can be explained with testable and falsifiable arguments

33

This was difficult to define! I welcome suggestions for improvement.

natural phenomenon

- lunar phases
- variation in a tree's shadow

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Here are two examples of simple natural phenomena.

Occam's Razor

- Given two or more models that explain a natural phenomenon equally well, Nature prefers the simplest model.
- "equally well" means all current evidence must be accounted for

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The "equally well" part is frequently overlooked. Understand that it is a necessary part of the definition. "Simplest" means "containing the fewest ad hoc assumptions."

Occam's Razor

- Global climate change is a conspiracy among left-wing scientists to control the world. All scientists are in on it.
- Global climate change is real.

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Of these two explanations, the former requires more ad hoc assumptions than the latter. Thus, Occam's razor would have us choose the latter explanation.

open-mindedness

- willingness to accept any **scientifically valid** model and to stay within **established frameworks**
- when taken beyond scientific validity, open-mindedness becomes gullibility

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The difference between open-mindedness and gullibility must be emphasized. It's also important to understand that the restrictions of open-mindedness do not inhibit creativity! Quite to the contrary, scientists are among the most creative people on Earth.

opinion

- a **personally** held judgement that is not necessarily supported by evidence, but is formed by the **individual**
- opinions are neither valid nor invalid, merely a statement of **personal** judgement formed by the **individual**
- opinions may be relevant or irrelevant; Nature doesn't care about our opinions

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I spent a lot of time thinking about this word and incorporated the OED's definition into mine, with the emphasis of the personal nature of an opinion. Are all opinions equal? Is everyone really entitled to an opinion? Is everyone entitled to express that opinion? Should some opinions carry more weight than others? Which opinions should be ignored? Which opinions should be heeded?

philosophy

opinion

- ~~theory~~ or attitude held by a person or organization that acts as a guiding principle for behavior
- this is from the OED

39

I now distinguish between "religion" and 'philosophy" since I think they can be, but are not often, detached from one another.

religion

- the belief in and worship of a superhuman controlling power, especially a personal God or gods
- this is from the OED

40

I thought long and hard about this word, but the OED seems correct.

science

- the process of describing or explaining a natural phenomenon by applying successively better models
- "better" is subjective
- all natural phenomena have scientific explanations

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I think my definition of science is equivalent to that of the AAPT. I am concerned about the possibly circular definition of "natural phenomena" here.

supernatural phenomenon

- an event, occurrence, or process that can only be explained with untestable and unfalsifiable arguments

42

This too was difficult to define! I welcome suggestions for improvement.

supernatural phenomenon

- miraculous medical recoveries
- eclipses caused by dragons eating Sun

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Here are two examples of supernatural phenomena.

testable

- having some experiment(s) that can be performed or observation(s) that can be made in an attempt to verify an argument, with at least two possible outcomes

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I am not entirely comfortable with this definition, but it is the best I could come up with. Are two outcomes really necessary? Is one outcome sufficient?

testable

- A shadow's behavior is influenced by Sun's position in the sky.
- Aliens first brought life to Earth.

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Examples of testable and untestable claims.

theory

- a model that has survived repeated testing to the extent that it is generally accepted as correct even though it is always subject to further testing

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This is one of the most misused words in all of science. Scientists caused this problem and scientists should fix it!

theory

- theory of relativity
- theory of evolution

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Here are two examples of correct usage of “theory.” I have advocate replacing “theory” with “accepted body of knowledge” in introductory science textbooks.

uncertainty

- inherent inexactness present in all scientific endeavors

48

To be precise, doubt must not be confused with, or equated to, uncertainty. The former is frequently used as a tactic to discredit science. The latter is present in all scientific endeavors, and is not inherently a reason to discredit science.

DIFFICULT!
NECESSARY!

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I have learned two things. Defining terms precisely is difficult. Defining terms precisely is necessary, especially in introductory science. It is a neglected issue long overdue for correction.

References

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Thank you!

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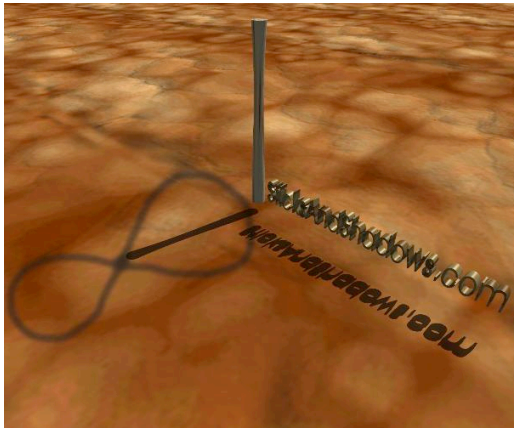

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