CAN WE EVER BE ABSOLUTELY CERTAIN THAT A SCIENTIFIC THEORY IS TRUE?

In this lesson, you'll learn the answer to the following questions:

1. What are the differences between **analytic** and **synthetic** statements?
2. What are some examples of analytic and synthetic statements? What parts of science deal with each type of statement?
3. Is it possible to have absolute knowledge of analytic statements? Synthetic statements? What does this entail about the limits of science?
4. What is the **problem of sense perception?**
5. What is the **problem of induction?**
6. What is the **problem of the theory-ladeness of observation?**

As we've seen, the scientific mosaic—that is, the set of scientific theories supported by the scientific community—has changed radically over last 600 years. In astronomy and physics, the ideas of Aristotle were supplanted by those of Newton and these, in turn, were supplanted by those of Einstein. Moreover, it's tough to overestimate just how radically different these "worldviews" really area. So, for example, when it comes to the case of physics and astronomy, its not simply that Aristotle, Newton, and Einstein disagreed on the value of certain constants, or on which equations should be used where. They disagreed on fundamental questions about what the universe, and things in it, really *are,* and what our relationship to them was.

From Aristotle's time until well after 1500, physics (and science more generally) was the study of the "essences" of different types of things, whether this be the four (or five) elements, animals, or even human beings. For Newton and his successors, science meant uncovering the mechanical laws by which dumb, inert matter was "pushed" and "pulled" around. Finally, in the modern era after Einstein, the "fields" described by modern physical theories could be described *only* by complex mathematical models, and both the relationships between these different models (e.g., of quantum mechanics and general relativity) and the physical "meaning" of these models was opaque in a way that would have been unimaginable to scientists from previous epochs. Moreover, this is just one part of science! Similar changes happened (often over much shorter intervals) in biology, psychology, economics, and many other areas.

Given the history of continual scientific change, we're in a place to ask our first truly philosophical questions of class: How sure can we be that our *current* theories are correct? Or, more broadly, **can we ever know (with absolute certainty) that a given scientific theory is true?** It is to this question we now turn.

Question: Try to give examples of statements (ideally, statements related to science) that you'd classify according to the following (1) I'm (nearly) certain it's false, (2) I think that it's false, but it could be true, (3) I think that it's true, but it could be false, and (4) I'm (nearly) certain it's true.

ANALYTIC VS SYNTHETIC STATEMENTS

Both Aristotle and Newton believed strongly that (1) absolute certainty was possible in science, and (2) there theories were examples of things that we could be absolutely certain of. We've already said that modern science contradicts the result of (2). However, perhaps more surprisingly, it also contradicts (1). Einstein, for instance, did NOT claim that we could be absolutely certain that General Relativity was true. In fact, he notably claimed that we could be certain that his own theory was (at least in part) false! Moreover, this sort of attitude is now almost universal among not only historians and philosophers of science, but also most research scientists. Why is this?

To begin answering this, it will help to distinguish between two fundamentally different sorts of statements (or propositions):

An **analytic statement** is a statement whose truth is determined *entirely by the meanings of the words within it.* So, for example "1 + 1 = 2" is analytic and true since the number "2" is *defined as* "1 + 1". Other classic examples include "All white things are white," "All bachelors are unmarried", "All triangles have three sides," or "If Bob is shorter than Bonnie, Bonnie is taller than Bob." Many statements of mathematics and logic are analytic.

- Other ways of expressing this same idea: An analytic statement is one that could NEVER be disproven by any possible experiment or observation. Or, an analytic statement is one that is true in EVERY possible imaginable world.
- The truth of analytic statements is generally determined by some sort of logical or mathematical proof. In this way, we *can* have absolute knowledge of analytic statements. However, this is an empty sort of knowledge, since it doesn't actually tell us anything about what our world is actually *like.* That is, we can be sure that triangles have three sides, and that bachelors are unmarried. We just can't tell whether there are actually exist any triangles, or whether anyone is actually unmarried!

A **synthetic statement** is one whose truth or falsity is determined, at least in part, by the way the world is. So, for example, “Geese have feathers” is synthetic. So are statements like “All swans are white,” “Bob is a bachelor” or “Bonnie is taller than Bob.” Other synthetic statements include “apples fall to the ground if dropped”, “water will boil if heated to 100 degrees Celsius” or “my neighbor isn’t a werewolf.”

- Other ways of expressing this same idea: synthetic statements are ones that COULD be disproven by some imaginable observation. (So, I might see my neighbor turn into a werewolf). Or, equivalently, they are false in at least ONE possible world (even if they happen to be true in *our* world).
- The truth of synthetic statements can only be determined by experience. So, for example, the only way I cans determine whether geese have feathers is to somehow examine geese (or at least consult someone else’s report of someone else’s examination of geese), and the only way to determine whether Bonnie is taller than Bob is to somehow measure them. This feature of synthetic statements will have big consequences for science.

Are Scientific Theories Synthetic or Analytic? Now, let’s move on to a tougher case, and consider the sorts of statements that form the heart of the scientific theories we considered earlier, such as Newton’s law of gravitation: $F_G = G\frac{m_1 \times m_2}{d^2}$. Is this statement analytic or synthetic? While it looks sort of math-y (which might give us hope that it is analytic), a moment’s thought will show us that it *has* to be synthetic. After all, it is not part of the *definition of mass* that it has to obey a law of this form. In fact, as Einstein showed, the massive objects in our world don’t even follow this law. So, we can clearly imagine possible worlds where it is false. Something similar can be said about Aristotle’s proposition regarding the natural motions of elements, and of Einstein’s statements of relativity.

As a rule, we’ll say that a scientific theory as a whole is analytic only if EVERY proposition of the theory is analytic. There are such theories, but they are limited to the **formal sciences,** mainly limited to mathematics and formal logic. By contrast, the **empirical sciences** (basically everything we call **natural science** or **social science,** such as physics, chemistry, astronomy, biology, etc.) are synthetic, since they involve at least ONE synthetic statements. Since the empirical theories are synthetic, they must ultimately be justified by *experience.* And this, in turn, will make absolute knowledge impossible.

Question: Can you give examples of (a) a synthetic statements that is true, (b) a synthetic statement that is false, and (c) an analytic statement that is true. Now, explain why you can NOT give example of (d) an analytic statement that is false.

THREE PROBLEMS FOR ABSOLUTE KNOWLEDGE IN EMPRICAL SCIENCE

Synthetic statements, and the empirical theories that the contribute to, are ultimately justified by experience. So, for example, let’s suppose my theory is “All swans are white” (a perennial favorite of philosophers). How could I determine whether this theory is true or false? I’d have to make observations! Maybe these would be observations of particular swans—e.g., “Swan 1 is white”, “Swan 2 is white”, “Swan 3 is white”, or so on. However, maybe these observations are more complex: “I read a book that said all swans ever observed so far are white,” or “I obtained a swan’s DNA, did a fancy genetic analysis, and got the following result…this explains why all swans are white.” I might well all of these statements (rightly!) as support for my theory. However, have I *proven* that my theory is correct—can I be *absolutely certain* that there’s no “black swan” to be encountered sometime place far away or a long time in the future? No! (As it turns, there ARE black swans in Australia, which was quite a surprise to the early scientists who though all swans were white!).

This problem—the possibility of a given theory of empirical science might be proven false—is universal. There are a number of arguments for showing this. However, we’ll focus on just three: the problems of sense-perception, induction, and theory-ladeness of observation.

The Problem of Sense-Perception. Empirical science requires that we use evidence about things that we *observe* in order to draw conclusions about what *really is the case.* However, this is not an inference that comes for free! Consider the difference between statements 1-3 and statement 4:

1. “I see a white swan ten feet in front of me.”
2. “I asked my friend what she saw, and she also saw a white swan ten feet in front of me.”
3. “I have a dog who I’ve trained to only bark at white swans; she barked at the swan.”
4. “There really is a white swan in front of me.”

The first three statements about things I observe—what I see, hear, etc. The last statement is about what is *really the case.* However, the truth of 1-3 do not guarantee the truth of 4. That is because our senses can mislead us. For example, perhaps we are dreaming, or it is dark, or there is a combination of factors (“My friend and I drank a bit too much, and walked home late at night. We both mistook a goose for a swan! My dog got so excited he began barking…”). Moreover, we can go further than this. If we are really interested in ABSOLUTE certainty, than we need to rule out EVERY possible source of error. Rene Descartes (who offered perhaps the most famous version of this argument) gave the following example: Is there any sense-perception so secure that it couldn't be faked by an evil demon intent on tricking me? It sures like there isn't[i].

The Problem of Induction. OK, so let's assume we've solved the problem of sense-perception. A second problem comes from the philosopher David Hume[ii], who pointed out there are two fundamentally different sorts of reasoning we engage in, both in science and every day life. **Deductive reasoning** involved "proving" that a conclusion was true from a set of premises. So, for example, if I already know that "all swans are white" than I can (deductively) reason that "The next swan I see will be white." In our earlier terms, we can say that a statement expressing a deductive inference ("If all swans are white, this swan is white" is analytically true. This sort of reasoning is widespread in mathematics and logic. However, empirical science also crucially involved **inductive reasoning,** which involves making inferences that are not analytically true. So, for example, consider the following inference (the reverse of the one we just considered):

1. All of the swans I've seen in the past have been white.
2. So, the next swan I'll see will be white. (Or more, ambitiously, "all swans are white.")

A statement sort of inference ("X has been true so far; so, X will continue to be true.") is most definitely NOT analytic. Of course, as Hume recognized, we could make it analytic by including a new premise, as follows:

1. All the swans I've seen in the past have been white.
2. The future will be like the past. (Alternative version: "the parts of nature I haven't yet observed will be like the parts I have observed.")
3. So, the next swan will be white as well.

The problem here is to just premise 2, which is just another synthetic claim: *Why* should I think that the future will be like the past, or that the swans I haven't yet observed will be like those I have observed? I, of course, can say something like "Well, *in the past,* the future has usually been like the past." But this is just going in a circle! And as well all know, sometimes the future is NOT like the past; how can we tell when this is going to happen?

In the end, this is probably the CENTRAL problem in history and philosophy of science, and there's no agreed upon solution to it. For example, let's consider a much concerning version of the argument (based on one given by Hume):

1. In the past, the sun hasn't exploded and engulfed the Earth, killing all living beings.
2. So, the sun won't explode tomorrow.

According to our best scientific theories, it's really unlikely that the sun will explode tomorrow. However, these theories are *themselves* just based on what we've observed in the past. So, in the end, we can't be absolutely certain that our theories are correct. (And, in fact, it proves to be very, very difficult just to say something sensible about "how" certain we can be that our theories are correct).

The Theory-Ladenness of Observation. The final problem for absolute knowledge springs from the fact that (1) as humans, we are never perfectly "neutral" observers of the world—we always believe in some theory or other of the world (if we didn't, we couldn't function!) and (2) these theories will affect both the things we observe and the way we interpret those observations. However, this can cause problems for when we are trying to show how the evidence "objectively" supports one theory over the other. For example, consider Galileo (who got in trouble for defending Copernicus's sun-centered theory, among other things). His evidence for this theory rested, in large part, on observations made with the improved telescope that he himself had made. So, for example, he assumed "I can see moons of Jupiter through the telescope" to be more or less equivalent to "I can see moons of Jupiter." However, this is itself a theoretical claim, based in part on the theories of optics that made construction of the telescope possible (and indeed, defenders of the Aristotelian view attacked Galileo on just this point). Thomas Kuhn[iii], who is something like the "father" of modern history of science, went further than this, and claimed that even basic ideas like a "observing a pendulum's motion" (central to Galileo's scientific breakthroughs) were themselves theory-laden.

So Does This Mean All Theories Are Equal? There can be a temptation to conclude from the above problems that all hope is lost, and that any theory is as good as any other. And indeed, in their most challenging passages, some of philosophers and scientists that helped formulate these problems (including Rene Descartes, David Hume, and Thomas Kuhn) sometimes consider arguments that this might be the case. However, the much more common view (and one we'll be considering in later classes, if you stick with us!) is that these arguments show only that our knowledge of empirical science is **fallible.** That is, no matter how good of evidence we have, we *might* be wrong. However, this still allows plenty of room to make claims like the following "Einstein's theory of relativity is *better supported* by the evidence that is Aristotle's theory of natural motion."

QUESTIONS FOR REVIEW

We've covered a lot of stuff here. Consider a scientific theory that you are familiar with, at least in passing. Now, answer the following questions to the best of your ability.

1. What are some of the key synthetic propositions in this theory? (That is, what does this theory say about the world?)
2. How does this theory differ from older theories about this same phenomena?
3. What are some of the observations that might provide evidence for this theory?

OK, now its time to play the skeptic. Explain how you might use each of the following arguments to show why we can't be *absolutely certain* the theory is true.

4. The problem of sense perception.
5. The problem of induction.
6. The theory-ladenness of observation.

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[i] Descartes "solved" this problem by offering one of the most famous circular arguments of all time. It goes something like the follows: "The reason I can be sure that (1) anything I *clearly and distinctly* perceive is true is because (2) I can *clearly and distinctly* perceive that an all-good, all-powerful God exists, and (3) this sort of God wouldn't let me tricked!" The problem here is that his justification for (2) relies on his already having solved the problem in 1!

[ii] David Hume, *An Enquiry Concerning Human Understanding: With Hume's Abstract of A Treatise of Human Nature and A Letter from a Gentleman to His Friend in Edinburgh*, ed. Eric Steinberg, 2nd ed. (Indianapolis: Hackett Publishing Company, Inc., 1993).

[iii] Thomas S. Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, 1970).