## 9.4 Scientific Method

When you look at the development of early modern science, it quickly becomes clear that at the heart of the new enterprise was *method*...[However,] Today there is no single scientific method...The procedures of inquiry among theoretical physicists are different from those among experimental physicists, and the methods of psychology and sociology are different from those of primatology, ornithology, and astronomy...

[Notwithstanding,] Empirical scientific method is...committed to empiricism, in the sense that scientific claims must be grounded in observation. Not just any observation may count as the sort proper to underwrite scientific claims. The observations with which science is concerned must be the kind any normal human observer can make and that are therefore open to confirmation by others... [And yet,] science can investigate not only what is *actually* observed but can also make claims about what is *unobserved* and even *unobservable*. In fact, it does so all the time. While ghosts may not meet the conditions for scientific investigation, science does make meaningful claims about magnetic fields and electromagnetic spectra (such as X-rays) that are beyond the range of human observation, such as dark matter... That's because claims about those unobservable entities are associated in precise ways with observations that can be currently made and shared...

### Verification and falsification

Observation, in short, plays a crucial role in deciding whether or not some claim or *hypothesis* is true....We might understand verification to work this way: *If the hypothesis is true, then the predicted result of the experiment takes place.* 

### True hypothesis $\rightarrow$ Prediction comes about

For example: *if the hypothesis that caesium reacts with water is true, then this piece of caesium explodes when placed in this water*. This seems right given our immediate intuitions about experiments. But if we think of verification this way, it's technically possible for the conditional to be true where the caesium explodes while the hypothesis is nevertheless false. (That is, the hypothetical as a whole can be true even if the antecedent – the hypothesis – is false and the consequent true, as you'll recall from [studying] conditionals...) For example, it might be the case that caesium explodes when it is exposed to light refracted by water and not by the water itself. If that were the case, this logic would yield something like a false positive verification...

Worries like these have led some to conceive of science as a process of *falsification* rather than verification. Falsification, indeed, works very well for the general and universal claims commonly investigated by science. We can easily falsify the claim that "all light travels at 100m/sec" by conducting a test that shows an example of it traveling at another speed. We can falsify the claim that "All swans are white," simply by finding just one black (or non-white) swan...

So, falsification shows us what is false. In this way, as the philosopher of science Karl Popper argues, science works like natural selection in biological evolution, eliminating

maladaptive hypotheses through falsification. There's something disappointing about this thought, at least for those who think science finally settles questions. Falsification doesn't prove anything to be *true*. Although we can easily disprove it, we cannot fully prove that "*all* light in space travels at 299,792,458 meters per second" – as modern physics holds. This way of thinking about scientific method renders science methodologically *open* in a sense – which for those who don't require final answers is actually one of the best things about science. Unlike religious dogma, science always stands open for more testing to be done and always allows the possibility that new testing will falsify what has so far passed our scrutiny. Now, in practice, many scientists would say they're engaged with a combination of falsification and verification, accepting the limits of doing so. But in light of the logical complexities of verification and falsification, it seems reasonable to say that to the extent scientific inquiry proves anything, it does so *only in provisional ways*. Even the central idea in physics that nothing travels faster than light has been challenged (albeit still unsuccessfully) by recent experimental findings regarding neutrinos. Those who think that in modern science anything has been proven once and for all just don't understand science....

# 9.5 Unfalsifiability and Falsification Resistance

### Ad hoc hypotheses and the fallacy of unfalsifiability

[T]he fallacy of *unfalsifiability* occurs when an arguer [supplements] his or her definition of a term, concept, or worldview in an *ad hoc* manner in [a way that protects it from falsification]...

Imagine Sarah says to you: "There is an elephant in this room." And you say, I don't see an elephant." Sarah might respond, "Oh, it's an invisible elephant." You could try to say, "Well, I don't smell it; elephants are smelly," but Sarah could simply say, "Invisible elephants don't smell." And you might get up and walk around and say, "Well, I'm walking all around the room, and I don't feel or bump into an elephant." But even then, Sarah, convinced there is an elephant in the room, could say, "You don't understand; it's an *insensible* elephant. But it's there." At this point, you would probably feel exasperated. Sarah has so qualified her "elephant" that there's *no* criterion by which to prove her wrong. Her claim that there's an elephant in the roomis simply unfalsifiable. But, of course, the fact that Sarah can do this doesn't [show she is wrong].

Upon first encountering this fallacy, you might think it isn't fallacious at all. After all, *if there is no way to prove that a claim is false, surely it must be true!* That's a very tempting line of thought. Falsifiability (the capacity for a claim to be falsified) is, as we've seen, an important feature of well-supported claims. We have a better idea of how to support a claim adequately if we know what sort of evidence could *dis*prove it, that is, if we know what to expect if it isn't true. This is clear in empirical cases. We have evidence that the drug ibuprofen reduces pain, but we know what to expect if this were to be false: pain would consistently not diminish even after taking ibuprofen....

Consider another example of unfalsifiability. Imagine Trayvon says, "Senator Jones's policy is the most effective policy to reduce homelessness." We can imagine Sarah challenging

Trayvon's claim by presenting data that similar policies have failed to reduce homelessness adequately: "That policy was tried in Dallas, and it didn't work." In response, Trayvon might say, "Well, Dallas has a different demographic; it's likely to be more effective here." Sarah might then discover that a similar policy didn't work in a place with a similar demographic, but Trayvon could respond: "The problem wasn't the policy; it was the implementation. The state didn't put enough money in the right place." We can now begin to suspect that Trayvon isn't really open to the possibility that the policy is ineffective. He has a tendency to qualify all counterevidence so that it doesn't affect his opinion of the policy. If he just doesn't allow that some evidence would falsify his claim about the effectiveness of the policy, he is committing the fallacy of unfalsifiability...

... But there are cases that can seem as though they are being treated as unfalsifiable but aren't. Consider the hypothetical conversation between Trayvon and Sarah over Senator Jones's policy to reduce homelessness. Social science research is fraught with difficulties because social situations cannot be replicated in a laboratory. We can always criticize such a study by arguing that the study has a selection bias, or a sampling bias, or that the wrong statistical measurements were used to calculate the results, etc. (see 6.4). Because of this, a researcher can always defend his or her conclusions by noting that those conclusions are valid *given the limitations of social science methodology*. This isn't quite the same as unfalsifiability, but it is close. Social science researchers still owe us an account of how additional research could confirm or disconfirm their conclusions. Any one study may be problematic, but comparing similar studies with similar information might be informative. Nevertheless, if someone has an easy answer for any particular criticism you have, take the time to ask what sort of evidence would count against the claim at issue.