SHOULD WE BELIEVE OUR BEST SCIENTIFIC THEORIES?

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In this class, we'll be taking up some of the central questions in the philosophy of science:

1. What does it mean to be a "realist" about scientific theories? What does it mean to be an "anti-realist"?
2. What's the difference between "accepting" a scientific theory and merely finding it "useful"?
3. What is the "No-Miracle" argument in favor of realism?
4. What is the "Pessimistic Metainduction" argument in favor of anti-realism?

This class is the 4th in a series of 5 classes. However, this class stands on its own, so don't worry if you didn't attend the first three.

WHAT IS REALISM? SCIENTIFIC REALISM?

Realism is a difficult term to define, in large part because *many* philosophers (over thousands of years, and from many different traditions) have claimed to be "realists" of some type or other, even while disagreeing rather vehemently about what this has meant. For our purposes here, though, we'll be associating **realism** about a certain domain with the following general beliefs:

1. There is a mind-independent reality that exists outside of us. ("Metaphysical realism").
2. Claims about this domain are "about" this domain. They are true if they accurately describe the mind-independent reality, and false otherwise. ("Semantic realism").
3. We *can* know things about this domain, even if this knowledge might be partial or imperfect ("Epistemic realism").

There are a wide variety of ways in which one can be a realist (and we'll be discussing some of them later). Conversely, **anti-realism** denies at least ONE of the above claims (with different types of anti-realists denying different claims). Anti-realism is often associated with terms such as "pragmatism" or "empiricism".

Most of us are realists about some domains and anti-realists about others. So, a realist about the external world (a pretty weak form of realism) believes that there is *something* outside of my mind, while a realist about ethics believes that ethical truths (like "Nazis are bad") are true *even if people don't agree with them.* A realist about *numbers* believes that numbers exist independently of humans (and that they would have existed even if humans had never been around to "count" things). One could be a realist (or not) about God, ghosts, Santa Claus, the "superego", etc.

The debate between **scientific realism** and **scientific antirealism** is centered around the role the *unobservable entities and forces* play in scientific theories. Nearly every scientific theory (both current and historical) makes claims both about the *observable* world (e.g., "here's what you will see if you do X"), and about the *unobservable world* ("the *reason* you see this is because of force Y"). Examples of claims about the observable world include things such as "planet X will be observed at location X, Y at time T" or "the following measuring instrument will record reading R under conditions C" or even "The life expectancy of patients undergoing treatment T will be X greater than those not getting the treatment". Examples of unobserved entities include everything from quarks and electrons to genes to the process of natural selection to cognitive biases to [choose your favorite ideas from a scientific theory].

In keeping with the general picture of realism given above, scientific realists hold that (1) there is a matter of fact about what unobserved entities/forces are like, (2) our scientific theories should be interpreted as attempts to describe this reality, and (3) scientific methods really do make it possible to *know* something about this reality, even if these claims are partial or imperfect. Anti-realists, by contrast, tend to agree with the first claim (about the underlying reality of the world), but they often disagree with claim 2 (that this is what our scientific theories are really "about") and they almost always disagree with claim 3 (that we could know anything about these entities). For anti-realists, scientific theories involving claims about entities/forces we couldn't possibly observe should NOT be judged on whether they are true or false (in fact, anti-realists will argue they are almost certain to be false). Instead, they should be judged on whether they are *useful.*

Questions: (1) Can you think of a domain that you are a "realist" about? An "anti-realist" about? (2) Based on the initial descriptions of scientific realism and anti-realism, which view do you find more plausible?

THE DIFFERENCE BETWEEN "ACCEPTING" A THEORY AND FINDING IT "USEFUL"

Another way of thinking of this in terms of **theory acceptance** versus **theory use**. Roughly, we can say that a theory is "accepted" by the scientific community if they believe that is the most accurate description of the world we have at this point. By contrast, we can say that a theory is "used" by a scientific community if they have some practical use for a theory, whether or not they think it is worthy of acceptance. Realists think that scientists can be **justified** in accepting scientific theories involving unobservable entities, at least under conditions (e.g., if we have certain sorts of evidence). By contrast, antirealists think that scientists are *never* justified in accepting these sorts of theories, even though they might be justified in *using* these theories for certain practical purposes.

SCIENTIFIC REALISTS VS SCIENTIFIC ANTI-REALISTS		
Sample claim	**Realists**	**Anti-Realists**
"People with a BMI over 35 have a higher frequency of cardiac events than those with a BMI under 25"	So long as they have adequate evidence, scientists are justified in accepting and using this theory (as they currently do).	Since this theory involves only observable entities (BMI and cardiac events can be defined in terms of *measurements*), they agree with realists. We can both accept and use this theory.
"The gene BRCA is an oncogene—it is a cause of breast cancer."	So long as they have adequate evidence, scientists are justified in accepting and using this theory (as they currently do).	Genes (not to mention "causes"!) can't be directly observed. That being said, measurements (blood tests, etc.) based on theories involving BRCA are highly useful for predicting who will get cancer. So, we should continue using them. However, we are NOT justified in saying that "genes really exist."
"Vaccines cause autism by triggering an unhealthy immune response that inhibits neural development."	This is a claim about unobservable entities. However, it is one that our current evidence strongly suggests is false. Scientists are justified in NOT accepting it.	We shouldn't accept this theory, for the same reason we don't accept any claims involving unobservable processes or entities. However, unlike the BRCA theory, this isn't a *useful* or *helpful* theory, either.
"COVID-19 jumped to humans from acuminate horseshoe bats"	This is a claim about unobservable entities (We can't see viruses! We can see the past!). It's one we are currently **pursuing,** but we don't currently have evidence to accept (or reject) it at this point.	Again, we should NEVER accept theories like this, since they involve claims about unobservable entities (such as viruses). However, it is worth pursuing, because we want to know whether this theory is *useful* (for example, it may be that intervening on bat populations in certain ways will lead to fewer disease symptoms in humans).

Finally, a quick note of caution: nearly all scientists tend to talk *as if* they are realists when they are actually in the process of doing science (that is, they regularly talk about the properties of unobservable entities like electrons, viruses, and genes). However, this doesn't necessarily mean realism is true. First, scientists might be wrong about the "nature" of scientific practice, even if they are perfectly competent practitioners of science. (An analogy: practicing artists don't necessarily have any special insight into questions like "What is art?"). Second, at least some scientists, if pressed on what they are "really" doing, will often retreat to an anti-realist position. (That is, they'll say things like "I don't necessarily *believe* in all of the theories I use in my day-to-day work, but I think they are useful calculating tools).

Questions: The disagreements between scientific realists and antirealists revolve around which scientific theories we can justifiably *accept* as likely to be true. Can you think of other examples (besides those noted above) where realists and anti-realists would (1) agree as to their acceptability and (2) NOT agree as to their acceptability?

VARIETIES OF REALISM: NAÏVE, STRUCTURAL, ENTITY

As a group, scientific realists tend to see science as an investigation into the "nature" of the world outside of us. Moreover, they tend to think that science has made considerable *progress* toward its goal of providing an accurate description of this world. However, within this broad area of agreement, one can distinguish between several sub-types of realists.

Naïve realists believe that we have direct, perceptual access to the world "as it really is." So, there are real objects in the world (e.g., "that ball over there") with real properties (e.g., "the ball really is heavy, red, and round") and our senses (of touch, taste, hearing, etc.) directly connect us to these properties. Measuring instruments (such as telescopes) are something like "extensions" of our senses. Many historical philosophers/scientists, including Aristotle, Descartes, and Newton could probably be accurately described as naïve realists, insofar as they thought that the truth of their theories could be established simply by *paying careful attention to the world.* Another way of putting this: they didn't just think that science should aim to describe provide a complete, accurate description external world; they thought that their own theories had already accomplished this task!

- **Problems:** Modern psychology and neuroscience strongly suggests that we do NOT "directly" perceive the world—instead, what we perceive is inevitably going to be shaped by our brains, sense organs, etc. Moreover, many of the entities and forces discussed in modern scientific theories—magnetic fields, genes, etc.—simply can't be sensed directly. Finally, over the last 300 years, it has become clear (even to the most optimistic realists) that even those theories the seem to be *obviously* true on close inspection can still end up being false. After all, Aristotle, Descartes, and Newton all ended up being wrong! For all these reasons, almost no one defends this sort of naïve realism anymore in the context of science (and, in fact, naïve realism is often contrasted with scientific realism). Versions of naïve realism remain popular in other areas (e.g., many people are naïve realists about the objects we encounter in day-to-day life, such as toasters, cars, and other people).

Contemporary versions of scientific realism (such as structural and entity realism, discussed below) begin by acknowledging the failures of naïve realism: (1) scientists can't "directly perceive" many of the entities and forces that are discussed by their theories and (2) historically, even those theories that seem to be strongly supported by evidence have *eventually* been abandoned/replaced by the scientific community. So, we can't (and shouldn't) assume that our current theories are complete, accurate descriptions of the world. With this in mind, most contemporary scientific realists argue that we are justified in believing that our best scientific theories describe *certain aspects of reality* accurately. They are thus "selective" scientific realists—realists about some aspects of scientific theory and anti-realists about others.

Structural realists suggest that we are justified in believing in the *structures* (and, in particular, those structures described by mathematical equations) that are described by our best scientific theories, even while remaining agnostic as to the nature of the (unobservable) entities that realize these structures. So, for example, scientists have spent a long time thinking about things like *the motion of physical objects* (which includes everything from the planets to falling rocks to ships). How they've conceived of these objects has changed radically, even since the scientific revolution. For example, Aristotle thought that objects had an internal "essential motion", Descartes thought their motions resulted from a "vortex" of revolving particles, Newton thought they were pushed/pulled by forces like gravity, and modern physics posits "fields" of various types. However, even while our theories changed radically in terms of which "entities" they posited, certain equations (such as Galileo's law of falling objects, Newton's equations, etc.) have seemed to "stick." That is, once they were discovered, all future theories had to incorporate them somehow. Structural realists argue that we have good reason to think that these equations describe *something* about the underlying "structure" of our reality, even if we may never know much about the underlying "stuff".

Entity realists are, in some ways, the mirror image of structural realists. They believe that we have good reason to accept the fundamental *entities* that are posited by our best scientific theories, even while granting we might know little about the *properties* of these entities. A simple example here would be the concept of an "atom," which goes back at least to philosophers such as Epicurus and Lucretius. In the thousands of years since then, our ideas *about atoms* (and, in particular, the structural relationships of atoms to *other* entities in our ontology) have changed quite a bit. However, for the last 250 years or so (since we started conducting successful *chemical experiments* using early versions of atomic theory), no one has seriously challenged the existence of atoms. Entity realists argue that the same sort of story can be told for many other entities. So, for example, the science of 200 years from now will undoubtedly be very different from current science. However, it seems likely that future scientific theories will likely continue to talk about entities such as *electrons, genes, species,* and *stars.* It's simply that we will know more about these entities than we do now.

- **Problem 1:** Both structural and entity realism try to "save" realism by arguing we should be realists only about certain aspects of theories. The problem is that they offer diametrically opposed accounts of which aspects we should be realists about! The problem is that we can offer plausible examples of cases where scientific theories have seemed to preserve “structure” (while changing “entities”) and other cases where theories have preserved “entities” (while changing “structure”). Contemporary realists have a variety of ways of dealing with this (often by massaging the definitions of *entity* or *structure* to get the “right answer” to historical examples). However, the general worry is that this risks making scientific realism into a trivial claim: “Some parts of our current theories might end up being true.” This isn’t enough to show that we might be justified in *believing* in the truth of some *specific* scientific claims about unobservable (which is supposed to be the heart of realism).

- **Problem 2:** Both structural realism and entity realism have struggled with how to make sense of the idea that theories can be “partially true” or “approximately true.” That is, they want to say something like “We believe that our current ideas about science have *something right about them* but they probably don’t have *everything right about them.”* (After all, they want to leave room for future science to make improvements!) However, it has been challenging to make this idea more precise.

Summary: An easy (though not entirely accurate) summary of the above positions might be as such. A naïve realist thinks that we are justified in believing ALL of the claims of our best scientific theories, a structural realist thinks we are justified in believing in the claims about “structure”, and the entity realist in the claims about “entities.” An anti-realist, by contrast, thinks that we should never "believe" claims about unobservables, even if we find them useful on occasion.

Question: Why do you think naïve realism has been rejected, at least in the context of science? How would you describe the DIFFERENCES between structural and entity realism? The similarities? Why do you think that these sorts of positions have become popular?

THE “NO MIRACLES” ARGUMENT FOR REALISM

“Realism is not a dirty word. If you wonder why all scientists, philosophers, and ordinary people, with rare exceptions, have been and are unabashed realists, let me tell you why. No scientific conjecture has been more overwhelmingly confirmed. No hypothesis offers a simpler explanation of why the Andromeda galaxy spirals in every photograph, why all electrons are identical, why the laws of physics are the same in Tokyo as in London or on Mars, why they were there before life evolved and will be there if all life perishes, why all persons can close their eyes and feel eight corners, six faces and twelve edges on a cube, and why your bedroom looks the same when you wake up in the morning.” (Martin Gardener)

Not merely trainee and professional members of the medical profession commit the base-rate fallacy. Even very eminent scientists do, as we have seen. And all the philosophers who use the No-Miracles argument do so as well. (Colin Howson)

Realists—of whatever stripe—believe that science is aimed at getting things right, and in making true claims about the world. Moreover, they tend to believe that our current best scientific theories really *do* get at least some things right and that these theories are at least "approximately true." Why do they think this? One common reason has been dubbed the **No-Miracle Argument for Realism.** It goes something like this:

1. Modern scientific theories (which include many claims about unobservable entities) do an extremely good job of making accurate predictions about the observable world, especially compared to ancient, pre-scientific theories. Modern science has built iPhones, launched rockets, designed vaccines, etc.
2. If our theories were approximately true, as scientific realism claims that they are, this sort of predictive success is exactly what one would expect.
3. On the other hand, if our theories were wildly false (as anti-realism suggests that they are likely to be), this success is something like a miracle.
4. As a general rule of science, non-miraculous explanations are more likely to be true than miraculous ones.
5. Therefore, realism is more likely to be true than is anti-realism.

This argument attempts to use a form of argument sometimes used within science—sometimes called **Argument to the Best Explanation—**and apply it to science as a whole. The basic idea is that, when one is faced with two competing hypotheses or theories (in this case, realism and anti-realism), one should choose the hypothesis that gives the *best explanation* for the evidence one has. In this, our "evidence" is just the success of science itself!

Does the No-Miracle Argument Commit The "Base Rate Fallacy"? In response to the No-Miracle Argument, many anti-realists have argued that it relies on faulty logic, albeit a sort of faulty logic that is widespread among both scientists and non-scientists. In particular, many have argued that this argument commits the "Base Rate Fallacy". The **base rate** in question here is the probability that a "randomly chosen" scientific theory would be true *before* we knew anything about the evidence.

To see why base rates are, and why they can matter (a lot), consider the following scenario from medical testing (an area in which this fallacy has been extensively discussed):

Suppose that a patient is given a test for cancer that has a 0% false-negative rate (100% sensitivity) and a 10% false-positive rate (90% specificity). If a patient gets a positive test result, what should you (as their physician) tell them about the probability they have cancer?

The correct answer is "you can't really tell them anything unless you also know something about the *base rate* of the cancer in question." So, for example, if this was a *breast cancer test,* and the person was in a relatively high-risk group for breast cancer (40 yrs old female, BRCA mutation), the base rate of breast cancer might be 20%. In this case, the probability of them having cancer is $\Pr(C|P) = \frac{0.2}{0.2+0.8*0.1} = .71$. This means there is a 71% chance of them having cancer. On the other hand, if this person was in a low-risk group for breast cancer (e.g., adolescent male, no other symptoms), the base rate might be something more like .01% (or even less). This patients' probability of cancer—given the exact same test result!—would be $\frac{0.0001}{0.0002+0.8*0.1} = .001$. That is, even after a positive test result, they still have only a .1% chance of having cancer.

So how does this relate to realism? The critics of the no-miracle argument contend that premises 2 and 3 (in the argument above) are something like the "specificity" and "sensitivity" numbers in the cancer case. If this is the case, then the defenders of realism ALSO have to tell what the "base rate" of true scientific theories is. So, for example, if it is really, really is to come up with scientific theories that are true (maybe 10% of our guesses end up being right?), the no-miracles argument provides us pretty good reason for thinking that our successful theories are the true ones. On the other hand, if coming with true theories is really tough (maybe only 1 out of 10,000,000 guesses are true), then the no-miracle argument will NOT succeed in showing that our successful theories are the true ones. The problem is that we seemingly have no way of providing this sort of "base rate" since doing so would require that we have some *independent* way of checking whether scientific theories were true (besides their making successful predictions).

Question: This was a lot of ground to cover! How would you describe the "basic idea" behind the No-Miracles Argument for Realism? The anti-realist criticism of it? Which do you find more persuasive?

THE "PESSIMISTIC METAINDUCTION" ARGUMENT FOR ANTI-REALISM

"If rationality consists in believing only what we can reasonably presume to be true, and if we define 'truth' in its classical nonpragmatic sense, then science is (and will forever remain) irrational." (Larry Laudan, Progress and its Problems).

The No-Miracle Argument for Realism tries to take a common way of reasoning within science—the argument to the best explanation—and apply it to philosophical questions about science. The **Pessimistic Metainduction** does something similar, only on behalf on anti-realism. In particular, it tries to use **inductive** reasoning to show that our available evidence makes it *more likely* that anti-realism is true than is realism. Inductive reasoning involves the use of information about things that we *have* observed to draw conclusions about things that we *haven't* observed. We engage in this sort of reasoning every time we predict the future, reason about causes or effects, or make generalizations from "samples" to "populations." By its nature, inductive reasoning can never have the certainty associated with the **deductive** reasoning of mathematics. However, induction is at the heart of almost everything that scientists do.

With these ideas in mind, here is the structure of the Pessimistic Metainduction:

1. In this past, humans have come up with many, many, many scientific theories containing claims about unobservables. Moreover, many of these theories were **empirically successful** (that is, they made some successful predictions about the observed world).
2. All of these theories have eventually been shown to be false, at least after some time has passed. (E.g., There probably isn't a *single* scientific theory from 100 years ago that we continue to believe in the literal truth of. ALL of these theories have changed in some way).
3. So, our best current scientific theories are highly likely to false, as well.
4. So, we should not "accept" these theories as true (that is, anti-realism is likely to be correct).

The basic picture here is "science as the history of mistakes"—we *know* that no past scientific theory has ever succeeded in "getting everything right". So, why should we expect that our *current* theories get everything correct? It's important to note that anti-realists (such as Larry Laudan, quoted above) generally do NOT take this sort of argument to be "pessimistic" about science in general. They are often very impressed by the empirical/pragmatic success of science and think that it is perfectly rational for scientists to continue to experiment and hypothesize to find more and more useful theories. They simply think it is a mistake to think (as the realist does) that scientific theories are "true" in the way that we usually understand this word.

A Realist Response: What if our theories are "approximately" true? Positions such as structural realism and entity realism attempt to address the Pessimistic Metainduction by articulating a sense in which our past theories were NOT "completely false", but instead "partially true." So, for example, maybe these theories DID make true claims about structure or entities, even if other aspects of the theories were flawed. If this move succeeds, then the Pessimistic Metainduction doesn't look so threatening. After all, if the conclusion (in 3) is revised to be "Some parts of our best scientific theories are false, but others are true" this doesn't look to be nearly as threatening! The problem for this answer, however, is to try to make sense of the idea of how theories can be **"approximately true".** This has turned out to be a non-trivial problem (and versions of it arise in areas like machine learning when we try to teach machines how to choose the hypothesis that "best" explains a given set of data).

Question: In what sense is the Pessimistic Metainduction an "inductive" argument? Do you find the realist response successful?

FINAL QUESTIONS

1. What do you think the *practical* implications of the realist / anti-realist debate are? That is, what sort of difference would it make if the general public (and/or practicing scientists) accepted scientific realism? Accepted scientific anti-realism? (In different times and places, scientific realism has been associated with both democratic politics and totalitarian politics; the same is true of scientific antirealism).
2. It's possible to be a realist about some areas of science (say, astronomy) while remaining anti-realist about others (say, macroeconomics). Which areas do you think are most promising for realism? For anti-realism?
3. On a scale of 1 to 5 (with 1 = "totally anti-realist" and 5 = "completely realist"), how would you describe your own attitude toward science? Why?