Chapter 8

Instrumentalism and Realism

Reality is the business of physics.

-Albert Einstein

The goal of this chapter is to introduce two common attitudes toward scientific theories. These attitudes are generally labeled *instrumentalism* (or *operationalism*) and *realism*. We will begin with a discussion of two central issues relevant to scientific theories, namely, prediction and explanation.

Prediction and Explanation

Suppose we ask the question“what do we want from scientific theories?” Certainly, the ability to make accurate predictions is one feature we want from a scientific theory. As discussed in Chapter 4, when Einstein introduced his theory of relativity in the early 1900s, one of the points in the theory’s favor was that it made accurate predictions, not made by any other theory, as to what would be observed during the solar eclipse of 1919. Clearly, the ability to make accurate predictions such as this is a feature we desire in scientific theories.

In addition, there is widespread agreement that the ability to explain the relevant data is another feature we desire in a theory. However, although there is agreement that explanation is an important feature, there is much less agreement on what exactly counts as an adequate explanation. For example, can there be more than one correct explanation for a single event, or does each event have only one single, correct explanation? Does an adequate explanation have to specify the exact series of events that produced the data? Is it sufficient for a theory to specify *that* certain data should be observed, or does an adequate explanation need to go further and specify *how* or *why* the events in question occurred? These and other questions about the nature of explanation are difficult and controversial.

To help clarify some of these issues, philosophers of science sometimes distinguish between *explanation* (or what is sometimes referred to as "formal explanation"), on the one hand, and what is often termed *understanding* on the other. In this distinction, "explanation" is used in a fairly minimalist way. More specifically, one says that a theory explains a piece of existing data or observation if one could have predicted the data from the theory. Used this way, explanation is sort of a retroactive prediction.

An example may help to illustrate this notion of explanation. In the early 1900s it had been noted, for some decades, that there were certain peculiarities about the orbit of Mercury. Einstein's theory of relativity did not come about until after these observations about the orbit of Mercury had been made, but had Einstein's theory of relativity been developed before these observations, the theory could have been used to predict that such peculiarities should be observed. In other words, when Einstein's theory was developed in the early 1900s, it could be used to explain (again, in this minimalist and sort of retroactive sense of "explanation") these peculiarities. And it was certainly a point in favor of Einstein's theory of relativity that it could explain this unusual data.

In contrast, and broadly speaking, "understanding" is used to refer to a somewhat more thorough appreciation of the data and observations. For example, consider the observation that falling bodies accelerate at about 10 meters per second squared. One can use Newton's theories and equations concerning gravity to show that falling objects should accelerate at about this rate. That is, Newton's physics can be used to explain (in the minimalist sense of "explanation" described above) this data. Now if you take gravity as a really existing force acting on objects (that is, you take what is called a *realist* attitude, which we will explore more fully in a moment, toward Newton's concept of gravity), then you might say you know not only *that* objects accelerate at about 10 meters per second squared, but you also know *why* they do so (because they are under the influence of a gravitational force). That is, you have both an explanation for the data, and also an understanding of the data.

The notion of explanation (again, in the somewhat minimalist sense described above) is a reasonably straightforward and uncontroversial notion, whereas issues surrounding understanding are quite complex and controversial. Many of the reasons for this complexity will emerge as the book progresses. (To take one quick example, as just noted, using the Newtonian notion of gravity to say we understand why dropped objects accelerate as they do requires taking gravity as a really existing force, and as we will see, Newton himself had substantial qualms about taking gravity in this way.) So for now, to keep our discussion relatively straightforward, we will take the minimalist approach to the concept of explanation described above. That is, we will say that a theory explains an existing piece of data or observation if the theory could have been used to predict that data or observation.

As noted, there is widespread agreement that prediction and explanation are very important requirements for any adequate theory. While explanation and prediction are the most important characteristics of theories, it should be noted that they are not the only desirable characteristics. For example, characteristics such as simplicity, elegance, and beauty are regularly appealed to in arguing for and against theories. In what follows, I will usually focus just on prediction and explanation, since these are agreed to be the most important characteristics, but the other attributes just mentioned should also be kept in mind.

So, there is general agreement that accurate predictions and explanations are required from scientific theories. But are these characteristics enough? Or is it the case, as Einstein came to believe (at least, the older Einstein–the younger Einstein was not so committed to this view), that reality is the business of physics (and, of course, other sciences as well)? That is, is it important that a theory reflect, or model, reality?

This issue–whether we require theories to reflect the way things really are–is a controversial issue. It is the issue that distinguishes instrumentalists and realists. For an *instrumentalist*, an adequate theory is one that predicts and explains, and whether that theory reflects or models reality is not an important consideration. For a *realist*, on the other hand, an adequate theory must not only predict and explain, but in addition it must reflect the way things really are.

To illustrate the differences between instrumentalists and realists, it will help to look at an actual theory. In this case, let us look at certain aspects of the Ptolemaic astronomical system.

The Ptolemaic system was formulated by Claudius Ptolemy around 150 AD. Ptolemy's approach is an Earth-centered one, with the sun, planets, and stars revolving around the Earth. Ptolemy considers each of the relevant objects–for example, the moon, sun, and planets–in turn, specifying the mathematics needed to predict and explain the observed positions of these objects.

One of the more interesting aspects of Ptolemy's approach is his use of *epicycles*.

Ptolemy did not invent the technique of epicycles, but he put them to more extensive use than any before him. To understand the notion of epicycles, it might help to begin with a picture.

<Insert Figure 8.1 here.>

It should be noted that this is an overly-simplified picture of Ptolemy's approach, and we will not look at details of Ptolemy's approach until later chapters. This picture will, however, be sufficient to illustrate the points of interest to us in this chapter. In particular, and roughly speaking, a planet such as Mars moves in a circle around a point (labeled A on the diagram), while this point moves in a circle around the Earth. The circle traced out by the movement of Mars around A is called an *epicycle*. In short, an epicycle is a small circle around which a planet moves, with the center of the epicycle itself moving around some other point (usually, though not always, the center of the system).

On an Earth-centered view of the universe, epicycles, or something at least as complex and (to our eyes, at least) as odd looking as epicycles are necessary in order for the theory to predict and explain the relevant data. In this case, the relevant data consists largely of the observed position of the planets (and other heavenly bodies) in the night sky. For example, consider the point of light we call 'Mars'. The observed position, in the night sky, of this point of light varies from night to night, week to week, year to year. A theory such as Ptolemy's needs to accurately predict and explain this data, and to do so, Ptolemy's theory (and any other Earth-centered approach) needs epicycles, or something at least as complex. We will defer discussion of why an Earth-centered system requires such complexities until later, but at this point, trust me: an Earth-centered model without epicycles (or something similar) cannot accurately predict and explain the motion of the planets.

So without epicycles, the Ptolemaic system (and any other Earth-centered system) would be unacceptable due to a failure to adequately explain and predict. On the other hand, with epicycles the Ptolemaic system is quite good at explanation and prediction. In fact, the Ptolemaic system is a marvelous mathematic model, able to explain and predict the motion of all the visible planets and stars with remarkable accuracy. The Ptolemaic system is not perfect with respect to prediction and explanation (few theories are perfect), but it is very good, and certainly far superior to any other approaches available at the time.

Thus, in terms of explanation and prediction, the Ptolemaic system, with its peculiar-looking epicycles, is excellent. But are epicycles real, or are they included simply because they are necessary in order to predict and explain the motion of the planets?

Suppose we were back in the second century and considering the question of whether Mars really moved in a small circle around the point P. And suppose we were of the opinion that the only important point is that Ptolemy's system, with epicycles, is good at prediction and explanation, and whether Mars really moves on an epicycle is just not important. This attitude would not have been at all unusual in Ptolemy's day, nor is it at all unusual today. A large percentage of working scientists, and philosophers of science, take the approach that the main task of a scientific theory is to explain and predict the relevant data, and it simply is not important whether or not a theory (or parts of a theory) reflect the way things "really are." As noted above, this attitude toward scientific theories is generally labeled instrumentalism, and those who take this attitude are considered instrumentalists.

And again, as briefly mentioned earlier, in contrast to instrumentalists are realists. Realists agree that a scientific theory ought to explain and predict the relevant data, but beyond this, realists require that a good scientific theory be real, that is, that it reflect the way things really are.

To an instrumentalist in 150 AD, the question "are epicycles real?" would not have been an important question. Ptolemy's theory accurately predicts and explains the relevant data, and that is all that is important. On the other hand, for a realist this question would be important. Even though Ptolemy's theory accurately predicts and explains, a realist would also require that it reflect the way things really are. So if Mars does not really move on an epicycle, that is, if epicycles are not real, then Ptolemy's system would be unacceptable.

Incidentally, with respect to the question "are epicycles real," it is not obvious how Ptolemy himself would have answered. In recent writings about the Ptolemaic system, Ptolemy is almost always portrayed as an instrumentalist. But this is not entirely accurate. It is true that Ptolemy generally is concerned with explanation and prediction, with little discussion as to whether his system reflects the way things really are. When Ptolemy speaks like this (which, again, is the majority of the time), he sounds like an instrumentalist. On the other hand, there are passages where Ptolemy discusses issues such as the mechanism by which planets are carried around on their epicycles. Such discussions make sense only from a realist perspective, and if Ptolemy had a purely instrumentalist attitude, it is difficult to explain why he includes such discussions. I think the most accurate view is that Ptolemy, like many of us, held something of a mix of instrumentalist and realist attitudes.

Mixtures of these attitudes are not uncommon. It is certainly possible, and not at all contradictory, to hold a realist attitude toward certain *parts* of a theory while having an instrumentalist attitude toward other parts of the theory. For example, before the 1600s it would not be unusual for someone to hold a realist attitude toward the Earth-centered part of the Ptolemaic system, while holding an instrumentalist attitude toward the part of the theory involving epicycles. That is, prior to the 1600s it was widely, and quite reasonably, believed that the Earth really was the center of the universe. Thus, people would generally view the Earth-centered part of Ptolemy's theory as reflecting the way things really are. Many, perhaps most, of those same people took an instrumentalist attitude toward the epicycles in the Ptolemaic system.

It is also common for someone to have a realist attitude toward theories in one branch of science while holding an instrumentalist attitude toward theories in other branches of science. For example, virtually everyone I know holds a realist attitude toward the current sun-centered model of our solar system. Many of those same people, though, take an instrumentalist attitude toward much of modern quantum theory.

It is also possible to "accept" two competing theories by having an instrumentalist attitude toward one and a realist attitude toward the other. For example, the Copernican system (a sun-centered view) was published in the 1550s, and in the late 1500s it was not unusual for a European university to teach both the Ptolemaic system and the Copernican system. Before the invention of the telescope (about 1600), there was good reason to think the Earth was indeed the center of the universe. Thus, people typically took a realist attitude toward the Ptolemaic system (or at least, the Earth-centered part of the system). On the other hand, in certain ways the Copernican system was somewhat easier to use, and so an instrumentalist attitude was taken toward this system. That is, the Copernican system was not viewed as reflecting the way things really are, but it was accepted and widely used as a convenient theory for making predictions and explanations. In short, between about 1550 and 1600, the Ptolemaic and Copernican systems co-existed peacefully. A realist attitude was typically taken toward the former and an instrumentalist attitude toward the latter. This relatively peaceful co-existence changed dramatically with the invention of the telescope and the discovery of evidence indicating that the Earth-centered view was wrong. But that is a story for later chapters.

In summary, instrumentalism and realism are attitudes toward theories. Both instrumentalists and realists agree that an adequate theory must accurately predict and explain the relevant data. But realists require, in addition, that an adequate theory picture, or model, the way things really are. Finally, it is neither contradictory nor unusual to find mixtures of instrumentalist and realist attitudes, or for an individual to hold realist attitudes toward certain theories and instrumentalist attitudes toward others.

Concluding Remarks

I will close with two quick notes. As is the case with the concept of falsifiability discussed in the previous chapter, authors often speak of instrumentalism and realism as if they were features of scientific theories. But instrumentalism and realism are better thought of as *attitudes toward* scientific theories, rather than being aspects of the theories themselves. That is, just as typical theories are not inherently falsifiable or unfalsifiable, so also typical theories are not inherently instrumentalist nor realist. Rather, one's attitude toward a theory is what is better classified as instrumentalist or realist.

Lastly, in Chapter 2 we discussed correspondence and coherence theories of truth. Recall that advocates of correspondence theories see truth as a matter of a belief corresponding with reality, whereas advocates of coherence theories view truth as a matter of a belief cohering, or fitting in with, some overall set of beliefs. One might wonder whether correspondence and coherence theories go hand in hand with realism and instrumentalism.

It should be noted that there is no necessary connection between theories of truth, on the one hand, and instrumentalism and realism on the other. For example, it would not be logically contradictory to be an advocate of a coherence theory of truth and at the same time be a realist about theories. And likewise, it would not be contradictory to be an advocate of a correspondence theory of truth while being an instrumentalist.

However, it should come as no surprise that there is some linkage between instrumentalist/realist attitudes and coherence/correspondence theories of truth. Recall from Chapter 2 that advocates of coherence theories of truth are often motivated by qualms about reality, or more precisely, about our knowledge of reality. It would be rather odd (though strictly speaking not contradictory) for someone having qualms about reality when considering theories of truth to then insist, in the context of instrumentalism and realism, that theories model or reflect they way things really are. And so it is not surprising that advocates of coherence theories of truth are more likely to hold instrumentalist attitudes.

Likewise, it is not surprising that advocates of correspondence theories are more likely to hold realist attitudes toward theories. The reasons are essentially the same–if one sees truth as a matter of corresponding to the way things really are, it would be natural to insist that scientific theories likewise model or reflect the way things really are.

This, then, ends our survey of some of the preliminary and basic issues involved in the history and philosophy of science. With an understanding of these issues, we are in a better position to explore the issues raised in the next part of the book, in which we investigate the transition from the Aristotelian to the Newtonian worldview.

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<Below are the captions for the figures for this chapter.>

Figure 8.1: Mars’ Motion on the Ptolemaic System