Carnap 1
Theory and Observation

(pp. 225–246)

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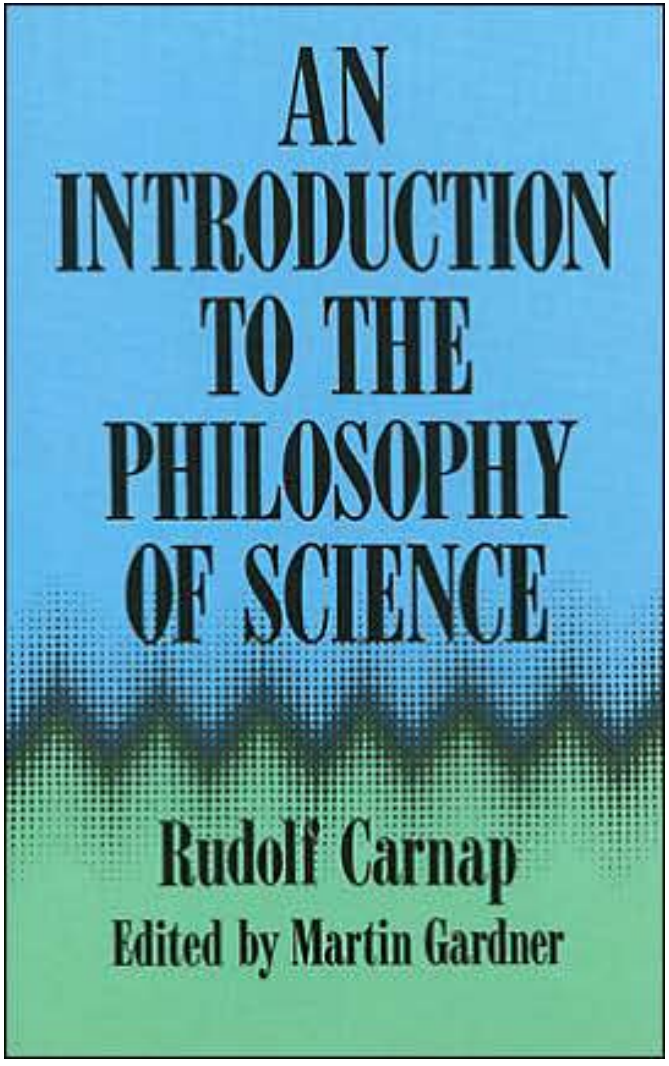
The book



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One of the most memorable privileges of my life was to have attended Rudolf Carnap's seminar on "philosophical foundations of physics" when he was at the University of Chicago. It was an even greater privilege, many years later, to be allowed to shape those seminar lectures (after Carnap repeated them at the University of California) into the present volume. — Martin Gardner (p. ix)

Observability

Two definitions (pp. 225–226)

To a philosopher, "observable" has a very narrow meaning. It applies to such properties as "blue," "hard," "hot." These are properties directly perceived by the senses. To the physicist, the word has a much broader meaning. It includes any quantitative magnitude that can be measured in a relatively simple, direct way. A philosopher would not consider a temperature of, perhaps, 80 degrees centigrade, or a weight of 93 1/2 pounds, an observable because there is no direct sensory perception of such magnitudes. To a physicist, both are observables because they can be measured in an extremely simple way. The object to be weighed is placed on a balance scale. The temperature is measured with a thermometer. The physicist would not say that the mass of a molecule, let alone the mass of an electron, is something observable, because here the procedures of measurement are much more complicated and indirect.

The distinction isn't sharp (p. 226)

There is a continuum which starts with direct sensory observations and proceeds to enormously complex, indirect methods of observation. Obviously no sharp line can be drawn across this continuum; it is a matter of degree . . . In general, the physicist speaks of observables in a very wide sense compared with the narrow sense of the philosopher, but, in both cases, the line separating observable from nonobservable is highly arbitrary.

Observable and theoretical terms

Definition assumed by Carnap

- Observable terms designate observable things.
- Theoretical terms designate unobservable things.
- "Things" may be properties or relations.
- "Observable things" are things either directly observable by the senses or measurable by relatively simple techniques.

His examples

- Observable terms: "blue," "hard," "hot," "temperature of 80 degrees centigrade."
- Theoretical terms: "molecule," "atom," "electron."

Empirical and theoretical laws

Empirical laws (pp. 226–227)

Empirical laws, in my terminology, are laws containing terms either directly observable by the senses or measurable by relatively simple techniques. Sometimes such laws are called empirical generalizations, as a reminder that they have been obtained by generalizing results found by observations and measurements. They include not only simple qualitative laws (such as, "All ravens are black") but also quantitative laws that arise from simple measurements. The laws relating pressure, volume, and temperature of gases are of this type. Ohm's law, connecting the electric potential difference, resistance, and intensity of current, is another familiar example. The scientist makes repeated measurements, finds certain regularities, and expresses them in a law. These are the empirical laws.

Theoretical laws (p. 227)

A theoretical law is . . . distinguished from an empirical law . . . by the fact that it contains terms of a different kind. The terms of a theoretical law do not refer to observables even when the physicist's wide meaning for what can be observed is adopted. They are laws about such entities as molecules, atoms, electrons, protons, electromagnetic fields, and others that cannot be measured in simple, direct ways.

The distinction is usually clear (p. 228)

It is true, as shown earlier, that the concepts "observable" and "nonobservable" cannot be sharply defined because they lie on a continuum. In actual practice, however, the difference is usually great enough so that there is not likely to be debate. All physicists would agree that the laws relating pressure, volume, and temperature of a gas, for example, are empirical laws. Here the amount of gas is large enough so that the magnitudes measured remain constant over a sufficiently large volume of space and period of time to permit direct, simple measurements which can then be generalized into laws. All physicists would agree that laws about the behavior of single molecules are theoretical. Such laws concern a microprocess about which generalizations cannot be based on simple, direct measurements.

How theoretical laws are discovered (p. 230)

The term "molecule" never arises as a result of observations. For this reason, no amount of generalization from observations will ever produce a theory of molecular processes. Such a theory must arise in another way. It is stated not as a generalization of facts but as a hypothesis. The hypothesis is then tested in a manner analogous in certain ways to the testing of an empirical law. From the hypothesis, certain empirical laws are derived, and these empirical laws are tested in turn by observation of facts. Perhaps the empirical laws derived from the theory are already known and well confirmed. (Such laws may even have motivated the formulation of the theoretical law.) Regardless of whether the derived empirical laws are known and confirmed, or whether they are new laws confirmed by new observations, the confirmation of such derived laws provides indirect confirmation of the theoretical law.

Correspondence rules

According to Carnap:

- Empirical laws contain only observable terms. (p. 232)
- Theoretical laws contain only theoretical terms. (p. 233)
- Therefore, empirical laws cannot be derived from theoretical laws alone.
- We need in addition *correspondence rules*, which contain both observable and theoretical terms.

Example (pp. 232–233)

- Laws about the molecules in a gas are theoretical laws.
- Laws relating the pressure, volume, and temperature of a gas are empirical laws.
- A correspondence rule connecting the two is: The temperature of a gas is proportional to the mean kinetic energy of its molecules.

Questions

1. According to Carnap, what does it mean to say a law is empirical, and how are empirical laws confirmed? Give an example of something he regards as an empirical law.
2. According to Carnap, what does it mean to say a law is theoretical, and how are theoretical laws confirmed? Give an example of something he regards as a theoretical law.
3. What does Carnap mean by "correspondence rules"? Why does he believe they are needed? Give an example of something he regards as a correspondence rule.