Philosophy of Science

The philosophy of science is the inquiry into the assumptions and methods of the sciences and into scientific modes of reasoning.

The philosophy of science goes back at least as far as Aristotle (384-322 B.C.), who wrote several works on logic and various treatises on scientific topics. The most important modern contributors to the philosophy of science were Francis Bacon (1561-1626), René Descartes (1596-1650), and David Hume (1711-1776). Bacon's *Novum Organon* (the New Instrument) (1620) directly challenged Aristotle's emphasis on logical method in favor of an empirical and inductive approach to scientific knowledge. He identified two main obstacles to science: 1) forming generalizations (inductions) without a sufficient empirical basis and 2) common prejudices (such as assuming more order in nature than is truly present). For Bacon, the only way to overcome these obstacles is form scientific generalizations only from direct experience of nature.

Descartes rejected the Aristotelian belief that the material universe exhibits purpose (in Aristotle's terms, final causation). For Descartes, the only cause operative in the material universe is efficient causation–the impact of one body on another as they move in space. The emphasis on efficient causation meant that things studied by science could be treated as simple entities with basic characteristics such as spatial location, mass and speed. As a result, these entities became amenable to mathematical description.

Hume's importance lies in his critique of induction. Hume observed that the principle of induction (the expectation that future effects will resemble past effects) cannot be rationally justified. Attempts to prove this principle must make use of the relation of cause to effect; however, determining this relation assumes the validity of induction. Accordingly, proving the validity of the principle of induction begs the question by presupposing the validity of the principle.

One stream of 20th century philosophy of science emphasized the rational character of science. Karl Popper (1902-1994) is representative. In his *The Logic of Scientific Discovery* (1959) he attempted to distinguish genuine science from pseudo-science by identifying science's logical features. He also responded to Hume's critique of induction by arguing science uses deductive (not inductive) logic. Scientists set forth conjectures (hypotheses) and then seek to falsify them by creating experiments designed to see whether the conjectures are false. If the experiment falsifies the conjecture, the conjecture is rejected; otherwise it is accepted. This is a deductive approach because a single instance of falsification can, in principle, conclusively disprove the theory. Subsequently, Imre Lakatos (1922-1974) extended the rationalist approach by noting that scientists accept the validity of theories not simply because they pass the falsification test but because they help scientists find relevant data and generate theoretical insights.

The other main stream of 20th century philosophy of science was represented by Thomas Kuhn's (1922-1996) book, *The Structure of Scientific Revolutions*. In it he argued that the normal practice of science takes place within paradigms, which consist of fundamental conceptions and methods. Newtonian physics is an example of a paradigm. Normal scientific investigation inevitably creates anomalies–data that don't fit the paradigm. The result is a condition in which normal science cannot take place because the old paradigm is not adequate to the data. Sooner or later, the scientific community devises a new paradigm that accounts for the data and normal science resumes within the new paradigm. Kuhn's view of science was a departure from the predominant rationalist

view (represented by Popper) because he confined the logical aspect of scientific investigation to normal science within the paradigm while arguing that the transition from one paradigm to another was not governed by strictly logical principles. He further argued that it is a mistake to think of the movement from one paradigm to another as a movement of progress. The history of science, in other words, is not a progressive march toward the truth. Instead, the truth of scientific theories is relative to the paradigms in which they are used.