

world as a means of regulating the sciences and of vindicating the act of human interpretation of visible reality.

**Existentialism.** The existentialists made their own return to the existent reality of man, partly to liberate him from being a modalized phase of the idealistic absolute, partly to recover the sense of freedom and moral decision, and partly to gain orientation for the study of being. But each of them made a distinctive development and came eventually to resist classification along with the others.

K. JASPERS and G. MARCEL maintained a threefold kinship. They were highly critical of the depersonalizing effect of technological civilization; they regarded the free human existent as being related to transcendence as well as to the world; and they recognized the limiting effect of life situations upon the project of reaching God. Marcel worked out a theory of recollection and participation in being whereby the human searcher is united to God, whereas Jaspers remained fundamentally ambiguous about this relationship. For J. P. SARTRE's part, both the social and the religious projects of man are unavoidable and yet doomed to frustration. Sartre based this conclusion on a sharply dualistic theory of matter and consciousness in man, reminiscent of the idealistic thesis and antithesis taken in isolation from any unifying principle. M. HEIDEGGER's route led him backward from things-that-are to being, from technology to the pre-Socratic grasp of nature, and from the long philosophical tradition to the act of thinking in which being can perhaps be enshrined. His analyses of being in the world, being along with others, and being related to instruments and to integral things, were clues to the metaphysics of being for which he sought. (See EXISTENTIALISM.)

**Scholasticism.** In the wake of the papal recommendations after Leo XIII's *Aeterni Parris*, there was a quickening of traditional Christian philosophies. The historical labors of M. GRABMANN and M. DE WULF restored knowledge of the medieval philosophies, a task carried on by É. GILSON, who also gave special place to St. Thomas Aquinas. J. MARITAIN's work was to bring THOMISM into living relation with modern problems in science, art, and society. The task of rethinking the scholastic heritage was continued in all areas of thought. (See SCHOLASTICISM, 3.)

**Bibliography:** J. L. BLAU, *Men and Movements in American Philosophy* (New York 1952). I. M. BOCHENSKI, *Contemporary European Philosophy*, tr. D. NICHOLL and K. ASCHENBRENNER (Berkeley 1956). J. D. COLLINS, *Three Paths in Philosophy* (Chicago 1962). F. C. COPLESTON, *Contemporary Philosophy* (Westminster, Md. 1956). A. DONDEYNE, *Contemporary European Thought and Christian Faith*, tr. E. MCMULLIN and J. BURNHEIM (Pittsburgh 1958). J. FERRATER MORA, *Philosophy Today* (New York 1960). A. W. LEVI, *Philosophy and the Modern World* (Bloomington, Ind.

1959). J. A. PASSMORE, *A Hundred Years of Philosophy* (New York 1957). *The Library of Living Philosophers*, ed. P. A. SCHILPP (Evanston, Ill. 1939), separate volumes on Broad, Buber, Carnap, Cassirer, Dewey, Einstein, Jaspers, Lewis, Moore, Radhakrishnan, Russell, Santayana, and Whitehead. V. E. SMITH, *Idea-Men of Today* (Milwaukee 1950). H. SPIEGELBERG, *The Phenomenological Movement: A Historical Introduction*, 2 v. (The Hague 1960). M. F. SCIACCA, *Philosophical Trends in the Contemporary World*, 2 v. (Notre Dame, Ind. 1964).

[J. D. COLLINS]

## PHILOSOPHY AND SCIENCE

Prior to the 19th century, the philosophy of nature and natural science were one and the same discipline (see PHILOSOPHY OF NATURE). Their union dates back to Greek antiquity, when Aristotle considered as a single science what are now called the philosophy of nature, cosmology, chemistry, and biology. Such a unified view of philosophy and science survives in the title of Isaac Newton's masterwork *The Mathematical Principles of Natural Philosophy* (1687) and, more than a century later, in John Dalton's *A New System of Chemical Philosophy* (3 v., 1808, 1810, 1827). Contrasted to the "mathematical philosophy" fostered by Newton was another study, "experimental philosophy." These mathematical, chemical, and experimental philosophies, as they were then called, are today considered as science—a term that, with the foundation of the British Academy of Science in 1831, came into vogue to designate modern physics, chemistry, biology, and related disciplines.

**Status before Kant.** The separation of science and philosophy and the restriction of the term science—which Aristotle had used in a sense broad enough to include his philosophy of nature—must also be viewed against the background of modern philosophy (see PHILOSOPHY, HISTORY OF). Aristotle had applied the term physics to the single science of nature whose parts are listed above, and contrasted this with another science subsequently called METAPHYSICS. Aristotle's physical science was a project to explain material realities in terms of the four causes: MATTER, FORM, AGENT, and END. But the philosophers Francis BACON and René DESCARTES restricted the scope of physics. Bacon held that the concern with form and end belonged to metaphysics; Descartes, removing from physics the concern with FINAL CAUSALITY, conceived the world of nature as a machine and identified the physical with the mechanical. These developments, which had great influence, effectively destroyed the philosophy of nature as a physical science, leaving the material world to be studied only in the spirit of those subjects officially labeled science in the Anglo-American world of 1831.

Bacon and Descartes left metaphysics standing. But in a series of philosophies climaxed by that of Immanuel Kant, metaphysics itself was declared impossible. Science in the spirit of Newton and his successors was thus left as the only legitimate body of speculative knowledge concerning existing things. At this historical stage of the relations between philosophy and science, it could be said that science stood alone as a study of things, whereas philosophy, with respect to science, was purely critical and epistemological, warning students of nature against treading beyond knowledge like that in Newtonian physics.

**Idealism and Positivism.** In the wake of Kant's work, two new philosophical currents were put in motion. One was IDEALISM, which reached a climax with Georg HEGEL. Hegel constructed a philosophy of nature but in a sense quite different from its Aristotelian version. For Hegel, the idealist, nature was Spirit or Idea externalizing itself; these external manifestations could be studied by the philosophy of nature in three disciplines: (1) mechanics, which begins with a study of empty space; (2) physics, a study of things in their totality; and (3) organics, a study of the living world where Idea or Spirit, fractured in the externalizing process, is struggling in a more intense way to recover its unity. Hegel's notion of the estrangement (externalization) of a primitive reality from itself, and the subsequent struggle, in various stages, toward reunion, is important not only for understanding the Hegelian notion of nature and its sciences, but also for understanding the Marxist philosophy of science to be sketched below.

The other 19th-century view of science is called POSITIVISM and was begun by Auguste COMTE. He regarded his so-called positive philosophy as having concern not with the causes or origins of things but with "their invariable relations of succession and resemblance." This apparently descriptive, as opposed to explanatory, program for the study of nature leaves the material world entirely to the positive sciences. Herbert SPENCER, a later positivist, assigned to philosophy the role of synthesizing scientific results. But most positivists conceived the main burden of speculative philosophy as one of accounting for the apparent necessity and universality in the laws discovered by the sciences.

This project dates back to Kant, who had prepared its way by his ban on metaphysics and by his restriction of valid knowledge to PHENOMENA. Kant had argued that the phenomenal world could not give rise to the universality and necessity found in physical laws, and that such universality and necessity had therefore to come from a priori structures in the human mind. Comte's own preference was to view all history as following a law of three



*Charles Sanders Peirce.* (Bettmann/CORBIS)

stages: a theological stage, wherein the world is explained by an appeal to supranatural deities; a metaphysical stage, wherein things are explained by abstract essences; and a positivistic stage, wherein reality is accounted for by sciences like that of Newton. Necessity is attributed to nature's laws, according to Comte, because even modern man has not yet outgrown the so-called metaphysical stage.

Other positivists proposed different theories. Ernst Mach regarded scientific laws as economies of thought that make it psychologically easier for man to study nature. Henri Poincaré held such laws to be mere conventions. Karl Pearson (d. 1936) considered scientific law a mental shorthand. For Hans Vaihinger (d. 1933) law was a fiction, but since one could proceed practically "as if" laws were real, he called his view "the philosophy of 'as if.'"

**Other Philosophical Views.** At the end of the 19th century and the beginning of the 20th, the relations between philosophy and science, as indeed the whole fabric of Western philosophy, were elaborated in a context of idealism or of positivism. Early in the 20th century, Anglo-American philosophy experienced a return to REALISM in one or other of its forms. For this and other reasons associated with the 20th-century revolution in

physics, the relations between philosophy and science took new turns. Even 20th-century idealist and positivist philosophies of science became different from philosophies of the 19th century bearing similar labels. Generally speaking, six theories of the relations between philosophy and science can thus be identified; pragmatism, idealism, linguistic philosophy, existentialism, dialectical materialism, and realism of scholastic and nonscholastic varieties.

*Pragmatism.* PRAGMATISM owed its immediate origin to Charles Sanders PEIRCE, who held that ideas could be made clear only by looking to their "effects." This is the so-called pragmatic test. But Peirce, a self-styled scholastic realist, rejected positivism in its account of scientific laws and held to the existence of "particular characters," analogues to "natures" in the Aristotelian sense. Somewhat like Aristotle also, and again in contrast to positivism, he regarded man's first questions about nature as being "the most general and abstract ones." Unlike the arrangement in positivism, this would put philosophy, not after science, but before it.

Other pragmatists like William JAMES and John Dewey did not have the intellectual interests of Peirce. They did not make distinctions of any importance between philosophy and science. But both James and Dewey insisted that experience extends beyond the phenomena of Kant or the sense data of British EMPIRICISM. According to this larger view, there is personal experience, religious experience, experience of values, etc. Such an enlargement of the Kantian and positivist notion of experience, while important in itself, prepared the way for philosophies of science like Whitehead's.

*Idealism.* Idealism, as a philosophy of science, was defended in the 20th century principally by Arthur Eddington and James Jeans. Eddington was led to his position by arguments that science consists of "pointer readings" recorded on instruments. The scale for such readings, which determines how much of the real will register on us, is selected by the mind. Hence the mental or idealistic component in science. What lies behind the pointer readings escapes science, Eddington alleges. He likened this basic reality to spirit and consciousness, stressing once more his preference for "idealism." Jeans was led to a similar position by the predominance in modern science of the mathematical, which he identified with the mental.

*Linguistic Philosophy.* Linguistic philosophy must be subdivided into LOGICAL POSITIVISM and analytical philosophy. Both have common ancestors in Bertrand RUSSELL and Ludwig WITTGENSTEIN. Like earlier positivisms, logical positivism recognized as meaningful the various propositions occurring in a science; these are al-

leged to be either about sense data (in the British empiricist sense) or about what is reducible to sense data. It is the work of philosophy to clarify the meanings of such empirical statements. A second type of meaningful expression is the analytic statement, which is true by the very meaning of its symbols, e.g.,  $A$  is  $A$ . In working with both types of statement, philosophy is reduced to logic, and science alone is left to study the real. Even among those who do not accept it completely, logical positivism has heightened interest among philosophers such as Ernest Nagel in searching for criteria by which scientific laws and theories are accepted.

Because of its concern with the propositions of the science, logical positivism has been referred to as a philosophy of artificial language. In contrast, another branch of linguistic philosophy, represented by Gilbert Ryle, P. F. Strawson, R. B. Braithwaite, and Stephen Toulmin, insisted on the importance of analyzing ordinary language. Such analytical philosophers, apart from their other commitments, argue that language can be meaningful without being merely analytic or empirical in the logical positivist sense. By recognizing ordinary language as a layer of first-level meanings that must be examined before the technical second-level terminology of science, analytical philosophers, while strictly concerned with language, acknowledge as genuine at least some of the questions raised by Aristotle in his philosophy of nature.

*Existentialism and Phenomenology.* EXISTENTIALISM as a philosophy of science can be seen best in the work of Karl JASPERS (b. 1883). For him there is an authentic primordial experience of subjectivity, existence, and transcendence. But science, while not itself such authentic experience, enlarges the field within which the act of transcendence can be accomplished. In form, though not in content, Jaspers's view here is reminiscent of the PHENOMENOLOGY of Edmund HUSSERL, who launched a program for the reduction of knowledge to primordial intuitions, e.g., of time and space, which condition man's interpretation of scientific results. Such a phenomenology was advanced also by Maurice MERLEAU-PONTY.

*Dialectical Materialism.* Though initiated in the 19th century, dialectical materialism reached its climax in the 20th century (see MATERIALISM, DIALECTICAL AND HISTORICAL). It has always claimed to remain close to science. Its theorists have insisted that philosophy precedes science and lays down such truths as the union of opposites in the essence of matter. Science, by such findings as the wave-particle duality in quantum theory, is regarded as confirming the earlier philosophical commitment.

*Nonscholastic Realism.* Finally, several 20th-century philosophers of science can be associated with realism, if merely for want of a better term to characterize their

opposition to positivism and to idealism. Peirce, the pragmatist, belongs among these. Other realist philosophers include Emile Meyerson, Henri BERGSON, and Alfred North WHITEHEAD. Meyerson held that there was an ontology in all science, as shown by the scientist's commitment to the existence of abiding identities in a changing world. Bergson maintained that science as such presents a geometrized, hence static, view of a world in motion, and that motion can be grasped only by an intuition that lies beyond the techniques of science. Whitehead proposed that the scientist, in advance of his science, commits himself to "half truths" that the philosophers must examine. Using experience in the wide sense given it by James, Whitehead elaborated a philosophy of organism. He used science more to confirm and correct this philosophy than to establish it.

**Scholastic Positions.** With the revival of Thomistic philosophy in the wake of Leo XIII's encyclical *Aeterni Patris*, scholastics began to develop their own distinctive views on the relation between science and philosophy. One of the earliest and most active centers of this revival was the University of Louvain; its dominant figure was Cardinal Désiré MERCIER. As a follower of Aquinas, he subscribed to Thomistic metaphysics; he also accepted a philosophical physics that preceded metaphysics in the pedagogical order. With later generations at Louvain, however, the philosophy of nature, under the name of COSMOLOGY, gradually lost its originality and came to be considered more or less as an applied metaphysics. The most extreme presentation of this view is that of Ferdinand Van Steenberghen, for whom the sciences are subdivided into epistemology, which includes logic; positive science, which includes mathematics; and metaphysics, which includes cosmology, psychology, and even moral science.

Jacques MARITAIN (d. 1973) departed from the position just outlined by his recognition of a philosophy of nature distinct from metaphysics. The philosophy of nature is called by him ontological knowledge, in contrast to the modern sciences, which are called empiriological and are subdivided into empirioschematic and empiriometric. At the physical level of ABSTRACTION Maritain proposed a distinct type of natural science, called empirioschematic; such science, for him, uses so-called qualitative models, like the theory of evolution in biology, as explanatory tools. Empiriometric knowledge, on the other hand, is a mixed or intermediate science, described in principle by Aristotle, Saint Thomas Aquinas, and Cajetan, and roughly equivalent to today's mathematical physics. In such empiriometric knowledge the explanatory tools are quantitative, and the resulting science may be considered terminally physical.

Charles DE KONINCK of Laval University proposed a view denying that Maritain's so-called empiriological knowledge represented a distinct type of science. For De Koninck the modern sciences are dialectical in Aristotle's sense, whereas true or demonstrative natural science, again in Aristotle's sense, is found only in the general philosophy of nature and philosophical psychology (*see* DIALECTICS; DEMONSTRATION). The modern natural sciences are thus dialectical continuations of the philosophical study of nature, where demonstration can be achieved and science thus attained.

The Albertus Magnus Lyceum in the United States, taking its inspiration from Anicetus Fernandez and William H. Kane, agreed with Maritain that mathematical physics is a science distinct from the philosophy of nature. The Lyceum position agreed with De Koninck's in recognizing that empirioschematic knowledge is not a distinct science but a continuation of the philosophy of nature. However, this continuation of the philosophy of nature is regarded as not only dialectical; some of it is said to be demonstrative also. To this extent it continued the philosophy of nature not merely in a dialectical but also in a scientific way.

*See Also:* SCIENCE (IN ANTIQUITY); SCIENCE (IN THE MIDDLE AGES); SCIENCE (IN THE RENAISSANCE); SCIENCES, CLASSIFICATION OF; PHILOSOPHY OF NATURE

**Bibliography:** V. E. SMITH, ed., *The Philosophy of Physics* (Jamaica, New York 1961). J. MARITAIN, *Distinguish to Unite, or the Degrees of Knowledge*, tr. G. B. PHELAN from 4th French ed. (New York 1959). C. DE KONINCK, "Les Sciences expérimentales sont-elles distinctes de la philosophie de la nature?," *Culture* 2 (1941) 465-76. J. A. WEISHEIPL, ed., *The Dignity of Science* (Washington 1961). P. H. VAN LAER, *Philosophy of Science*, 2 v. (Pittsburgh 1956-62). S. STRASSER, *Phenomenology and the Human Sciences* (Pittsburgh 1963). R. MCRAE, *The Problem of the Unity of the Sciences: Bacon to Kant* (Toronto 1961). B. K. MILMED, *Kant and Current Philosophical Issues* (New York 1961). A. J. AYER, ed., *Logical Positivism* (Glencoe, Illinois 1959). S. E. TOULMIN, *The Philosophy of Science* (New York 1953). K. JASPERS, *Way to Wisdom: An Introduction to Philosophy*, tr. R. MANHEIM (New Haven 1960). C. S. PEIRCE, *Philosophical Writings of Peirce*, ed. J. BUCHLER (New York 1955). R. M. PALTER, *Whitehead's Philosophy of Science* (Chicago 1960).

[V. E. SMITH]

## PHILOSOPHY OF NATURE

The philosophy of nature, variously referred to as natural philosophy, COSMOLOGY, and the science of nature, is the discipline that treats of the world of nature or the physical universe in its most general aspects. Traditionally it considers such topics as the definition of matter, nature, motion, infinity, time, life, soul, and similar