

bined with what is good in Paracelsus. If he was not a great discoverer, he was a tireless experimenter and an exciting person who could not be ignored. He shook the very foundations of Galenic medicine and helped establish a climate favorable to future discoveries. The discovery by SERVETUS of the lesser or pulmonary circulation was another blow to the Galenic medicine since it did away finally with the invisible pores in the septum of the heart. Two more doctors deserve mention: Jean Fernel (1497 to 1558) and Ambroise Paré; the first, the founder of physiology; the second, of a new surgery. Fernel's *Opera* went through 34 editions before 1681. His physiology was the study of the body's normal functioning, and he divided his texts into circulation, respiration, digestion, muscular function, etc. He made no great discovery—many of these had to await the microscope, but he was a careful observer and a good physician who stimulated further research. Paré was a military surgeon who promoted the humane treatment of gunshot wounds, and his worth was such that he was surgeon to three kings.

Conclusion. This brief survey has tried only to indicate a few trends and to place some of the great Renaissance scientists in their historical context. The bibliography cites only general works; for material on particular scientists, see the bibliographies at the end of their respective biographies.

See Also: BIOLOGY I (HISTORY OF).

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[N. SCHEEL]

SCIENCE, CLASSIFICATION OF

SCIENCE (*scientia*) is an analogical term legitimately but diversely applicable to many differing disciplines in a set in which demonstrated knowledge ranks as prime analogate (*see* DEMONSTRATION). This article considers the division of science, understood in this analogously general sense, into its types. There are as many legitimate divisions as there are formally diverse relevant principles of differentiation. To illustrate the various possibilities, several different ways in which the sciences can be classified are first considered. Then the different ways in which the sciences have been classified by certain key figures in the history of thought are sketched, with emphasis upon the classification proposed by St. Thomas Aquinas.

Principles of Differentiation

Sciences can be distinguished on the basis of relevant differences in OBJECT (i.e., subject matter), END (i.e., intention or purpose), or method. We say ‘relevant’ because there are some differences that touch sciences only accidentally, and these suggest divisions that are noetically trivial at best, e.g., the intention of the scientist as a man (*finis scientis*) as contrasted with the intention of the science as such (*finis scientiae*).

Difference in Object. LOGIC can be distinguished from the other sciences on the basis of a difference in subject matter. Logic studies second intentions, the non-real relationships that accrue to things *as known* and that set the demands for discursive procedures. The other sciences confront the things themselves. Only the object of logic is second intentional; the object of every other science is first intentional; and logic can be seen to differ from these other sciences on the basis of a difference in object. It will be seen later that the other sciences can themselves be distinguished one from another on the basis of a further difference in object.

Difference in End. Some sciences in themselves intend nothing beyond truth in knowledge; others intend some activity beyond knowing. The former are said to be theoretical or speculative sciences, while the latter are practical (*see* COGNITION SPECULATIVE-PRACTICAL). This is a distinction based upon a difference in end. METAPHYSICS consists in a knowledge of being, whereas medicine consists in a knowledge of the curable body. Being is worth knowing about only for the sake of the very knowledge of being. The end of metaphysics is truth about being: it is a speculative discipline. On the other hand, the curable body as curable is worth knowing about not primarily for the knowledge of the curable but for the curing of the curable. The end of medicine is action: it is a practical discipline.

Difference in Method. Sciences can also be distinguished by differences in method. For example, one type of science, namely, sacred theology, resolves its conclusions into divinely revealed truths. The ultimate criterion according to which a proposition in sacred theology is to be judged is the authority of God revealing. No other science depends for its ultimate illumination upon the word of any authority. The others depend upon the natural light of reason; they resolve their conclusions into premises seen by the scientist himself to be true. A difference in method can be seen to distinguish a science such as Euclidean geometry from a science such as contemporary physics. The geometer attempts to establish theorems by resolving them ultimately into self-evident premises. If he is successful, his theorems are certainly seen to be necessarily true. The method of geometry is strictly demon-

strative. The physicist, on the other hand, attempts to “verify” his hypotheses by showing that true conclusions (observed to be true in experiments suggested by the hypotheses) follow from them. Since a true conclusion *can* come from a false antecedent, the physicist can never ascertain the truth of his hypotheses. The best he can do, as his hypotheses are seen repeatedly to lead to true consequents, is to establish their probability. His method is dialectical, not demonstrative.

Interrelations. Though some sciences have been distinguished on the basis of a difference in object, others on the basis of a difference in end, and still others on the basis of a difference in method, it would be a mistake to suppose that there can be but one type of difference in force at any one time. Speculative sciences intend truth in function of an object that is nonoperable; and practical sciences intend action in function of an object that is operable. Further, the method of the speculative sciences, in virtue of their object and end, is characteristically resolutive, whereas the method of the practical sciences, in virtue of their object and end, is characteristically compositive. However, it would also be a mistake to suppose that object, end, and method are always identically proportioned to one another. For example, though an operable is worth knowing about primarily so that it can be produced (and, under this formality, the end of the science in question is action and its method is compositive), an operable can be approached simply for the knowledge it affords (and then the end of the science is truth and its method is resolutive). Science of an operable with action as its end that is achieved in a compositive mode is wholly practical, while science of an operable with truth as its end that is achieved in a resolutive mode is partly practical and partly speculative.

Classifications in the History of Thought

The key figures in the history of thought who have proposed distinctive classifications of the sciences include Aristotle, Boethius, St. Thomas Aquinas, and Christian Wolff; more recent developments include the classifications proposed by the positivists and contemporary Thomists.

Aristotle. Aristotle divides the sciences into the theoretical, the practical, and the productive. The theoretical is knowledge for the sake of knowledge; the practical, for the sake of conduct; and the productive, for the sake of useful or beautiful artifacts. The theoretical sciences, which are more excellent than the others, are further divided into physics (whose object is inseparable but not immovable), mathematics (whose object is immovable but not separate), and theology, i.e., first philosophy or metaphysics (whose object is separate and immovable).

The object of mathematics is known by way of an abstraction that consists in a subtraction of matter rendering the now separated form of quantity present to the mind of the mathematician. The object of physics, on the other hand, is known by way of an addition, for the forms of natural things must be known *with* matter if they are to stand present to the mind of the physicist as subject to motion. The object of first philosophy, which is being *qua* being, is known neither as conditioned by a subtraction nor with an addition. Logic is not classified with the sciences but is spoken of as a discipline demanded of any cultured mind prior to any serious approach to the sciences.

Boethius. BOETHIUS divides science into two kinds: theoretical, which is knowledge for its own sake, and practical, which is knowledge ordered to action. Though he classifies theoretical sciences differently on different occasions, in the *De Trinitate* he follows the lead of Aristotle, listing them as natural science, mathematics, and theology. These three are distinguished by differences in their objects, depending upon whether these are forms more or less separated from matter.

Thomas Aquinas. St. THOMAS AQUINAS gives his most significant treatment on the classification of the sciences in questions 5 and 6 of his commentary on the *De Trinitate* of Boethius. Three of the most significant articles in these questions are articles 1 and 3 of question 5 and article 1 of question 6. In these articles St. Thomas distinguishes between sciences on the basis of differences in object, end, and method. The following are brief summaries.

In Boeth. de Trin. 5.1. The practical sciences have operables as objects and operation as end, while the speculative sciences have nonoperables as object and knowledge of these as end. The speculative sciences are in turn distinguished one from another by differences in their objects precisely in reference to what makes them objects of scientific speculation. An object is speculable insofar as it is immaterial, for the INTELLECT is an immaterial power; and it is scientific insofar as it is immobile, for science is of the necessary. Objects of speculative science are thus differently objects, and so objects of different sciences, insofar as they are differently related to matter and motion. One object of speculation depends on matter both to be and to be known: this is the object of physics or natural science. Another depends on matter to be but not to be known: the object of mathematics. Still another depends on matter neither to be nor to be known: the object of metaphysics. Logic is not included under speculative science as a principal part but remains outside these sciences as a tool for them.

In Boeth. de Trin. 5.3. The intellect can consider one thing without considering another (even though the first

cannot exist without the other) so long as the meaning of the first does not depend on the other. This is a way of abstracting spoken of strictly as ABSTRACTION (*abstractio, proprie loquendo*). The intellect can think one thing to be without another so long as the first does not depend upon the other for its existence. This is a way of abstracting spoken of strictly as separation (*separatio, proprie loquendo*). The objects of natural science or physics and mathematics are known by an abstraction: for physics, an abstraction of the whole essence of the natural thing from its nonessential characteristics (*abstractio totius*); for mathematics, an abstraction of the form of quantity from sensible matter (*abstractio formae*). The object of metaphysics is known by a separation of being from all matter (*separatio*).

In Boeth. de Trin. 6.1. It is especially characteristic of natural science or physics to proceed according to the mode of reason (*rationabiliter*), of mathematics to proceed according to the mode of learning (*disciplinabiliter*), and of metaphysics to proceed according to the mode of intellect (*intellectualiter*). The mode of reason involves moving from things more knowable to man but less knowable in themselves, and from one thing to another thing. The mode of learning is one that most easily assures certainty in its conclusions. The mode of intellect involves a unified vision of all things in the light of the most universal of principles.

Other Teaching on Abstraction. Elsewhere Aquinas adds to what is found in these articles (*In 1 phys. 1.1–3; In 3 anim. 8.707–717; Summa theologiae 1a, 85.1 ad 2*). Abstraction of the natural species (*abstractio totius* of 5.3) is described as an abstraction from individual sensible matter but not from common sensible matter. The abstraction of the mathematical species (the *abstractio formae* of 5.3) is described as an abstraction from all sensible matter and from individual intelligible matter but not from common intelligible matter. The abstraction of such things as being (the *separatio* of 5.3) is explained as an abstraction from all matter.

These three abstractions (which can be correlated with the three degrees of formal abstraction of CAJETAN and JOHN OF ST. THOMAS, namely, with physical, mathematical, and metaphysical abstraction) yield formally different scientific objects that, precisely as different, constitute diverse genera of speculative science. Each genus of speculative science is, at least theoretically, open to specific differentiation. For example, mathematics is a genus of science that divides specifically into arithmetic and geometry. John of St. Thomas shows that arithmetic and geometry are in the same genus of science insofar as they share, apropos of abstraction, the same *terminus a quo*. The object of each abstracts from all sen-

sible matter and from individual intelligible matter. Yet they differ in the *terminus ad quem* of the abstraction appropriate to each. Discrete quantity, which is the object of arithmetic, is known without reference to position. It is thus attained on a higher level of abstraction than is continuous quantity, the object of geometry, which, including a reference to position, is less immaterial than discrete quantity.

Unity and Diversification. St. Thomas, following Aristotle, teaches that the unity of a given science depends on the unity of its characteristic subject and that the diversification of different sciences depends upon a diversification in the principles from which they proceed. Effectively this reduces to the same thing, for a subject is subject in a given science in virtue of the peculiar mode of its abstraction from matter, and the middle term of any scientific demonstration (which is *the* principle of demonstration) is a principle in a given science precisely insofar as it represents, as a DEFINITION, a mode of defining involving a peculiar degree of abstraction from matter.

Relationships between Sciences. In addition to showing how sciences are one in themselves and yet different from other sciences, St. Thomas shows how sciences, though different, can be interrelated. For example, a given science can be different from another and yet be included under it as subalternated to it. This is the case when one (higher and subalternating) science supplies the reason for the fact established in another (lower and subalternated) science. In natural philosophy, for example, reasons are given for things that are seen to be facts in medicine, and in arithmetic reasons are given for things that are seen to be facts in music. St. Thomas also recognizes the existence of sciences that are noetically mixed, that is, sciences that are formally mathematical and materially physical. These sciences, e.g., astronomy, are mathematical in their mode of demonstrating, but the subjects investigated in them are physical. Contemporary physics, which is spoken of by many as *the* science, is an example of one of these mixed sciences; much of its content is aptly described as mathematical physics.

Wolff. Christian WOLFF proposed a classification of the sciences considerably different from that of St. Thomas. Yet his classification has made its influence felt on many supposedly Thomistic manuals in philosophy. Wolff distinguishes between logic, which comes before all the other disciplines, and philosophy proper. Philosophy is subdivided into the speculative and the practical. Practical philosophy includes ethics, economics, and politics, while speculative philosophy is identified with metaphysics. Metaphysics, in turn, includes ONTOLOGY, rational psychology, COSMOLOGY, and THEODICY. Ontology is general metaphysics, while the latter three represent different types of special metaphysics.

Positivists. The classification of Wolff, who is a rationalist, can be contrasted with that of the positivists, whose influence is significant in contemporary philosophy. Auguste COMTE, the founder of POSITIVISM, rejected all sciences except the positive sciences, listing the six major positive sciences, in a hierarchical order going from the most abstract and independent to the most concrete and dependent, as mathematics, astronomy, physics, chemistry, biology, and sociology. Philosophy at best is a generalized theory of the several positive sciences.

Recent positivism is distinguished from the earlier positivism by reason of the emphasis more lately placed upon the logical analysis of language (see LOGICAL POSITIVISM). Contemporary logical positivists of the school of linguistic analysis set philosophy off against science. The aim of science is the discovery and use of laws. The aim of philosophy is simply the elucidation of concepts. Science is divided into logic (which includes pure mathematics), wherein resolution is finally into analytic statements or pure tautologies, and empirical science, wherein resolution is finally into experience. The empirical sciences include physics, chemistry, biology, and even ethics and aesthetics. Philosophy is essentially a method of elucidation, involving for the most part the analysis of the concepts, methods, and presuppositions of the sciences. It includes, in metalogic, the analysis of logical concepts; in the philosophy of science, the analysis of concepts common to all the sciences; and in the philosophy of physics, or of chemistry, etc., the analysis of concepts appropriate to the science in question. Metaphysics, as thought to deal with synthetic a priori statements, is rejected as a meaningless enterprise.

Recent Thomists. The Louvain school has been a major influence in scholastic philosophy in the 20th century, and the classification of the sciences of Cardinal D. MERCIER has made its mark on the teaching of philosophy, especially in Catholic schools. Mercier distinguishes between the particular sciences of observation (physics, chemistry, biology, and the like), philosophy, and mathematics. Philosophy is further divided into the speculative and the practical. Speculative philosophy is subdivided into general physics (which includes cosmology, rational psychology, natural theology, and even epistemology) and general metaphysics or ontology. Practical philosophy includes logic, moral philosophy, and aesthetics. In general the order of learning requires that the particular sciences come first, to be followed by general physics, which is the philosophical complement of these sciences. This is followed by mathematics, then ontology, and finally logic.

This manner of dividing and arranging the sciences owes something to Aquinas, but it represents a revision

of St. Thomas's scheme in the face of contemporary demands. Other Thomists of this century, though intent upon keeping philosophically up-to-date, see no need for revising St. Thomas's scheme of the sciences though they may build from it. This is true of the Laval school (C. De Koninck), the River Forest school (Albertus Magnus Lyceum), and the Maritain school—though these schools do differ in their explanation of the way in which the philosophy of nature is related to the contemporary physical sciences (see PHILOSOPHY AND SCIENCE; SCHOLASTICISM, 3).

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SCIENTIA MEDIA

According to Molinists, *scientia media*, middle knowledge, is that knowledge by which God, prior to any absolute decree, but not without the supposition that He would decree, infallibly perceives free FUTURIBLE acts of creatures. He knows what a man would do in any circumstances if He would decree to concur in them, before He makes any absolute decree establishing the situation.

Free futuribles are known by God prior to any absolute decree existing in Him; for, being only conditional existents, they presuppose only conditionally existing causes, a subjectively conditional decree in God, and conditionally existing human cooperation.

God's knowledge of futuribles had long been recognized, but the name *scientia media* applied to it first occurs explicitly in theological literature of the 16th century. Peter da FONSECA (1528–99) in his commentaries on the *Metaphysics* of Aristotle speaks of *scientia mista*. Independent of Fonseca, who was never his teacher, Luis de MOLINA made middle knowledge famous in his solution of problems connected with human freedom, on the one hand, and, on the other, God's foreknowledge and efficacious GRACE, proposed in his *Concordia* (1588).