the Sacraments, waiting for the time when a general agreement could be reached, he did not become an organizer of another evangelical church. Expelled from Silesia, he spent some time in Strassburg, Ulm, and other places in southern Germany. In Strassburg he met Melchior HOFFMAN and Pilgram MARBECK. With the latter he entered into a considerable literary exchange of views.

Schwenckfeld was a prolific writer. His writings were read by his followers in reading circles, which was the primary reason that the group survived despite its small numbers. He had followers in Silesia and in southern Germany. Promoters of his views were Adam Reusner and Daniel Sudermann. In southern Germany, followers of Schwenckfeld were found up to 1660. In Silesia they underwent severe persecution. Between 1725 and 1736 more than 500 Schwenckfelders fled, finding refuge on the estate of Nikolaus ZINZENDORF, in Saxony. With the help of some Dutch and German MENNONITES, some 212 of them migrated to southeastern Pennsylvania in 1734 and settled in Philadelphia, Montgomery, Berks, and Lehigh counties.

The first minister was George Weiss, and the first meetinghouse was built in 1789. In 1909 the group incorporated as the Schwenckfelder Church with a congregational church polity. Since 1877 the Lord's Supper and (adult) baptism, which were discouraged by Schwenckfeld, have been observed. The Schwenckfelder Board of Missions was organized in 1895 and the Board of Publication in 1898. The Schwenckfelder Library at Pennsburg, Pa., and the Perkiomen School (1891) belong to the church.

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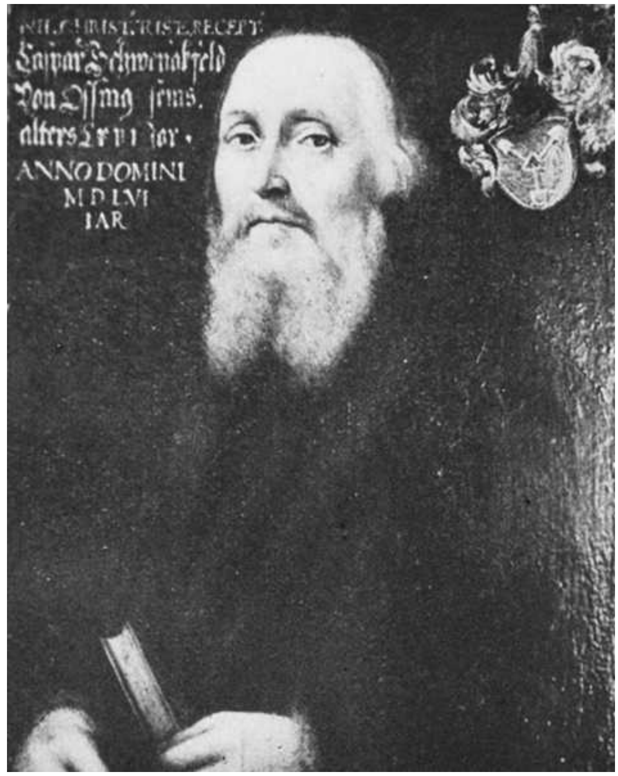
[C. KRAHN]




*Caspar Schwenckfeld.*

## SCHWETZ, JOHANN BAPTIST

Theologian; b. Bosan, Moravia, 1803; d. Vienna, 1890. He taught dogmatic theology first at Olmütz and then at the University of Vienna. In 1863 he was named head of the canons of the cathedral chapter of Vienna and director of St. Augustine Seminary. In 1861 he had published his *Theologia dogmatica catholica,* a work remarkable for its precision, clarity, and erudition. Because of its opposition to the errors of JOSEPHINISM and A. GÜNTHER, it was prescribed by civil and ecclesiastical authority as the textbook in dogmatic theology for use throughout the Austro-Hungarian Empire for some years. Schwetz took part in Vatican Council I by preparing a schema against the errors of Günther.

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[C. MEYER]

## SCIENCE (SCIENTIA)

A term much used in the Aristotelian-Thomistic tradition to designate a type of perfect knowing (*scire simpliciter*). According to Aristotle, one obtains such knowledge of any object when he knows its cause, when he knows that that cause is what makes the object be what it is, and when he therefore knows that the object could not be otherwise than it is (*Anal. post.* 71b 8–12). For St. THOMAS AQUINAS, science is KNOWLEDGE of something through its proper cause (*C. gent.* 1.94). He locates it in the category of intellectual knowledge, as opposed to sense knowledge; and within this category he characterizes it as mediate intellectual knowledge, as opposed to immediate knowledge of concepts and FIRST PRINCIPLES, insofar as it is acquired through the prior knowledge of principles or causes. As a type of knowledge it can be further considered as the ACT itself by which such knowledge is acquired or the habit of mind resulting from one or more such acts (*ibid.* 2.60). And apart from the act and the habit, the body of knowledge that is known by one possessing the habit—the body of truths and conclusions attained—also is said to constitute the science (*ibid.* 1.48, 56).

Apart from this strict notion of science, Aristotle allowed application of the term to a less perfect type of knowledge: thus he spoke of more or less perfect explanations and those that merely ''save the appearances,'' somewhat akin to the explanations of modern science. This broader usage was countenanced by the scholastics and figured prominently in the evolution of the concept of science that dominated the modern period. In contemporary thought there is no full agreement on the definition of science; yet there is, for the most part, agreement that some intellectual knowledge is scientific and some nonscientific and that the scientific enterprise is an effort to find the order of things and to assign reasons for this order. Science has thus become an analogical term legitimately but diversely applicable to many differing disciplines in a set wherein perfectly demonstrated knowledge ranks as the prime analogate.

This article considers first the stricter notion of science in discussing its object and subject, its kinds, and its status as a habit, and then describes the evolution of the broader notion with the rise of modern science.

**Object and Subject.** When a psychological analysis of any act of knowing is made, the act itself is said to be specified by its object, because this is what confronts the mind, or is ''thrown against'' (*ob-iectum*) the mind, when something is actually known. In this object, St. Thomas Aquinas makes the distinction between what is formal and what is material: the former is the aspect under which the object is related to the knowing faculty, whereas the latter is that which underlies this aspect (*De carit.* 4). In the classical example of the faculty of sight, the formal object is thus said to be color or the colored, whereas the material object is said to be the body in which the color is seen. And the formal object is further distinguished into two aspects: that which is attained by the knowing faculty, or the *obiectum formale quod*, and that by which it is attained, or the *obiectum formale quo* (Capreolus). Again in the example of sight, the formal object *quod* is said to be color, as that which is seen as such, whereas the formal object *quo* is said to be light, as that by which color is made visible, and therefore able to be attained by the sense of sight (*De ver.* 14.8 ad 4).

Applying this terminology to the act of knowing that is characteristic of science, the object of a science is that at which the act of scientific knowing terminates, which, in turn, is the result of the DEMONSTRATION that is proper to the science. The terminating object is ultimately some singular thing that exists in extramental reality; but since the knowing act itself is a JUDGMENT, even though a mediate one, the knowledge attained is expressed by the mind as a complex entity composed of subject and predicate. The latter complex entity is the matter that is known, and it can be spoken of as the material object of the science; the formal aspect under which it is known is the middle term of the demonstration that produces the assent to the conclusion (*De carit.* 13 ad 6; *Summa theologiae* 2a2ae, 1.1). The formal object *quod* of the science is, then, what is attained by the particular formality (*ratio formalis*) under which the object is viewed, while the formal object *quo* is the particular intellectual light by which it is attained, after the analogy of visual knowledge already mentioned (*see* ABSTRACTION).

The expression ''object of a science'' is thus proper whenever one is talking about the knowledge act involved in scientific knowing and, consequently, about the intellectual habit produced by one or more such acts. When, by way of contrast, attention is focused on the knowledge that is the result of such acts, or what is known in the science that results when such objects are attained, then it is more proper to speak of the subject of the science. This view is more logical than psychological: it considers the object confronting the mind as the subject of various operations in the order of demonstration. Thus the subject of a science is that about which the scientist seeks to learn, or that to which predicates are applied in the science through mediate judgments, or that about which there is demonstration that is proper to the science.

**Kinds of Science.** Although sciences can be classified in various ways, one of the most basic divisions is that into speculative science, which is concerned primarily with knowing and not with doing, and practical science, which is concerned with knowing as ordered to doing.

*Speculative Science.* The subject of any speculative human science must fulfill two conditions: it must be something that has prior principles, known as the principles of the subject; and it must have parts and passions that belong to it *per se.* Yet the distinction of the sciences does not arise precisely from a diversity of subjects, but rather from a diversity of principles or of formal considerations that can be found in a subject. Thus, for the unity of a science, it is necessary to have one subject genus that is viewed under one formal light or way of considering, whereas for the distinction of sciences it suffices to have a diversity of principles (*In 1 anal. post.* 41.10).

All human sciences have their origin in sense knowledge, and all therefore commence with the same material objects. The differentiation of the sciences comes about from the different ways of demonstrating properties of these objects, and this in turn is traceable to the different middle terms or definitions that are employed. Careful examination of the various possibilities shows that there can be but three distinct speculative sciences—natural science, mathematics, and metaphysics—each with its own subject and its own proper principles (*see* SCIENCES, CLASSIFICATION OF). Should the principles proper to one subject be applicable to another subject, however, it is possible to generate a hybrid science, known technically as a *scientia media.* Thus mathematical physics can be seen as a *scientia media* intermediate between mathematics and natural science, insofar as it takes the same subject for its consideration as does natural science but considers it under the light of mathematical principles. This possibility gives rise to what is known as the subalternation of speculative sciences, when, for example, mathematical physics is subalternated to mathematics and natural science is subalternated to mathematical physics.

Apart from the human sciences, it is possible also for man to possess a divine science known as sacred theology. This can happen only when the human intellect is illumined by a special light that enables it to understand divine being, and thus it requires a revelation or manifestation of truths that exceed the natural capabilities of the human mind. Granted such a revelation and its acceptance through FAITH, man can develop a theological science that takes divine things, as they are in themselves, as its proper subject (*In Boeth. de Trin.* 5.4). This science, although divided into DOGMATIC THEOLOGY and MORAL THEOLOGY as integral parts, is formally only one science (*see* THEOLOGY).

*Practical Science.* Just as speculative knowledge is distinct from practical knowledge, so also is speculative science distinct from practical science. As sciences, both speculative science and practical science seek knowledge through causes; what distinguishes them is that speculative science seeks causal knowledge of what man can only know, viz, universals, whereas practical science seeks causal knowledge of what man can do or make, viz, singular operables. To the extent that a practical science engages in causal analysis, it can speculate and use analytical procedures similar to those of the speculative sciences. But whereas a speculative science seeks demonstrative knowledge of its subject, a practical science seeks actually to construct or produce its subject, and needs scientific knowledge in order to do so. This operational requirement demands of practical science an even more detailed knowledge of its subject than is found in speculative science. It does not suffice in practical science, for instance, merely to know the cause of an effect; the perfection of the science requires knowledge of all the movements and operations necessary to assure that such an effect will actually follow from that cause in the order of execution.

Among the practical sciences may be listed the moral sciences, the medical sciences, and the architectural and engineering sciences. Moral sciences are concerned with human action and with the direction of such action to its proper end as human; they employ an analytical or resolutive procedure similar to that of philosophical anthropology or psychology and a compositive procedure that is peculiarly their own. They do not attain the singular operable, i.e., the HUMAN ACT, directly, but must be complemented by the art of PRUDENCE, which has as its proper concern the individual human act in its particular concrete circumstances. The medical sciences are concerned with health and with all the means necessary to restore health to those who do not possess it; they employ an analytical procedure similar to that of biology and their own proper compositive procedures such as are found in doctoring, nursing, and the administrations of medical technicians. The architectural and engineering sciences are concerned with buildings and other products of man's mechanical abilities; they employ analytical procedures similar to those of the physical sciences and their own proper constructional methods and procedures.

None of the practical sciences is concerned with truth or certitude for its own sake. They do attain a type of practical truth and practical certitude, however, which is determined by their conformity or adherence to the norms or rules that determine sound practice. It is difficult to draw a sharp line of demarcation between any practical science and the art or arts with which it is associated, because both practical science and art are judged by their conformity to rules. *See* ART (PHILOSOPHY). It can be said, however, that art is more properly concerned with the actual construction of the singular object or operable and that its truth is more judged by freedom from errors in execution, whereas practical science is more concerned with causal analysis that will lead to proper construction of the object or operable and is judged true more on the basis of its ability to provide sound norms for such execution. (*See* COGNITION SPECULATIVE-PRACTICAL.)

**Habit of Science.** St. Thomas, following Aristotle, taught that science is a habit of the INTELLECT, or an intellectual VIRTUE, and as such is distinct from the other intellectual virtues, UNDERSTANDING (*INTELLECTUS*) and WISDOM (*Summa theologiae* 1a2ae, 50.4). As a habit, it disposes one to reason accurately and with ease in a particular subject matter, i.e., to arrive at truths that can be expressed as conclusions reached by syllogistic reasoning from self-evident premises. To grasp the difference between the habit of science and that of understanding, one should note that some propositions have only to be understood in order to command assent; an example is the principle of CONTRADICTION. The ability to grasp and exercise such propositions or principles is the fundamental endowment of the intellect and is known as understanding. The human intellect has also the power to deduce conclusions in the light of these self-evident principles by seeking proper definitions in various subject matters and discoursing from these to predicate new attributes to appropriate subjects. This ability is referred to as the reasoning faculty of the intellect; it is perfected by the habit of science. Science, as such, is concerned with causes, because the knowledge of proper causes is what enables the intellect to discourse accurately and predicate new attributes. It is distinguished from the habit of wisdom in that it is concerned with all causes, whereas wisdom is concerned only with the highest causes (*Meta.* 981b 28, 982b 9). As St. Thomas states, ''Wisdom is a science, insofar as it has that which is common to all the sciences: viz, to demonstrate conclusions from principles. But since it has something proper to itself above the other sciences, inasmuch as it judges of them all, not only as to their conclusions, but also as to their first principles, therefore it is a more perfect virtue than science'' (*Summa theologiae* 1a2ae, 57.2 ad 1).

The knowledge of many conclusions pertaining to a single science counts as a single habit. A geometer who learns a new theorem extends the scope of his knowledge of geometry but does not acquire a new habit. As a habit, science comes into being and is increased or diminished in strength or perfection just as are other habits. It is generated by a single act of demonstration in the appropriate subject matter; this demonstration, of course, must be seen and understood by the one who is said to acquire the habit. It grows, or is perfected, as more conclusions are demonstrated or grasped with greater certitude, whereas it diminishes through disuse or through persistence in erroneous reasoning. (*See* HABIT.)

**Evolution of the Concept.** The concept of science described above is that accepted in Greek and scholastic philosophy and is not to be identified completely with the concept of modern science. There can be no doubt, however, that the medieval precursors of modern science subscribed to the Aristotelian ideal of strict demonstrative knowledge and, in complying with that ideal, prepared the way for the 17th-century development. Thus ROBERT GROSSETESTE initiated a current of thought at Oxford University that strongly influenced ROGER BACON and others in their early attempts at experimental science (see Crombie). Similarly, THEODORIC OF FREIBERG performed exhaustive experimental and theoretical researches on the rainbow and related optical phenomena in the framework of a strict Aristotelian procedure (see Wallace). As science passed from the medieval to the modern era, however, the rigorous Aristotelian ideal was gradually relinquished, to be replaced by a looser and broader conception of the nature of scientific knowledge.

In the initial stages of this evolution, it appears that most thinkers thought of science as capable of achieving complete certainty concerning its subject matter. Renaissance scientists such as Leonardo da Vinci and Luiz Coronel were clearly of this conviction. Francis BACON thought of science as a search for causes, but had special views concerning the role of forms and of final causality in scientific explanation. Galileo GALILEI and Rene DESCARTES were insistent on developing all science along mathematical lines and prepared the way for the acceptance of RATIONALISM and MECHANISM as the dominant philosophy behind scientific investigation. It has been argued, somewhat unconvincingly, that such 17th-century thinkers had a conception of the interplay between theory and experiment that characterizes 20th-century science (see Blake). It seems more accurate to think of these thinkers as motivated by the Aristotelian ideal in their search for truth and certitude, but as placing more faith in mathematical insight than in the search for causes in the traditional Aristotelian mode. (For a fuller discussion of these and later thinkers, *see* PHILOSOPHY AND SCIENCE.)

The 20th-century conception of science differs from the Aristotelian-Thomistic notion mainly in its insistence that science is not concerned exclusively with a search for causes and in its conviction that science can never attain to knowledge that is absolutely certain and not subject to further revision. Associated with these is the rejection, by most philosophers of science, of Aristotle's requirement that the premises of scientific reasoning be better known than the conclusion arrived at. Thus, ''Aristotle's requirement that the explanatory premises be better known than the explicandum is entirely irrelevant as a condition for anything that would today be regarded as an adequate scientific explanation'' (Nagel, 45). Although it is in accord with the logical positivist ideal of science, this characterization leaves unexplained the substantial contributions made by scientists to man's knowledge of the universe and reduces all of science to the status of DIALECTICS. A more accurate characterization seems to be that science can attain to *some* truth and certitude, even though this is frequently buried in the great mass of theories and hypothetical constructions with which contemporary scientists must surround their work. To the extent that TRUTH or CERTITUDE is attained, it may be accounted for by an implicit following of the Aristotelian canons, granted that these are not explicitly acknowledged by the practicing scientist.

*See Also:* SCHOLASTIC METHOD; METHODOLOGY (PHILOSOPHY).

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[W. A. WALLACE]

## SCIENCE (IN ANTIQUITY)

Though science is often used in a broader sense, it is here taken to mean the conscious search for regularities in nature. To describe the first instances of such activity is impossible. This article reviews certain aspects of the search that have been ancestral to Western culture; they took place in Egypt, Babylonia, the Greek cities, and the Roman Empire. For the sake of continuity of ideas, the physical sciences and biological sciences will be treated separately.

### Physical Sciences

The oldest scientific activity that scholars are acquainted with is that of Egypt, whose people used a calendar established prior to 2500 B.C. However—apart, perhaps, from the admiration of Egyptian accomplishment expressed in the writings of Herodotus and other Greeks—there are no indications that native Egyptian science ever rose to any considerable level. Astronomical observation was used for timekeeping. It gave rise not only to the concept of the four cardinal directions but also to their accurate determination; the Great Pyramid of Khufu (or Cheops), built about 2500 B.C., had a base aligned on true north within less than one-tenth of a degree. This sort of activity, taken together with the engineering skill manifested in so many ways—most strikingly in the fabrication, transportation, and upending the giant obelisks—might seem like a beginning from which a growth of science must follow. In fact, it did not follow; surviving papyri show that medicine, after an auspicious start, developed hardly at all during the succeeding 1,000 years, and that when the late Egyptians learned astronomy, they learned it not from their ancestors but from the Chaldeans and the Greeks.

**The Chaldeans.** The Chaldeans, or Babylonians, were intellectual heirs of the Old Babylonians, whose clay tablets dating from 1800 to 1600 B.C. show a highly developed arithmetic far surpassing that of the Egyptians. For example, one Old Babylonian tablet evaluates $\sqrt{2}$ to within one part in a million. If the Old Babylonians had an astronomy, little or nothing is known of it. Political and social upheaval submerged them and their Semitic conquerors; after 1600 B.C., there are but few tablets from Babylonia until the Seleucid period, which began in 312 B.C. From the four centuries that followed there is a wealth of recovered tablets, of which many hundreds contain astronomical texts or tables.

Cuneiform tablets dealing with astronomy were first deciphered by J. Epping, who worked from texts laboriously transcribed from clay tablets in the British Museum by J. N. Strassmaier [Strassmaier and Epping, ''Zur Entzifferung der Astronomischen Tafeln der Chaldäer,'' *Stimmen aus Maria Laach* 21 (1881) 277–92]; their initial work was followed by the significant contributions of F. X. Kugler. Many other tablets have been translated in more recent years, notably by O. Neugebauer and his coworkers.

Though the Seleucid period followed the conquest of Babylon by Alexander, its culture was Babylonian, not Greek; the astronomers continued the development begun by their predecessors. Unlike the Greek methods, which were based on geometrical models, the Chaldean astronomical techniques were essentially arithmetical. Nevertheless, they were highly successful.

*Development of the Calendar.* The Chaldean astronomical techniques can be discerned in broad outline by considering the Chaldean calendar, whose fundamental units were the day and the month. The month was the period between successive new moons; a new day began at sunset, and a new month began on the first day at whose beginning the moon's new crescent was visible. This system generated two important problems of an astronomical kind. One was that some months had 29 days, whereas others had 30; it was desirable to know in advance how many days a given month would have. The other major problem was that a 12-month year would not stay in step with the sun; rigid adherence to a 12-month year would mean that a given month would not correspond to any particular season.

At first the authorities solved the second problem simply by inserting a 13th month in any year in which they deemed it beneficial. By about 400 B.C. astronomical progress permitted the establishment of a fixed system of intercalation. A lunation, the time between new moons, averages 29.5306 days as presently calculated, whereas the time between vernal equinoxes is 365.242 days. The