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Pythagoreanism

The philosophical school and religious brotherhood known as Pythagoreanism is believed to have been founded by Pythagoras of Samos, who settled in Croton in southern Italy about 525 bc.

GENERAL FEATURES OF PYTHAGOREANISM

The character of the original Pythagoreanism is controversial, and the conglomeration of disparate features that it displayed is intrinsically confusing. Its fame rests, however, on some very influential ideas, not always correctly understood, that have been ascribed to it since antiquity. These ideas include those of (1) the metaphysics of number and the conception that reality, including music and astronomy, is, at its deepest level, mathematical in nature; (2) the use of philosophy as a means of spiritual purification; (3) the heavenly destiny of the soul and the possibility of its rising to union with the divine; (4) the appeal to certain symbols, sometimes mystical, such as the *tetraktys*, the golden section, and the harmony of the spheres (to be discussed below); (5) the Pythagorean theorem; and (6) the demand that members of the order shall observe a strict loyalty and secrecy.

By laying stress on certain inner experiences and intuitive truths revealed only to the initiated, Pythagoreanism seems to have represented a soul-directed subjectivism alien to the mainstream of Pre-Socratic Greek thought centring on the Ionian coast of Asia Minor (Thales, Anaximander, Anaxagoras, and others), which was preoccupied with determining what the basic cosmic substance is.

In contrast with such Ionian naturalism, Pythagoreanism was akin to trends seen in mystery religions and emotional movements, such as Orphism, which often claimed to achieve through intoxication a spiritual insight into the divine origin and nature of the soul. Yet there are also aspects of it that appear to have owed much to the more sober, "Homeric" philosophy of the Ionians. The Pythagoreans, for example, displayed an interest in metaphysics (the nature of Being), as did their naturalistic predecessors, though they claimed to find its key in mathematical form rather than in any substance. They accepted the essentially Ionian doctrines that the world is composed of opposites (wet-dry, hot-cold, etc.) and

generated from something unlimited; but they added the idea of the imposition of limit upon the unlimited and the sense of a musical harmony in the universe. Again, like the Ionians, they devoted themselves to astronomical and geometrical speculation. Combining, as it does, a rationalistic theory of number with a mystic numerology and a speculative cosmology with a theory of the deeper, more enigmatic reaches of the soul, Pythagoreanism interweaves Rationalism and irrationalism more inseparably than does any other movement in ancient Greek thought (see PHILOSOPHY, HISTORY OF WESTERN).

MAJOR CONCERNS AND TEACHINGS

The problem of describing Pythagoreanism is complicated by the fact that the surviving picture is far from complete, being based chiefly on a small number of fragments from the time before Plato and on various discussions in authors who wrote much later—most of whom were either Aristotelians or Neoplatonists (see below *History of Pythagoreanism*). In spite of the historical uncertainties, however, that have plagued searching scholars, the contribution of Pythagoreanism to Western culture has been significant and therefore justifies the effort, however inadequate, to depict what its teachings may have been. Moreover, the heterogeneousness of Pythagorean doctrines has been well documented ever since Heracleitus, a classic early-5th-century Greek philosopher who, scoffing at Pythagoras' wide-ranging knowledge, said that it "does not teach one to have intelligence." There probably never existed a strictly uniform system of Pythagorean philosophy and religious beliefs, even if the school did have a certain internal organization. Pythagoras appears to have taught by pregnant, cryptic *akousmata* ("something heard") or *symbola*. His pupils handed these on, formed them partly into *Hieroi Logoi* ("Sacred Discourses"), of which different versions were current from the 4th century on, and interpreted them according to their convictions.

Religion and ethics. The belief in the transmigration of souls provided a basis for the Pythagorean way of life. Some Pythagoreans deduced from this belief the principle of "the kinship of all beings," the ethical implications of which were later stressed in 4th-century speculation. Pythagoras himself seems to have claimed a semidivine status in close association with the superior god Apollo; he believed that he was able to remember his earlier incarnations and, hence, to know more than others knew. Recent research has emphasized shamanistic traits deriving from the ecstatic cult practices of Thracian medicine men in the early Pythagorean outlook. The rules for the religious life that Pythagoras taught were largely ritualistic: refrain from speaking about the holy, wear white clothes, observe sexual purity, do not touch beans, and so forth. He seems also to have taught purification of the soul by means of music and mental activity (later called philosophy) in order to reach higher incarnations. "To be like your Master" and so "to come nearer to the gods" was the challenge that he imposed on his pupils. Salvation, and perhaps ultimate union with the divine cosmos through the study of the cosmic order, became one of the leading ideas in his school.

The advanced ethics and political theories sometimes ascribed to Pythagoreanism may to some extent reflect ideas later developed in the circle of Archytas, the leading 4th-century Pythagorean. But a picture current among the Peripatetics (the school founded by Aristotle) of Pythagoras as the educator of the Greeks, who publicly preached a gospel of humanity, is clearly anachronistic. Several of the Peripatetic writers, Aristoxenus, Dicaearchus, and Timaeus, seem to have interpreted some principles—properly laid down only for esoteric use in the brotherhood—as though these applied to all mankind: the internal loyalty, modesty, self-discipline, piety, and abstinence required by the secret doctrinal system; the higher view of womanhood reflected in the admission of women to the school; a certain community of property; and perhaps the drawing of a parallelism between the macrocosm (the universe) and the microcosm (man), in which (for instance) the Pythagorean idea that the

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Fig. 1
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cosmos is an organism was applied to the state, which should thus mix monarchy, oligarchy, and democracy into a harmonic whole—these were all universalized.

Metaphysics and number theory. According to Aristotle, number speculation is the most characteristic feature of Pythagoreanism. Things “are” number, or “resemble” number. To many Pythagoreans this concept meant that things are measurable and commensurable or proportional in terms of number—an idea of considerable significance for Western civilization. But there were also attempts to arrange a certain minimum number of pebbles so as to represent the shape of a thing—as, for instance, stars in a constellation that seem to represent an animal. For the Pythagoreans even abstracted things “have” their number: “justice” is associated with the number four and with a square, “marriage” with the number five, and so on. The psychological associations at work here have not been clarified.

The harmony of the cosmos. The sacred decad in particular has a cosmic significance in Pythagoreanism: its mystical name, *tetraktys* (meaning approximately “fourness”), implies $1 + 2 + 3 + 4 = 10$; but it can also be thought of as a “perfect triangle,” as in Figure 1.

Speculation on number and proportion led to an intuitive feeling of the *harmonia* (“fitting together”) of the *kosmos* (“the beautiful order of things”); and the application of the *tetraktys* to the theory of music (see below *Music*) revealed a hidden order in the range of sound. Pythagoras may have referred, vaguely, to the “music of the heavens,” which he alone seemed able to hear; and later Pythagoreans seem to have assumed that the distances of the heavenly bodies from the earth somehow correspond to musical intervals—a theory that, under the influence of Platonic conceptions, resulted in the famous idea of the “harmony of the spheres.” Though number to the early Pythagoreans was still a kind of cosmic matter, like the water or air proposed by the Ionians, their stress upon numerical proportions, harmony, and order comprised a decisive step toward a metaphysics in which form is the basic reality.

The doctrine of opposites. From the Ionians, the Pythagoreans adopted the idea of cosmic opposites, which they—perhaps secondarily—applied to their number speculation. The principal pair of opposites is the limit and the unlimited; the limit (or limiting), represented by the odd (3, 5, 7, . . .), is an active force effecting order, harmony, “cosmos,” in the unlimited, represented by the even. All kinds of opposites somehow “fit together” within the cosmos, as they do, microcosmically, in an individual man and in the Pythagorean society. There was also a Pythagorean “table of ten opposites,” to which Aristotle has referred—limit-unlimited, odd-even, one-many, right-left, male-female, rest-motion, straight-curved, light-darkness, good-evil, and square-oblong. The arrangement of this table reflects a dualistic conception, which was apparently not original with the school, however, or accepted by all of its members.

The Pythagorean number metaphysics was also reflected in its cosmology. The unit (1), being the starting point of the number series and its principle of construction, is not itself strictly a number; for, to be a number is to be even or odd, whereas, in the Pythagorean view, “one” is seen as both even and odd. This ambivalence applies, similarly, to the total universe, conceived as the One. There was also a cosmogonical theory (of cosmic origins) that explained the generation of numbers and number-things from the limiting-odd and the unlimited-even—a theory that, by stages unknown to scholars, was ultimately incorporated into Plato’s philosophy in his doctrine of the derivation of sensed realities from mathematical principles (see *PLATONISM AND NEOPLATONISM: Greek Platonism from Aristotle through Middle Platonism, its nature and history*).

Mathematics and science. Pythagorean thought was scientific as well as metaphysical and included specific developments in arithmetic and geometry, in the science of musical tones and harmonies, and in astronomy.

Arithmetic. Early Pythagorean achievements in mathematics are unclear and largely disputable, and the fol-

Use of the
gnōmones

lowing is, therefore, a compromise between the widely divergent views of modern scholars.

In the speculation on odd and even numbers, the early Pythagoreans used so-called *gnōmones* (Greek: “carpenter’s squares”). Judging from Aristotle’s account, *gnōmon* numbers, represented by dots or pebbles, were arranged in the manner shown in Figure 2. If a series of odd

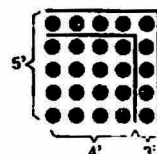


Figure 2: Gnōmones of Pythagorean number theory (see text).

numbers is put around the unit as *gnōmones*, they always produce squares; thus, the members of the series 4, 9, 16, 25, . . . are “square” numbers. If even numbers are depicted in a similar way, the resulting figures (which offer infinite variations) represent “oblong” numbers, such as those of the series 2, 6, 12, 20, . . . On the other hand, a triangle represented by three dots (as in the upper part of the *tetraktys*) can be extended by a series of natural numbers to form the “triangular” numbers 6, 10 (the *tetraktys*), 15, 21, . . . This procedure, which was, so far, Pythagorean, led later, perhaps in the Platonic Academy, to a speculation on “polygonal” numbers.

Probably the square numbers of the *gnōmones* were early associated with the Pythagorean theorem (likely to have been used in practice in Greece, however, before Pythagoras), which holds that for a right triangle a square drawn on the hypotenuse is equal in area to the sum of the squares drawn on its sides; in the *gnōmones* it can easily be seen, in the case of a 3, 4, 5-triangle for example (see Figure 3), that the addition of a square

Figure 3: Gnōmon for Pythagorean theorem. The marked off “carpenter’s square”—comprising 3 groups of 3 dots each (3×3)—thus represents 3^2 , which when added to 4^2 yields 5^2 (the total *gnōmon*).



gnōmon number to a square makes a new square: $3^2 + 4^2 = 5^2$, and this gives a method for finding two square numbers the sum of which is also a square.

Some 5th-century Pythagoreans seem to have been puzzled by apparent arithmetical anomalies: the mutual relationships of triangular and square numbers; the anomalous properties of the regular pentagon; the fact that the length of the diagonal of a square is incommensurable with its sides—i.e., that no fraction composed of integers can express this ratio exactly (the resulting decimal is thus defined as irrational); and the irrationality of the mathematical proportions in musical scales. The discovery of such irrationality was disquieting because it had fatal consequences for the naïve view that the universe is expressible in whole numbers; the Pythagorean Hippasus is said to have been expelled from the brotherhood, according to some sources even drowned, because he made a point of the irrationality.

In the 4th century, Pythagorizing mathematicians made a significant advance in the theory of irrational numbers, such as the square-root-of- n ($\sqrt{n}$), n being any rational number, when they developed a method for finding progressive approximations to $\sqrt{2}$ by forming sets of so-called diagonal numbers.

Geometry. In geometry, the Pythagoreans cannot be credited with any proofs in the Euclidean sense. They were evidently concerned, however, with some speculation on geometrical figures, as in the case of the Pythagorean theorem, and the concept that the point, line, triangle, and tetrahedron correspond to the elements of the *tetraktys*, since they are determined by one, two, three, and four points, respectively. They possibly knew practical methods of constructing the five regular solids, but the theoretical basis for such constructions was given by non-Pythagoreans in the 4th century.

The
problem of
irrational
numbers

It is notable that the properties of the circle seem not to have interested the early Pythagoreans. But perhaps the tradition that Pythagoras himself discovered that the sum of the three angles of any triangle is equal to two right angles may be trusted. The idea of geometric proportions is probably Pythagorean in origin; but the so-called golden section—which divides a line at a point such that the smaller part is to the greater as the greater is to the whole—is hardly an early Pythagorean contribution. Some advance in geometry was made later, by 4th-century Pythagoreans; e.g., Archytas offered an interesting solution to the problem of the duplication of the cube—in which a cube twice the volume of a given cube is constructed—by an essentially geometrical construction in three dimensions; and the conception of geometry as a “flow” of points into lines, of lines into surfaces, and so on, may have been contributed by Archytas; but on the whole the achievements of non-Pythagorean mathematicians were in fact more conspicuous than those of the Pythagoreans.

Music. The achievements of the early Pythagoreans in musical theory are somewhat less controversial. The scientific approach to music, in which musical intervals are expressed as numerical proportions, originated with them, as did also the more specific idea of harmonic “means.” At an early date they discovered empirically that the basic intervals of Greek music include the elements of the *tetraktys*, since they have the proportions 1:2 (octave), 3:2 (fifth), and 4:3 (fourth). The discovery could have been made, for instance, in pipes or flutes or stringed instruments: the tone of a plucked string held at its middle is an octave higher than that of the whole string; the tone of a string held at the $\frac{2}{3}$ point is a fifth higher; and that of one held at the $\frac{3}{4}$ point is a fourth higher. Moreover, they noticed that the subtraction of intervals is accomplished by dividing these ratios by one another. In the course of the 5th century they calculated the intervals for the usual diatonic scale, the tone being represented by 9:8 (fifth minus fourth); i.e., $3/2 \div 4/3$, and the semitone by 256:243 (fourth minus two tones); i.e., $4/3 \div (9/8 \times 9/8)$. Archytas made some modification to this doctrine and also worked out the relationships of the notes in the chromatic (12-tone) scale and the enharmonic scale (involving such minute differences as that between A flat and G sharp, which on a piano are played by the same key).

Astronomy. In their cosmological views the earliest Pythagoreans probably differed little from their Ionian predecessors. They made a point of studying the stellar heavens; but—with the possible exception of the theory of musical intervals in the cosmos—no new contributions to astronomy can be ascribed to them with any degree of probability. Late in the 5th century, or possibly in the 4th century, a Pythagorean boldly abandoned the geocentric view and posited a cosmological model in which the Earth, Sun, and stars circle about an (unseen) central fire—a view traditionally attributed to the 5th-century Pythagorean Philolaus of Croton (see PHYSICAL SCIENCES, HISTORY OF).

HISTORY OF PYTHAGOREANISM

The life of Pythagoras and the origins of Pythagoreanism appear only dimly through a thick veil of legend and semihistorical tradition. The literary sources for the teachings of the Pythagoreans present extremely complicated problems. Special difficulties arise from the oral and esoteric transmission of the early doctrines, the profuse accumulation of tendentious legends, and confusion caused by the split in the school in the 5th century BC. In the 4th century, Plato's inclination toward Pythagoreanism created a tendency—manifest already in the middle of the century in the works of his pupils—to interpret Platonic concepts as originally Pythagorean. But the radical skepticism as to the reliability of the sources shown by some modern scholars has on the whole been abandoned in recent research. It now seems possible to extract bits of reliable evidence from a wide range of ancient authors, such as Porphyry and Iamblichus (see below *Neo-Pythagoreanism*).

Most of these literary sources hark back ultimately to the environment of Plato and Aristotle; and here the importance of one of Aristotle's students has become obvious, viz., the musicologist and philosopher Aristoxenus, who in spite of his bias possessed firsthand information independent of the point of view of Plato's Academy. The role played by Dicaearchus, another of Aristotle's pupils, and by the Sicilian historian Timaeus, of the early 3rd century BC, is less clear. Recently, the reliability of Aristotle's account of Pythagoreanism has also been emphasized against the doubts that had been expressed by some modern scholars; but Aristotle's sources, in turn, hardly lead farther back than to the late 5th century (perhaps to Philolaus; see below *Two Pythagorean sects*). In addition, there are scattered hints in various early authors and in some not very substantial remains of 4th-century Pythagorean literature. The mosaic of reconstruction thus has to be to some extent subjective.

Early Pythagoreanism. Within the ancient Pythagorean movement four chief periods can be distinguished: early Pythagoreanism, dating from the late 6th century BC and extending to about 400 BC; 4th-century Pythagoreanism; the Hellenistic trends; and Neo-Pythagoreanism, a revival that occurred in the mid-1st century AD and lasted for two and a half centuries.

Background. The background of Pythagoreanism is complex, but two main groups of sources can be distinguished. The Ionian philosophers (Thales, Anaximander, Anaximenes, and others) provided Pythagoras with the problem of a single cosmic principle, the doctrine of opposites, and whatever reflections of Oriental mathematics there are in Pythagoreanism; and from the technicians of his birthplace, the Isle of Samos, he learned to understand the importance of number, measuring, and proportions. Popular cults and beliefs current in the 6th century and reflected in Orphism introduced him to occultism, ritualism, and the doctrine of individual immortality. In view of the shamanistic traits of Pythagoreanism, reminiscent of Thracian cults, it is interesting to note that Pythagoras seems to have had a Thracian slave.

Pythagorean communities. The school apparently founded by Pythagoras at Croton in southern Italy seems to have been primarily a religious brotherhood centred around Pythagoras and the cults of Apollo and of the Muses, ancient patron goddesses of poetry and culture. It became perhaps successively institutionalized and received different classes of esoteric members and exoteric sympathizers. The rigorism of the ritual and ethical observances demanded of the members is unparalleled in early Greece; in addition to the rules of life mentioned above, it is fairly well-attested that secrecy and a long silence during the novitiate were required. The exoteric associates, however, were politically active and established a Crotonian hegemony in southern Italy. About 500 BC a coup by a rival party caused Pythagoras to take refuge in Metapontum, where he died.

During the early 5th century, Pythagorean communities existed in many southern Italian cities, a fact that led to some doctrinal differentiation and diffusion. In the course of time the politics of the Pythagorean parties became decidedly antidemocratic. About the middle of the century a violent democratic revolution swept over southern Italy; many Pythagoreans were killed, and only a few escaped, among them Lysis of Tarentum and Philolaus of Croton, who went to Greece and formed small Pythagorean circles in Thebes and Phlius.

Two Pythagorean sects. Little is known about Pythagorean activity during the latter part of the 5th century. The differentiation of the school into two main sects, later called *akousmatikoi* (Greek: *akousma*, “something heard,” viz., the esoteric teachings) and *mathēmatikoi* (Greek: *mathēmatikos*, “scientific”), may have occurred at that time. The *akousmatikoi* devoted themselves to the observance of rituals and rules and to the interpretation of the sayings of the master; the “mathematics” were concerned with the scientific aspects of Pythagoreanism. Philolaus, who was rather a mathematician, probably published a summary of Pythagorean philosophy and science in the late 5th century.

Mathematical ratios and tones.

Fourth-century Pythagoreanism. In the first half of the 4th century, Tarentum, in southern Italy, rose into considerable significance. Under the political and spiritual leadership of the mathematic Archytas, a friend of Plato, Tarentum became a new centre of Pythagoreanism, from which acousmatics—so-called Pythagorists who did not sympathize with Archytas—went out travelling as mendicant ascetics all around the Greek-speaking world. The acousmatics seem to have preserved some early Pythagorean *Hieroi Logoi* and ritual practices. Archytas himself, on the other hand, concentrated on scientific problems, and the organization of his Pythagorean brotherhood was evidently less rigorous than that of the early school. After the 380s there was a give-and-take between the school of Archytas and the Academy of Plato, a relationship that makes it almost impossible to disentangle the original achievements of Archytas from joint involvements (but see above, *Geometry and Music*).

Archytas
and his
school

The Hellenistic Age. Whereas the school of Archytas apparently sank into inactivity after the death of its founder (probably after 350 BC), the Academics of the next generation continued "Pythagorizing" Platonic doctrines, such as that of the supreme One, the indefinite dyad (a metaphysical principle), and the tripartite soul (see PLATONISM AND NEOPLATONISM). At the same time, various Peripatetics of the school of Aristotle, including Aristoxenus, collected Pythagorean legends and applied contemporary ethical notions to them. In the Hellenistic Age, the Academic and Peripatetic views gave rise to a rather fanciful antiquarian literature on Pythagoreanism. There also appeared a large and yet more heterogeneous mass of apocryphal writings falsely attributed to different Pythagoreans, as if attempts were being made to revive the school. The texts fathered on Archytas display Academic and Peripatetic philosophies mixed with some notions that were originally Pythagorean. Other texts were fathered on Pythagoras himself or on his immediate pupils, imagined or real. Some show, for instance, that Pythagoreanism had become confused with Orphism; others suggest that Pythagoras was considered a magician and an astrologist; there are also indications of Pythagoras "the athlete" and "the Dorian nationalist." But the anonymous authors of this pseudo-Pythagorean literature did not succeed in re-establishing the school, and the "Pythagorean" congregations formed in early imperial Rome seem to have had little in common with original Pythagoreanism; they were ritualistic sects that adopted, eclectically, various occult practices.

Neo-Pythagoreanism. With the ascetic sage Apollonius of Tyana, about the middle of the 1st century AD, a distinct Neo-Pythagorean trend appeared. Apollonius studied the Pythagorean legends of the previous centuries, created and propagated the ideal of a Pythagorean life—of occult wisdom, purity, universal tolerance, and approximation to the divine—and felt himself to be a reincarnation of Pythagoras. Through the activities of Neo-Pythagorean Platonists, such as Moderatus of Gades, a pagan trinitarian, and the arithmetician Nicomachus of Gerasa, both of the 1st century AD, and, in the 2nd or 3rd century, Numenius of Apamea, forerunner of Plotinus (an epoch-making elaborator of Platonism), Neo-Pythagoreanism gradually became a part of the expression of Platonism known as Neoplatonism; and it did so without having achieved a scholastic system of its own. The founder of a Syrian school of Neoplatonism, Iamblichus, a pupil of Porphyry (who in turn had been a pupil of Plotinus), thought of himself as a Pythagorean sage and about AD 300 wrote the last great synthesis of Pythagoreanism, in which most of the disparate post-classical traditions are reflected. It is characteristic of the Neo-Pythagoreans that they were chiefly interested in the Pythagorean way of life and in the pseudoscience of number mysticism. On a more popular level, Pythagoras and Archytas were remembered as magicians. Moreover, it has been suggested that Pythagorean legends also influenced the Christian monastic tradition.

Medieval and modern trends. In the Middle Ages the popular conception of Pythagoras the magician was combined with that of Pythagoras "the father of the quadri-

vium"; i.e., of the more specialized liberal arts of the curriculum. From the Italian Renaissance onward, some "Pythagorean" ideas, such as the tetrad, the golden section, and harmonic proportions, became applied to aesthetics. To many Humanists, moreover, Pythagoras was the father of the exact sciences. In the early 16th century, Nicolaus Copernicus, who developed the view that the Earth revolves around the Sun, considered his system to be essentially Pythagorean or "Philolaic," and Galileo was called a Pythagorean. The 17th-century Rationalist G.W. Leibniz appears to have been the last great philosopher and scientist who felt himself to be in the Pythagorean tradition.

It is doubtful whether advanced modern philosophy has ever drawn from sources thought to be distinctly Pythagorean. Yet Platonic-Neoplatonic notions, such as the mathematical conception of reality or the philosopher's union with the universe and various mystical beliefs are still likely to be stamped as Pythagorean. Even today uncritical admiration of Pythagoreanism is common.

EVALUATION

The history of the projection of Pythagoreanism into subsequent thought indicates how fertile some of its core concepts were. Plato is here the great catalyst; but it is possible to perceive behind him, however dimly, a series of Pythagorean ideas of paramount potential significance: the combination of religious esoterism (or exclusivism) with the germs of a new philosophy of mind, present in the belief in the progress of the soul toward the actualization of its divine nature and toward knowledge; stress upon harmony and order, and upon limit as the good; the primacy of form, proportion, and numerical expression; and in ethics, an emphasis upon such virtues as friendship and modesty. The fact that Pythagoras, to later ages, also became alternatively a Dorian nationalist, a sportsman, an educator of the people, or a great magician is a more curious consequence of the productivity of his teaching.

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Amalgamation
with
Neoplatonism

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Pythagoras of Samos

Metaphysic of number. All of the philosophies mentioned so far are in various ways historically akin to one another. Toward the end of the 6th century, however, there arose quite independently another kind of philosophy, which only later entered into interrelation with the developments just mentioned: the philosophy of Pythagoras of Samos. Pythagoras travelled extensively in the East and in Egypt and, after his return to Samos, emigrated to southern Italy because of his dislike of the tyranny of Polycrates. At Croton and Metapontum he founded a philosophical society with strict rules and soon gained considerable political influence. He appears to have brought his doctrine of the transmigration of souls from the East. Much more important for the history of philosophy and science, however, was his doctrine that "all things are numbers," which means that the essences and structures of all things can be determined by finding the numerical relations contained in them. Originally, this, too, was a very broad generalization made on the basis of comparatively few observations: for instance, that the

same harmonies can be produced with different instruments—strings, pipes, disks, etc.—by means of the same numerical ratios—1:2, 2:3, 3:4—in one-dimensional extensions; the observation that certain regularities exist in the movements of the celestial bodies; and the discovery that the form of a triangle is determined by the ratio of the lengths of its sides. But, because the followers of Pythagoras tried to apply their principle everywhere with the greatest of accuracy, one of them—Hippasus of Metapontum—around 450 bc made one of the most fundamental discoveries of the entire history of science, that of incommensurability, viz., that the quantitative relation between the side and diagonal of such simple figures as the square and the regular pentagon cannot be expressed as a ratio of integers, however great. At first sight this discovery seemed to destroy the very basis of the Pythagorean philosophy, and the school thus split into two sections, one of which engaged in rather abstruse numerical speculations while the other succeeded in overcoming the difficulty by ingenious mathematical inventions and laid the foundations of all quantitative science. Pythagorean philosophy also exerted a great influence on the development of Plato's thought in his later years.

The speculations described so far comprise in many ways the most important part of the history of Greek philosophy because all of the most fundamental problems of Western philosophy turned up here for the first time and one finds here the formation of a great many concepts that have continued to dominate Western philosophy and science down to the present day.

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thagoras' society eventually died out toward the end of the 4th century BC, largely because of the violent democratic opposition to its aristocratic politics.

It is difficult to distinguish Pythagorean teachings from those of his disciples. None of his writings have survived, and Pythagoreans invariably supported their doctrines by indiscriminately citing their master's authority. Pythagoras, however, is generally credited with the theory of the functional significance of numbers in the objective world and in music. Other mathematical principles and discoveries often attributed to him (e.g., the Pythagorean theorem for right triangles) were developed only later by the Pythagorean school at a time when mathematical concepts had evolved to a more advanced state. More probably the bulk of the intellectual tradition originating with Pythagoras himself belongs to mystical wisdom rather than to scientific scholarship.

Accordingly, it is only to the legacy of Pythagorean tradition that the following philosophical and ethical teachings can be ascribed: the famed dictum "all is number," meaning that all existing things can be ultimately reduced to number relationships; the dependence of the dynamics of world structure on the interaction of contraries, or pair of opposites, the first of which is the even-odd relationship essential to numbers; the viewing of the soul as a self-moving number experiencing a form of metempsychosis, or successive reincarnation in different species until its eventual purification (particularly through the intellectual life of the ethically rigorous Pythagoreans), and liberation from the repetitive "wheel of life"; the understanding, as in the Socratic tradition, that all existing objects were fundamentally composed of form and not of material substance. Additional Pythagorean doctrine applied number relationships to music theory, acoustics, geometry and astronomy (in which the Earth was termed a moving spheroid, but without clear expression of heliocentrism); identified the brain as the locus of the soul; and prescribed certain secret cultic practices.

Pythagoreanism deeply influenced the development of classical Greek philosophy and medieval European thought (especially the astrological belief that the number harmony of the universe decidedly affects all human endeavour). In the scientific realm Pythagorean mathematics aided the discovery of Kepler's Law, which posited the relation between the different orbital radii of the planetary system.

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Pythagorean brotherhood, an association or cult founded in the 6th century BC and dedicated to the Muses and to the god Apollo. The exact purposes of the cult are unknown, but the association originally had strong religious motivation; also, its members engaged in political activity creating enmity and resentment in many cities where Pythagoreans

meeting-houses had become centres of political power. Some early Pythagoreans had a kind of communal life, owned buildings that served as lodges or meeting houses, took meals together, had a distinctive dress, underwent periods of initiation and testing, and were admitted to different grades of membership. Individual structural differences and adaptations were doubtless maintained throughout the troubled history of the order, with relative importance given at different places and times to mathematics, music, medicine, and various ascetic practices.

Important Pythagorean centres were located at Thebes, the home of the Pythagoreans Simmias and Cebes, characters in Plato's *Phaedo*; at Tarentum, whose Pythagorean ruler, Archytas, was a friend of Plato; and at Rhegium and Phlius. About 454 BC meeting houses of the order were destroyed by political enemies, and by about 390 most of the important Pythagoreans (except Archytas) had been forced into exile. The brotherhood was, for all practical purposes, inactive by the end of the 4th century.

Pythagoreanism 15:322, a philosophical school and religious brotherhood, believed to have been founded by Pythagoras late in the 6th century BC, holding: (1) that at its deepest level, reality is mathematical in nature; (2) that philosophy can be used for spiritual purification; (3) that the soul can rise to union with the divine; (4) that certain symbols have a mystical significance; and (5) that all brothers of the order should observe strict loyalty and secrecy.

The text article covers the general features of Pythagoreanism; its major concerns and teachings in religion and ethics, metaphysics and number theory, and mathematics and science; and its history, including literary sources, early, 4th-century, Hellenistic, and Neo-Pythagoreanism, and medieval and modern trends.

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number metaphysics, Pythagorean; opposites, table of; Pythagorean Brotherhood

Pythagoras (b. c. 580 BC, Samos, Greece—d. c. 500 BC, Metapontum, near present Metaponto, Italy), philosopher, mathematician, and founder of the Pythagorean brotherhood that, although religious in nature, formulated principles that influenced the thought of Plato and Aristotle, and contributed to the development of mathematics and Western rational philosophy.



Pythagoras, contorniate engraved between AD 395 and 410, in the Bibliothèque Nationale, Paris
Reproduction of the Bibliothèque Nationale, Paris

Pythagoras migrated to southern Italy c. 532, apparently to escape Samos' tyrannical rule, and established his ethico-political academy at Croton (now Crotona). Flourishing throughout southern Italy and Greece, Py-