

lying the apparent chaos and multiplicity of the sense world there must be some sort of unity that the human mind can fathom. Yet if flesh is nothing but flesh or hair nothing but hair, it is meaningless to try to find the basic elements that these diverse "things" have in common. To erect the apparent diversity of the world into a philosophical principle, as Anaxagoras did, puts an end to the scientific enterprise, which must be guided by a kind of Milesian belief in still simpler simples, still more unified unities.

At this point in our study, then, the basic problem remains intact, though Empedocles and Anaxagoras have helped formulate it more clearly: How can we get to the world of various sense things from qualitatively single but quantitatively plural real things?

The next step in the development of pluralism will take us to Atomism, a school of thought that spanned the centuries from Socrates' youth until the beginnings of Christianity. Study of the Atomists will be postponed until we have examined certain philosophical movements that grew up side by side with those we have been tracing. Since thinkers of these other schools raised questions the later pluralists felt called upon to answer, it will be necessary to consider their

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§1 Pythagoras and the Pythagoreans

About the life of Pythagoras we know almost nothing; we know even less about his views, as distinguished from those of his followers. He is mentioned by Heraclitus in two surviving fragments, which at first sight appear contradictory. In one it is said that Pythagoras "practiced scientific inquiry beyond all other men"; in the other he is linked with Hesiod and Xenophanes, who were religious teachers, not in any sense scientists.^{28,1} Other reports about Pythagoras suggest that this dual characterization is correct. There is good evidence that Pythagoras was born on the island of Samos just off the coast of Asia Minor opposite Ephesus and that he emigrated to southern Italy about 530 B.C., where he founded a society at Croton. This society was primarily a religious fraternity, but it also conducted scientific research and for a time it dominated the political life of Croton and nearby communities. Perhaps the Pythagorean order was not unlike a medieval monastery, where the exercise of political power was joined with the worship of God and the pursuit of learning. And just as in the mind of the monks these varied activities combined for the greater glory of God, so the Pythagoreans seemed to think of their science as a part of their worship.

28 Heraclitus, of course, had nothing but contempt for Pythagoras in either role.

THE MYSTERY CULTS

Let us begin our discussion of the Pythagoreans, therefore, with an account of their religious views. During the seventh and sixth centuries B.C. a new religious feeling appeared in Greece, a feeling that hardly touched the Milesians but of which there are echoes in Xenophanes and Heraclitus. This was very different in tone from the Olympian religion of Homer, in which man's relation to the gods was largely commercial. In Homer, man shows little wish to become like the gods or to be joined to them; there is no evidence, for instance, of a desire for immortality. In the *Odyssey* Homer describes a visit that the gods permit Odysseus to make to the dwelling place of the spirits of the dead. There the pale, bloodless ghosts of the dead sit all day longing for the earth and the warmth of the sun. When Odysseus urges Achilles not to grieve because he is dead, the latter replies, "Nay, speak not comfortably to me of death, oh great Odysseus. Rather would I live on ground as the hireling of another, with a landless man who had no great livelihood, than bear sway among all the dead that he departed."²⁹ The fact that a great noble would prefer enslavement—and enslavement to a poor man at that—to immortality shows the extent to which the Homeric ideal was conceived in terms of the good things of this life—fighting, chariot racing, drinking, debating in counsel. To lead this life, to be a man, above all to be a Hellenic, seemed to Homer so fine a thing that no reasonable person could ask for more; an afterlife could only be an anticlimax.

The new religious movement, introducing the worship of Dionysus, sounded a very different note. Here the primary motif was a yearning for immortality, motivated by a profound discontent with what was felt as the finitude, the defeats, and the inadequacies of this earthly life. This was a religion of redemption—the religion of a savior god who draws his worshipers to him in complete and joyful union.

The new worship was organized into cults whose rituals were regarded as precious secrets. For this reason there is much uncertainty about the details of the worship and about its origins, but it is known that Dionysus was worshiped under various animal forms and invoked by wild dance and song. The ceremonies took place, often at night, in remote places, and women—to the scandal of conservative males—took a prominent part in them. In a frenzy of intoxication the worshipers tore living animals apart, drank their blood, and danced to the point of exhaustion. They felt the spirit of the god pass into their bodies; the union so passionately desired was consummated, and the worshipers exulted in a supreme happiness and utter freedom from any sort of restraint.

The chorus in Euripides' play, the *Bacchae*,²⁹ represents women worshipers of Dionysus, and a few lines from one of their hymns will give some idea of this religion and of its powerful effects on the human personality.

- Blessèd, blessèd are those who know the mysteries of god.
- Blessèd is he who hallows his life in the worship of god,
he whom the spirit of god possesseth, who is one
with those who belong to the holy body of god.
- Blessèd are the dancers and those who are purified,
who dance on the hill in the holy dance of god. . . .
- Blessèd are those who wear the crown of the ivy of god.
- Blessèd, blessèd are they: Dionysus is their god. . . .
He wears the holy fawn-skin. He hunts the wild goat
and kills it. . . .
He delights in the raw flesh,
He runs to the mountains of Phrygia, to the mountains
of Lydia he runs!
He is Bromius who leads us! *Evohe!*
Flames float out from his trailing wand
as he runs, as he dances,
kindling the stragglers,
spurring with cries,
and his long curls stream to the wind!
—And he cries, as they cry, *Evohe!*—
On, Bacchae!
On, Bacchae!

In its early stages, at least, this type of worship was certainly no moral advance over Homeric religion. If the latter urged the performance of certain acts lest the gods hurl a thunderbolt in man's direction—a negative injunction, certainly—the former recommended for the sake of a pleasant reward, a life of permanent leisure and security. In both cases the acts prescribed were ritualistic rather than moral.

The Pythagoreans, obviously deeply affected by this religious movement, did much to elevate its tone. That some of their precepts, however, had originated in magic and taboo is evident from instructions to members of the order not to eat beans, not to stir the fire with iron, not to leave the impress of their body on the bed upon rising from it, and so on. But instead of using wine to intoxicate the body, the Pythagoreans used music to purify the soul; their emphasis was on a way of life rather than simply on the performance of certain rites. They were deeply concerned for the well-being of the soul, which they believed to be immortal and to pass through a cycle of births, appearing on earth in various guises, each determined by the kind of life led by the soul in its preceding existence. For them the moral goal was to obtain release from this cycle of birth and death. This could be accomplished by attaining wisdom. Men, the Pythag-

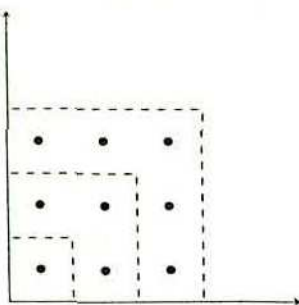
29 See pp. 61-63.

oreans thought, fall into three classes that correspond to the three types of people who frequent the Olympic games. Lowest are the "lovers of gain"—those who set up booths and sell souvenirs. Next are the "lovers of honor"—the competing athletes. Highest are the "lovers of knowledge"—the spectators who contemplate, without participating in, the vulgar competition for money or fame. In the same way, contemplation of the eternal truths to which their science gave them access lifted the Pythagoreans out of the tensions and conflicts of the "wheel of birth" and projected them into a higher sphere. Hence the importance to them of "science." For the Milesians, science was good in that it satisfies the natural human appetite of curiosity. They also saw that a knowledge of the processes of nature has a practical application.³⁰ But to the Pythagoreans this was inconsequential; they cultivated science, as they cultivated music, as the means to spiritual redemption.

PYTHAGOREAN SCIENCE

This conception of the end and purpose of science had a profound effect on the Pythagoreans' conception of the nature of science. It meant that they were more interested in mathematics than in physics and still more interested in the application of mathematics to large-scale cosmological speculation. Fascination with this latter type of inquiry has been recurrent in the history of culture; there are still "Pythagoreans" among scientists, and probably there always will be.

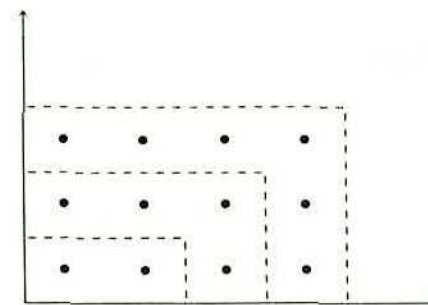
In mathematics the Pythagoreans made many notable advances, including the invention of a new notation. Since they used arrangements of pebbles to represent numbers, it was natural for them to give spatial names to their numbers. Suppose, for instance, that one wants to describe the sequence of the sums of successive odd numbers. Today this would be written in the following way: 1, 4, 9, and so on. The Pythagoreans represented this sequence as follows:^w



³⁰ There is an old story to the effect that Thales applied his theoretical knowledge of astronomy to weather forecasting and, predicting a bumper olive crop for the coming year, bought up all the olive presses and made a killing. Whether the story is true is unimportant. It shows an appreciation of the practical advantages of theoretical science.

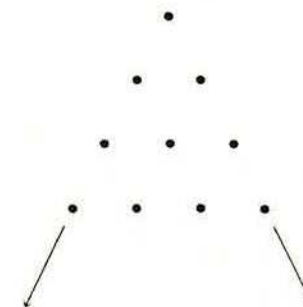
This led them to call the numbers making up this sequence "square numbers." (The dotted lines and the arrows have been inserted to show how the Pythagoreans added successive odd numbers together: $1, 1 + 3, 1 + 3 + 5, \dots$)

Similarly, today the sequence of the sums of successive even numbers would be written as 2, 6, 12, and so on. The Pythagoreans represented this sequence of sums as



and called the numbers in this sequence "oblong numbers."

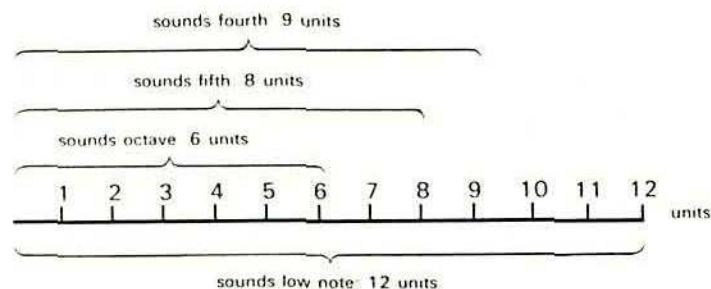
The Pythagoreans were most pleased by the *tetraktys*, the formula for "triangle numbers":



This is the formula for the sums of natural integers, 1, 3, 6, 10, and so on (that is, $1, 1 + 2, 1 + 2 + 3, 1 + 2 + 3 + 4, \dots$). The *tetraktys* shows that the Pythagoreans conceived of the number series as being generated from the unit by a process of division. This was to have an important bearing on their cosmological theory.

The Pythagoreans made some interesting applications of mathematics to natural phenomena. Of these the most striking is their study of harmonics. They found that the relationships between the lengths of the strings of a tuned lyre were simple proportions. The lyre was a seven-stringed instrument of which four strings—the first, fourth, fifth, and seventh—were harmonically basic. Since it was tuned by tightening or relaxing the tension of strings of equal length, the Pythagoreans could not simply look at the strings of the tuned lyre and observe the mathematical relationships. They must have performed an experiment in the

modern sense of the term: They had to find a way of measuring indirectly what they could not measure directly. This, of course, was not difficult. But the point is that since they could not have reached their conclusion by direct observation, they must first have formed an hypothesis and then found a way, however simple, to check it. Perhaps they stopped a string at various points and measured the length of the segments whose notes corresponded to those of the tuned lyre. Such measurement would show that the section of string sounding the note an octave above the low note is half as long as the section of string sounding the low note. If the latter is 12 units long, the former is 6 units long, a ratio of 2 : 1. When the fourth string is put in accord, it is found to be sounded by a section of string 9 units long, and the fifth, by a section 8 units long. These measurements give ratios of 4 : 3 (12 units to 9 units) and 3 : 2 (12 units to 8 units) respectively for the relation between these strings and the low-note string.



Further, the fourth and fifth strings each stand in a mathematical relationship as a mean between the low and high strings. The length of the fourth is 9 units when the low is 12 and the high 6; $12 - 3 = 9$ and $6 + 3 = 9$. In other words, 9 is a mean which is exceeded by one extreme by the same amount that it exceeds the other extreme. This is called the "arithmetic" mean. Again, the length of the fifth is 8 units when the low and high strings are 12 and 6 respectively; and 8 exceeds and is exceeded by the same fraction of the extremes: $12 - 12/3 = 8$ and $6 + 6/3 = 8$. This is called the "harmonic" mean.

The Pythagoreans applied this idea of the mean to the conflict of opposites that, as we have seen, Milesian physics had proved incapable of resolving. The wet and the dry, the hot and the cold, far from being in irreconcilable conflict, might be "harmonized" just as the high and low notes are. And if the mean that harmonized them were similarly capable of mathematical statement, it would follow that the relation between the opposites is thoroughly intelligible.

The idea of the mean was also used by the Pythagoreans in medicine and in morals. Health they conceived to be an attunement and harmony of opposites; the body is healthy, for instance, when it is neither too hot nor too cold but is in a mean between having a chill and having a fever. It was easy to define the good generally as the mean. Thus the traditional notion of *sophrosyne*, or moderation, received a precise and formal statement.

The Pythagoreans also pursued cosmological studies similar to those of the Milesians. But instead of taking some physical material (water, air, or fire, for instance) as their basic concept, they derived everything from numbers. This paid handsome dividends in astronomy. The Pythagoreans argued that the earth is a sphere, instead of a disk or a drum as the Milesians had variously supposed. They held that it and the other planets (including the sun) revolve about a "central fire" that we do not see because the earth turns on its axis as it revolves and so always presents the same surface to the fire. It was, in fact, Aristotle's reaffirmation of the geocentric theory and the weight of his prestige that necessitated the "discovery" of Copernicus, who was well acquainted with the Pythagorean view, in the sixteenth century.

When we turn, however, from the Pythagoreans' astronomical theories to their accounts of the cosmological process, we find that we have passed from exact, mathematical science to murky mysticism. According to Aristotle, the Pythagoreans held that there are two basic principles: the Limit and the Unlimited. Thus they were neither monists like the Milesians nor pluralists like Empedocles and Anaxagoras, but dualists.

The Unlimited they conceived to be a "boundless breath"—a mass of indeterminacy and indefiniteness. This suggests that they were acquainted with the views of Anaximander and Anaximenes. The Limit they thought of as fire, which sounds like Heraclitus. But—more fruitfully—they also conceived of it as number. That they could think of it in both ways is but another example of the difficulty of thinking abstractly. Since numbers are the most abstract of all abstractions, it is not surprising that the Pythagoreans found it easier to picture them as material.

All numbers, they believed, are generated by partition from the unit.³¹ Consequently, the "principles" of the world are the infinite and the unit. But how do the unit and the infinite combine to form the material things of this world? To this question, of course, we get no firm answer. "Fire," the Pythagoreans maintained, "is composed of twenty-four right-angled triangles surrounded by four equilaterals. . . . Air is composed of forty-eight triangles surrounded by eight equilaterals," and so on.³²

Unlike the case of the lyre, for which there was empirical evidence, this is sheer speculation. However, the analogy of the lyre will help us to understand at least the general lines on which Pythagorean thought was operating here. We can think of the mathematical ratios 12 : 6, 12 : 8, 12 : 9, as being, quite literally, imposed on the various strings by the musician as he tunes his lyre. And these ratios, when imposed, create a significant concord—a particular something—out of a jumble of noises and discords that was previously nothing in particular.³² Out of boundless noise, as it were, a concord of notes is formed by limiting the

³¹ See p. 35.

³² Compare the difference between the noise an orchestra makes as it tunes and the music it makes when the conductor leads it.

strings to certain designated lengths. As an account of how the world comes to be, this is, of course, nothing but a weak analogy that suggests a human agent. Who imposes the limit? How does he impose it? Why? These questions are enough to show that, conceived as a process in time (as the Pythagoreans undoubtedly thought of it), the notion of a limit is not particularly helpful. But after the Parmenidean bombshell was exploded³³ and the whole idea of process underwent criticism, Plato was to take up this notion of a limit and employ it in a novel way.

The Pythagoreans conceived of the cosmic order as having a unity that is mathematical in character. The discovery of the mathematical relationships underlying the harmonies of the tuned lyre led them to extrapolation on a cosmic scale. Why, if numbers underlie and express the musical harmonies of the tuned lyre, do not similar mathematical relationships lie at the heart of all the qualitative variety of the sense world? Why not indeed? The thought was father to the assertion, and what would be merely a daring hypothesis to a modern scientist became a statement of fact to the Pythagoreans.

Accordingly, they declared that everything has its number. Since they did not experiment to discover (as they had with the tuned lyre) what the numbers actually are, an enterprise that was at first truly scientific in spirit soon collapsed into an esoteric mystery: They said that justice is four, marriage is seven, and so on. This is, of course, nonsense; but even when the Greeks talked nonsense it was on so grand a scale as to contain ideas on which future generations could work with profit. And so it was with the Pythagorean notion that number is at the heart of the universe.

ESTIMATE OF PYTHAGOREANISM

To characterize Pythagoreanism as a whole, one can say that it was an extraordinary mixture of mysticism and brilliant insight. The Pythagoreans' most notable achievement, certainly, was the concept of "cosmos"—the notion that the universe is not a chaotic hodgepodge but a thoroughly ordered system in which every element is harmoniously related to every other. Of course, this idea had been implicit in Greek thought almost from the start; for instance, there were signs of it in theological dress in Hesiod. It appeared too in the Milesians, but for them, as for Hesiod, order was something imposed on a basic chaos. The opposites, Anaximander thought, had to "make reparation for their injustice" to one another. So, too, Heraclitus: The logos, the eternal process, "will not overstep its measures; if it does the Erinyes, the handmaidens of justice, will find it out."³⁴

What had long been implied was finally stated emphatically by the Pythagoreans. The universe, they held, is well ordered because all its parts are related to one another mathematically (on analogy with the lyre). Since the kind of

knowledge we have in mathematics is knowledge par excellence, the universe must be thoroughly intelligible. To say that it is well ordered and that it is intelligible is simply to express the same idea two ways. This idea, taken up by Plato and passed on to Christian theology, is one of the great heritages of the modern mind. How could science with its technique of experimentation and measurement ever have made a beginning, let alone have had the fixity of purpose to continue its researches, without the Pythagorean conviction that the universe constitutes a cosmos pervaded by a single intelligible order?

Pythagoreanism and Atomism³⁴ complement each other in a remarkable way. The Pythagoreans conceived of a world that, when measured, shows simple mathematical relationships, but they never thought their way through to a clear concept of what must be the nature of a world capable of being measured. The Atomists, in reducing the world to spatial and temporal relations of particles, conceived of a world that is in essence measurable, but they never conceived of the utility of measuring those relations and so discovering the mathematical relationships that obtain. If we combine Pythagorean emphasis on mathematics and measurement with the Atomists' view that reality consists in entities varying only in shape, size, and velocity, we have the conception from which modern physical theory began its great career.

Only the dominance first of Platonism, with its emphasis on other aspects of Pythagoreanism and its lack of interest in Atomism, and then of Christianity, with its extreme otherworldliness, prevented the possibilities of this combination from being immediately seen. As it was, the world had to wait until the seventeenth century for the combination to be effected.

The puzzles about the nature of reality and about the possibility of change, which the earliest thinkers had uncovered in Thales' original formulation and which they themselves had been unable to resolve, form the main topics of Plato's philosophy. Pythagoreanism furnished him with some of the leading concepts in which his answer was formed. But examination of this answer must be postponed until we have considered some of the other elements, drawn from the general culture rather than from the specifically philosophical tradition, that entered into his theories.

³³ See pp. 21-24.

³⁴ See Chapter 3.