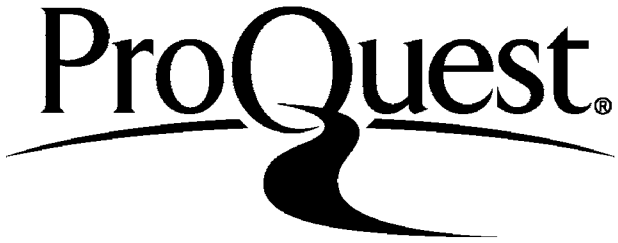
DOROTHY MILDRED TURLEY

Experience, observation and experiment
in early Greek philosophy and medicine.



ABSTRACT

F. M. Cornford thought that the pre-Socratic philosophers were rationalizing myth and originally using the *anamnesis* method of gaining knowledge, which resembles the inspiration of shamans, "empiricism" being introduced into philosophy from medicine by Alcmaeon.

The elements which Cornford thought came from myth may be (i) logical ideas based on insufficient observation or (ii) symptoms of Greek psychological tendencies. Myth differs from philosophy in the way in which it uses (i) logical and mythopoeic thought and (ii) experience and observation. Philosophy took its subject from myth and probably its method from technology.

The Milesians' cosmology was probably the result of observation, however insufficient. Xenophanes was primarily interested in religion, but favoured the "empirical" method. Heraclitus supported an *a priori* theory by observation. The method of *anamnesis* probably originated in Pythagoreanism; but Pythagoras paid attention to reason and sense-perception, unlike the shamans. Some of the Pythagoreans' discoveries were "empirical". Alcmaeon was very "scientific" and originated the "empirical" theory. The Eleatics, while ignoring the evidence of the senses, made use of reason. In the works of Empedocles and Anaxagoras there are examples of observation and

experiment. The Atomists gave precedence to reason over sense-perception.

In the works of the Italian doctors there are many theories taken from philosophy, but also some careful observations and experiments; the Cnidians tended to be over-empirical, often drawing no conclusions from their observations and experiments; the Coan doctors, while not accepting the theories of philosophy sometimes went too far beyond the evidence of the senses.

Conclusions; the empirical method existed before Alcmaeon; all the Greek philosophers, except the Eleatics, paid some attention to sense-perception; Greek medicine was often no more empirical than philsophy; sense-perception and reasoning were used by both; the most successful systems are those in which reason and sense-perception are complementary.

CONTENTS

List of Abbreviations.

D	H. Diels. Fragmente der Vorsokratiker, 4th edition.

Works of Hippocratic Corpus

Aff.	Affections.
A.M.	Ancient Medicine.
Aph.	Aphorisms.
A.W.P.	Airs Waters Places.
Ep.	Epidemics.
Hum.	Humours.
I.D.	Internal Diseases.
Mal.	Maladies.
P. in M.	Places in Man.
Prog.	Prognosis.
R.A.D.	Regimen in Acute Diseases.

Books and Periodicals.

A.J.P.	American Journal of Physics.
C.J.	Classical Journal.
C.R.	Classical Review.
C.Q.	Classical Quarterly.
E.G.P.	J. Burnet. Early Greek Philosophy.
J.H.S.	Journal of Hellenic Studies.
Met.	Aristotle. Metaphysics.
P.S.	F. Cornford. Principium Sapientiae.

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CHAPTER I

THE TWO THEORIES OF THE SOURCE OF KNOWLEDGE.

The Classical scholars of this century have, with few exceptions, insisted upon the "scientific" character of the work of the pre-Socratic philosophers. J. Burnet[1] was of the opinion that the early physiologoi proceeded by observation and experiment and that the reason for so few examples of this method being found in the accounts which we possess of their work is that the authors of these accounts were not interested in, or actually wished to discredit the discoveries of "science"; and therefore the examples of the use of observation and experiment which can be found carry much more weight than they would do otherwise. This thesis was supported by W. A. Heidel,[2] who claimed that the absence of records of observation and experiment[3]

1 Essays and Addresses, pp. 253 ff. and Scientia, vol XXXIII pp. 93 ff.

2 The Heroic Age of Science and Hippocratic Medicine, its spirit and method.

3 O. Bluh, (Did the Greeks perform experiments?, American Journal of Physics, 1949), suggests that either the Greeks did not keep scientific records or else they did not publish them because (1) they were sworn to secrecy (as in the Pythagorean brotherhood) or (2) they wished to win a reputation for being "inspired" or (3) they were more interested in the final result of their work than in the methods used to obtain it (like an artist) or (4) they were afraid of being thought guilty of for "probing nature with human tools;" (on the last point see Plato, Timaeus, 68 D).

among the fragments of the pre-Socratic philosophers does not mean that their pronouncements were the result of pure *a priori* reasoning. Both these writers maintained that if we possessed the records of the early Greek *physiologoi*, supposing that they kept any, we should see that they were truly "scientific".[1]

In reply to these arguments F. M. Cornford stated that it is wrong to assume that "the motives which prompted their (i.e. the Greek philosophers') enquiries and the quarters to which they looked for the sources of knowledge, were the same then as now . . . . . Rather we should fix attention on elements which strike us as strange and unaccountable.[2] He then attempted to show that in Epicurus' philosophy (which he assumed to be the final outcome of Ionian speculation) there can be found two methods of approach to the discovery of truth; (i) the empirical, in which the mind proceeds by induction from particular observations to general conclusions - a method first formulated by Alcmaeon and recapitulated in the Hippocratic *Precepts*, chapter I,[3] and (ii) the *a priori*, based on the doctrine of *anamnesis*

[1] See also O. Blüh, op. cit. The following also believed that the pre-Socratics were "scientific":- A. Rey, *La Science dans l'antiquité*; J. McCue, *Ancient Science in the Modern Curriculum*, American Journal of Physics, 1948; W. D. P. Wightman, *The Growth of Scientific Ideas*; B. Farrington, *Greek Science* and G. Sarton, *A History of Science*.

[2] *Principium Sapientiae*, pp. 4-5.

[3] p. 41

formulated by Plato in the Meno and the Phaedo[1] and comparable with the method used by the present-day Shamans of Siberia.[2] Cornford believed the former to have originated in the study of medicine and to have been introduced into philosophy from that source, whereas the latter was much older,[3] being, in fact, the method of the Milesians of the sixth century B.C.[4]

On consideration of these statements it becomes apparent, as Burnet said, that since many of the doxographers were, in fact, not interested in "science",[5] if we can find even a little evidence for the use of a "scientific" method on the part of the pre-Socratics, it will be of considerable importance. But it seems that he was wrong in assuming that the ancient Greeks had the same outlook as modern scientists; the influence on their philosophical theories of traditional thought, intellectual and cultural environment and individual temperament must be taken into account.

On the other hand, several points made by Cornford need closer examination.

(i) It was surely a gross error on his part to assume that Epicurus' philosophy was the "final outcome of Ionian

1 ibid. ch.IV
2 ch.VI
3 p. 61
4 p. 64; see also his article "Was the Ionian philosophy scientific?" J.H.S., 1942.
5 Many were Christian apologists e.g. Athenagoras, Hippolytus, Eusebius etc.; see J. Burnet, E.G.P. pp. 31-38.

speculation".[1] This may be true of the atomic theory,[2] but Epicureanism was not simply a repetition of the system of the Atomists. Epicurus was not an original thinker in the sphere of natural science, but revived those theories of earlier philosophers which best suited his aim of freeing men from fear; and, indeed, he went so far as to accept several different explanations of natural phenomena[3] because they had no bearing on his philosophy of life. Unlike the Ionians, it seems that he was never motivated by disinterested curiosity.[4] It is certainly not valid, then, to argue, as Cornford did, that any methods of approach to the discovery of truth found in Epicurus' work must exist also in the works of earlier thinkers from whom his views on natural science were derived.[5]

(ii) As we have seen, Cornford thought that Alcmaeon was the first to formulate the "empirical" theory.[6] However

1 P.S. p. 12.

2 If it is true that later schools of Greek philosophers tried to improve upon the views of earlier thinkers, then atomism may be regarded as the result of the inevitable revolt of the senses against the extreme philosophy of the Eleatics, which in turn was a development of the monism of the Milesians, see ch.VII.

3 e.g. explanations of eclipses, etc.; Lucretius, De Rerum Natura, Bk.V 592-770, etc.

4 cf. Diogenes Laertius, X, 142.

5 G. Vlastos, reviewing P.S., Gnomon, 1955, argues that the anamnesis method is not found in Epicurus' philosophy; and even if it were, there is no reason to suppose that ἐπιβολή had the "original" meaning of "projection" of the mind; but, in fact, ἐπιβολή was used in Ep. ad Herod. 50-51, to mean, not the "projection" of the mind, but the grasping of an impression made by sense-experience.

6 P.S. p. 41.

that may be,[1] he certainly did not invent the method of "empiricism." This is a natural method of gaining knowledge and it must have been used long before the time of the earliest Greek philosophers. It is difficult to see in what other way the Greeks and other peoples before them could have acquired such remarkable technical knowledge.[2] Moreover, it does not seem correct to credit the Hippocratic writers with the formulation of the "empirical" theory. Although they made use of the method (as we shall see later) the formulation of the theory in the Hippocratic Precepts, chapter I, is of little value to Cornford's argument, as the work seems undeniably Epicurean in thought and language.[3] On the other hand, a description of this method was given by Plato (Phaedo 96b5-9) as well as an account of the doctrine of anamnesis (Phaedo 72b) to which Cornford

[1] G. Vlastos, op. cit., thinks that the fragments of Alcmaeon do not necessarily imply that he actually formulated this theory. But according to Theophrastus (D.24A5) Alcmaeon thought that the brain was the seat of sensation; and he said (D.24B1a) "Man differs from other animals in that he alone understands; the others have sense-perception but do not understand (συνίησι = puts together (of sense-impressions?)" Surely this implies that he considered understanding to be the result of sensation. If so, then the brain was the seat of understanding. Vlastos thinks that the passage in the Phaedo (96b), if it refers to Alcmaeon, (which he doubts) goes beyond the evidence. It is difficult to see to whom it could refer, if not to Alcmaeon, and Plato probably had access to works of Alcmaeon which we do not possess (see R. S. Bluck, Plato's Phaedo).

[2] see B. Farrington, Greek Science, G. Sarton, A History of Science, W. A. Heidel, The Heroic Age of Science.

[3] see L. Bourgey, Observation et expérience chez les médecins grecs de la collection hippocratique, p. 40.

compared the "inspiration" of the pre-Socratics.[1]

(iii) Then there is the question whether the "empirical" method entered philosophy from medicine. If "empiricism" is a natural method of gaining knowledge (as stated above), it surely existed in medicine and philosophy independently of each other. We shall see later that the inductive method was used by some of the physiologoi, at least, before Alcmaeon introduced medical ideas into philosophy.

(iv) Finally, did the pre-Socratic philosophers rely at all on knowledge from another sphere? It is hoped to show that even the philosophers whom Cornford considered to be the successors of the Shaman, i.e. Heraclitus, Pythagoras, and Empedocles, did not entirely ignore the evidence of the senses.[2]

As J. Tate pointed out,[3] the lines cross; Cornford's distinction between "dogmatism" and "empiricism" was too sharply drawn. The aim of this work is to try to trace how far the theories of the pre-Socratic philosophers and Hippocratic physicians were based on experience, observation and experiment.

[1] Cornford does not seem to have taken into account the fact that, in all probability, Plato's theory of "forms" was not derived, as he thought, from experience in a previous life, but was the result of his abstracting essentials from the objects which he saw around him i.e. reasoning from experience and observation.

[2] see G. Vlastos, op. cit.

[3] Review of Principium Sapientiae, C.R., 1954, pp. 237 ff.

CHAPTER II

THE INFLUENCE ON PHILOSOPHY OF MYTH AND ORIENTAL KNOWLEDGE.

(1) The influence of myth.

Owing to the fragmentary nature of the evidence, it is very difficult to know which elements of early Greek philosophy were inherited from tradition. In his attempt to show that the Ionians were deriving their knowledge from sources other than the sensible world, like the present-day Shamans of Siberia, Cornford[1] tended to over-estimate the part played in early speculative thought by the rationalization of myth. He saw likenesses between Greek mythology and the physical systems of the Ionian philosophers in a) the following fundamental assumptions of both; i) that the world, as we know it, has not always existed and will one day come to an end;[2] ii) that everything first arose from a single, living and imperishable substance, or a primitive confusion in which "all things were together;"[3] iii) that from this unity the primary opposites emerged to form the great masses of the world-order;[4] and iv) that these opposites re-united to form living creatures;[5] and b) in the interest taken by both in the origin of the world and

1 P.S. ch.XI.
2 p. 188
3 p. 188
4 p. 189
5 p. 189

in natural phenomena, or "meteorology."[1]

Let us now examine these likenesses.

a), i) The world has not always existed and will one day come to an end.

This is undoubtedly a tacit assumption of the Milesians. But it may well be that, even if the idea were borrowed from cosmogonical myths, support was found for it in the direct observation of nature. We must remember that at that time there was no distinction between animate and inanimate matter.[2] The movement of flowing water, rushing wind, etc., could only mean to the indiscriminating mind that these were actually alive.[3] From that assumption it was an easy step, by analogy with the birth and death of living creatures, to suppose that the world must have had its origin in some other substance and would one day "die", (probably returning to its original state).

ii) All things are derived from a unity.

This is merely a symptom, found in both mythology and philosophy, of a tendency of the Greek mind towards simplification.[4] It may well have existed in both

1 P.S. ch.X.

2 for possible evidence of this in Thales see D.11A1 and 11A3; see Zeller, A History of Greek Philosophy, Vol.I, p. 149 and W. K. C. Guthrie, The Greek Philosophers pp. 31-3.

3 This is a relic of mythopoeic thinking, discussed below p. 13.

4 see W. K. C. Guthrie, Orpheus and Greek Religion, p. 221. For examples of this tendency in Greek literature, see H. Kitto, The Greeks, p. 176.

independently of each other. It should also be noted that it is, in fact, the beginning of systematic thought, which later played such an important part in shaping early "science". The supposition that the primitive substance was alive was a rational conclusion from the belief in an animate world, by analogy with biological life in which living creatures are born from living creatures. Likewise, the assumption that the original substance was imperishable is necessary to account for its unfailing power of creation. The "primitive confusion" of the "pluralists" in which "all things were together" may also be, not an idea inherited from myth,[1] but a logical construction aimed at combining the idea of a single original substance (a belief which resulted from the Greek desire to find a unity behind phenomena) with the obvious pluralism of existing objects, as witnessed by the senses.

iii) The four opposites, hot, cold, wet and dry, emerge from the Unity.

This probably means no more than that the world arose from a single source (the four opposites representing the

[1] as Cornford thought, P.S. p. 189, though as G. Vlastos (review, Gnomon 1955,) points out, he did not cite the obvious passage in support of this theory, i.e. Hesiod, Theogony, vv. 736 ff, where "the sources and boundaries of Earth, airy Tartarus, the Sea and Sky are located all in a row in Chaos", but only vv. 116-132 where Earth is said to be born not of Chaos, as in vv. 736 ff, but of Uranus and Pontus, and only to come into being after Chaos.

heavenly bodies, the air, the sea and the earth) and, as we saw before, this is probably a symptom of the tendency towards simplification, inherent in the Greek mind.[1]

iv) The elements re-unite to form living creatures.

This belief is found only in the works of Anaximander and Empedocles. It simply seems to be expressing the fact that living creatures, like everything else in the world, are composed of the basic elements.

b) The interest taken by both mythology and philosophy in the origins of the world and in "meteorology".

This may be explained as the result of the natural curiosity of man, which seeks an explanation for the world around him.

Such are the likenesses between mythology and philosophy; the differences may be observed in the way in which the following are used; i) language, which shows the development of logical thought and ii) experience and observation. We shall now examine these differences.

i) The language used in myth is the language of poetry, a product of the imagination. It relies upon metaphors and similes, which see likenesses between the apparently unlike. In the creation of myth there is

[1] Here we may note that the idea of opposites is not (as Cornford implied, pp. 188-9) manifest in the systems of all the Milesians. As far as we know, Thales did not mention opposites.

little exercise of the will;[1] images come and go without any effort on the part of the creator, like the images of a dream.[2] Presumably the primitive minds which thought in this way believed in myths literally and were not troubled by any internal inconsistencies or contradictions of the evidence of the senses, because they had not yet learnt to distinguish between the reality of the world of sense and the illusion of the dream- (or imagination-) world.[3] Homer and Hesiod, however, are far removed from this primitive state[4] and almost certainly did not believe literally in myths. Hesiod, in fact, as Cornford said,[5] had begun the work of rationalization, although he still used the language of myth, as is especially noticeable in his personifications;[6] but there is much logical and systematic thought in his work.[7]

Logical thinking differs from mythopoeic thought in

1 see B. Snell, The Discovery of the Mind, translated by T. G. Rosenmeyer, p. 224.
2 see E. Dodds, The Greeks and the Irrational, p. 104 (of myth) "It has been well said that it is the dream-thinking of the people, as the dream is the myth of the individual" (J. Harrison, Epilegomena to the Study of Greek Religion, p. 32).
3 see E. Dodds, op. cit. p. 102.
4 see L. Robin, Greek Thought, p. 24 "The earliest evidence (of myth) in literature is four to twenty centuries later than the archeological remains of Troy, Mycenae, the Cyclades and Crete".
5 P.S. p. 193; see L. Robin, op. cit. p. 25.
6 It is possible, in fact extremely probable, that he recognized the personifications as such. If so, this is a great advance on primitive thinking which does not distinguish them.
7 L. Robin, op. cit. pp. 25-27.

that it demands the full exercise of the powers of the mind and the will.[1] The first thing which strikes the reader of the pre-Socratic fragments is the difference of language from that used by the mythologers; there are few personifications, and similes are used more often than metaphors, showing that the two objects compared are not confused with each other. The language is prosaic; abstract nouns, formed from adjectives or verbs by the addition of the generic article[2] are preferred to the proper nouns of mythology; universals take the place of individuals and some progress has been made towards the abstraction of qualities from concrete objects.[3] These are all signs of the growing ascendancy of logical over mythical thinking. This difference was not under-estimated by Cornford, who thought that it was a sign that philosophy was nothing but a rationalization of myth.[4] It is true[5] that philosophy developed the rational outlook already existing in Hesiod's work; and, as there are logical elements in myth, so there

1 see B. Snell, op. cit. p. 224.
2 ibid. pp. 228 ff.
3 ibid. pp. 237-8 e.g. Oceanus of Homer is replaced in Thales' cosmology by the universal, water, and the four "elements" of early myth are replaced in Anaximander's system by the four opposites, substances that are recognized by their qualities, hot, cold, wet and dry. Although it seems unlikely that any of the pre-Socratics fully grasped the idea of quality existing apart from matter, some of them (e.g. Anaximander and Alcmaeon) must have been on their way towards understanding it.
4 P.S. p. 187.
5 see L. Robin, op. cit. p. 27.

are relics of illogical and mythical thought in philosophy.[1] It should, however, be noted that some of these relics are not necessarily to be condemned as "unscientific". For example, the Love and Strife of Empedocles represent actual forces which he had observed at work in the world, and personifications of this kind were probably the best means he had of expressing an obvious truth. There seem to be two kinds of mythical thought; the good and the bad; the good expresses in poetical terms an actual, observed truth and recognizes as such personifications and metaphors; the bad does not recognize them and consequently leads to confusion.[2] These two kinds of mythical thinking often exist alongside of logical thought.

ii) The second difference between mythology and philosophy, (i.e. the use each makes of experience and observation) was overlooked by Cornford. It is true that Homer and Hesiod seem to rely on knowledge from another sphere;[3]

[1] e.g. personifications, such as the Love and Strife of Empedocles and the Nous of Anaxagoras, etc. and false analogies, e.g. the macrocosm compared with the microcosm by Anaximenes (D.13B1) etc. This last is probably a relic of the animistic outlook of primitive man, see above, p. 8.

[2] see W. K. C. Guthrie, Myth and Reason. The good kind of myth is of particular value in dealing with spiritual truths. As an example, Guthrie cites the story of Adam and Eve; because we cannot believe in them as actual people, we should not suppose that there is no truth in the story of the Fall of Man.

[3] But it should be noted that in the instances where they call upon divine aid (Iliad II, vv. 484 ff. and Theogony vv. 22 ff.) they call upon the Muses to give them, not

(cont'd on p. 14)

yet their use of metaphor shows that their senses were fully alive to impressions made on them by the external world. The difference between this kind of experience and that of the philosophers is that the former is criticised and systematized hardly at all. We shall see that the majority of the philosophers made extensive use of the senses and also of the reasoning powers of the mind in ordering the data provided by sense-perception; and, in fact, many of the so-called "rationalizations of myth" may well be rational constructions of the intellect, reasoning from experience.

We have seen, then, how the elements of Greek philosophy, which Cornford thought were rationalizations of myths, may be explained as either symptoms of certain deep-seated tendencies of the Greek mind or as logical constructions of the intellect which proceeds inductively from observations. Greek philosophy certainly developed the trend towards logical thought, already manifest in Hesiod's mythology, though we find relics of the mythical way of thinking in the systems of some of the philosophers. Without doubt the thoughts of the "physiologoi" must have been

inspiration, but knowledge of actual facts; the Muses were the daughters of Mnemosyne, who knew and remembered all things that happened on earth; and so, in asking them for aid the poet is really stressing the importance of the authority of the eye-witness and so of actual experience, although he has not distinguished between divine aid and poetic imagination. See B. Snell, op. cit. p. 137.

unconsciously moulded by the ideas of mythology; it could hardly be otherwise, when the myths were such an important part of Greek culture. It seems likely that the subject of philosophy was derived from myth. But that does not mean that Greek philosophy was nothing but the old, cosmogonical myths, rationalized and published in a new form. We cannot ignore the part played in the physical schemes of the pre-Socratics by experience, observation and experiment and by logical thought. However, before, we proceed to consider how far their theories originated in sense-perception, we must examine the possibility of another influence on Greek thought, namely the knowledge derived from the East.

(2) The influence of Oriental knowledge.

As we saw above,[1] the "empirical" procedure was employed from the very beginning of civilization. All crafts rely on experience, which is gradually systematized until it forms a compact body of knowledge.[2] This may as justifiably be called "scientific" as the industrial techniques of the present day. G. Sarton[3] gives an account of the remarkable knowledge acquired by the Egyptians in the fields of architecture, engineering, metallurgy, technology, medicine and mathematics and by

1 p. 5.
2 G. Sarton, A History of Science, p. 49.
3 op. cit. chs. II, III, IV and VI; see also A. Rey, Science Orientale.

the Assyrians and Chaldeans in mathematics, astronomy, technology, natural history and medicine. The records we possess of these sciences show a fairly systematic method of dealing with knowledge gained from experience.[1]

Now the harbours of Ionia were the terminals of Greek, Phoenician and Egyptian sea-routes and of Anatolian caravan-roads connecting them with the whole of Asia,[2] and Miletus, the home of the earliest philosophers, was the richest of these ports. Moreover, we are told that some of the philosophers actually visited Eastern countries.

Thales is said[3] to have learnt geometry from the Egyptians. They probably knew something of geometrical principles, which would be necessary for measuring out their land after the annual flooding of the Nile[4] and for building the pyramids.[5] We are told[6] that Thales knew certain abstract theorems concerning triangles and circles. We do not know whether he knew the geometrical proofs of these, but he must have known the actual propositions in order to

1 e.g. the Rhind papyrus in the British Museum which contains an attempt at making mathematical tables, the Edwin Smith papyrus on medicine which classifies cases in remarkably scientific fashion and gives evidence of the rational treatment of disease (Sarton, op. cit. ch. II); the mathematical tables found on Sumerian tablets of ancient date (ibid. p. 70) and the astronomical tables of the Babylonians (ibid. p. 76).

2 see G. Sarton, op. cit. p. 162 and J. Burnet E.G.P. p. 21. Milesian pottery has been found in Egypt, the Aegean islands, Anatolia and South Russia.

3 D11A11

4 Herodotus II, 109.

5 see G. Sarton, op. cit. pp. 35-6.

6 D11A20.

work out the distance of a ship at sea.[1] It is probable that the Egyptians knew of these propositions in an empirical way and that Thales made use of them, applying them to problems not tackled in this way before.[2]

Thales is also said to have foretold an eclipse of the sun.[3] Several modern scholars have doubted the truth of this tradition.[4] They argue that Thales could not have known of the Saros, a period of 18 years, 11 days, 8 hours, which enables scientists to predict eclipses of the sun and moon; it is said to be very difficult to discover, though not hard to recognize when once it has been discovered; and the fact that it is not mentioned in any Babylonian documents of early date is taken for proof that it had not been discovered at that time. Sarton[5] adds that if Thales had predicted the eclipse only for the year and not for the day on which it occurred, the psychological effect on the Kings of Lydia and Persia[6] would have been lost. But Herodotus does not say that the kings stopped fighting because Thales had predicted the eclipse for that day. In all probability they stopped fighting because they were superstitious and thought the eclipse to be a bad omen.

1 D11A21.
2 see Burnet, E.G.P. p. 46.
3 D11A1, 2, 5.
4 G. Sarton, op. cit. p. 170, following O. Neugebauer, The Exact Sciences in Antiquity.
5 op. cit. p. 171.
6 Herodotus I, 74.

It is possible that the Babylonians had discovered the Saros. We know that they kept records of daily events predicted by eclipses of the sun[1] and Simplicius tells us that before the capture of Babylon by Alexander, Callisthenes, who accompanied him, sent to his uncle, Aristotle, a collection of observations of eclipses for 1,903 years.[2] The full moons were observed on account of the lunary nature of the Chaldean calendar and, as lunar eclipses always occur about the time of the full moon, these must have been observed.[3] Records of lunar eclipses kept over a long period could have enabled the Babylonians to discover the lunary Saros, and, if the solar eclipses that were observed were also recorded for a sufficiently long time[4] and compared with the records of lunar eclipses it would then be possible to recognize the same cycle for solar eclipses. If Thales did know of the Saros he could have predicted the eclipse of May 28th 585 B.C. from knowledge of the eclipse of May 18th 603 B.C. which would

1 The astrological treatise of the palace of Sargon of Akkad of the year 2,800 B.C. contains such a list.
2 see A. Rey, Science Orientale. Ptolemy states that complete lists of eclipses are available since the reign of Nabonassar of 747 B.C.
3 see A. Rey, op. cit.
4 see note 2. We know from the letters of the Assyrian court-astrologers of c. 700 B.C. that the astrologers of Mesopotamia had predicted lunar and solar eclipses for some time with varying success, see B. Van der Waerden, Science Awakening.

have been visible in Egypt.[1] However, it is true that the solar Saros is difficult to discover when observations are made from one particular place. But it does seem that the Babylonians used to foretell eclipses in some fashion.[2] It maybe that they had noticed that eclipses of the sun sometimes precede and sometimes follow eclipses of the moon, in a cycle.[3] There is also another cycle in which a lunar eclipse of some kind occurs 47 synodic months after a total lunar eclipse and a solar eclipse occurs 23½ synodic months after a total lunar eclipse. In view of the text quoted in note 2 it seems most likely that the Babylonians predicted solar eclipses by reference to records of eclipses of the moon in one of the ways suggested above.[4] So, it seems that even if Thales did not know of the Saros, he could have predicted the eclipse with a fair degree of accuracy after studying Babylonian records. There is no need to insist that he must have predicted it for the actual day on which it took place, although he may have been able to do so.

1 H. Diels, Antike Technik.

2 see G. Smith, Assyrian Discoveries, p. 2. "The following report was found in the palace of Sennacherib (reigned from 702-680 B.C.) at Kouyunjik:- To the king, my lord, thy servant Abil-Istar; concerning the eclipse of the moon of which the king, my lord, sent to me; in the cities of Akkad we saw part . . . (inscription broken off). The observation was made and the eclipse took place. And when for the eclipse of the sun we made an observation, the observation was made and the eclipse did not take place" (i.e. could not be seen from there?). When the eclipse did not appear it was considered a good omen.

3 see under Eclipses in the Encyclopaedia Britannica.

4 see B. Van der Waerden, op. cit.

Pythagoras also is said to have visited Egypt.[1] It seems probable that he learnt something of geometry there. We do not know whether the Egyptians knew of "Pythagoras'" theorem. It is possible that they had discovered that a triangle whose sides are in the proportion 3:4:5 has a right angle. Pythagoras may have been the first to discover the general proposition that the square on the hypoteneuse of a right-angled triangle is equal to the sum of the squares on the other two sides and to prove the theorem.[2]

We are told[3] that Democritus travelled widely, visiting Babylon, Egypt, Aethiopia and, according to some, India. Some scholars have tried to trace the source of atomism to India. G. Sarton[4] tells us that atomic theories were developed in India by philosophers of the Nyāya and Vaiśeshika schools, at a time probably later than Christ. If these theories were preceded by earlier speculations Democritus may have heard of them in his travels in Persia

1 D14A4.
2 see G. Sarton, p. 39 and following note.
3 D68A1 §35, A2, 16, 40 etc. D68B299 is considered spurious by Diels, vol. II, p. 124. However, there must have been some people called ἁρπεδονάπται though we do not know exactly what their task was. Burnet, E.G.P. p. 20 thinks that they laid out foundations for buildings, etc. with a cord divided into segments of 3:4:5 units, making a right angle. Sarton op. cit. thinks they were responsible for correctly orienting temples by stretching a cord in the direction of the meridian by means of a rope divided into 3:4:5 units. It seems as if there is some connection between hypoteneuse and ὑποτείνουσα which suggests stretching under or measuring (with a rope?). Whether the fragment is genuine or not it appears that the Egyptians knew certain mathematical rules in empirical fashion.
4 op. cit. pp. 245 ff.

and India.[1] There is another tradition about the Oriental origins of atomism. Poseidonius ascribes the theory to a Phoenician, Mochus of Sidon, and Philon of Byblos ascribes it to another Phoenician, Sanchuniaton of Beirut, whose works he translated into Greek; a part of the translation was preserved by Eusebius. Both Mochus and Sanchuniaton were supposed to have lived before the Trojan war.[2] It is possible that the Phoenicians may have transmitted some theory of the Hindus which resembled atomism, but it is hardly likely that they were sufficiently original to invent such a theory. It seems more probable that Democritus accepted the theory of Leucippus, who worked it out for himself from observation. Either of them may have heard of some similar theory of the Oriental peoples, which may have confirmed their ideas, but it seems most likely that they developed the theory independently of other races.

Whereas it does not seem that the Greeks borrowed any of the cosmological ideas of the Oriental peoples (in fact, even if the peoples of the East had passed beyond the mythological stage, which is unlikely, it would have been extremely difficult for philosophical ideas to pass from one language to another[3]), there is plenty of evidence to show that some of the Greek philosophers visited Eastern

[1] The Indian philosophers mentioned here may have borrowed the theory from the Greeks.
[2] G. Sarton, op. cit. p. 255.
[3] see L. Robin, Greek Thought.

countries and learnt something of the sciences of the people of these lands. It seems that in the case of mathematics, at least, they made an abstract science out of the more or less empirical knowledge of the Egyptians and Babylonians.

There is another way in which the culture of the East influenced Greek thought. We have seen[1] how important a trading centre Miletus was. Here people from many countries would meet and the Greeks would begin to doubt the truth of their own traditional beliefs.[2] In the new explanations of the world which they gave, the interest they showed in practical things[3] may be the result of their living in so prosperous a city where old techniques would be developed and new ones learnt from the East.

We shall now try to discover how far the early Greek philosophers were practical men of science who based their theories on experience and supported them by observation and experiment.

1 p. 16.
2 G. Sarton, op. cit. p. 162.
3 Anaximander mentions the "nozzle of the bellows" (D. 12B1) (used by a smith?). Anaximenes is interested in the relation between heat and density (D13A5; 7; 8) perhaps from considering the expansion of heated metal. cf. also D.13A19 etc.

CHAPTER III

THE MILESIANS.

(1) Thales.

We have seen[1] that Thales probably laid the foundations for the science of geometry by systematizing the empirical knowledge of the Egyptians.[2] He also made practical use of geometrical propositions to calculate the distance of a ship at sea[3] and the height of a pyramid.[4] His discoveries in the sphere of astronomy were considerable;[5] and he is said to have used this knowledge to predict a good harvest and so to make a fortune from a corner in olive-presses;[6] he may also have used it for the benefit of shipping, if it is true that he wrote a book on Nautical Astronomy.[7] We are told that he noted the attraction of the magnet and of

1 above, ch. II.
2 D11A11.
3 D11A20.
4 D11A21. We do not know whether he solved this problem by measuring the shadows of a man and of the pyramid at a time of day when the man's shadow equalled his height, as might be the meaning of Pliny's statement (D11A21), or whether he made use of a theorem concerning right-angled triangles, as is suggested by Plutarch (D11A21); the astonishment of the King of Egypt at this feat (Plut, *Conv.* 147a) suggests that he solved the problem by geometry. R. Baccou, *Histoire de la science grecque*, p. 60, shows how Pliny's statement could also imply the use of a theorem.
5 D11A13c, A1 §§23, 24. On the question of the size of the sun and moon, see A. Wasserstein, *Thales' determination of the diameters of the sun and moon*, J.H.S., 1955, who thinks that Thales' accurate calculation of the sun's diameter as 1/720th of its orbit was worked out by geometry and not by the use

(cont'd on p. 24)

amber;[1] if this is true, he may have actually experimented with amber since it only becomes active when rubbed with certain materials. Whether these traditions are all reliable or not, they show that Thales was famous as a practical man of considerable ingenuity.

We are told[2] that Thales believed that the primary substance from which all things were derived was water. Some have considered this to be a rationalization of myth. Aristotle[3] mentions that Homer thought Oceanus and Tethys were the parents of all and made the gods swear by Styx, the oldest of their company. There is also a tradition that Thales found the idea in Egyptian myths.[4] Cornford thought that water was chosen because it was one of the four traditional "elements" which occupied an intermediate

5 of the water-clock, as some have thought.
6 D11A10.
7 D11B1.

1 D11A22.
2 D11A1, 3, 12, 13.
3 Metaphys. A3, 983b6, cf. R. Onians, The Origins of European Thought, who supposed that Thales was following the traditional belief in the generative powers of water, identified with the ψυχή in man, which is spoken of as moist and life-giving, and is represented in serpent-form. Oceanus is often represented as a serpent.
4 D11A11, 14; see W. K. C. Guthrie, Myth and Reason, who notes that the Egyptians believed the earth to have arisen out of Nun, the primordial waters, and that the Babylonian creation myth gave a similar picture, describing the earliest stage of the world as one of watery chaos; see also G. Sarton, A History of Science, who states that Mohammed expressed a similar belief twelve centuries after Thales.

position between earth and heaven.[1]

Let us now see whether Thales could have found a basis for his hypothesis in every-day experience. According to Simplicius,[2] Aristotle believed that Thales reached his conclusions from observations of the necessity of water for life.[3] This seems a likely explanation in view of Thales' interest in the flooding of the Nile,[4] which restored fertility to the land. He would also have noticed the importance of rain in the Mediterranean countries where there are often long periods of drought. We do not know whether he attempted to describe how the world came into existence, but, if he did, he must have pointed to the three states in which water can be observed, the solid, liquid and vaporous. Perhaps he had also noticed, from observing some technique involving the melting of metals, that other solids can be reduced to a liquid state. It would then be easy to show by analogy how all the various solids of the world arose out of a primitive liquid.[5] We

1 P.S. p. 167, following Aristotle, Phys. III, 5, 205a25. But it seems that both are judging Thales' theories in the light of later philosophies. Since, as far as we know, Thales did not mention the "opposites" this does not seem a likely source of his theory.

2 Phys. 23, 21, D11A13 and Aristotle, Metaph. D11A12; D11A13 reads Θαλῆς μὲν. . . καὶ Ἵππων δὲ ὁ ἐλεγον τὴν ἀρχὴν ἐκ τῶν φαινομένων κατὰ τὴν αἴσθησιν εἰς τοῦτο προαχθέντες. This suggests that Thales' hypotheses were not based on a priori reasoning.

3 D11A13.

4 D11A16.

5 If this should be so, he may not have been far wrong, since modern scientists believe the world was originally a mass of molten metals, etc.

are told[1] that he believed that the world would eventually return to the watery state. R. Baccou[2] thinks he may have found support for this theory in the traditional stories of the floods of Ogyges and Deucalion. It seems equally probable that he based this notion on observations of the sea encroaching upon the land, of underground rivers, etc.[3]

His belief that the world floats, like wood, upon water,[4] which causes earthquakes by its movement,[5] is thought to be nothing more than an interpretation of the Homeric epithets of Poseidon, γαιήοχος and ἐννοσίγαιος .[6] It seems more likely that Thales made the earth float on water because it was the principle of all things.[7] It is possible that he believed the earth to grow in water which gave it its life-giving properties. Cornford[8] thought that Thales made this water rest on the solid firmament, like the shell of the World-Egg in Orphic myth. We do not know whether the idea of the World-Egg was an original part of Orphic doctrine,[9]

1 D11A13.
2 op. cit. p. 53.
3 This idea may have been supported by observations of the alternation of wet and dry in winter and summer.
4 D11A12, 14.
5 D11A15. The evidence for this idea is late.
6 see R. Onians, op. cit. and J. S. Morrison, Parmenides and Er, J.H.S., 1955. L. Robin, Greek Thought, points out that a similar idea is to be found in Egyptian myths; see D11A14.
7 D11A14; note; some islands were thought to float; cf. the legend of Delos and the Symplegades in the Argonaut story. Perhaps the Greeks knew about ice-bergs.
8 P.S. p. 165
9 see below, p. 29.

but in any case it is doubtful whether Thales ever considered the problem of finding a support for the water; or he may have thought it stretched down to infinity.[1]

(2) Anaximander.

Let us now turn to the work of Thales' successor, Anaximander. He also is credited with certain practical achievements. He is said to have discovered the gnomon,[2] or to have introduced it into Greece,[3] and to have made a map of the known world.[4]

His cosmology seems to have been much more detailed than that of Thales. He thought that the world came from an unlimited substance (τὸ ἄπειρον) which separated out (ἐκκρίνεσθαι) into the four Opposites, the Hot, Cold, Wet and Dry, which constitute the world.[5] Living creatures came from the Moist "element" as it was dried up by the Hot.[6]

Cornford based his theory that the pre-Socratic philosophers were deriving their ideas from a source other than the sensible world, mainly on the following likenesses which he saw between the system of Anaximander and the

1 cf. Xenophanes D21B28.
2 D12A1.
3 D12A2. This instrument was used in Babylonia and Egypt. Anaximander may have heard of it from people of the East or discovered it himself from observing the shadow cast by an upright object; see G. Sarton, A History of Science, p. 174.
4 D12A6.
5 D12A9.
6 D12A30.

ideas of traditional thought.[1]

(i) The apeiron is imagined as a single, indistinct fusion of the Hot, Cold, Wet and Dry "elements" which correspond to the four great masses of the world-order, an idea often found in traditional thought.[2] We saw above[3] that this tendency to unify may be merely an expression of the desire for simplification, inherent in the Greek mind. The apeiron is also said to be (a) eternal and divine[4] (like the Homeric Olympus) and (b) alive and conscious.[5] We have seen that (a) is necessary to account for the substrate's unfailing power of creation and (b) to account for the life in the world, especially as the Milesians made no distinction between animate and inanimate matter.[6]

(ii) The apeiron is said to "separate out" into the four Opposites.[7] This is supposed to be similar to the process described by Euripides[8] and Hesiod.[9] The latter

1 P.S. ch. X.
2 e.g. in Euripides, Melanippe the Wise, Frag. 484; in Orphic doctrine, e.g. in Apollonius' Argonautica, I, 496, Orpheus sings "how earth and heaven were once joined together in one form". In Aristophanes Birds, the state of indistinction is called "Chaos and Night, black Erebus and Tartarus;" Night produces the World-Egg. Aristotle compares Night to the "all things together" of the philosophers. Cf. also O. Kern, Orphicorum Fragmenta, 484 ἐξ ἑνὸς τὰ πάντα γίνεσθαι καὶ εἰς τοῦτο ἀναλύεσθαι (see W. K. C. Guthrie, Orpheus and Greek Religion, p. 74) and 168-9; "All that is mingled in the body of Zeus, the Creator, Fire, Water, Earth and Aether, night and day, and Metis, the first father, and Eros of many delights (Guthrie, op. cit., p. 97).
3 p. 9.
4 D12A15; θεῖον often means no more than immortal, eternal.
5 D12A15.
6 see above, p. 9.
(cont'd on p. 29).

told how Earth was not born of Chaos, but came into being after Chaos. Cornford[1] suggested that Chaos here means the "yawning gap" between heaven and earth. But it is difficult to see[2] how Chaos could have existed as a gap between heaven and earth when these had not yet come into being. Another account of the emergence of the world-order is given,[3] in which a piece of the apeiron "separates off" (ἀποκρίνεσθαι). Cornford[4] compared this piece which is called γόνιμον (a word used by Aristophanes of the fertilized egg) to the World-Egg of Orphic cosmogony. Probably if Aristophanes had not used the word in this connection Cornford would not have likened the γόνιμον to the Orphic egg. γόνιμον need mean no more than "generative" (of hot and cold). Now the earliest mention of the World-Egg is in Aristophanes' Birds. It is also mentioned by Athenagoras[5] who gives an account of Orphic myth which seems to contain certain early elements.[6] But

7 D12A16.
8 Melanippe, frag. 484.
9 Theogony vv. 116-132.

1 P.S. p. 195.
2 as G. Vlastos points out (Gnomon, 1955). He sees likenesses between the apeiron and Chaos as described at vv. 720 ff.
a) its immensity of size, vv. 740-41.
b) it is the source of Earth, Sea, Sky and Air.
c) it is "agitated by squalls" and the apeiron is in motion D12A16.
d) it is immortal and indestructible (it is the source of Earth, Sky etc. all immortal gods.
3 D12A10.
4 P.S. p. 183 cf. W. K. C. Guthrie, Orpheus and Greek Religion, p. 223.

(cont'd on p. 30).

we cannot tell which elements are really early and Aristophanes may have confused the accounts he was parodying or actually invented some of the ideas expressed.[1]

(iii) The Opposites, the Hot, Cold, Wet and Dry are continually at war with each other until they return to the apeiron, where they "do justice and make reparation to one another for their injustice, according to the ordinances of time".[2] Cornford thought that the idea of strife among the "elements" was derived from the belief in the "circularity of the year".[3] But what does this mean except that Anaximander had noted the changes of the seasons and the alternate supremacy of each of the Opposites? Guthrie suggests[4] that this fragment[5] shows Orphic influence, since according to Orpheus, Justice was a mighty goddess.[6]

(iv) Anaximander believed that living creatures came from the Moist "element" as it was dried up by the Hot.[7] Cornford and Guthrie thought that this was a rationalization of the myths in which Heaven and Earth are united by the

5 a Christian apologist of the 2nd century A.D.
6 as is witnessed by certain likenesses between his version and that of Pherecydes of c. 550 B.C.; e.g. the presence of Time in both.

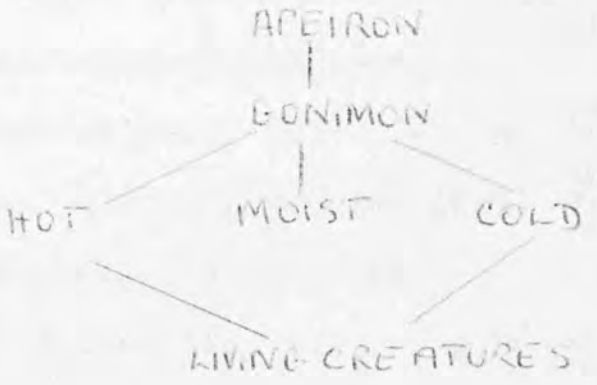
1 as Guthrie admits, op. cit. p. 104.
2 D12B1.
3 P.S. p. 168.
4 Orpheus and Greek Religion, p. 223.
5 D12B1.
6 according to O.F. 23 "which goes back at least to the 4th century". It seems more likely that Anaximander was using a metaphor derived, perhaps, from political experience (see G. Vlastos, Equality and Justice in

(cont'd on p. 31)

action of Eros and produce living creatures. Guthrie shows the likenesses between Orphic myth and Anaximander's system by means of the following diagrams.

Orphic Cosmogony

Anaximander's system



Athenagoras is the first authority we have for supposing that the shell of the Egg forms Heaven and Earth which are united by Eros. As we saw above, it is impossible to tell which elements in Athenagoras' version are early. In Hesiod's Theogony Eros unites Heaven and Earth which produce the Titans, Cyclopes and Giants.[1] But Guthrie seems to be confusing two separate parts of Anaximander's system; the γόνιμον produces Hot and Cold, not Moist, and the product of these is not living creatures

6 Early Greek Cosmologies, Cl. Ph. 1947).
7 D12A30.

1 cf. Pherecydes, frag. 3 where Zeus, when about to fashion the world, was formed into Eros, because (adds Proclus) he brought into agreement and love the Opposites of which he was framing the Cosmos.

but the four divisions of the world. Living creatures come from the COLD and Moist BY THE AGENCY OF THE HOT It seems probable that Anaximander based his theory on observations of the necessity of warmth and water for life (following Thales?, see above p. 25). It is possible also that he observed fossils of sea-creatures in midland districts[1] and presumed that there was earth and water in those districts originally and the action of the sun (Hot) on the mud (Cold) resulted in the emergence of living creatures whose skeletons are found fossilized in rocks.[2]

(v) Anaximander believed that this world would end by being dried up by the sun.[3] Cornford thought that this belief was derived from the traditional idea of the alternate destruction of mankind by fire and flood,[4] an idea which was deeply rooted in Greek thought and was connected with the "circularity of time". It is at least possible that Anaximander based his theory on observations of the sea retreating from the land, the silting up of rivers, etc.

(vi) In Anaximander's system the sun-ring was supposed

1 cf. Xenophanes D21A33 85 and see R. Baccou, Histoire de la science grecque.

2 From the assumption that creatures live originally in the Wet "element" Anaximander concluded that man must have existed in the first instance inside a fish-like creature and then emerged from it to live on the land (D12A10, 11, 12). He may have supported this hypothesis by observations of amphibians, e.g. frogs which live on on land, beginning life as tadpoles in the water. He is also said to have observed the habits of the galeus.

3 D12A27.

4 cf. myths of Phaethon and Deucalion.

to be twenty-seven times and the moon-ring eighteen times the size of the earth,[1] which was three times as broad as it was high.[2] This probably shows a belief in a mystic number three.

Let us now see how far Anaximander's description of the emergence of the world from the primitive substance was based on experience and observation. First we must examine the nature of the apeiron. It seems that in postulating this as the substrate Anaximander considered himself to be improving upon Thales' identification of the primary substance with water.[3]

1) The apeiron was probably contrasted with the limited order of the world where the "elements" are distinct.[4] But it does not seem to be correct to call it "qualitatively indeterminate".[5] It is doubtful whether at the time of Anaximander qualities were fully abstracted from objects. (We should note that Anaximander speaks of τὸ θερμὸν, τὸ ψυχρόν, etc., implying actual substances.) If this is so, it would be virtually impossible to imagine anything indeterminate in quality. This is probably an idea of Aristotle's which has been transferred to

1 D12A22.
2 D12A10; 11.
3 see J. Burnet, E.G.P. p. 53 and D12A15.
4 D.12A15, P.S. p. 173.
5 as L. Robin thinks in Greek Thought. Note; περιέχειν does not mean to "contain potentially", but to "surround", so implying, perhaps, that the apeiron continues to exist after the world has emerged from it.

Anaximander.[1] It has been thought that the apeiron was a single substance "intermediate between the elements",[2] like hot water mixed with cold. But in that case it is difficult to see how the "elements" could "separate out". It is perhaps simpler, then, to understand a mixture of particles[3] (the idea of particles was probably not fully understood by Anaximander, but seems to be implicit in his theory), each having one of the four qualities, mingled in equal proportions, making a substance which had a different quality from each particle, yet was capable of being separated out into its constituent parts.[4]

2) It is doubtful whether the apeiron was strictly infinite in extent, since the idea of spatial infinity was not fully grasped until after the time of Parmenides.[5]

3) If it was not infinite in extent, then, as Cornford believed,[6] it was probably conceived of as circular (though not necessarily spherical).

Bearing in mind these three possible meanings of the

1 Burnet, E.G.P. p. 55.
2 as Cornford thought.
3 It might be argued that this is too advanced a view for so early a thinker, but we should note that the idea is implicit in Anaximenes' theory of rarefaction and condensation. For the view that the apeiron was a mixture, see D12A9; 9a.
4 So a whirlwind might pick up sand (hot and dry) and drops of moisture from a pool or river (cold and wet) and make them into a mixture of different quality from each of the particles. But when the whirlwind dropped, the two would separate out again.
5 Parmenides could still argue that Being could not be bounded by something, since it contained all that existed, nor could it be bounded by nothing, since nothing did not exist. (cont'd on p. 35).

word apeiron, let us see how Anaximander could have imagined the emergence of the world.

The apeiron is said to be in "eternal motion".[1] If it was conceived of as circular, it seems most likely that its motion was rotatory. If we follow the account of pseudo-Plutarch,[2] we may suppose that this motion caused a piece to leave the apeiron (ἀποκρίνεσθαι). Observations of centrifugal force, e.g. of pieces of clay flying off a potter's wheel,[3] may have been the basis of this idea. Now although the particles (implicit in the theory) throughout the whole of the apeiron were in equal proportions,[4] in this one piece, the γόνιμον they may have chanced to be in unequal proportions.[5] This would account for the "injustice" of the "elements" and for the idea that the Hot was gaining supremacy, because the quantity of Hot in the γόνιμον was greater than the quantity of the other substances. In this piece which separated off the circular motion would continue, now perhaps resembling the movement

6 P.S. p. 177.

1 D12A16.
2 D12A10.
3 This would allow for the whole movement of both apeiron and gonimon, which continues to rotate, to be more or less in a plane. This seems most likely considering the flat pillar-shape of the earth and the rings of sun, moon and stars which are placed slant-wise to the plane of the earth (D12A22); see also the comparison with a cross-section of a tree-trunk (12A10).
4 necessary to account for the equal balance in the apeiron, 12B1.

(cont'd on p. 36).

of a whirlwind or whirlpool[1] and the four "elements" would separate out (ἐκκρίνεσθαι). In such a movement the heavier particles would tend towards the centre and the lighter ones towards the circumference.

If Anaximander's system was a logical construction, based on experience, as it seems reasonable to suppose in view of his practical achievements, rational explanations of meteorological phenomena[2] and observations of biological facts,[3] he PROBABLY IMAGINED SOME SUCH SYSTEM AS THE ONE outlined above, though he may not have understood all the implications of his theory.

(3) Anaximenes.

Anaximenes, like Thales, postulated a simple material substrate; but instead of water he chose air,[4] probably at that time equated with mist and even darkness.[5] Air was preferable to water, since it was apparently capable of almost infinite extension; it needed no support and yet was itself able to support other objects.[6] It seems that

5 as is illustrated by the following diagram; the entire circle represents the apeiron with the particles in equal proportions and the shaded area the gonimon, which contains more Hot, particles than Cold, Wet or Dry.

1 cf. the δίνη of Anaxagoras, etc.
2 D12A27.
3 D12A10.
4 D13A1; 4; 5; 6; 7.
5 see Homer, Odyssey, VIII, 1 and Plut, De Prim. Frig. 948e ὅτι δ' ἀήρ, τὸ πρῶτος σκοτεινὸν ἔστι τοῖς πολίταις λέληθεν· ἀέρα γὰρ τὸ σκότος καλοῦσιν
6 L. Robin, Greek Thought.

Anaximenes believed in an animate world and considered air to be necessary for its life.[1] It is more probable that these were the reasons for Anaximenes' choice of air than that his theory was merely a rationalization of Orphic myth as related by Epimenides, according to whom Air and Night were the source of all things.[2]

The various substances of the world were explained as the result of the condensation and rarefaction of air.[3] This may have been suggested by the observation of the changing of water into steam and ice or of the process of felting wool.[4] It was surely an important step to notice that entirely different substances may result from a difference in density (cf. graphite and diamonds).[5] Anaximenes also tried to establish a relationship between temperature and density by means of a simple experiment;

1 D13B2 R. Onians, The Origins of European Thought, records that the view that the soul is air is a popular belief. The ψυχή is the living strength of the body and since the dead do not breathe is equated with the breath and so with air. Cornford said (P.S. p. 186) that the influence of medicine cannot be traced in the Milesians. This fragment, at least, shows an interest in physiology.

2 L. Robin, Greek Thought, suggested that Epimenides altered Orphic myth to fit in with "scientific" developments. We do not know whether Epimenides lived before or after Anaximenes. But, in any case, it seems more likely that Epimenides altered the traditional account of Orphic myth in which Night alone is the source of all and introduced Air (sometimes equated with Night) to make the sex-imagery more clear.

3 D13A5; 6; 7.

4 as is suggested by B. Farrington, Greek Science; πιλέω, the word used by commentators on Anaximenes seems to be the usual word for "to felt" of wool.

5 see W. Wightman, The Growth of Scientific Ideas.

he thought that when we blow with lips pursed, the breath is cool because it is condensed, but when we breathe out with mouth wide open, the breath is warm because it is rarefied.[1] Although he drew the wrong conclusion from his experiment, it nevertheless shows a desire to confirm his hypothesis by reference to experience. Cornford appears to have ignored this experiment and complained[2] that Anaximenes never tested his hypothesis, as he could quite easily have done, by putting a jar of water outside on a frosty night; the next morning he would have found the jar broken and revised his theory. But it is possible that Anaximenes might have taken this as confirmation of his hypothesis.[3] And in any case, such an experiment would have been misleading since the expansion of ice is an exception to the general rule that substances contract when cooled. ~~Cornford remarked that substances contract when cooled.~~ Cornford remarked that a similar experiment was actually performed by a Hippocratic writer.[4] But he failed to notice that the experiment was not carefully conducted[5] and the conclusion

1 D13B1.
2 P.S. p. 6.
3 as the Arabs appear to have done (acc. to E. Wiedemann, Über das Experiment im Altertum und Mittelalter, Unterrichtsblätter für Mathematik und Naturwissenschaft, 12, 1906, p. 122). They held a similar theory to that of Anaximenes and believed that a jar of water split when the water froze, not because the ice expanded, but because it contracted and forced out the air, which made the jar break; see G. Vlastos, Gnomon, 1955).
4 Airs Waters Places, ch. VIII.
5 The water was measured again, not while it was still frozen, but after it had melted, when it was, in fact,

(cont'd on p. 39).

drawn from it was not any nearer to the truth than the assumption made by Anaximenes as a result of his experiment.[1]

He also put forward a theory that the sun derives its heat from its movement.[2] It is possible that this idea may have been based on observations of the way in which chariot wheels become hot in the course of rapid driving.[3]

The rest of his cosmological and meteorological theories are based on observations[4] or are logically derived from his main hypothesis, that air is the source of all things.[5]

We have seen that the systems of the Milesians were not merely rationalizations of myths. The few ideas that were borrowed from myth were supported by observations. The Milesians were obviously practical men and it is likely that most of their theories were based on experience. We have found one example of a simple experiment; there may have been others which have not been recorded. These early scientists went beyond the evidence of the senses, but that

5 less, owing to a certain amount of evaporation having taken place.

1 The conclusion drawn by the Hippocratic writer was that "freezing dries up and causes to disappear the lightest and brightest" parts of the water.

2 D13A6.

3 cf. also the potter's wheel which would feel hot to the touch as it rotated, and possibly the drill: drills were used by primitive peoples to make fire (see under Fire in the Encyclopaedia Britannica); a Hippocratic writer noted that drills become hot when used for trephining (On Wounds in the Head, XXI).

4 D13A7 §5.

5 D13A7 §§3, 7; A17.

is not a fault in science.[1] Their mistake lay in insufficient checking of their theories. But we ought not to expect present-day scientific accuracy from these early pioneers.

[1] see C. Bernard, An Introduction to the Study of Experimental Medicine, p. 22.

CHAPTER IV

XENOPHANES AND HERACLITUS.

Xenophanes.

Xenophanes of Colophon does not seem to have been primarily interested in "science". We can see from the fragments we possess of his poems that he was chiefly concerned to condemn anthropomorphic conceptions of the gods.[1] This led him to describe a deity whose attributes were directly opposed to those of the gods of Homer and Hesiod. He removed offensive anthropomorphic features and gave his God unlimited power,[2] unrestricted perception[3] and freedom from toil.[4]

Cornford said[5] that Xenophanes believed that the world was God and that this is a relic of traditional thought. In none of the fragments does Xenophanes make such a statement. Probably later writers[6] identified his God with the world in an attempt to show that he was applying a metaphysical theory to the visible universe.[7] No doubt he believed that the world was alive,[8] but it can hardly be

1 D21B11; 12; 14; 15; 16.
2 D21B23.
3 D21B24.
4 D21B25.
5 P.S. p. 146.
6 Simplicius D21A31, Cicero D21A34, Galen D21A35, Theodoret D21A36.
7 as Theophrastus saw, D21A31, §2.
8 note D21B33, living creatures come from mud.

identified with a God who "sees all over, thinks all over and hears all over"[1] and "sets everything in motion by the thought of his mind".[2] Moreover, if Xenophanes thought that the world was God, he was guilty of several inconsistencies. We are told[3] that he believed God to be eternal but the world, as we know it, is said to come from mud and return to mud.[4] It seems that he believed that the world was infinite,[5] but Nicolaus of Damascus[6] said that Xenophanes' God was bounded and motionless, Alexander of Aphrodisias[7] that it was bounded and spherical and Theophrastus[8] that it was neither bounded nor boundless. These confusions arose from an attempt to show that Xenophanes' God was identified with the world.

The cosmological fragments were probably originally included in the Satires and were only later classified under the heading περὶ φύσεως.[9] They seem to be an attempt to improve upon the personifications of myth.[10] For example he affirms that the rainbow is not the goddess Iris, but a cloud.[11]

1 D21B24.
2 B25.
3 A32; 33.
4 B27; 29.
5 B28; γαίης μὲν τόδε πεῖρας ἄνω παρὰ ποσσὶν ὁρᾶται ἠέρι προσπλάζον, τὸ κάτω δ' ἐς ἄπειρον ἱκνεῖται.
A41a ὁ δ' αὐτὸς τὸν ἥλιον εἰς ἄπειρον μὲν προϊέναι
6 A31 §8.
7 ibid.
8 A31 §2.
9 see Burnet, E.G.P. p. 116.
10 op. cit. pp. 121 ff.
11 B32.

We are told that he held that the earth stretched downwards[1] and the air upwards to infinity.[2] He may intend by this to dispense with Tartarus, Ouranus and Gaia and the unseemly stories attached to them.[3] The statement that the heavenly bodies are ignited clouds[4] may have been offered as an alternative to the belief that they were divine beings, and the theory that living creatures come from mud[5] in opposition to the prevalent idea that they were children of Heaven and Earth.[6]

However, many of his notions were based on accurate observations. This theory of the emergence of living creatures from mud was based on his discovery of fossils of sea-creatures in rocks in midland districts;[7] though, as we saw above,[8] Anaximander may have made a similar discovery and Xenophanes may have borrowed this idea from Anaximander who is said to have been his teacher.[9] From his observations of St. Elmo's fire[10] and clouds above volcanoes[11] he concluded that all the heavenly bodies must be composed of

1 D2,B28.
2 A47.
3 see Burnet, E.G.P. p. 125.
4 A38; 40.
5 B33. It seems that this was a popular belief, as Homer Iliad VII, 99 and Hesiod, Works and Days, 61. But Xenophanes obviously found support for the idea from observations, whether his own or Anaximander's; see above, p. 32.
6 Hesiod, Theogony, 45.
7 A33.
8 p. 32
9 A1.
10 A39.
11 A48.

some sort of ignited cloud. He had noted the percolation of water through rock in certain caves[1] and this probably led him to suppose that the world would one day return to mud.[2]

Cornford thought[3] that when Xenophanes condemned the myths of the Titans and Giants[4] he was rejecting the claim of Hesiod's muse to be revealing the truth about the remote past and setting up his own claim to prophetic insight. But surely he can hardly be said to claim prophetic insight when he had written these lines;[5] "And as for certain truth, no man has seen it, nor will there ever be a man who knows about the gods and about all the things I mention. For, if he succeeds to the full in saying what is completely true, he himself is nevertheless unaware of it; and Opinion is fixed by fate upon all things." Fragment 35 "Let these things be stated as conjectural only, similar to the reality" shows that he did not claim objective truth for his views. However it is obvious from fragment 34 that Truth does exist and he believed that man can approximate to the truth by research.[6] But fragment 18 "Truly the gods have not revealed to mortals all things from the

1 B37.
2 A33 B6.
3 P.S. p. 148.
4 B1.
5 B34, trans. by K. Freeman, Ancilla to the pre-Socratic Philosophers.
6 B18.

beginning" shows that he did not believe in prophetic insight of any kind. These fragments reveal Xenophanes' empirical approach to the discovery of truth as do his observations in the sphere of natural science. But the chief value of his work does not lie in his "scientific" theories, since they were not his primary interest, but in his theological and ethical views.

Heraclitus.

It is clear from a reading of the fragments of Heraclitus that he again differed from the Milesians. We have seen that the latter worked in a "scientific" way, but went beyond the evidence of the senses in framing their hypothesis that everything is derived from a single, material substance. It was this very hypothesis, the formulation of which was the least "scientific" of their achievements, that was set forth, developed and emphasized by Heraclitus.

The unity which he saw behind phenomena seems to have been a hidden connection[1] produced by the Λόγος which is universally present[2] and combines the manifold objects of the world into a kind of ordered plan.[3] Such a relationship may be seen by analogy in the identity of

1 D22B54; 123.
2 B2; 114.
3 the κόσμος of B30.

apparent opposites; for example, sea-water is drinkable for fish, undrinkable for men;[1] pigs wash in mud[2] and donkeys prefer rubbish to gold,[3] unlike men for whom the opposites are proper; the end and the beginning of a circle are the same;[4] etc.[5]

The Λόγος, being a law of proportion,[6] ensures a balance in the world between opposites, like the tension in the strung bow or lyre.[7] For this reason the Λόγος is sometimes called War;[8] and this idea may have led to the identification of the Λόγος with Fire.[9] It is difficult to be sure whether Heraclitus was here speaking literally or metaphorically. He may have thought that everything really was Fire, the earth and sea being Fire temporarily extinguished.[10] In this case, if he thought of Fire as heavenly aether, he may have envisaged the ὁδὸς ἄνω κάτω as the change from fire to sea (in the fall of rain), from sea to earth (in the silting up of harbours, etc.), from earth to sea (in the receding of the coast) and from sea to fire (in evaporation, ἀναθυμίασις,[11]

1 B61.
2 B13.
3 B9.
4 B103.
5 see B58; 59; 60; 48.
6 see G. S. Kirk, Heraclitus, the cosmic fragments. p. 40 and B94.
7 B51.
8 B53; 80.
9 B30; 31; 64; 90.
10 as may be implied by B. 30.
11 A1 89.

which is fuel for the heavenly bodies).[1] It seems more probable that he was speaking metaphorically (perhaps unconsciously), using Fire as an example of measured change; the flame is more or less stable, yet it is continually changing, consuming fuel and producing smoke. This interpretation is perhaps supported by Heraclitus' river analogy;[2] the waters in the river are continually changing, yet the whole retains a certain shape. It is even possible that Heraclitus sometimes spoke metaphorically and sometimes literally without any real distinction between the two. It seems that often he was trying to express an abstract truth in the terms of physical speculation.

It has been suggested that Heraclitus followed popular thought in his astronomical theories. In fragment 6 he says that the sun is new each day. Some commentators[3] have suggested that this means that the sun is extinguished at night and rekindled in the morning, which seems likely enough. Others have suggested that Heraclitus was here following the mythical story that the sun was carried round Oceanus in a golden bowl. Now Heraclitus believed that all

[1] as Kirk thinks, op. cit. pp. 333 ff. It seems unlikely that Heraclitus included air in his scheme; the passages where air is mentioned are all written by late authors and the insertion of air into the scheme is probably a Stoic variation on B36.

[2] B49a; B91.

[3] Olympiodorus on Aristotle's Meteorology and the scholiast on Plato, Republic, 498a.

the heavenly bodies were fire in bowls; but there is nothing to suggest that he believed the sun to be a horse-drawn chariot, driven by Helios. The idea of the bowls may owe its origin to myth, but the theory of "exhalations" that are burnt in the bowls was based on observation of the evaporation of water. These "exhalations" were rather like the fiery clouds of Xenophanes, and Heraclitus may well have modified Xenophanes' theory, perhaps with the same purpose in mind, namely to ridicule the popular conception of the gods (cf. fragments 14 and 15). It is clear from fragment 99[1] that Heraclitus knew that night is due to the disappearance (or quenching) of the sun; so he obviously did not follow the popular belief that night is caused by moisture. The other fragment about the sun[2] says that it is the breadth of a man's foot. It seems most unlikely that Heraclitus really believed this. It seems probable that he is here referring to its apparent width and suggesting that appearances are deceptive;[3] or he may be censuring the reverence accorded to the sun as a divinity, suggesting that he hardly seems like a deity, since he is only the size of a man's foot. But as the original

1 "If there were no sun, so far as depended on the other stars it would be night."
2 B3.
3 cf. B123.

context has been lost, it is difficult to know how to interpret the fragment.[1]

It is apparent from Heraclitus' cosmological theories and from the analogies he used to support his views that he did not entirely ignore the evidence of the senses; and this is borne out by his epistemological fragments. He stressed the importance of sense-perception;[2] mere conjecture was not permissible;[3] but we should be careful to distinguish the more reliable of the senses.[4] Those who wish to be wise must enquire into many things;[5] but much learning is not enough;[6] facts learnt from sense-perception must be united by intelligence.[7] Real wisdom consists in recognizing the Λογος.[8]

However, in spite of his insistence upon the "empirical" method, it seems that he himself began with an a priori belief in the unity of the world and then proceeded to find examples from the sensible world to prove his theory. In many ways he resembled a poet; he probably did not distinguish between literal and metaphorical meanings (e.g. of Fire) and he used personifications[9] and analogies.[10]

1 see G. Kirk, op. cit. Group 9.
2 B55 "Those things of which there is sight, hearing, knowledge, these are what I honour most".
3 B47; 70.
4 B101a.
5 B35; cf. B22.
6 B40.
7 B107.
8 B41; 50.
9 B53; 64.
10 B49a; 91; 61; 13 etc.

But it can hardly be true that he was a successor of the poet-prophet-sage of early times, as Cornford would have us believe.[1] He highly disapproved of the teaching of the poets[2] and of the kind of knowledge which the Muses impart to their devotees;[3] nor did he put forward a cosmogonical scheme, like those of Hesiod, Pherecydes, etc., but believed that the universe had always existed.[4] Moreover, he did not claim a "unique inspiration"[5] and it seems unlikely that he thought of the Λόγος as actually speaking through him;[6] the Λόγος was an external truth which could be discovered by anyone who would use his intelligence.[7] Unless Heraclitus was an Orphic (which Cornford himself doubted) and so believed in transmigration, he cannot have shared in the claim of the shaman's soul to have discovered the truth from its journeys through the universe.[8]

Although Heraclitus often spoke in poetical terms and within the framework of the physics of his time and although he began with an a priori belief in a unity behind phenomena, the truth that he discovered through using his senses combined with intelligence was that there is an order behind the apparently disordered constituents of the universe; and this truth has been the basis of all modern science.

1 P.S. pp. 112 ff.
2 B40; 42; 56; 57; 104; 106.
3 B40.
4 B30.
5 P.S. p. 116.
6 as some have thought is the meaning of B50.
7 B114.
8 see G. Vlastos, Gnomon, 1955.

CHAPTER V

THE PYTHAGOREAN AND ELEATIC SCHOOLS.

1) The Pythagoreans.

Pythagoras is a strange figure about whom we know VERY little. The general impression one gains from reading accounts of his life is of a highly intelligent religious mystic. We cannot say definitely which parts of the Pythagorean doctrine date back to the founder; but it seems almost certain that he was responsible for the belief in the transmigration of souls[1] and for the interest in mathematics[2] which we find among his followers.

Cornford thought that Pythagoras was a successor of the shaman.[3] Now Pythagoras was the first of the pre-Socratic philosophers to believe in transmigration and consequently to think of the soul as being able to exist apart from the body.[4] This latter belief is held by the shaman, who thinks that his soul can gather knowledge while wandering apart from his body throughout the universe.[5] Possibly Pythagoras thought he had gained knowledge in a previous existence. This is especially likely in view of the nature of the discoveries he is said to have made. They are all concerned with mathematics and since this is

1 D14A1; A8a s19; 21B7.
2 D58B19; 14A6a.
3 P.S. p. 108; cf. E. Dodds, The Greeks and the Irrational, p. 143.
4 D14A8a s19.
5 P.S. p. 94.

an *a priori* science which often has no reference to sensible objects these discoveries may well have seemed like revelations from another sphere. At least, it seems very probable that the theory of ἀνάμνησις had its origin in Pythagoreanism. In this respect, then, Pythagoras resembled a shaman, but, as far as we know, he was not a prophet or a poet, in both of which capacities the shaman is supposed to excel. Moreover Pythagoras' mysticism was by no means completely illogical[1] and it certainly seems that he won a reputation for being a very knowledgeable man.[2]

It is also possible that some of Pythagoras' discoveries in mathematics had their origin in sensible experience. He is said to have discovered that the square on the hypotenuse of a right-angled triangle is equal to the sum of the squares on the other two sides.[3] If it is true that he visited Egypt[4] he may have learnt this fact there; possibly he gave a geometrical proof of the proposition.[5] But if he arrived at the discovery independently, he may have reached his conclusion from observation (e.g. a tiled floor arranged in a pattern like this would

1 see R. Reichenbach, The Rise of Scientific Philosophy, ch. I.
2 D14A2; 22B40; 22B19 (Diels considers the last frag. to be spurious).
3 D58B19.
4 D14A4; 8; 9.
5 see above, p. 20

make it clear).

It is possible that the theory that Number is the first principle[1] dates back to Pythagoras himself. This hypothesis may have been the result of the practice of using pebbles for counting (calculus; calculation); it would be easy to see how objects could be built up from units. It was an important discovery to realize that concrete objects can be accounted for in mathematical terms, but there is some illogical thinking in the identification of things with numbers.

Of Pythagoras' followers those who were interested in the mystical side of his teaching worked out a scheme according to which there were ten pairs of opposites,[2] the principal pair being the Limited and the Unlimited. All these opposites were of an immaterial nature. They developed the theory that things were numbers, extending

[1] D58B15.
[2] D24A3.

its application to abstract qualities,[1] and they believed that the unifying force in the world was the harmony which resulted from the proportional arrangement of everything.[2] This last theory was supported by the discovery that the musical intervals depend upon numerical ratios.[3]

Many of the Pythagoreans made considerable discoveries in higher mathematics;[4] some practised research in other fields.[5] Menestor of Sybaris made some remarkable observations in the sphere of botany;[6] Hippon, who followed Thales in supposing the substrate to be water[7] was interested in reproduction;[8] in fact, he was led to the conclusion that water is the first principle from observing that it is

[1] D58B4; the Pythagoreans believed that One was the beginning of all things; sometimes in accordance with the list of opposites it was identified with the Limited. The Monad exists in the Unlimited, i.e. there is a simple unit existing in space (58B9; 10; 28; etc.). Space is equated with the principle of Twoness, the Dyad, since its existence allows for the multiplication of the One (58B14; 15). Guthrie thinks (Orpheus and Greek Religion, p. 219) that this idea was derived from the myth of the Orphic Egg. It seems more likely that it was the result of using pebbles for counting and for geometrical diagrams. (see J. Burnet, E.G.P. p. 102).

[2] D58B27.

[3] D18A14; 44B6; 47A16. It is probable that Pythagoras himself made the discovery and Hippasus supported it by experiments; also see E. Schrödinger, Nature and the Greeks; modern scientists have found that numerical ratios discovered in reference to one study apply to material settings entirely different from those in which they were first discovered.

[4] Theodorus, D43, Archytas, D47 and others D58.

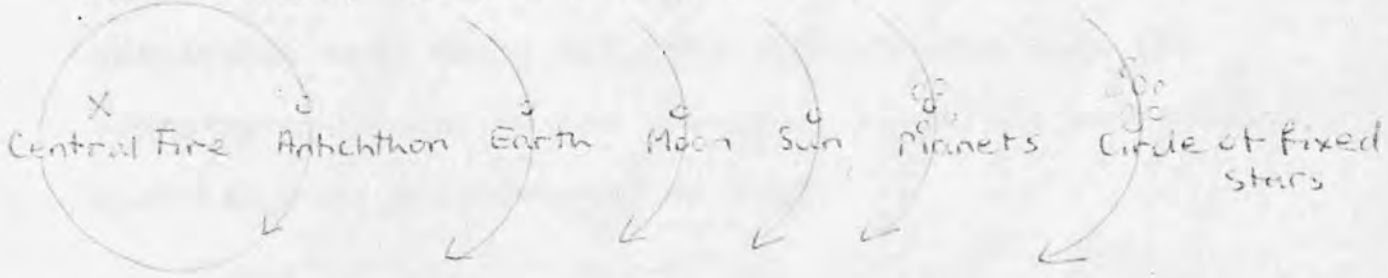
[5] medicine, 58B1 §163-4, 57A2, music, 52A3, astronomy, 50A1.

[6] D32A5 §§5-7.

[7] D38A4; 7.

[8] D38A3; 10; 12; 16; 17; 18.

necessary for life.[1] He also studied the action of the heart.[2] Philolaus likewise showed an interest in physiology. He put forward the theories that the body is made of the hot element and has no admixture of the cold until after its birth, when the air breathed in acts as a cooling agent,[3] and that disease is caused by the action of bile, blood and phlegm.[4] He believed the four elements of man to be the brain (the seat of the mind, peculiar to man), the heart (the seat of the feelings and the soul, common to all animals), the navel (like a root and proper to plants) and the reproductive organs (common to all living things since all come from seed).[5] Philolaus' ideas on the arrangement of the universe are of considerable interest. The earth is no longer considered to be at the centre of the universe but is supposed to rotate on its own axis along with the stars, the planets, the sun, the moon and the antichthon, an imaginary body, around a central fire,[6] in this fashion.



1 D38A3; 10.
2 D38A10.
3 D58B27.
4 ibid.
5 D58B13.
6 D44A17.

We cannot be sure whether the antichthon was supposed to be between the earth and the central fire or on the other side of the central fire from the earth,[1] nor why Philolaus introduced the antichthon; it may have been, as Aristotle suggested, to bring the number of heavenly bodies up to the holy number ten[2] or to explain lunar eclipses[3] or perhaps to account for the fact that we do not see the central fire or its rays. In spite of mystical elements, Philolaus' recognition that the motion of the heavenly bodies across the Sky from East to West was only apparent and that the earth revolves around its own axis and is not at the centre of the universe was an outstanding achievement.[4]

The Pythagoreans, then, though not conspicuous for their use of the "empirical" method, occasionally made important scientific discoveries which must have involved considerable observation. Their most important contributions to science, however, were their mathematical researches and, above all, their insistence upon the symmetry and order of the universe, which has since been shown to have been founded on fact.[5]

1 D44A17; the antichthon is said to be opposite to the earth.
2 D58B4.
3 D58B36.
4 see Burnet, E.G.P. p. 97.
5 see E. Schrödinger, Nature and the Greeks.

2) Alcmaeon.

Alcmaeon, who is sometimes thought to have been a Pythagorean[1] was an extremely careful observer of nature. It seems improbable that Alcmaeon belonged to the Pythagorean sect, since there are considerable differences between some of their basic ideas; Alcmaeon believed that only the gods may know about τὰ ἀφανέα (which were the chief objects of knowledge among the Pythagoreans) and limited enquiry to things determinable by inference.[2] Aristotle thinks that Alcmaeon may have been a Pythagorean because his theory of opposites was similar to theirs;[3] but, the characteristic Pythagorean pairs of opposites, odd and even, limited and unlimited are missing from the list credited to Alcmaeon, which is of wider scope than the Pythagorean list, the latter being limited to ten pairs.[4] Alcmaeon's list of opposites was based on the observation of fevers, distinguished by high temperature, shivering and biliousness. It is possible that he thought that this theory could be extended to apply to the universe in general; this is the more likely in view

[1] He dedicated his book to three Pythagoreans (D24B1). Aristotle does not know whether the Pythagoreans influenced Alcmaeon or he them (D24A3).

[2] D24B1.

[3] D24A3.

[4] On the whole question of whether or not Alcmaeon belonged to the Pythagorean sect, see G. Vlastos, Isonomia, A.J.P. 1953; he points out the difference in the attitude towards knowledge and in the lists of opposites;

(cont'd on p. 58).

of the formulation of the "empirical" theory of knowledge generally credited to Alcmaeon, according to which particular observations may lead to general inferences and so to memory and knowledge.[1] If this is so, then the Pythagoreans may have taken over Alcmaeon's theory of opposites and modified it to fit in with their number mysticism.[2]

The "empirical" theory of knowledge formulated by Alcmaeon seems to have been the result of his investigation into sense-perception. He performed an operation to remove an eye[3] and, either then or in later dissection, discovered the optic nerves, which join behind the eye and lead to the brain; from this and probably other examinations of the sense-organs, he came to the conclusion that all sense-impressions are carried to the brain by means of "paths".[4]

Alcmaeon was also interested in the processes of reproduction[5] and in this connection he made observations of the development of the embryo in birds' eggs.[6] It seems likely that he dissected the human body and found

> he shows also that the balance of the opposites in the body, which was necessary for health depended on their equality (isonomia) while in Pythagorean cosmology the unifying factor was proportion, as in music.

1 D24A11.
2 as W. H. S. Jones thinks, Philosophy and Medicine in Ancient Greece, p. 4.
3 D24A10.
4 D24A5.
5 D24A13; 14; 17.
6 D24A16

that some of the blood-vessels are empty of blood in death, since he held a theory that sleep is caused by a partial and death by a total withdrawal of the blood from the arteries into the veins.[1]

Alcmaeon is a very important figure in the history of both medicine and philosophy; his theory of the κράσις of opposites played a very important part in later Greek medicine[2] and his theory of knowledge had considerable influence on later philosophy.[3]

3) The Eleatics.

Parmenides was the founder of the Eleatic school. Cornford believed that he, like Pythagoras, was a shaman.[4] It is true that he wrote in verse a description of a divine revelation of the truth, which contradicted the evidence of the senses.[5] But there is a notable difference between this revelation and that received by the shaman. The latter accepted the revelation as true without any effort on his part to confirm the truth of it by reasoning or otherwise;[6] but the goddess, who Cornford thinks is a personification of reason, tells Parmenides to "judge by reason" (κρῖναι λόγῳ); and Parmenides' poem is in fact a rigid logical exposition of the revelation

1 D24A18.
2 see below, ch. VIII, the Coan school,
3 especially on Aristotle, (Metaphysics I etc.)
4 P.S. p. 117.
5 The Way of Truth.
6 P.S. p. 96.

that the universe is an uncreated, indestructible, immovable plenum. The denial of any kind of reality to space ("what is not"),and the conclusion that the universe is a plenum, contradict our experience of motion and time. It seems most unlikely that this reason on which Parmenides relied is a relic of the "inspiration" of the shaman; "inspiration" is a passive, reason an active process.

The second part of Parmenides' poem presents a difficulty. We cannot be sure whose opinions are here being set out; but it seems unlikely that they are meant to be an alternative view of the universe offered by Parmenides to account for the evidence of the senses,[1] since Parmenides placed absolutely no reliance on sense-perception.[2] It is more likely that "The Way of Opinion" contains the views held by other philosophers, especially the Pythagoreans,[3] which Parmenides, who is said to have belonged at one time to the

1 See 28 A 24.

2 D 28 B 8.

3 As Burnet thinks, E.G.P. p. 184. Aristotle thought they were Parmenides' own views, and it is unlikely that the true explanation should have been lost by Aristotle's time. However, if they were Parmenides' own views he is guilty of considerable inconsistency; why should he have given any value to the "Way of Opinion", when he considered the "Way of Truth" to be the only way of discovering reality? Some of the views expressed here seem to resemble those of earlier philosophers, e.g. B 12, cf. Anaximander A 22; 15a, cf. Thales, above p. 26; 17, cf. Pythagoreans.

Pythagorean sect,[1] has since found to be unsatisfactory.

Parmenides, then , was not an empirical scientist, but neither was he a shaman who accepted any divine revelation as true without using his critical or reasoning powers. Parmenides applied the method of deductive reasoning used in mathematics to physical science. This method has since proved to be of considerable value. Parmenides' fault lay in limiting reality to matter and denying the evidence of the senses with regard to our experience of motion and time.

Parmenides' successors, Zeno and Melissus, developed his system, but they too are shown to have completely disregarded the evidence of the senses.[2]

1 D 28 A 1.
2 D 29, D 30.

CHAPTER VI.

EMPEDOCLES AND ANAXAGORAS.

1) Empedocles.

Empedocles of Acragas was another of the pre-Socratic philosophers whom Cornford claimed to have been a successor of the shaman.[1] Certainly he believed that he had had previous existences and was an exile from bliss;[2] he was a poet who professed to be inspired by the Muse[3] and thought that the final incarnation of a man before his return to a life of bliss was as seer, minstrel, physician and prince.[4] But although he resembled the shaman in these respects, he laid great emphasis on the validity of the information gained by the senses, which though limited in their powers[5] must all be taken into account.[6]

The purpose of Empedocles' cosmology seems to have been to provide to the monistic scheme of Parmenides an alternative system which might, to a certain extent, take into account the evidence of the senses.[7] It is possible, too, that it owes something to Anaximander

1 P.S. p. 121.
2 D31B115, 117, 118, 119.
3 D31B4.
4 D31B146.
5 D31B2.
6 D31B3.
7 Burnet, E.G.P. p. 227.

(e.g. the four opposites, now identified with earth, air, fire and water, and possible the ideas of mixture and the ἄπειρον).[1] The four elements are now given mythological names[2] but it seems that this was his poetical way of expressing their immortality. The two elements called Love and Strife[3] seem to be poetical personifications of forces observed at work in nature,[4] namely the attraction of like for like (e.g. oil and water do not mix (i.e. they are separated by Hate), but particles of the same substance cling together[5]) and of unlike for unlike (e.g. amber attracts different materials to itself, as Thales is said to have observed[6] (this would be the work of Love)). It also seems that Empedocles' theory that all things were created by the juxtaposition of the elements[7] had its basis in the observation of chemical mixtures;[8] he explained this process by analogy with painting; colours are mixed and all shapes portrayed by them.[9] Love and Hate were supposed to operate in the world alternately; the description of the world when Love is in the ascendant was based on observation of the processes of making cheese[10]

1 see my interpretation of Anaximander above, ch. III.
2 D31B6.
3 D31B16.
4 the good kind of mythopoeic thought, see above, ch. II.
5 cf. D31B91.
6 D11A22.
7 D31B8.
8 D31A34.
9 D31B23.
10 D31B33.

and bread.[1] When Hate is being driven out of the world by Love a circular motion is set up[2] and, later, by this the four elements are separated out into the four great masses of the world-order, fire going to the outside,[3] then air,[4] leaving the earth, from which the sea is drawn out by the sun.[5] This idea may have originated from observing the potter's wheel or a mixture being stirred.[6] Empedocles believed that the heavens revolved and kept the world in place; he is said to have demonstrated how this could happen by whirling round a jar full of water; the water did not fall out because of the motion.[7] He knew the true explanation of solar eclipses[8] and believed that salt is solidified by the action of the sun,[9] perhaps from observing salt left behind by evaporated sea-water; he also thought that fish live on fresh water which exists in the sea; the proof of this, which may have originated with Empedocles, was to leave an empty vessel floating on the surface of the sea for a certain length of time; when it was removed it would be found to contain a certain amount of fresh water.[10] It was not realized that this was caused by condensation of water in the atmosphere. Empedocles

1 D31B34.
2 D31B35.
3 D31B51.
4 D31B54.
5 D31B55.
6 see Anaximander above, ch. II.
7 D31A67.
8 D31B42.
9 D31B56.
10 D31A66.

also put forward a theory of evolution which included beliefs in the adaptation of species to their environment and the survival of the fittest.[1]

In Empedocles' work we also find a considerable interest in biology. It has been suggested that he was a practising physician;[2] in any case he was certainly connected with the Italian medical school.[3] In his works we find a comparison between the macrocosm and the microcosm (e.g. the sea is the sweat of the earth;[4] living creatures are composed of the four elements[5]); this was probably the result of his interest in both physics and medicine. He seems to have made a fairly extensive study of botany; he believed that the soil in which the vine grows has an effect on the quality of the wine made from its grapes[6] and that the amount of water a tree can retain decides whether it is deciduous or evergreen.[7] He knew that trees have sexes[8] and that the fruit is connected with the reproduction of the tree.[9] He seems also to have been interested in the process of reproduction in animals and

1 D31B61; 83; 97.
2 by Zafiropulo, Empédocle d'Agrigente, p. 149; cf. B112.
3 Galen, On the Therapeutic Method, I. cf. Anc. Medicine, I.
4 D31B85.
5 D31B98.
6 D31A70.
7 D31A77; 78.
8 D31A70.
9 D31B79.

and men,[1] and in the function of the sense-organs.[2] He likened the ear to a bell in which the clapper is struck by air moving inside[3] and connected the sense of smell with breathing.[4] All the sense-organs were supposed to receive effluences from objects which fitted into "paths" and caused sensation;[5] unlike Alcmaeon, however, Empedocles did not realize the importance of the brain but thought that intelligence dwelt in the blood around the heart.[6] By far the most interesting of Empedocles' medical theories is his explanation of the process of respiration. He thought that respiration first began after birth by the flowing of air into the empty spaces in the body; this air was expelled by the innate heat which was striving to get out of the body; then air flowed back again to take the place of the air expelled.[7] The process of respiration was continued in the following way; breathing took place through the pores as well as the nostrils; the blood was brought to the surface of the body by tubes empty of blood, and drove out the air; when the blood flowed back again the air was drawn in.[8]

1 D31 B63-70; 92.
2 D31B88; 89; 99; 101; 102.
3 D31B99; A86 89; 93.
4 D31B102.
5 D31B89; A86.
6 D31B105.
7 D31A74.
8 D31A74; B100.

This theory assumed that the blood is always circulating, which in itself was an important discovery; it probably owed something also to the observation of the arteries which are relatively empty of blood in death. Cornford complained that the theory that we breathe through the pores would never have been put forward by anyone who had sat in his bath and watched to see if bubbles entered and left his body. This is not a good argument since as far as we know the Greeks were not in the habit of sitting in baths.[1] Moreover Empedocles actually tried to prove his theory by reference to the clepsydra, an instrument with an opening at the top of a narrow neck and small holes perforated in the bottom.[2] Empedocles pointed out that when the vessel is empty, if the hand is placed over the top of the neck and it is immersed in water, the water will not enter through the perforations because of the pressure of the air inside; when the hand is removed and the air allowed to escape, the water flows in; again, if it is filled with water and lifted out of the water with the hand over the opening at the top, the water will not fall out because of the pressure of the outside air; when the hand is removed the water flows out. This experiment

[1] see The Companion to Greek Studies, p. 58 and Plato, Republic I, 334D; the bather leaned over a wash-basin and an attendant poured water over him.

[2] see H. Last, Empedocles and his clepsydra again, C.Q. 1924, p. 169.

was intended to illustrate Empedocles' respiration theory; what it really did was to show that air is a corporeal substance. Cornford remarked that Empedocles did not invent the clepsydra for his own purpose, but only drew an inference from a commonplace observation. But surely this does not detract from the importance of the discovery that air is a corporeal substance (it is equally as scientific as the discovery made by James Watt of the power of steam from the observation of its lifting a kettle lid); and in any case the experiment was of such a kind that it could be repeated and the results observed more than once, so that it had universal value.

Empedocles, then, has some claim to be called "scientific"; beside the mystical elements in his work and some theories which are not based on fact, we find a considerable amount of careful observation and some experiments. There is no reason to suppose that he resembled the shaman in not taking into account the phenomena of the sensible world.

2) Anaxagoras.

Anaxagoras' theory that everything comes from "seeds" which contain a portion of every kind of material and are infinite in number[1] and infinitely divisible[2] seems to be a conclusion deduced by logic from the ideas of Parmenides and Empedocles, which Anaxagoras found to be incompatible with the evidence of the senses; he discarded the excessive monism of Parmenides which made no allowance for our experience of motion and time and the over-simplicity of Empedocles which could not account for the manifold phenomena of the world. Anaxagoras tried to account for the multiplicity of things and their variety by his theory that the "seeds" contained μοῖραι, each of a different material, which varied in size from "seed" to "seed". In this way he explained the change of "black" water into white snow[3] and of food into flesh, blood, etc. In Anaxagoras' system we find, besides the "seeds", another element, Mind, which he seems to have introduced to explain the difference between amimate and inanimate matter.[4]

The rest of Anaxagoras' cosmology seems to follow the general pattern of Ionian speculation; the four great masses are separated out from a primitive confusion by means of a

1 D 59 B 1.
2 D 59 A 44.
3 D 59 A 97.
4 D 59 B 12.

rotatory motion. But Anaxagoras believed that the sun, moon, stars and unseen bodies of the heavens were stones flung from the earth.[1] This seems to have been the result of his knowledge that a meteoric stone had fallen in the Thracian Chersonese.[2] The earth was supposed to be held in position in the middle by the force of the eddy around it, as large bodies settle in the middle of an eddy of liquid or air.[3] Anaxagoras seems to have taken a particular interest in air, perhaps because he knew of Empedocles' experiment with the clepsydra. If Empedocles himself did not draw from the experiment the inference that air is a corporeal substance, it is possible that Anaxagoras did so; in any case, he is said to have demonstrated the truth of this theory by pointing out that inflated wineskins resist pressure when any one jumps on them.[4] He also observed that hot air rises, from watching motes in the sunlight rise as the air became hot.[5]

Although there are not many instances of observation in Anaxagoras' work it is clear that he did not entirely ignore the evidence of the senses. He believed that although sense-perception could not by itself lead to the truth it was not entirely[6] misleading but should be used along with memory, wisdom and skill.[7]

1 D 59 A 42 §6.
2 D 59 A 10; D 59 A 11; D 59 A 12.
3 D 59 A 88.
4 D 59 A 68.
5 D 59 A 74.
6 D 59 B 21.
7 D 59 B 21b.

CHAPTER VII

THE ATOMISTS

The atomic theory of Leucippus and Democritus seems to have been the result of a critical consideration of the earlier attempts to explain the composition of the universe. The theory was that everything was composed of an infinite number[1] of indivisible,[2] imperceptibly small[3] particles of matter (atoms),[4] devoid of the secondary qualities[5] but each having a different shape,[6] moving in space[7] which is infinite in extent.[8] The whole of previous philosophy, e.g. the theories of Anaximenes and probably Anaximander, in which the existence of particles seems to be implicit, the Pythagorean belief in the monad which existed in space, the theory of the Eleatics that the One is indivisible, Empedocles' realization that the monistic system was incompatible with the evidence of the senses, and Anaxagoras' formulation of the hypothesis that everything comes from "seeds", shows the development of thought which paved the way for the system of Leucippus and Democritus. Although this theory was evolved chiefly by the use of reason, we find a little evidence that

1 D 67 A 14; 68 A 1.
2 D 67 A 14.
3 D 68 A 37.
4 D 67 A 14; 68 A 58.
5 D 68 B 9; 67 A 6.
6 D 67 A 6.
7 D 67 A 7; 68 A 37, 68 A 57.
8 D 68 A 37.

little evidence that observation was used, at least, to support it. It seems that Leucippus probably likened the atoms to letters of the alphabet which can be rearranged to form innumerable words[1] and to motes moving at random in a ray of light;[2] he probably realized that the motes are there all the time but can only be seen when they are illuminated; it would then be an easy step to assume that the whole world is composed of similar particles, which, however, are always imperceptible. It also seems that the atomic theory owed a great deal to the study of geometry. Democritus is supposed to have written a book on the Contact of the Circle and Sphere;[3] in this connection he must have realized that although it is impossible to draw such a figure, the circle must touch the sphere at one point only and that point can have no magnitude; otherwise, the edge of the circle would follow the circumference of the sphere.

I. Therefore i) geometrical points have no magnitude.
ii) It is possible to choose any part of a geometrical figure as a point.

Therefore geometrical figures are composed of points, which have no magnitude.

[1] D67A6.
[2] D67A28.
[3] D68B11 L.

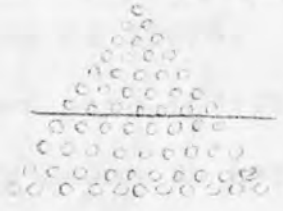
iii) Physical objects are also composed of points, for the same reason as ii).

But iv) physical objects have magnitude.

Therefore v) physical objects are composed of particles which have magnitude.

Democritus is said to have discovered that the volume of a cone is one third of the volume of a cylinder, having the same base and height.[1] It seems that in order to discover this he must have experimented by cutting cones and cylinders into pieces.[2] If a cone is cut into two pieces by a plane parallel to its base, the question arises whether the circles produced on the two parts by the cut are equal or unequal. If they were equal, since this would hold for any such cut, the figure would be not a cone, but a cylinder, if they were unequal, the surface of the cone would be covered with indentations.[3]

II. Therefore i) the sides of a cone are covered with indentations (created by the particles of which the cone is composed, see above I and the following figure).



section through cone.

1 D68B155.
2 G. Sarton, A History of Science, p. 277.
3 D68B155.

But ii) the sides of a cone generally look and feel smooth.

Therefore iii) the particles of which the cone is composed must be imperceptibly small.

From I and II it is clear that physical objects must be composed of imperceptibly small corporeal particles; and because of the Eleatic proof of the indivisibility of the One, these must be indivisible (i.e. atoms).

The cosmology of the Atomists followed the outline of earlier cosmologies. The atoms were supposed to separate out from an eddy, like joining like;[1] as examples of this principle observed operating in nature Democritus cited the gregariousness of birds, the sorting out of similar grains in a sieve and similar stones on a sea-shore.[2] Democritus gave explanations of various meteorological phenomena and knew that thunder and lightning occur simultaneously;[3] he may have realized this from observing, for example, that, watched from a distance, a battering-ram would be seen to hit the wall before the noise it made could be heard.

Democritus was also interested in biology and and medicine. He seems to have made considerable obser-

1 D68B167.
2 D68B164.
3 D68A126a.

vations in the sphere of biology[1] and he believed that the power to attain health depended upon man's control of the appetites;[2] he thought that insomnia was caused by inadequate nourishment.[3] He compared the human body to the universe.[4]

It might seem at a first glance at the epistemological fragments that the Atomists paid little attention to the senses. In fragment 9 Democritus says that none of the qualities we perceive with the senses exist except by convention. But elsewhere[5] he declares that there are, in fact, two kinds of knowledge, the legitimate (i.e. of the atoms and the void) and the bastard, (i.e. of the sensible things around us). By the use of the metaphor of legitimate and bastard children it seems that he meant to imply that the two kinds of knowledge exist, but that the legitimate take precedence over the other, since its objects are more truly existent. This is probably his solution to the problem of the often self-contradictory evidence of the senses[6] (e.g. an oar appears bent when seen through water[7]). It seems, then,

1 D68B22; 126; 154; etc.
2 D68B234.
3 D68B209; 212.
4 D68B34.
5 D68B11.
6 D68A112.
7 D67A33.

that he thought the truth was hidden from the senses.[1] Yet in Aristotle's De Anima[2] we find τὸ γὰρ ἀληθὲς εἶναι τὸ φαινόμενον and in Metaphysics[3] τὸ φαινόμενον κατὰ τὴν αἴσθησιν ἐξ ἀνάγκης ἀληθὲς εἶναι φασιν. However, taken in conjunction with a passage in De Generatione et Corruptione,[4] where Aristotle is contrasting the method of the Eleatics who proceeded by reasoning alone with that of the Atomists who began with sense-perceptions, found λόγοι consistent with them and by these λόγοι explained sense-perception, it is clear that the two passages above must mean that sense-perceptions have some value (cf. D68B11) and from the passage from De Gen. et Corr. it appears that they have value when they are interpreted by the λόγος which goes beyond sense-perception. This view is supported by Democritus' own words;[5] the intellect says "Colour exists by convention, sweet by convention, bitter by convention", to which the senses reply "Poor intellect, you get your evidence from us and do you try to overthrow us? Our overthrow will be your downfall." The Atomists were not like the Eleatics, who completely disregarded the evidence of the

1 D68B8; 9; 117.
2 D68A101.
3 D68A112.
4 D67A7.
5 D68B125.

senses; their problem was that the atoms and void were not simply creations of the mind but existed and could be seen in conglomeration; so the objects of cognition of the λόγοι were, in fact, sensible.[1] In this way the Atomists realized the importance of both intellect and sense-perception for the discovery of the truth. They can hardly be called "empirical" since they gave precedence to the intellect over the senses. But they did not deny to sense-perception a certain value.

[1] on the whole subject of Democritus' epistemology see H. Weiss, Democritus' Theory of Cognition, C.Q. 1938.

CHAPTER VIII.

THE GREEK MEDICAL SCHOOLS.

We shall now try to see to what extent Cornford was justified in calling the Greek doctors "scientific" by examining the most note-worthy books of the Hippocratic corpus. It will be convenient to assign each of the works to one of the three medical schools mentioned by Galen,[1] the Italian, the Cnidian and the Coan, although characteristics of more than one school can be found in a number of works of eclectic tendencies. As to the date of the Hippocratic books, according to L. Bourgey[2] almost the whole of the corpus belongs approximately to the time between 440 and 350 B.C.; he allots each of the works to one of three periods, the early, the middle and the late, within those dates, the period of the best works being between 430 and 440 or 390 B.C.

1) The Italian School.

Herodotus mentions a centre of medical activity in the south of Italy to which belonged Democedes,[3] who is said to have been a Pythagorean doctor of considerable

1 On the therapeutic method, X, 6(Kühn).
2 L. Bourgey, Observation et expérience chez les médecins grecs de la collection hippocratique, p. 41. Throughout this chapter I have followed Bourgey's dating of the works. For his reasons for giving these dates see op. cit. ch. I.
3 Histories III, 31.

ability,[1] and at a much later date Galen speaks of the Italian school as connected with Empedocles.[2] The author of Ancient Medicine[3] criticizes those who, like Empedocles, insist that before the physician can treat his patient he must know what are the constituents of man and that this knowledge can only be supplied by philosophy. Earlier in the work the author censures those who postulate one or two causes (the hot, the cold, the wet, the dry) for all diseases and claims that medicine has no need of empty postulates as have the insoluble mysteries of the heavens.[4] In later chapters[5] he shows how useless these theories are in medical practice. Now it certainly seems that the author of Ancient Medicine is attacking a particular school of medical thought and his mention of Empedocles suggests that this was, in fact, the Italian school. The chief characteristic, then, of the Italian doctors seems to have been their insistence upon the importance of philosophical theory in medicine. The books of the Hippocratic corpus where this tendency is uppermost are Sevens, Winds, Regimen, Fleshes, Nutriment and The Heart. Sevens seems to fall naturally into two

1 D19A1; 2c.
2 op. cit. X, 5.
3 A.M. 20.
4 A.M. 1.
5 A.M. 15, 16.

parts, part one from chapter I to chapter II and part two from chapter XII to the end. The first part appears to be very early, and Bourgey would place it at the beginning of the fifth century B.C., outside the period assigned to the corpus as a whole.[1] The second part was written much later and probably belongs, together with Nutriment and The Heart, to the late period of Hippocratic writings. Winds, Regimen and Fleshes probably belong to the middle period.

a) Philosophical theories in the works of the Italian school.

Part one of Sevens deals with the role played by the number seven in the world as a whole (ch. I) and in the life of man (5; 10). Chapter VI contains an arbitrary comparison of the macrocosm with the microcosm.[2] It seems unlikely that the theory of sevens was based on observation: it was probably the result of a superstitious belief in the value of the number seven (cf. the seven sages, etc.), perhaps encouraged by the number mysticism of the Pythagoreans.[3] It is found in other works probably belonging to the Italian school: in the Seventh-Month Embryo the number seven is said to control the development of illnesses[4] and a similar theory is expanded in Fleshes;[5]

1 op. cit. p. 38.
2 the earth is the flesh, the water is the blood, etc.
3 see H. Miller, Philosophy and Medicine in Ancient Greece, C.J., 1949, who says that philosophy and medicine are hereunited in a presentation of the significance of the number seven.
4 ch. 19.
5 19.

it is possible that in these two cases the theory of sevens resulted from a consideration of recurring crises in certain diseases.[1] In part two of Sevens the importance of cosmological speculation for the study of medicine is emphasized (12). The author maintains that the world is composed of two elements, the hot and the cold (15); illnesses are caused by the breaking of the equilibrium between the two elements (24) and fevers by the moving of the soul's heat through the body (19).[2]

The author of the Hippocratic treatise called Winds claims that air is the chief constituent of the body (1), as it is of the world (3);[3] it is invisible to the sight but visible to the reason (3). This air within the body is the cause of diseases (4). He believed that the blood is the seat of the intelligence (14).

In Regimen again we find the idea that the physician must first acquire knowledge of the nature of man in general (I, 2). The author would obtain this knowledge not by the senses, but by reason (I, 4). According to

[1] e.g. in pneumonia; see Bourgey op. cit. p. 134. Modern drugs have made crises in illness less noticeable than they used to be.

[2] The importance of hot and cold elements in the world and in living creatures was stressed by Anaximander (D12A10, 30) and later Philolaus made heat the chief element in the body (D58A27); the idea of the harmony of opposites being necessary for health is found in the teaching of Alcmaeon (24B4). This theory of hot and cold elements is particularly criticized by the author of A.M. (15; 16).

[3] cf. Anaximenes and Diogenes of Apollonia (D3B2; 61B4).

[4] cf. Empedocles D31B105.

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[3] cf. Anaximenes and Diogenes of Apollonia (D3B2; 61B4).

[4] cf. Empedocles D31B105.

him the chief constituents of man are fire and water (I, 3)[1]; the fire is hot and dry and the water cold and moist and from these many things are separated off (ἀποκρίνεσθαι) (I, 4);[2] nothing perishes and nothing comes into being which did not exist before, but things change by mingling and being separated (I, 4)[3] and are always in a state of flux and exchange (I, 5).[4] He goes on to expound a theory of the dependence of health on a harmony of the elements of nutrition, like the harmony of notes in music (I, 8)[5] and explains differences of sex and degrees of intelligence by the proportion of fire to water in the body (I, 27; 32; 35). In Book II he claims that the universe is like the human body since both contain air (II, 38).[6] Book IV deals with dreams and contains a theory that there is a relation between health and the heavenly bodies seen in dreams (IV, 89).[7]

The author of Fleshes claims that heat is the first principle, an immortal substance which has life and intelligence (2). There was at first a rotating mass of

1 This seems to be an echo of the teaching of Thales (D11A1; 3; 12; 13) or Hippon (D36B1), combined with that of Heracleitus, (D22B30; 31; etc.)
2 cf. Anaximander D12A10.
3 cf. Empedocles D31B8; 12; Anaxagoras D59B17.
4 cf. Heracleitus, D22B90.
5 Heracleitus mentions harmony (D22B51; 54) but the comparison to music here suggests Pythagorean influence (D58B6; 63B1; 2).
6 cf. Anaximenes D13B2.
7 influence of Pythagoreanism? -see interest in heavenly bodies and mysticism.

undifferentiated matter, from which the four elements came to take their traditional places, with fire on the outside (2);[1] living creatures are formed of earth and heat with proportions of sticky, fat and wet elements, etc. (3).[2]

Nutriment is a short work written in an enigmatic style, like that of Heracleitus. Its author stresses the importance of change and relativity.

In The Heart we find a belief in the innate heat which is identified with intelligence and resides in the left ventricle of the heart (6; 10).[3] This intelligence is nourished by a pure and luminous substance, which comes from the blood (11).[4] The breath in the lungs moderates the heat in the heart (9).[5]

b) Observation and experiment in the works of the Italian school.

Alongside of these speculations we find in all the works of the Italian doctors a considerable amount of accurate observation and a few ingenious experiments.

Part one of Sevens is wholly concerned with speculations on the value of number seven without any reference to observed facts; but the second part was obviously written by a practising physician. He knew the signs which portend

1 cf. Anaximander D12A9; 10; Anaxagoras D59B12; 15.
2 cf. Anaxagoras D59A42 §12.
3 cf. Heracleitus D22B43 (intelligence = fire).
4 cf. Empedocles, D31A86 §10.
5 cf. Philolaus, D58A27.

a cure or death (46) and the importance of sweats (24) and of the appearance of the eyes (42), the tongue (43), the urine, stools and nails (44) in determining the course of illnesses. He also noticed the pulse (51) and emphasized the importance of the coction of the four humours (27). For treatment he recommended purging and blood-letting (29), nostril remedies (38) and cataplasms (39). He seems to have been an eclectic writer[1] who kept his medical theory apart from his practice.

The author of Winds insists that it is necessary to discover the cause of the disease before one can cure it (1). Air, he says, is usually the cause of diseases (4) but there are other causes, such as a flux of phlegm in ophthalmia and affections of the lung. He believes that epidemics are caused by air, since the same air is inhaled by all those who catch the disease; animals do not always take it, since they are not affected by it in the same way as men (6). He thinks that gapes before fevers are caused by the heat in the body forcing the air out in the same way as the steam from boiling water lifts the lid of a cooking-pot; and he compares sweats to the drops of moisture on the outside of the pot. He also noted the

[1] Prognostic, critical days and the coction of the humours are emphasized by the Coan doctors, while the remedies are those prescribed by the Cnidians, see below.

pulse in the temples (8). Dropsy, he thought, was caused by air as well as moisture, since the amount of water consumed by the patient is not enough to cause the swelling (12). These theories probably arose from vague observations of eructations after eating in sporadic fevers and the reappearance of the swelling in dropsy after it had been drained.[1]

The author of Regimen seems to have been not a practising physician but a health-expert,[2] perhaps a master of a wrestling-school. He is more concerned with maintaining health than with curing disease. In Book I he describes how exercises must be taken in proportion to the amount of food consumed, the age and constitution of the person and the season of the year (2). He knows the importance of nourishment and good habits for health (28). Walks are recommended in the morning, after dinner and after running (35). In Book II the author gives reasonable explanations for the various qualities of the different winds; he knows that there is snow and ice at the South Pole and attributes the heat of the South wind to the fact that it passes over torrid zones (28). There follows a discussion on the effects of various preparations of

[1] Bourgey, op. cit. p. 118.
[2] Plato, Republic, 406B-D, description of Herodicus of Selymbria who killed his fever patients by excessive exercise!

barley on patients (40), the different ways of preparing cyceon (41) and wheat (42), on the effect of various meats (46), vegetables and herbs (54), of oiling (58) and exercises. Book III gives an account of a diet to be followed and exercises to be taken in winter (68) and insists that prevention of disease is better than cure and and that signs of illness approaching should be heeded in order to prevent it (72). Regimen IV deals with dreams; the author realizes that dreams are sometimes caused by disturbances of the body (88) and by anxiety (89); in the latter case the cure is to take a rest and occupy the mind with pleasurable pursuits. Throughout this work philosophical theories and sensible recommendations for health are juxtaposed. Apart from a few passages in Regimen I, there is no attempt to relate philosophical theory to observation and practice.

In Fleshes we find some very accurate observations. The author has experimented with various tissues of the body, testing their reaction to boiling; by this means he discovered that the spinal cord is not the same as the marrow in the bones, as was popularly supposed, but comes from the brain and is not marrow at all (4). He dissected the body and discovered the pericardium and the venae cavae. He thought that the skin is formed by the action of cold air on the blood (9), probably from observing that bleeding

is staunched and a membrane forms when cold is applied to a wound. He discovered the synovial fluid (10) and the tunics and humours of the eye and its crystalline lens (17). He had noted that a man who has had a wound in the larynx loses his voice until the wound has healed and from this he concluded that the voice is produced by the passage of air through the larynx (18). Most of his observations are very accurate but he is led to the wrong conclusion sometimes by his desire to prove that living creatures are formed from the hot and cold elements,[1] sometimes by insufficiently careful observation.[2]

In Nutriment we find that the author has noted various symptoms of diseases (26). He gives a description of veins arising from the liver and arteries from the heart, a system which lasted till Harvey's time (31) and he noted the differences in the pulse according to age, disease and health (48).

The author of The Heart has considerable knowledge of anatomy. He has seen the pericardium and has noted the liquid contained in it; to explain the presence of this liquid he resorted to a theory, common among the Cnidian doctors, that when we drink a portion of the liquid passes the epiglottis and enters the lung. He

1 e.g. the theory of skin being formed by the action of cold air on (hot) blood.

2 e.g. the theory that the brain resounds during audition (15).

thought that it was some of this liquid which was found in the pericardium. To show that drink passes into the lung he performed an experiment; he gave a pig some water to drink which contained a dye; then he cut its throat and discovered that the trachea was stained by the dye (2). He probably mistook the oesophagus for the trachea. He describes the heart as a strong muscle (4), cushioned on the lungs (5). He has seen the two ventricles and describes them accurately; they are knotty inside, the left more so than the right (6); he concludes that the reason for this is that the left ventricle is the receptacle of the innate heat (6). To prove this he conducted another experiment; he cut an animal's throat, then opened its left ventricle and found it empty of blood, but containing a yellow fluid, like bile,[1] which he concluded was the substance which nourishes the intelligence (11). He also discovered the main arteries and the auricles; the latter, however, he thought were the instruments by which air was drawn into the heart, (he likens them to a pair of bellows (8)). He thought that this was shown by the fact that the auricles have a separate beat from the heart as a whole (8). It seems that he must have practised vivisection to discover this

[1] now known as the "chicken-fat clot".

last fact.[1] He had discovered the valves of the heart and gives an accurate description of them. By taking the heart from a dead man and supporting water on the sigmoid valves to test the system of closure, he discovered that the valve in the left ventricle is the stronger and will not let any water through it (10). But he thought that this supported his theory that the innate heat is in the left ventricle. This is the most remarkable anatomical treatise in the corpus and contains the seeds of scientific observation and experiment; but often the truth is obscured by the author's desire to prove some unverifiable hypothesis.

The Italian school, then, was strongly influenced by philosophical thought and yet many of its members practised accurate observation and carried out careful experiments; but because they began with philosophical theories, based on insufficient observation, they often, though not always, arrived at the wrong conclusions.

2) The Cnidian School.

The author of Regimen in Acute Diseases (ch. I) begins his treatise with an attack on the writers of Cnidian Sentences; he complains that although they have correctly described the experiences of patients and the outcome of certain diseases they have omitted to find out anything apart from what the patient tells them; the remedies they

[1] Bourgey, op. cit.

prescribe are few, consisting mostly of purges and prescriptions of milk and whey (2); and although later revisers of the work have shown more insight in their discussion of the remedies to be employed, none of them has paid enough attention to regimen; moreover, they are at fault in diagnosing diseases as different whenever there is a difference in symptoms (3). The books of the corpus where these tendencies are most conspicuous are Internal Diseases and Maladies II, of the early period[1] and the gynaecological works[2] which were written at a later date.[3]

Internal Diseases is a long work which contains evidence of careful observation on the part of its author who was almost certainly a practising physician. The symptoms of diseases are described in graphic terms; in a certain lung disease[4] the patient dilates his nostrils, like a galloping horse, and hangs out his tongue, like a panting dog (7). A distinction is made between three kinds of consumption; in the first kind the throat is full of a substance like down and the breath whistles through it, as through a reed pipe (10); in the second kind the patient feels as though there were a stone in his

1 Bourgey, op. cit. p. 37.
2 with the exception of the Seventh-Month Embryo and the Eighth-Month Embryo which more probably belong to the Italian school, see above.
3 Bourgey, op. cit. p. 39.
4 Modern doctors have been unable to identify this disease with any certainty.

chest (11).[1] We find similar striking descriptions in Maladies II; the sputum in consumption is hard, like a hailstone (49); a tumour feels like a stone suspended from the affected side (60); in a case of pleurisy a noise like the creaking of leather can be heard inside the chest (59). The author has also observed changes in the appearance of the sputum, urine, etc. and their importance in foretelling the course of the disease (46; 47); and he has noticed the swelling of the feet, the retreat of the nails from the fingers and toes and swellings below the eyes in a lung disease (47) and the falling of the hair in consumption (48).

In both works we find the tendency to make too many distinctions between diseases. The author of Internal Diseases differentiates four kinds of jaundice (35-38), three kinds of hepatitis (27-29), four diseases of the kidneys (14-17), etc. In Maladies II there are several kinds of jaundice (38; 39;), four kinds of consumption (48; 49; 50; 53), three kinds of pleurisy (44; 45) etc.[2]

In Internal Diseases we find the typically Cnidian[3]

[1] There are other vivid descriptions of symptoms, e.g. of kidney disease (14, 17) and a nervous disorder (47).

[2] for further examples of over-classification, see Bourgey, op. cit. p. 151. We may note that in Affections, which is probably a Cnidian work, there are real distinctions between dysentry, lientery, diarrhoea and tenesmus (23-26).

[3] according to Galen, περὶ ἀρίστης αἱρέσεως, I, 128-9 (Kühn).

belief that when we drink a portion of the liquid passes into the lung (23). The author had observed in the lungs of animals tumours containing fluid and he thought that "hydropsy of the lung" was caused by the bursting of the tumours; the fluid that they contained he thought to be that which enters the lung when liquid is drunk.[1]

The authors of both works thought that diseases were caused by bile and phlegm.[2] This was probably a false conclusion drawn from observation of fluxes of these secretions in the diseases common in ancient Greece, namely malaria and consumption.[3] The author of Internal Diseases distinguishes several different kinds of bile and phlegm which appear in different diseases.[4] For treatment are recommended prescriptions of milk,[5] whey,[6] cyceon (a mixture of barley-meal, grated cheese and wine)[7] and hellebore;[8] blood-letting,[9] cauterization,[10] vapour baths,[11] nasal remedies (the "purges of the head")[12] and cold

1 cf. On the Heart, 2.
2 I.D. 4; 5; 14; 16; etc., Mal. II 1; 3; 5; 10; 19; 40. cf. Aff. 1, Haem. 1.
3 see W. H. S. Jones, Malaria; a neglected factor in the history of Greece and Rome; and Hippocrates, Loeb edition, vol. I, p. xlviii.
4 salty phlegm, white phlegm, corrupt phlegm, yellow bile and black bile (20; 21; 49 etc.)
5 I.D., 3.
6 ibid, 13, Mal. II, 12.
7 I.D. 4.
8 Mal. II, 16.
9 I.D., 4.
10 ibid, 6; Mal. II, 12; 34; 60; cf. Haem, 2; Vision, 4.
11 Mal. II, 16.
12 ibid.

compresses.[1] In Internal Diseases we find the famous "cure" by infusion into the lung (6);[2] a mixture of honey, milk, vinegar and water is introduced into the trachea by means of a pipe in order to provoke coughing. This and similar brutal "cures" must have been extremely distressing for the patient and more harmful than beneficial. The Cnidians also appear to have been very bold in using surgery; in Internal Diseases it is recommended in cases of chronic pneumonia (3); stone in the kidney (14), phthisis of the kidney (15) and a disease of the lung where trepanation of the ribs is advised (23). In Maladies II surgery is recommended for the removal of a polypus (33), for empyema (47) and "hydropsy of the lung" (61). One very important discovery made by the Cnidian doctors was the practice of succussion and auscultation to discover the presence of fluid in the chest cavity.[3] The author of Internal Diseases recommends this practice before surgery to discover where the incision should be made (23).

In these two works we find a considerable amount of accurate observation, a remarkable knowledge of anatomy, enabling the authors to perform successful surgical operations and at least one excellent discovery, the practice of auscultation. There is also a notable

1 Mal. II, 27.
2 cf. Places in Man, 18.
3 I.D., 23; Mal. II, 47; 59; 61.

absence of philosophical theories. But there is no generalization and very few conclusions are drawn from the observations they made.

In the gynaecological treatises there are many of the Cnidian tendencies but also improvements on earlier works. We find proofs that drink does not pass into the lungs;[1] there is more systematization (e.g. instead of distinguishing between various kinds of bile and phlegm, the author of Maladies IV (32) differentiates the four humours, bile, blood, phlegm and water) and more attention is paid to details of individual cases (e.g. the patient's age, the place where she lives, etc., Maladies of Women, II, 111). Many of the remedies employed are bizarre, as in the early works, but we find some very interesting analogies between botanical and human life and a considerable number of simple experiments. It seems likely that these improvements resulted from the contact with the Italian school, which, according to Diogenes Laertius, took place in the fourth century B.C.[2] We may find likenesses between these gynaecological works and the writings of Empedocles.[3]

1 Mal. IV, 54.
2 Lives of the Philosophers, VIII, 86; 89.
3 comparison between botanical life and human life; Empedocles D31B82; A70; interest in reproduction, B63; A81; A82 and experiments, B100. We do not find any of Empedocles' philosophical theories in these Hippocratic writings.

The experiments described in these books are very interesting. In Maladies IV (39) the author supposes that the stomach is a sort of reservoir for the four humours; when the stomach is full, the four organs corresponding to the four humours, (i.e. the liver, the heart, the lungs and the bladder), as well as the body generally, draw from the food in the stomach. The organs then distribute their particular humours to the body; but when the stomach is empty, the humours flow back into it. He thought that he had proved this by the following experiment; he placed three pots on a level surface and joined them by pipes fixed into holes in their sides; when he filled one with water he found that it seeped into the others and when one was emptied the water left the others in the same way. Later in the same work (51) the author describes an experiment to prove that after a blow the blood is gathered together in one spot in such quantity that it cannot escape; he filled a narrow-necked jar quite full and discovered that when it was inverted the fluid would not run out easily unless the jar was tipped to one side.[1] The author of The Nature of the Child describes an experiment meant to prove that the limbs, organs, etc. of the human embryo are formed by the action of air which is in the seed; a bladder is attached to the end of a pipe;

[1] cf. Mal. IV, 57.

soil, sand and lead filings are put into it; water is poured in and finally it is inflated by means of the pipe. At first all the sustances are mixed together in the water, but, if the bladder is allowed to dry and is then opened, it will be found that particles of each of the three substances have gathered together;[1] in the same way the different substances of the human body are supposed to be differentiated by the action of air.

Although these experiments show an interest in concrete things and a desire to confirm a theory, they were not very successful because the analogies made were not accurate; the conditions in both cases were not comparable to each other. Other analogies in these works are more accurate and useful in giving insight into the mysteries of reproduction and growth. In The Nature of the Child (22) a connection is established between the health of the mother and the health of the child by comparison with the condition of the soil and the plants which grow in it. In the same work (29) an excellent comparison is made between the human embryo and a bird's egg; twenty eggs are given to two hens to hatch and each day from the second day until the hatching one is broken and the development of the embryo is watched.

In the Cnidian works, then, there is some evidence of

[1] cf. Empedocles D31B22, attraction of like to like.

a scientific method; careful observation and experiments which, since they can be repeated, are of universal value. Although, in the early works especially, there is little attempt to reach any conclusion from these observations, this is perhaps preferable to the Italian habit of accepting the theories of philosophy. The Cnidian doctors did some valuable work, but their methods were inclined to be haphazard and over-empirical. It is not until we examine the works of the Coan school that we find the combination of empiricism with reason which can lead to valuable advances in scientific knowledge.

3) The Coan School.

We have seen that the authors of Ancient Medicine and Regimen in Acute Diseases criticized the doctors of the Italian and Cnidian schools respectively. The alternative procedure recommended by these writers is not characteristic of either the Italian or the Cnidian schools and indicates the existence of another sect, the Coan school, mentioned by Galen,[1] to which Hippocrates himself is supposed to have belonged. The practices of this school find a supporter in the author of a short treatise, On the Art, which is an apologia for the art of medicine. From these three books we may deduce what were the outstanding characteristics of the Coan School.

[1] On the therapeutic method, X, 6 (Kühn).

Outline of the characteristics of the Coan doctors.

The authors of these works all placed great emphasis on the part played in the acquisition of knowledge by reasoning from experience and observation; discoveries made by earlier physicians by means of trial and error and observation must be contemplated and new discoveries made by comparing past with present cases, making further observations and reasoning accurately from the data thus obtained.[1] The author of On the Art seems to have approved of a certain kind of experimentation; in cases of internal disease when the symptoms are not pronounced it is possible to force nature to give up her secrets by artificial means, for example, by administering purges and emetics or forcing the patient to run uphill and observing the consequent reaction.[2] The author of Ancient Medicine strongly disapproved of philosophical theories which were based on insufficient observation;[3] but, unlike the Cnidians, the Coan doctors believed that it was necessary to go beyond the evidence of the senses, and, in spite of paying attention to detail, to gain an inclusive picture of the

1 A.M. 2; 12; 14; R.A.D. 4, On the Art, 7; 10. On the last point, the necessity for accurate reasoning see A.M. 21, where it is noted that it is important to realize that post hoc is not necessarily propter hoc.

2 On the Art, 13.

3 A.M. 20; contrast Italian school.

nature and circumstances of disease.[1]

The result of reasoning from observation and experience was that the Coan doctors adopted a modified version of Alcmaeon's theory of opposites. Whereas Alcmaeon believed that an unlimited number of opposite qualities[2] existed in the body,[3] the Coans identified these qualities with the actual humours in which they were manifested.[4] Like Alcmaeon, the Coans thought that disease was due to a disturbance of the balance of the humours;[5] health could be recovered by restoring the balance. This sometimes happened naturally by the process called coction, i.e. a mixing of the humours with each other, shown by a change in the consistency of the humour;[6] but, if nature failed to secure an adequate coction, it was necessary to attempt to remove the excess humour, e.g. by purging[7] or venesection.[8] The duty of

1 A.M. 14; R.A.D. 4; 6; 10-20; On the Art, 7. But note A.M. 20 where it is stated that generalizations are often too sweeping.

2 probably not fully abstracted from matter; but the fact that he calls the opposites by their distinguishing quality and not by other names (e.g. bile), as the Coans did, shows that he was progressing towards an understanding of quality existing apart from matter.

3 D24A3.

4 A.M. 14; 17.

5 D24B4; A.M. 14; there are also external causes of disease, e.g. weather.

6 A.M. 18; in the case of a cold in the head the patient is on the way to recovery when the discharge from the nose becomes thicker; 19, the same process can be seen in ophthalmia, pneumonia, etc.

7 R.A.D. 13; 19; 24.

8 R.A.D. 22.

the doctor involved the forecasting of the outcome of the disease and of the times of crisis,[1] when it was necessary for him to do all in his power to secure coction, e.g. by a special diet,[2] fomentations,[3] baths[4] etc. This practice of forecasting was called πρόγνωσις.

These, then, were the characteristics of the Coan school. The works in which they are mostly to be found are Aphorisms I-V, Airs Waters Places, Prognostic, Epidemics I and III, Joints, Fractures and Nature of Man of the middle period of Hippocratic writings and Humours, On Wounds in the Head, In the Surgery and Prorrhetic II of the late period.[5]

The importance of reason.

In many of these works we find the insistence upon reasoning from experience and observation. The author of Airs Waters Places (1 and 2) advises the doctor to learn about the peculiarities of each district he visits and to reflect upon this knowledge in order that he may know what illnesses to expect when he arrives there. In Epidemics III (16) we find emphasis laid on the importance of studying the writings of experienced physicians in order that errors may be avoided; and the author of Joints (10)

1 A.M. 19; R.A.D. 13.
2 A.M. 4; 15; R.A.D. 10-20 etc. gruel, oxymel and hydromel were given.
3 R.A.D. 21; 23.
4 R.A.D. 65, 68.
5 Bourgey, op. cit. pp. 36-38.

declares that practical experience is necessary as well as theoretical knowledge. In the work On Wounds in the Head (10) the doctor is recommended to ask the patient how the wound was acquired and then to decide the extent of the injury by "reasoning and examination". Later in the same work (18) the surgeon is advised to "devote his intelligence to trying to distinguish a thing which cannot be known by inspection."[1] A similar method of procedure is set out by the author of In the Surgery (1); every one of the senses must be used and the data they provide must be united by intelligence (γνωμη). The author of Prorrhetic II (4) gives a similar piece of advice.

Experimentation

We saw that the author of On the Art (13) was not averse from a certain amount of experimentation in connection with prognosis. It is possible that experiments of this kind were performed by the Coan doctors, but the author of Epidemics VI (5; 18) which contains some Coan characteristics criticizes those who experiment on patients. In none of the Coan works[2] do we find any experiments connected with anatomy and physiology, involving

1 trans. by E. Withington, Hippocrates, Loeb edition, vol. III.

2 with the exception of A.M. where (§22) the author states that the organs of the body which attract moisture taper from broad to narrow because, if one opens one's mouth wide, it is impossible to draw up liquid, but if one compresses the lips and places a tube between them, it is possible to do so. He remarks also that cupping instruments taper from broad to narrow.

the use of apparatus, like those conducted by the Italian and Cnidian doctors.[1]

Philosophical theories.

It has been noted that the author of Ancient Medicine disapproved of the theories of the philosophers. A similar sentiment is expressed by the author of Fractures (1). There are significantly few philosophical hypotheses in the Coan works. But in Aphorisms I (14) we find mention of innate heat,[2] in Aphorisms III (11) a description of the moist constitution[3] and in Aphorisms V (63) the theory that health and disease are due to the action of air.[4] The Aphorisms, however, are collections of brief sayings and it is possible that later revisers inserted philosophical ideas expressed in a terse style. In Airs Waters Places (8) we find a strange experiment to show that freezing dries up and causes to disappear the lightest and brightest parts of the water.[5] The other works of the Coan school are almost entirely free from philosophical speculations.

The humoural theory.

In spite of their censure of philosophy, it is clear

1 see above.
2 cf. Philolaus D58A27 and the Italian work, The Heart, 6; 9; 10.
3 cf. Regimen I and Hippon D36B1.
4 cf. Winds, 4 and Diogenes of Apollonia, D61B4.
5 cf. Anaxagoras D59B12; 15; 16; on the likenesses between Anaxagoras' work and A.W.P. see Vlastos, Review of P.S. Gnomon, 1955. For a description of the experiment, see above ch. III.

that the Coan doctors may be accused of the very fault which they criticised, namely the formulation of hypotheses based on insufficient observation. The humoural theory is of this kind. It was obviously based on the observation of bilious attacks, haemorrhage, discharges, etc. in illnesses,[1] but the Coan doctors went too far in supposing that these humours were actually the cause of disease; however, they were prepared to admit secondary causes, such as the season of the year, the place of residence, etc.[2] The Coans believed that disease was caused by a disturbance of the balance between the humours,[3] not, as the Cnidians thought, by their movement through the body.[4] The Cnidians limited the number of humours to four,[5] but the Coans appear to have admitted an unlimited number.[6] Again, the Cnidian humoural theory seems to have had little effect on practice; but, in the case of the Coans, it led to a belief in the occurrence of coction. The Coan doctors supposed this theory to be supported by their observations of the alterations in the condition of excretions, discharges, etc., as they watched the progress of the disease.[7] From observing

1 see A.M. 14; 18.
2 A.W.P., Prog. 25, Ep. III, etc.
3 Hum. 5, Nat. of Man, 3.
4 Mal. IV, 39; 51. It seems that the Cnidian belief was the one held more generally in later times; note: the terms catarrh, rheumatism, etc. imply movement.
5 Mal. IV, 32.
6 A.M. 14; 17.
7 A.M. 18.

the appearance of tumours, swellings at the joints and the occurrence of diarrhoea, haemorrhage etc. they came to the conclusion that these were the means by which nature tried to get rid of the excess humours, if coction were not complete. This process was called abscession (ἀπόστασις).[1] If neither coction nor abscession succeeded in removing the excess humour there was often a relapse (ὑποστροφή) and sometimes a change in the type or location of the disease (μετάστασις).[2] It was the physician's duty to encourage coction in every way, by special regimen,[3] hot and cold fomentations,[4] "anointings, ointments, plasters, salves, powders, dressings, applications."[5] If this treatment was not successful, it was necessary to remove the excess humour by purging[6] or blood-letting.[7] The other important part of the physician's work was the fore-telling of the critical days of the disease in order that on those days the patient might be treated in such a way that the crisis effected its purpose of restoring the balance of the humours. It is obvious that the doctors had observed the crises which occur in many febrile illnesses and which are most noticeable in malaria; this

1 Ep. I, 8.
2 Ep. I, 8; III, 12; Nat. of Man, 4.
3 Aph. I, 16; Prorrhetic II, 4.
4 Ep. III, 8.
5 Hum. 5.
6 Aph. I, 21; IV, 1-12; Hum. 5.
7 Ep. III, 8.

disease was very common in ancient Greece and probably made crises more pronounced in other illnesses.[1] This practice of prognosis seems to have occupied most of the doctor's time. In order to forecast when the critical days would occur it was necessary to keep a record of the progress of the disease. We possess some of these case-histories in Epidemics I and III; it seems that day-to-day observations were made and recorded. The author of Epidemics I, (23) gives a list of the conditions to be taken into account when making prognoses; they are "the common nature of all and the particular nature of the individual, the disease, the patient, the regimen prescribed and the prescriber . . . . . the constitution . . . . of the weather and of each region; the custom, mode of life, practices and age of each patient; talk, manner, silence, thoughts, sleep or insomnia, the nature and time of dreams, pluckings, scratchings, tears; exacerbations, stools, urine, vomit; . . . . the abscessions to a fatal issue or a crisis, sweat, rigor, chill, cough, sneezes, hiccoughs, breathing, belching, flatulence, harmorrhages and haemorr-oids."[2] In connection with prognosis the Coan doctors made some important observations, the two most remarkable

[1] see W. H. S. Jones, Malaria, a neglected factor in the history of Greece and Rome.

[2] trans. by Jones, Hippocrates, Loeb edition. cf. Hum. 2, Aph. I, 12; IV, 34; 35; 69; V, 1-12; Prog.; Ep. I and III.

being of the phenomenon now known as "Cheyne-Stokes breathing", when the patient takes deep breaths at short intervals[1] and of what is called the "Hippocratic countenance",[2] the appearance of the patient shortly before death. Experience and observation unconnected with humoural theory.

In the other works listed as typically Coan, namely Joints, Fractures, On Wounds in the Head and In the Surgery there is no evidence of any theory underlying the practices recommended, but a remarkable amount of experience and observation, combined with considerable ingenuity. In Joints and its appendix, Instruments of Reduction, there are accurate descriptions of most of the joints in the body and of methods of reducing dislocations, many of them involving the use of ingenious instruments.[3] In many cases the treatment recommended is still used in modern times.[4] The author of Joints (68) also noticed the danger from shock. In Fractures (4 ff.) we find detailed instructions on the methods of applying bandages to the best effect, which knowledge was clearly the result of long experience.

1 Ep. I, case 1; Ep. III, case 15.

2 Prog., 2; cf. Shakespeare, Henry V, Act II, sc. iii, 13-17, description of dying Falstaff "For after I saw him fumble with the sheets and play with flowers and smile upon his fingers' ends, I knew there was but one way; for his nose was as sharp as a pen and 'a babbled of green fields."

3 e.g. the Hippocratic bench for reducing a dislocation of the hip, Joints, 72-3.

4 e.g. the method of curing a club-foot is in many respects the same as the methods used at the present time, even to the wearing of a special kind of shoe (Joints, 62).

In the work, On Wounds in the Head, the structure of the skull is accurately described (1) and methods of treating wounds are given with instructions on the proper use of incision and trephining (9 ff.). The author of this work made the valuable discovery that by putting black ointment on the skull it was possible to trace the extent of the fracture because of the porous nature of the bones which absorbed the ointment (14). In the small work, In the Surgery, great attention is paid to the light, to the position of the patient and doctor and to cleanliness in the performance of operations (3; 10). Here again we find instructions on various way of bandaging (7 ff.). These works are remarkable in that they show a considerable knowledge of anatomy and give evidence of practice based on experience and observation, combined with reasoning, but unhampered by hypotheses based on insufficient observation.

Coan breadth of view

In many of these works cited in the foregoing paragraphs there is a remarkable breadth of view. In Aphorisms I emphasis is laid on the effect of the season of the year, the district and the age of the patient, on the course of illnesses (2; 9; 17).[1] We often find relations established between apparently unconnected symptoms, e.g. between deafness and haemorrhage (Aphorisms

[1] cf. Epidemics I, 23; Aph. III 1-6, A.W.P., Prog. 25, Hum. 1 and 2.

IV, 60), between mumps and sterility (Epidemics I, 1), between the emotional state of the patient and his physical condition (Humours 9) and between a wound in the head and spasm on the opposite side of the body (On Wounds in the Head, 13).

Conclusion.

The Coan doctors, then, were remarkably free from the practice of adopting the theories of philosophers, unlike the doctors of the Italian school, and in none of their works do we find any of the excessive empiricism, over-classification and useless treatment, which are so often evident in the Cnidian works. In fact, the Coans generally combined the best characteristics of the other two schools, namely the use of reasoning and observation. By this synthetic method they produced a uniform system of practice based, to a large extent, on the humoural theory. Unfortunately this hypothesis, with its attendant theories of coction, abscession etc., went rather too far beyond the evidence of the senses and, as far as we can see, the Coan doctors made no attempt to check their hypotheses by experiment. The doctors of the school of Cos are to be seen at their best when they were actually treating their patients with whom they took the greatest care;[2] their wide experience and careful observation, especially in the

[1] Aph. I, 20; R.A.D. 4; Joints, 58.

surgical works, and their remarkable breadth of view are also to be commended. Modern medicine has found the best practices of the Cnidians, namely the use of drugs, surgery and experiments involving the use of apparatus, to be of considerable value; it has also proved the truth of the Coan belief in the power of nature and the advisability of preventing illness,[1] but above all it has shown that new discoveries can only be made by deductive reasoning from carefully observed facts, the method advocated by the physicians of Cos. In the Metaphysics[2] Aristotle speaks of the difference between experience (ἐμπειρία) and art (τέχνη); experience deals with particulars, art with universals.[3] The Cnidians may be said to possess ἐμπειρία, which, as Aristotle admits, is not inferior to art for practical purposes. But it is among the doctors of the Coan school that we find the true τέχνη, which results from experience and reasoning and is far superior to experience alone.

1 2 A.M. 4.
3 I, 1.
note that Aristotle takes his examples from the art of medicine.

CHAPTER IX.

CONCLUSION.

The conclusions which may be drawn from this survey can be listed as follows:

i) In chapter II we saw that the elements in Greek philosophy which Cornford thought were derived from myth can be explained as psychological phenomena, such as are to be seen in other spheres of Greek culture. Although the subject-matter of Greek philosophy was suggested by myth, the finished product was a structure of the intellect not laid on the foundations of myth but based on observation and perhaps to a certain extent on knowledge learnt from Oriental peoples.

ii) In the consideration of the work of the pre-Socratic philosophers we saw that they all, with the exception of the Eleatics, used the data of sense-perception to a certain extent; and even the Eleatics cannot be considered as the successors of the shaman simply because (as Cornford thought) the power of reasoning on which they relied resembled the prophetic faculty of the shaman, in that they, like him, claimed immediate and certain apprehension of the truth. There is a great difference between the logical reasoning of the Eleatics, which is an active process and the shaman's passive acceptance of a divine revelation. The other philosophers, viz. Heraclitus,

Pythagoras and Empedocles, whom Cornford thought to be successors of the shaman we found to have relied upon sense-perception, to a certain extent at least, even if they gave precedence to the intellect over the senses. We also found that a number of theories which appeared to be a priori were, in fact, based on observation, however insufficient; and those theories which were obviously a priori were supported by observation.

iii) According to Cornford the Greek doctors were more "empirical" than the philosophers. But Cornford made no distinction between the three medical schools; if he had, he would have found that along with the scientific observation and experiments, which are undoubtedly to be found in the Hippocratic corpus, there are in the works of the Italian school hypotheses taken over from the philosophers and unchecked by observation, and in the works of the Coan school theories which went as far beyond the evidence of the senses as any in philosophy; while in the works of the Cnidian school he would have been able to see the disadvantages of the "empirical" method, when unallied with reasoning. We also found that the experiments conducted by the Greek doctors seldom had a more successful result than those conducted by the philosophers, because generally both began with a false theory based on insufficient observation and often failed to establish an

exact parallel between the apparatus used and the object about which they were trying to discover the truth. (e.g. the clepsydra experiment of Empedocles and the experiment with jars joined by pipes described in Maladies IV; etc.). Occasionally we find in both philosophy and medicine experiments which prove a true theory (e.g. Anaxagoras' experiment with wine-skins to prove that air is a corporeal substance, and the experiment described in On the Heart to test the system of closure of the sigmoid valves). It seems that experiments are only of value when the original hypothesis is based on careful observation and when the experiment itself is carefully conducted and its results noted in full detail without consideration of the original hypothesis, in order that it may be possible to see whether there is any disagreement between the theory and the results of the experiment.

iv) Cornford thought that the "empirical" method was introduced into philosophy from medicine. This seems most unlikely, as the method already existed before it was formally described by Alcmaeon, and had, in fact, been used by the Milesians. Alcmaeon's theory probably had some effect on later pre-Socratic philosophy, but after the time of Alcmaeon we find rather more attention being paid to reasoning than to sense-perception (e.g. by the Pythagoreans and Atomists).

Cornford was probably nearer to the truth than

Burnet, when he laid emphasis on the intellectual achievements of the Greeks; but he was wrong to assume that, like the shamans, the Greeks paid no attention to sense-perception, that their philosophy was only a rationalization of myth and that reason, on which the philosophers relied, was like the prophetic faculty of the shaman. With regard to the latter point, it is much more likely that the Greek philosophers came to a realization of the truth which can be gained by reason from their considerable successes in the sphere of mathematics, a subject on which Cornford hardly touches. In any case, Cornford certainly did not suppose that medicine derived its tenets from shamanism or myth; and yet we find in the works of the very school which condemned philosophical theories (i.e. the Coan School, Ancient Medicine), hypotheses which go beyond the evidence of the senses, and, moreover, an insistence on the importance of reason.

The systems of philosophy and medicine which lasted longest, namely atomism and the practices of the Coan school, are the very ones which combined reason with sense-perception and even gave precedence to reason; and the failures of Greek science can be shown to be due to a lack of equilibrium between the two, to too great an insistence either on the collection of facts, as in the case of the Cnidian school, or on the use of reason separated from observation, as in the case of the Eleatics. Experience, observation

and experiment played an important part in Greek philosophy and medicine; without them the Greeks would never have made any progress in these sciences and we may say that the foundations of empirical science were laid by the Greeks; but their greatest achievement was the discovery of the value of the intellect which works upon the data provided by the senses. This, as Aristotle says,[1] is true τέχνη.

[1] Metaphys. I, 981a.

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