The First and Concluding Chapters from

THE ORIGINS OF ALCHEMY IN GRAECO-ROMAN EGYPT

by

Jack Lindsay

To
Marie Delcourt-Curvers

This solid flesh a circling smoke
in winds of bellying Time
haunts crevices of Space and seems
anchored here or there :
Men have thought the prospect strange
demonic scaring as they woke
from a ravishing crystalline dream
of abstract Eternities
to touch the edge of Change
where all Numbers twist and break :

yet Pattern lurks in the vanishing lair
of ragged particles. Alchemists
first kept the double vision and reckoned
as aspects of a single Stream
the Vortices of spinning mist
and the Structure of the unseizable second
when Life leaps upwards through the range
of fiery unstable Symmetries,
intricate dangerous Time.

Time
is the moving
image of Eternity
Plato remarked among the Stars.
Eternity
is the sudden
wholeness of Time
Apollo answers amid the Flowers.

J.L.

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AUTHOR’S NOTE

This is the fourth book of a series on the life and culture of Roman Egypt. It is, however, complete in itself, though naturally the more one knows of the period the more one is aware of its ways of thought and action, what it comes out of and what it is moving towards, and the richer becomes the background against which one views any particular aspect. The first book dealt with the more ordinary matters of daly life; the second with "leisure and pleasure" and the Dionysiac cult in its later phases; the third with the life on the Nile and the role of that river in Egyptian religion and world-outlook. Here I deal with the theory and practice of alchemy in its earlier centuries, its formative period. Egypt is centre of the picture, but to comprehend all the ideas and images flowing in to that centre we need to look also to the general trends in Greek scientific and philosophic thinking, and to the potent influences generated in the Iranian world of the Mazdean and Magian fire-cults.

Especially in the earlier phases the picture is involved and complex; but for this very reason the inquiry into what happened is in many ways all the more interesting. For we find an extremely rich and subtle merging of ideas and practices from a wide field to beget a new science, a new deep-going set of values and attitudes. With strange insight the Greeks intuited and sketched out systems of scientific thought which they were not able to explore with exact methods. Their atomist hypotheses are well-known; recently Sambursky has shown how the Stoics grasped the concept of fields of force, of continuous forces, of a cohesive and tensional continuum. I trust I have in turn shown how, amid much fantasy and confusion, the alchemists were not only the founders of experimental science, but also were struggling with ideas that belong to the future of science rather than its past.

J.L.

1: Greek Scientific Thought before Alchemy

If, as this book tries to show, the emergence of alchemy marked a deep crisis in ardent thought and science, a crisis which could not be resolved from within the given framework and its preconceptions, then it is clearly necessary to begin with a discussion of what was achieved in the Classical and Hellenistic periods, and what were the limitations of that achievement, what were the boundaries that it was found so difficult to cross. But Greek philosophy and science of the 5th and 4th centuries B.C., with their roots in the 6th and 7th centuries, are very rich and complex; and attempts to set them out in brief succinct definitions are liable to end by giving a very imperfect and devitalised effect of what actually happened. Still, the problem cannot be evaded. We must try to generalise on various aspects of the development, concentrating on the main issues that were raised and their relevance for the alchemic revolt.

We begin then with the 7th century, with the growth of Ionian thought which sought in various ways to explain the universe by finding its fundamental principles and substances (or substance), and by concentrating on natural phenomena; and the Pythagorean school of South Italy, which had the same end in view, but sought the explanation of reality in Number, in an abstract principle. As two important expressions of these opposing viewpoints in the 5th century we may take the atomic theory of Leukippos and Demokritos, which saw all bodies as composed of ultimate and indivisible elements or atoms moving in an empty space; and the hypothesis of the universe's construction by the Pythagorean Philolaos, who argued for a central condensed fire and an outer fire surrounding the spherical universe, which itself was divided into three spheres, *Olympos* (that of the fixed stars) *Cosmos* (with the planets, sun, moon,) and *Ouranos* (the sublunar region in which is the earth and a theoretical anti-earth, *Antichthon*). Philolaos also defined the elements in terms of geometrical figures: earth was made up by the cube, fire by the tetrahedron, air by the octahedron, water by the icosahedron, while a fifth element, which comprehended the others and was the bond of them all, was represented by the dodekahedron.

The Ionian thinkers had raised the question of what the universe was composed of, what single underlying substance--water or air or fire or some indefinable primary element, the *apeiron* (that without bounds or limits) of Anaximadros. Empedokles of Akragas in Sicily devised a theory of the elements working in a system of opposites, love and strife, attraction and repulsion; earth, water, fire, air floated in these two enclosing media which acted as material forces. At first there had been an harmonious spherical whole enveloped in Love, with strife extending on the outside. Strife absorbed the four elements, drove out Love, and created Chaos; but Love reasserted its power with a revolving motion; and in the central region, little affected by the universal rotation, the world was rebuilt. Air escaped first, but compressed by the limits of the universe it was changed into a hollow crystalline sphere; fire accumulated in one half of the sphere, making it luminous, while the other haft remained dark hence our earth, at the centre, sees the alternation of day and night. (Argument has gone on as to whether Empedokles saw the present world as belonging to the period of disorganisation by strife or to that of love-integration.[1]) Herakleitos had defined all things as moved by the unity and conflict of opposites; Empedokles sought to carry this sort of outlook into a detailed application of the struggles between the two conflicting forces, with Necessity as the sum of their activity, together with the "contract" that ties them together as they build and destroy---each of them limited by the effects of the other.

> Thus, Love brings forth at first partial assemblages with what it finds available at every point, and these assemblages undergo natural selection by virtue of Strife, which thus cooperates from the other side in creation; Love shapes forms out of drives caused by Strife, but also reabsorbs all varieties in the end, while later Strife sharpens, increases, articulates the variety brought forth by Love, yet to a destructive end. The forces remain constant in behaviour, but the fearful intricacies of their interaction give the effect of chance. The pattern of this interaction weaves together the obvious "intentionality", or shall we say functionality, seen in the order of life with the mechanical causality which ensures the over-all pulsation. Everywhere elements of matter and elements of function, of purpose and no-purpose,

> so to speak, are locked together in the universal mellay of process. (G. de Santillana) [2]

The emphasis put by Herakleitos and Empedokles on opposites or contraries continues in Greek thought, and is the source of both its greatest strengths and its greatest weaknesses. Aristotle, who makes the principle an insistent feature of his physics, declares that the theme was shared by Greek rational physics from the outset. [3] Indeed it could hardly have been otherwise; for in this matter the Greeks were carrying on the deepest and most pervasive element in primitive tribal thinking, where the dual organisation of society is reflected in every aspect of the way in which the universe and natural phenomena are regarded. [4]

The main bases of Greek thinking have thus been laid: (1) the idea of a *unitary process* in nature, of some *ultimate substance* out of which all things are built up, (2) the idea of a *conflict of opposites* which are held together by the overriding unity, as the force driving the universe onwards, (3) the idea of a definite structure in the ultimate components of matter, whether this structure is expressed by varying aggregates of atoms (*atomon*, indivisible unit) or by combinations of a set of basic geometrical forms at the atomic level. The two first positions were derived from the forms of thought created over very long periods by tribal society as it grew aware of its unity with, and its difference from, nature. The third idea was the product of a society in which individualism with all its small local conflicts, endlessly splitting up the general interest, had been born--above all, a society in which money-systems and mathematics had arrived as the expression of the new divisive forces inside the overriding unity, the strongly surviving tribal elements.

The whole of classical thinking was determined by the forms in which the problems of man and nature were thus presented. Action, movement, and change could be recognised and considered only under the categories devised out of general ideas of the unity of process and the conflict of opposites within that unity; but the thinkers were quite unable to arrive at concepts of causality in the sense of that term in the post-Galilean epoch. They could not fuse in any effective way the idea of the unity and conflict of opposites with that of the atomic substratum of reality. They saw the individual as a summation of a simple whole, as embodying the unity of society, not that unity together with its inner conflicts which linked him with the other individuals in a complex situation of agreement and dissent, likeness and unlikeness, union and opposition. They had carried too directly and uncritically a tribal concept or image into a society divided by all sorts of discords, conflicts, divisions of class, property, and power. The individual (person or object) was seen as a sort of large-scale atom, complete in himself or itself. Men did not inquire how each individual acted on another and affected him, or how objects impacted in motion; they thus avoided all problems of mechanical causation and the many connected matters. Instead, they asked what the nature of substance or identity was, and what were the links between the forms taken by substance. Relations thus became of extreme importance--but *relations regarded under the aspect of the powers or capacities of action residing inside the subject*. "Relations were assumed to have the status of attributes securely anchored in the independently existing substance" (Cornford).[5] Aristotle indeed has much to say of causes, but what he considers under this term is *form* and *matter*–that is, the internal constituents into which a total thing can be analysed. He sees three kinds of change: locomotion, or the movement from one place to another; growth or diminution, a change in quantity; alteration, a change in quality. So all changes are defined and explained in terms of the likeness or unlikeness of the things undergoing changes. We get comparisons of this sort, but not any precise computation defining the mechanics or dynamics of one object acting on another. Demokritos evolved his idea of atomic aggregations on the basis of *like to like*:

> All animals alike herd together with their own kind: doves with doves and cranes with cranes. And so it is with inanimate things, as you may see in the case of grains shaken in a sieve or the pebbles on the shore. The whirling motions of the sieve arranges the grains in distinct groups, lentils with lentils, barley with barley, wheat with wheat; and the motion of the waves rolls all the long shaped pebbles into one place, all the round ones into another, showing that the likeness of things tends to draw them together.[6]

And Leukippos remarked that the atoms, circling in the cosmic eddy, were "separated apart, like to like". Clearly the principle is drawn from some deep emotional need or predisposition, not from observation. If Demokritos had really watched the pebbles being rolled about on the beach, he would have noted the role of weight and size, rather than likeness in form, in determining the distribution. These examples might be indefinitely added to bring out the overwhelming predisposition of the Greek mind to find and apply the principle of "like to like". The Hippokratean treatise *On the Constitution of Children* accounts for the growth of various parts of the body from the seed on the principle of like to like: dense to dense, rare to rare, and so on. "Each thing moves into its proper place according to its own affinity.'' [7] The Hermetic work *Aphrodite* deals with the question why children look like their parents. The likeness is assumed; there is no question of glancing at children themselves and asking if they do in fact resemble the parents–as often they do not.

> When nutritive blood turns into a foam [? secretion] and the genital organs have provided seed, there is exhaled so to speak from the members of the whole body a certain substance, under the action of a divine force, as if it were the same man being born, and the same likeness results in the case of the woman. When the exhalation from the male dominates and remains intact, the babe is born resembling the father, just as, if the conditions are reversed, it will similarly resemble the mother. [8]

The ancients were thus primarily interested in *qualities*: what was like or unlike in various objects. *Quantities* such as weight seemed unimportant. In cosmic terms they saw the merging or separation of substances or elements with qualitative aspects such as hotness and coldness, wetness and dryness–or, when they dealt with atoms, similarities or differences in shape. Therefore the notions of heaviness or lightness were subsidiary, invoked only incidentally in describing the behaviour of like attracted to like or unlike repelled from unlike. Plato carried on the Empedoklean principle by which the scattered oddments of each element were always seen as rejoining the main mass. Weighing appears as a sort of violence done to the nature of substances:

> When we weigh earthy substances, we forcibly lift them into an unlike region [air] against their natural tendency, and they cling to their own kind. But the lesser bulk is more easily constrained than the greater and moves more quickly into the unlike region. Hence we have come to call such a bulk light and the region to which we constrain it up, and to call the opposites heavy and down .... So these determinatives must be variable and relative .... The passage of each body towards the kindred-aggregate gives the name heavy to the moving body and down to the direction of the movement.

Aristotle similarly refused to allow heaviness or lightness to be regarded as primary properties or powers of nature; they merely derived, he thought, from the tendency of simple bodies to make for their own proper region---earth to earth, air to air, and so on. So he lacked the basis for even beginning to work out any laws of movement, let alone a theory of gravitation. Things were moved by the attraction of likeness, not for any reasons of weight or mass. A free-falling body was seen as only one more example of the desire or need of unformed matter (potentiality) to reach the actuality of its form, as in the case of a seed becoming a fruit bearing tree. Only when a body has reached its "natural place" at rest has it attained the completion of its form (lightness or heaviness). [9]

In Greek physics weight was thus the innate force of a body producing its natural motion towards its natural place at the centre of the earth; and the weight of a body was often compared to the human soul. Just as a man was considered to move and act by virtue of his soul (i.e. his form or *eidos*), so a heavy body moved downwards by virtue of its weight, which also was nothing other than its eidos.

So much for movement in space. As for changes in size, which are of great significance with regard to processes of nutrition and growth in organic bodies, Empedokles, Anaxagoras, and Plato all again invoked the cosmic principle of like calling to like. "All the tissues," says Plato, "as they are irrigated with the blood, repair what they have lost by evacuation. The character of this depletion and restoration is the same as that of the movement of the universe, where all things go towards their own kind.''[10] Again, as for alteration in quality, Demokritos held that "agent and patient must be the same or alike; for if different things act on one another, it is only accidentally by virtue of some identical property." Aristotle said only Demokritos insisted that like alone could act on like, but elsewhere he saw the same principle in Empedokles' doctrine of perception; and Theophrastos attributed it also to Diogenes of Apollonia.[11] Here indeed most thinkers took the opposing view: that unlikes affected one another, *e.g.*, the heat of fire warmed cold hands. But they were all agreed in looking for qualities which affected other qualities.

In early theories of knowledge the like-affects-like formula was widely accepted. "The physical philosophers," says Sextus, "have a doctrine of high antiquity that like things are capable of knowing one another.''[12] Empedokles declared, "By earth we see earth, by water water," and so on. When attempts were made to explain perception by the passage of effluvia or exhalations from an object to the affected sense-organs, this outlook was given a new force. Like was considered to move to like. Theophrastos adds a further reason: "It is natural for all living creatures to recognise creatures of their own kind." In later antiquity, partly through the influence of Stoicism, which we shall soon examine, the idea of magical concordances and harmonies of force or influence entangling the whole universe in one vast and infinitely complicated network was general. Thus the Neoplatonist Plotinos says:

> How are magical practices to be explained? By sympathy, by the existence of a concordance of like things and a contrariety of unlike things, and by a diversity of many operative powers in the one living universe. Without any external contrivance, there is much drawing and spell-binding. The true magic is the Love and Strife in the universe. In magical practices men turn all this to their own uses.[13]

He uses the same terms, *Philia* and *Neikos*, as did Empedokles nearly 700 years earlier.

I have stressed the fact that certain preoccupations born from the social situation, from the whole way of life of the Greeks, held them up from breaking through into new fundamental positions. It was not any exhaustion of mathematics itself that caused the hold-up, as is often stated. With the least change in social pressures, there was a continual ferment of ideas and methods, which seem for a moment as if the leap into new positions is about to take place. An inability to conceptualise (to grasp as a general factor free for application ha new ways) the rate-of-change of the ram-of-change is what separates Archimedes from Newton by a barrier that the former could never cross.

> Purely mathematically, there is nothing in Newton's *Principia* that was not familiar to Archimedes, except the notion of the rate of change of a velocity. And even here, only the notion was alien to Archimedes, and not the power for formalising the notion mathematically, if by some reversal of history it had come within his purview. In fact, purely mathematically Archimedes was much better equipped for dealing with it formally than was Newton, seeing that Newton did not manage to define really rigorously the notions of velocity and acceleration to the very end of his days. (Bochner)[14]

One characteristic of Greek society in almost all fields was the carrying-over of tribal ideas and methods of organisation, thought the rapid development of the system kept lifting these ideas and methods on to new levels, with new centres and applications. Hence, as I have argued, the confusion induced by attributing to the new "atomic individual" with all his great powers of initiative (and also of discord and violent self-assertion) the simple refraction of the social whole which had been substantially true in fir-back days of tribal brotherhood and equality. A key aspect of the divisions introduced into society, denying the simple refraction, was the advent of the cash-nexus, of money-values continually disrupting old relationships and balances; another was the growth of slavery in all sorts of new forms outside its primitive aspect of chettel-slavery. The slave was the obvious example of a man reduced to a thing, the complete reflection of the cash-nexus with its "thingification" of relationships. The existence of large numbers of slaves, on whom was concentrated the burden of manual labour, meant that the slave (a thing, not a man) represented the mechanistic principle of his society. The use of a man-machine had obvious limits in comparison with the machine proper; but the latter, with its necessary mathematical and other scientific bases, could only develop in a society that felt the pressures urgently making for productive advances, yet could not put the burden simply on the man-machine. Hence the way in which the 17th century initiated the forms of modern science making possible the large-scale invention and application of all sorts of machine-extensions of the human frame. Slavery as it existed in the Graeco-Roman world created a social and psychological barrier to the development of mechanics and dynamics in the post-Galilean sense. Not that we must think of it as a sort of external system unfortunately imposed on its societies. In the last resort it proceeded, not out of any purely economic motivation or need, but out of the total human situation, which in turn it affected and modified. The concept of the "atomic individual" as the free man (with all its virtues of liberating men from ardent constraints) had as its reverse side the concept of the man-thing or man-mechanism; the new sense of freedom was dogged all the time by an increasing sense of fate or necessity. Hence the dilemma of Greek thought, which on the one hand was richly aware of the patterns of change and on the other hand could not advance from dialectical generalisations to applications in mechanics and dynamics.

The only quantitative formula which Aristotle attempted assumed a proportionality, not between force and acceleration, but between force and velocity. This was equivalent to saying, incorrectly, that the force is equal to the product of load and velocity--as against Newton's second law, in which acceleration takes the place of velocity. That is, Aristotle, like every other ancient thinker, was quite blank as to the existence of friction as an opposing force to be considered when defining relations between forces as causes-of-motion and the motions that in fact resulted. (The sole exception was Themistios in the later 4th century A.D., who remarked, "Generally it is easier to further the motion of a moving body than to move a body at rest.") Aristotle, considering men at work hauling a ship over land, saw as the only two factors the weight of the boat and the hauling powers of the men. These two factors were imagined as existing in a sort of vacuum, with all other factors (friction) eliminated. The notion of the men as abstract things or machines inhibited the thinker from approaching the situation coherently and discovering the actual laws of mechanics) [15]

It is perhaps not going too far if we link the Greek refusal to consider the mathematical forms that would have led to mechanics of the Galilean type (or the phenomena that led to the mathematics), with the hatred of the dominant thinkers for any form of equality. Ploutarch in a discussion on Plato's statement (authentic or apocryphal) that "God is always busy geometrising", makes one of his speakers remark:

> For the Equality aimed at by the many [arithmetical equality] is the greatest of all injustices, and God has removed it out of the world as being unattainable. But he protects and maintains the distribution of things according to merit, determining it geometrically, that is, in accordance with proportion and law.[16]

Hence the liking for geometrical systems, such as we find in Philolaos and Plato, where one set can be considered superior to another. Certainly Plato and Aristotle held strong views that the distribution of things to persons of unequal merit was unequal. The linking of social and intellectual positions in this relation is not so odd as may seem at first sight when we recollect how much the Pythagoreans' concepts of "proportion and law" were determined or stimulated by their political struggle as a middle force against both aristocrats and plebeians. Once such a bias had been established, a bias that was powerfully in accord with the emotional outlook of the main thinkers of the classical period, it became almost too deeply rooted to be questioned. To estimate its strength we must again link it with the whole psychological and intellectual complex set up by the existence of slavery. In defending the rejection of juridical equality by the Roman system, Cicero attacked as unequal that kind of equality which "does not recognise grades of dignity".[17] Such an attitude, pervading all the spheres of thought and emotion, was a second nature for the dominant class and its spokesmen, and affected th whole of society, limiting even the attempts at revolt.

The Greeks developed mathematics incomparably beyond the level reached by the previous most talented practitioners, the Babylonians; but despite all the new ground they broke, th limitations of outlook sketched above laid down in the law, resort the extent to which development here too was possible. Because of the concentration on the isolated object and il qualities, its form, geometry played a key part in the scientific approach and in defining the limits of mathematical expansion In the detailed development over the centuries the results were highly complex; for there was every now and then a strong chafing against the barriers, momentary flashes of deeper insight or the promise of methods that would in fact break through above all by the Stoics and then by Neoplatonists of later antiquity But always the barriers rose up again and prevented any effective application of the new ideas. The sort of dilemma that kept coming up may be illustrated from a paradox set out by Demokritos:

> If a cone were cut by a plane parallel to the base, what must we think of the surface of the sections? Are they equal or unequal? For if unequal, they will make the cone irregular, as have many indentations, like steps, and unevennesses; but if they are equal, the sections will be equal, and the cone will appear to have the property of the cylinder and to be made up of equal, not unequal circles, which is quite absurd) [18]

His problem could not be met within the static concepts of atomic lengths, i.e. of constant magnitudes, however small those magnitudes were conceived. The instrument for solving the query could only be provided by the dynamic concept of the limiting process and the other notions of the infinitesimal calculus. The Stoic Chrysippos did evolve a conception of the limiting process that made possible a deeper grasp of the nature of infinite sequences of inscribed and circumscribed figures, which Greek mathematicians cautiously evaded when using methods of exhaustion. But the sort of breakthrough that came with Galileo and Newton did not happen, and could not happen, in a world where there were so many assumptions and methods based in the older classical positions.

Astronomy was the field where the method was fully mathematical. Other branches of research acquired varying degrees of mathematical expression. Aristotle knew already a science of Optics subordinate to geometry and Harmonics subordinate to arithmetic, not to mention a Mechanics subordinate to three-dimensional geometry; and remarks of his show that the Pythagoreans visualised some sort of mathematising of physics.[19] But this was never brought about. Archimedes' laws on the balancing of the lever and on floating bodies pertain to mathematical physics and were the first of their kind, but they did not bring about any further movement in the same direction.[20] He and his followers arrived in some covert and unexplained way at the concept of the statical moment, but they left the concept untouched and unquestioned in their formulations. It was not conceptualised–that is, consciously grasped in its implications--till the 17th century. In the same way the Greek could not form a notion of the relation of relation, the property of properties, the aggregate of aggregates. Aristotle even polemised sharply against the possibility of a motion of motion.[21] Archimedes lacked coordinate systems or mathematical functions; still in *On Spirals* he came close in his own way to forming the derivative of a function:

$$dy/dx = df/dx \qquad (1) \qquad :$$

> which is the mathematical prerequirement for the "abstract" conceptualisation of the notion of velocity. However, in order to advance to the concept of acceleration, one has to be able to form a second derivative. This requires that one form the derivative (x) at each and every point x, then view the resulting mathematical object as a new function in x, and then apply the "abstract" process of differentiation to this new function again. It is this kind of interation of logico-ontological abstractions to which Greek thinking was never able to penetrate to any noticeable extent (Bochner). [22]

But we do not want to go into detailed mathematics here. We are concerned with the general points; and what has been said above will suffice to bring out on the one hand the limitations imposed on Greek scientific thinking by certain deep preconceptions, ultimately social in origin, and on the other hand the way in which they chafed against the limitations at various times but could not break through and establish new basic positions from which to advance in new directions.

How far late antiquity was able to devise a programme of theoretical physics without being able to put it into action can be gauged from a passage in Iamblichos (who died about A.D. 330):

> Sometimes it is also the practise of mathematical science to attack perceptible things with mathematical methods, such as the problem of the four elements, with geometry or arithmetic or with the methods of harmony, and similarly other problems. And as mathematics is prior to nature, it constricts its laws as derived from prior causes.
>
> This it does in several ways: either by *abstraction*, which means stripping the form involved in matter from the consideration of matter; or by *unification*, which means by introducing mathematical concepts into the physical objects and joining them together; or by *completion*, which means by adding the missing part to the corporeal forms which are not complete and thus making them complete; or by *representation*, which means looking at the equal and symmetrical things among the changing objects from the viewpoint whence they can be best compared with mathematical forms; or by *participation*, which means considering how concepts in other things participate in a certain way in the pure concepts; or by giving *significance*, which means by becoming aware of a faint trace of a mathematical form taking shape in the realm of perceptible objects; or by *division*, which means considering the one and indivisible mathematical form as divided and plurified among individual things; or by *comparison*, which means looking at the pure forms of mathematics and those of perceptible objects and comparing them; or by *causal approach* from prior things, which means positing mathematical things as causes and examining together how the objects of the perceptible world arose from them.
>
> In this manner, I believe, we can mathematically attack everything in nature and in the world of change. [23]

For our purpose the most important work by Plato was the *Timaios* in which he set out his cosmogony, his scheme of physics. He draws a bold and complex picture of the creation of the universe by the *demiurge* (a word he took from Philolaos). He makes no reference to Demokritos, probably through contempt for mechanistic systems; yet he draws from him the assumption that the phenomena known to our senses are rooted in discrete invisible elements, whose aggregates and interactions cause or underlie all physical occurrence. However grudgingly, his theory is an atomic one. From the Pythagoreans however he takes the assumption that Number forms the basis of all physical events. He holds that there are certain symmetries in the structure of matter, so that the correct approach is one of three-dimensional geometry. Not that he sees simple systems of order. In his universe there is a deep and ceaseless struggle of the uniform and the nonuniform, the ordered and the disordered, which we can best describe as a struggle of the symmetrical and asymmetrical aspects of structure. He himself uses these terms:

> All that is good is beautiful, and the beautiful is not without measure. ... Of symmetries we distinguish and reason about those that are small, but of the most important and the greatest we have no rational comprehension. With respect to health and disease, virtue and vice there is no symmetry or lack of symmetry greater than that which exists between the soul itself and the body itself. [24]

Asymmetry or non-uniform combinations and structure bring about instability and change. Speaking of Fire he writes:

> Now the liquid kind, in so far as it partakes of those small water particles which are unequal, is mobile

> both in itself and by external force resulting from its non-uniformity and the shape of its figuration [the *idea* of its *schema*]. But the other kind, composed of large uniform particles, is more stable than the first, and is heavy, being solidified by its uniformity; but when fire enters and dissolves it, this causes it to abandon its uniformity; and when this is lost, it partakes more largely of motion. And when it has become mobile, it is pushed by the adjacent air and extended upon the earth. For each modification [*pathos*] it has received a descriptive term: *Melting* and *Fluidity* for its extension over the earth. [25]

For the four elements he followed Philolaos in taking four perfect bodies, omitting the fifth one for which he had no use. He made the same correlations as Philolaos. Wanting to explain transitions from liquid to gaseous states and back again, he needed common features in all or some of the four elements in order to show how one could change into another. The first three figures were all bounded by equilateral triangles, which permitted the establishment of relations between them; the cube was however bounded by squares so that it could not be resolved into such triangles by further division. So there was no transition from earth to fire, air, or water. Still, Plato did not take the equilateral triangle or square as his basic structural unit; instead he divided all his elements into rectangular triangles. The advantage of the breakdown into small structural units was that sets of equilateral triangles or squares of varying and increasing sizes could be constructed, to represent the series of elementary bodies of different sizes. Plato was also thus able to differentiate between various kinds of fire (including light) and so on. But within each series the tetrahedron was the smallest body, being made up of the least number of triangles; it thus provided two of fire's characteristics: mobility (smallness) and penetrability (sharpness of the solid angle). Demokritos had had to suppose that two separate properties were owned by fire; smallness and sphericity; Plato reduced them to a single basis.

We are not sure how much detail he borrowed from Philolaos; but in general we may say that he first worked out a scheme of interlocked structures in matter which permitted the change of one element into another. He may then be claimed as the founder of alchemy as a science, even if it was to take some time before the implications were worked out. He saw metals as the product of fusible water (not to be identified with ordinary water).

> Of all the kinds of water we have termed fusible, the densest is produced from the Finest and most uniform particles: this is a kind of unique form, tinged with a glittering yellow hue, even that most precious of possessions, *Gold*, which has been strained through stones and solidified. And the offshoot of Gold, very hard because of its density and black in colour, is called *adamas* [perhaps hematite or platinum].
>
> And the kind that closely resembles gold in its particles but has more forms than one, and in density is more dense than gold, and partakes of small and fine portions of earth (so that it hardens), while it is also lighter because of the large interstices within it, this particular kind of solid waters, being thus compounded, is termed *Bronze*. And the portion of earth that it is mixed with becomes distinct by itself, when both grow old and separate again from each other; and then it is named *Rust* [*ios*]. [26]

There is a strong suggestion of the possibility of the transmutation of metals with special reference to gold. "Now imagine a man modelling all possible figures out of gold and then proceeding without stop to remodel each of these into every other, if someone were to point to one of the figures and ask what it is, by far the safest answer in point of truth would be that it is gold." Only "the substratum which receives all bodies" is stable and constant. [27]
We may note too the important role of fire, which suggests metallurgical process as does the very term "fusible water".

> As the fire, on issuing from the water, does not pass into a void but presses on the adjacent air, this in turn compresses the liquid mass which is still mobile into the abodes of fire and combines it with itself; and the mass, thus compressed and again regaining its uniformity, through the departure of the fire, the

> author of its non-uniformity, returns to the state of self-identity [symmetry]. And this cessation of fire is termed Cooling, and the combination that follows on its departure *Solidification*. [28]

It is important to note that the essential ideas of cosmic creation or natural process are all drawn from human crafts and industries. The term for the creator (or fundamental creative activity) is *demiourgos*, craftsman. Like all ancient thinkers (and many others besides), Plato assumes that any form of purposive movement or significant development implies a prior act of decision carried out by a person; he cannot rise to the concept of purpose as born out of the totality of a situation with its inner formative process, even though he himself has shown how development could occur through the symmetry-asymmetry principle. His demiurge works by a *paradeigma* or pattern, a term used by Herodotos for an architect's model or plan of a building, or for samples, e.g. of mummies made of wood. The term is also used for a sculptor's or painter's model. Plato himself uses the metaphor of modelling, as in the passage cited about gold and elsewhere: "Ben the generating Father perceived it [the cosmos] in motion and alive, an *agalma* [honour, statue in honour of the gods], he too rejoiced, and, well pleased, designed to make it resemble its *paradeigma* yet more closely."[29] He also draws on the techniques of perfume making. Substance is voided of all forms "just as with all fragrant ointment men bring about the condition by craft, *technë*, to make the odours as odourless as possible; and all who set out to mould figures in any soft materials wholly refuse to allow any previous figure to remain visible in it, and begin by making it as smooth as possible before they carry out their work." [30] He also uses the analogy of winnowing with a sieve to explain how the particles separate and fly about, the dissimilar driven apart, the similar drawing together. [31] In a play on words he brings out how the term *apeiros* suggests the unskilled as well as the unlimited or chaotic: that is, it represents the world before craft-skill (formative process) gets to work on it.[32]

Besides the principle of symmetry-asymmetry as the source of movement and development. Plato also uses his triadic formula. "It is not possible for two things to be joined together without third." On the principle of like-to-like he states that the triad nature of the soul (its fusion of Identity, Otherness, and Essence is reflected in the structure of the universe. He puts the point in: idealist way, turning the abstractions into substances and gives them as plastic material to the demiurge to make souls out of; but the notion of a triadic movement both in the soul and in nature making a dialectical unity of all process, is nonetheless present.[33]

We now come to two aspects of Aristotle's thought that concern us: the way in which he developed the scheme of elements able to move round or be combined in various ways, and his definition of metals and stones. He supposed the ultimate basis to be a primitive matter or *prima materia*, which had only potential existence till impressed by form. Form was not only the geometrical structure but also the total inner organisation of a thing; it was the sum of its qualities and properties, and gave it its identity. In its simple; manifestation it turned the primal matter into the four elements, fire, air, water, earth, through a variation of qualifies arising from heat and cold, fluidity and dryness. Each element had two of these qualities and no more. But the opposites, heat and cold, dryness and fluidity, could not be mated. So the four possible sets of combinations were: hot and dry (fire), hot and fluid (air), cold and fluid (water), cold and dry (earth). In every element one quality dominated: dryness in earth, coldness in water, fluidity in air, heat in fire. Through the medium of shared qualities one element could pass into another, *e.g.*, fire into air through the heat they shared, and so on. Two elements could pass together into a third through each discarding one quality, as long as the effect was no to leave two identical or two contrary qualities. Thus, air and earth, by dropping fluidity and cold, could produce fire (heat and dryness). Aristotle taught that what was changed was only the form; the underlying matter was always the same.[34]

Plato definitely bases his system of changes in matter on variations and combinations of geometrical structures, which are capable of mathematical definition. Aristotle appears to assume varying arithmetical combinations of the different elements, plus similar sorts of variation inside an element; but he gives no clue for example, as to how an element discards one of its qualifies *e.g.*, how air drops its fluidity and earth its coldness so that the two of them may produce fire. Neither are we given any idea how the proportions work out in any precise way in substances:

> They contain earth because every simple body is specially and most abundantly in its own place. And they all contain water because the compound must possess a definite outline and water alone of the simple bodies is readily adaptable in shape. Moreover earth has no power of cohesion without the moist. On the contrary the moist is what holds it together. It would fall to pieces if the moist were completely eliminated from it.
>
> They contain earth and water then for the reasons given; and they contain air and fire because these are contrary to earth and water-earth being contrary to air and water to fire, in so far as one substance can be contrary to another. Now all compounds presuppose in their coming-to-be constituents which are contrary to one another; and in all compounds there is contained one set of the contrasted extremes, i.e. cold-dry [earth] and cold-fluid [water]. Hence the other set [hot-fluid, air, and hot-dry, fire] must be contained in them also, so that every compound will include all the simple bodies.[35]

So deep-rooted is the concept of any body as involving a union of opposites that Aristotle assumes it in his exposition. He imagines the cosmos as made up of 59 concentric spheres, with the earth at the centre, water making up the next sphere, then air, then fire-though with no hard boundary-lines. Each element has a natural tendency to move to its own place. The union of contraries prevents what he has called "excesses". If earth gathers in excess, it will destroy the intermovements among the elements which create reality and its diversity of objects; and so on with each element. In fact then we find an enormous number of distinct compounds, though any one of them will be changed into any other if we alter the relative proportions of the composing elements in the required direction.

As for metals they are born of exhalations. Vaporous exhalation is moist and cold, produced when the sun's rays fall on water; the smoky is hot and dry, produced by the rays falling on dry land. In actuality the two vapours mix in varying degrees. The heat of the dry one causes minerals, stones that cannot be melted such as realgar (arsenious sulphide), ochre and ruddle (clayey iron oxides), and sulphur. The heat of the moist one causes metals, which are fusible or malleable, such as iron, copper, gold. Though metals and minerals like all things contain something of all four elements, water and air (chiefly water) predominate in metals, and earth and fire (chiefly earth) in minerals.[36] (The alchemists identified the dry vapour with sulphur, the moist with mercury, and developed the theory that all metals were made up of mercury and sulphur.) Aristotle distinguished chemical combination, *mixis*, and mechanical mixture, *synthesis*; the *mixis* of liquids had its own term, *krasis*. However his notion of chemical combination (as in drugs) was unclear. He thought it a kind of mutual assimilation if the components managed to form a homogeneous whole, and so was led to insist that a weak component was merely absorbed by a stronger one–without working out any ratios for such a situation to develop.[37]

Exhalation is compressed (*i.e.*, condensed) by the dryness of the rocks, and congealed or solidified, apparently by cold. The admixture of dry exhalation however prevents the metal from reverting to water. "All metals are thus affected by fire and contain earth, since they all contain the dry exhalation. Only gold is unaffected by fire." The exposure to fire makes metal produce dross and change colour; Olympiodoros adds that for the same reason they rust. The presence of earthy matter thus explains the difference between the baser and more precious metals.' Gold, with the least amount of dry exhalation, is at one end of the scale, and iron, with the largest amount, at the other. Aristotle did not make this point, but it was duly noted by the alchemists.[38]

Theophrastos in *On Stones* worked these positions out further. Stones and (mined) earths are made of earth as metals of water. The earth becomes a pure and uniform matter as the result of a conflux, when it is a lump, or of filtering, when it is in veins, or of some other process of separation. This uniform matter, subjected to heat or cold, undergoes solidification and forms the stones or mined earths. At what stage is colour thought to be brought in? At the stage of making matter uniform or that of solidification? Presumably at either or both. But there seems an idea that only solidification by heat will beget a change in colour at the final stage of formation; for the change of yellow ochre into red gets the comment, "Fire would appear to be the agent responsible for all these transformations." In the *Timaios* Plato had taken colour to be a fire itself, which owns particles "so proportioned to the visual stream as to produce sensation". Colour effects are brought about by the differing sizes of the particles, which dilate or contract the visual stream.[39] There was a strong fire-element also in Aristotle's smoky exhalation, "the most inflammable of substances", and "potentially like fire". He admits that it was something hard for us to envisage, but in some of its states it was fiery and in others not unlike a gas. Hence, once thinkers took an active relation to natural processes and wanted to repeat them in a laboratory, it was natural they should turn to fire, to fusion and distillation, in the attempt to change one metal into another.[40]

There was already indeed a clear idea that art (*technë*, which embraced any sort of craft-activity, including scientific experiment) was a way of learning to understand and control process by reproducing it under man-made conditions. Thus Theophrastos remarks, in connection with one of the colour-discoveries which played an important part in developing the alchemic idea:

> Here [a spot above Ephesos where alone cinnabar was manufactured] a sand which glows like the scarlet kermes-berrles is collected and thoroughly pounded to a very fine powder in stone vessels. It is then washed in copper vessels and the sediment is taken, pounded and washed again. There is a knack in doing this, for from an equal amount of material some workers secure a great amount of cinnabar, and others little or none. However, use is made of the washings that float above, especially as a wallpaint. The sediment which forms below turns out to be cinnabar, while all that is above, which is the great part, is merely washings.
>
> The process is said to have been invented and studied by Kallias an Athenian from the silvermines, who collected and studied the sand, thinking it contained gold owing to its glowing appearance. But when he found it contained no gold, he still admired its fine colour and so came to discover the process, which is by no means an old one, but dates back some 50 years before the Archonship of Praxiboulos at Athens.
>
> From these examples it is dear that *technë* imitates nature, *physis*, and yet produces its own peculiar substances, some for utility, some merely for their appearance like wallpaint, and some for both purposes, like quicksilver--for even this has its uses. It is made by pounding cinnabar with vinegar in a copper mortar with a copper pestle. And perhaps one might find several things of this kind.[41]

We see then that both Plato and Aristotle played a leading part in popularizing the idea that matter was composed of elements which could be changed into one another. The Aristotelean formulation in particular became very widely known and accepted. Plato's *Timaios* however received a new and deepened attention with the rise of Alchemy, Gnosticism and Neoplatonic philosophy in general.

There is one more important line of thought which we must glance at before we turn to alchemy itself: that of the Stoics. Stoic philosophy was the great creation which came up to sustain men's minds after the breakdown of the city-state and the philosophic forms derived from the way of life there. The free expansion of thought and art which had occurred in archaic and classical Greek cannot be separated from the successful building up of the city-states, their elimination of the kingship and the heavy hieratic culture which had everywhere accompanied growth of kingly state-forms. But now, after Alexander Great, the kingship had been imposed after all. The imposition occurred, however, on a culture which had been developed in city-state's days; and the result was therefore complex. The Stoics on the whole expressed the positive side of the situation, doing their best to get rid of what I have called the atomic individual or object. However, under ancient conditions the isolation of the individual in his specific form, his qualities attributes considered as a sort of self-generated entity, could not be overcome. The Stoic in one sense was more than ever driven back into himself, needing to work out an ethic of self-sufficiency, endurance, and *apatheia*; but in his struggle against isolation he produced a new conception of the unity of process and of interrelation of objects or beings inside it.

The key-concept was enclosed in the term *pneuma* (breath, often a synonym for air), defining the pervasive substratum in a cohesive universe, which, unlike Aristotle's, was surrounded by a void. For Aristotle, coherence, *syntecheia*, involved the notion of continuity in a geometrical or contiguous sense; the Stoics now gave the term a sense of dynamic cohesion in the physical world. The concept of *pneuma* had had a long history. Anaximenes, with his notion of the universe evolved out of air by condensation and rarefaction, declared, "As our soul, being air, holds us together, so do breath and air surround the whole universe." There was also in *pneuma* an association of in-and-out movement, of breathing, a rhythmic participation in the life-process. For the Stoics *pneuma* was air and fire, active elements or forces of cold and heat; they added the qualities of dry and moist in order to distinguish between the *pneuma* of the soul and that of plants, *physis*. The former *pneuma* was dry and warm; the latter moist and cold.[42]

The familiar Stoic aphorism, "Nature is a *technikon* fire, going on its way to creation," stated emphatically the unity of craft-method and natural process. *Technikon* means "working like art, like craft". Hippokrates had spoken of "innate heat", and Galen took this to be the cause of metabolism. The Stoic Kleanthes declared, "This element of heat possesses in itself a vital force that pervades the whole universe."[43] Matter was seen as of two kinds, *hyle*-like or passive, and *pneuma*-like or actively cohesive. Coherence was a positive force, *synetike dynamis*; and *pneuma*-like matter was characterised by tension, *tonos*, an inner heat of fire. As *pneuma* entered into organic and inorganic matter alike with its admixture of air and fire, it pervaded the whole universe and made it a single inter-related unit drawn together by an endless series of tensions. In the consistent linking of *pneuma* with *tonos* the Stoics made their greatest and most characteristic contribution to scientific thought.[44]

Pneuma, as an active force, generated all the physical qualifies of matter. Thus

> the Stoics generalised their continuum theory into a field theory; the pneuma is the physical field which is the carrier of all specific properties of material bodies, and cohesion as such thus gets a more specific meaning by becoming *hexis*, the physical state of the body. The following quotation from Chrysippos' *On Physical States* is very instructive:
>
> "The physical states are nothing else but spirits, because the bodies are made cohesive by them. And the binding air is the cause for those bound into such a state being imbued with a certain property which is called hardness in iron, solidity in stone, brightness in silver."
>
> And a little later he continues, "Matter, being inert, by itself and sluggish, is the substratum of the properties, which are *pneumata* and air-like tensions giving definite form to those parts of matter in which they reside."
>
> This gives some idea of the central position in the Stoic theory of matter of *hexis*, which denotes the structure of inorganic matter in a similar way to which *physis* expresses organic structure, and psyche the structure of the living being. (Sambursky).[45]

Inorganic entities were classified as discrete, contiguous and unified. Discrete entities might be in disorder or in a certain kind of order (like soldiers on parade); contiguous were conjoined, like chain-links or stones in a wall; unified, like a stone or a metal "ruled by a single state". The co-existence of the elements in the highest structure was *sympathei*a. A living body was a form of unified structure: Galen describes the faculties of the human body as structural elements of its physiology, extending throughout its totality.[46]

There are many more important aspects of Stoic physical theory; but here we may add three more points. First, each soul had an *hegemonikon*, a dominant part (generally considered the heart), The *hegemonikon* centralised and coordinated impressions, lifted them into consciousness, and set off the reacting impulses and actions. Secondly, that there were four successive stages thought to take place of increasing specification of an object, each stage including those that had happened before it. These were *substratum* (shapeless passive matter); *quality* (which the pervasive *pneuma* was imbued); state (the sum total of components, air and fire, in their varying proportions); and *relative* (determining the relation between the physical states of different bodies). It has been pointed out how well these categories correspond to the methodological scheme of Newtonian dynamics. Simplikios divided the fourth stage into two kinds of relations: relative state (defined by that of another thing outside the object) and relative, which referred to things capable of change (e.g. bitter and sweet). *Hexis* was an example of the relative, expressing the physical continuum that covered an infinity of differing states, each of which could evolve from the other by a continuous transition brought about through "the change of the former quality". Such a development involved a series of changes in the pneumatic tensions permeating the body in question. Thirdly, as we would expect from the notions of *pneuma, hexis*, and *tonos*, the Stoics deepened the whole concept of mixture. Fusion, as distinct from Aristotelean composition, they saw as a total mixture, "Whereby," as Plotinos, dissenting, said, "there is no part of the mixed substance which does not participate in the mixture as a whole." In order to show their opposition to Aristotle, Chrysippos stated, "There is nothing to prevent one drop of wine from mixing with the whole sea," and the Stoics were much interested in cases of extreme dilution: gold finely suspended in certain drugs or burnt frankincense rarefied in a vast volume of air.[47]

The Platonic, Aristotelean, and Stoic ideas that we have here outlined all played an important part in the development of alchemic theory and practice as we shall see with the unfolding story. The great period of Stoic physics was the 4th and 3rd centuries B.C., when alchemy was gradually coming to a head, if we are right in dating its founder, Bolos, around 200 B.C. and Stoic ideas certainly did a great deal in making the work of Bolos possible. The next five hundred years saw the maturing of alchemy; they also saw the development of Neoplatonism as the dominant philosophy of late antiquity. Alchemy and Neoplatonism shared many characteristics. What Neoplatonism stood for will emerge as our story goes on. Here it will suffice to say that in certain essential respects it represented an attempt to reassert the Platonic idea of hierarchical levels of being inside the organic pantheist Stoic universe. The Platonic system, partly modified and changed by the transposition, took on new complexities and richnesses as a result. But in seeking thus to define the existence of qualitative levels inside the unitary cosmos, the Neoplatonists were driven back to transcendental notions of deity, denying the pantheist materialism of the early Stoics. The ancient world always saw hierarchy or development as coming down by stages from above, not as a movement from below upwards. At most the upward movement was conceivable as a return along the tracks laid down by descending spirit or deity. Thus Neoplatonism was agitated by an inner tension between the notions of unity and of hierarchy, of organic and continuous forces or processes and of a pattern imposed from above by a Monad outside the universe.

Gnosticism and the Hermetic creeds shared with it a belief in the descent of life or spirit through different levels or stages down to the earthly level. They sought to find the way aloft again, not merely by philosophical reasoning, but by a *gnosis*, a knowledge that was the gift of revelation. As part of the Stoic heritage, together with the vast amount of folklore and magical recipes which were given a fresh force in the light of Stoic concepts, these creeds, like Neoplatonism itself, had a profound sense of the complex interrelationships and correspondences inside the organic or vital (pneumatic) whole--while at the same time they suffered from an intense sense of loss, of an agonising division that cut across the face of life. It was precisely, indeed, the dialectic of these two opposed positions which gave such strength and fascination to the period's dreams, fantasies, deep insights, comprehensions. Alchemy was richly a part of this world, torn by many of the same contradictions, but with a secure difference. Alone it clung, despite confusions and ambiguities, both to the belief in varying levels and structures, and to the Stoic position that the *psyche* was material, that there was a mutual penetration of soul and body, of *physis* and the world of plants, of *hexis* and the world of inorganic matter. It consistently saw all the more solid or specific elements as permeated and held together in the infinite network of pneumatic tensions.[48]

(Jack Lindsay, *The Origins of Alchemy in Graeco-Roman Egypt*, 1970:1-23)

18: CONCLUSIONS

WE have now viewed the birth of this strange science--strange in itself and strange in its whole way of development. It emerges and grows during its vital formative period in secrecy and does its utmost to remain secret and to avoid connections with any social or economic forces in its world, despite its strong links with many technological processes. The secrecy, we may say, was not altogether its own choosing. Through its connection with "gold-making" it was liable to bring the whole weight of the authorities down upon it--though its true exponents were not at all concerned with making gold for their own enrichment. They sought the clue to the nature of process, the nature of life itself, and nothing less. But, reinforced by the various cautions, there was the deep bias towards secrecy brought about by the two main bodies from whom the whole impetus towards the new science came: craft-fraternities and mystery-groups. Each of these in its own way had a strong tradition of keeping secret its essential lores or discoveries. The alchemist thus from the outset felt bound by a passionate devotion to his art, which he opposed to the world of power, money, accepted usages. He had staked everything on his personal quest into the unknown, and the demands of the world were felt only as shackles, corruptions, diversions, distortions. His lonely dedication became the pledge of his worth, of his right to the quest and its revelations. In all this he had affinities with the devotees of the various dissident religious groups, including early Christianity, but he also has his profound difference from those groups. In his pantheist-materialist way he was concerned with actual process, with the structure and laws of the nodal points in material change.

In a general way the notion of scientific research as somehow identical with mystery-initiation was widespread. Dion Chysostom remarked:

> Here is a correct enough comparison. Suppose you invited a Greek or a Barbarian and took him into a mystery-temple of a prodigious beauty and grandeur. He would see there all sorts of secret visions, he would hear all sorts of mysterious voices. Darkness and light would alternate in his eyes, not to mention an infinity of other spectacles. Besides, as is usually done in the ceremony of Enthronement, after installing the initiate on a throne, the initiators would dance in a choir around him. Is it credible that such a man would feel no emotion in his soul and that he would not grasp the idea that all that was accomplished in virtue of a design and of preparation full of wisdom?...

How is it different, he asks, in the Cosmos which is also a beautiful Temple? Seneca even more directly links the mysteries of Nature with those of Eleusis:

> There are mysteries where the initiation is not completed in one day. Eleusis reserves secrets that it reveals only to those who return to see her. Nature too does not reveal all her mysteries at once. We think we are initiates when we are still only in the vestibule. These arcania do not unveil themselves in a hurry, nor to all men. They have been withdrawn to the depths of the sanctuary, well apart in an inner chapel. Our century has seen a part of them; the age to follow us will make out others. When will they come in their entirety to our knowledge? Great discoveries are slow, especially when effort languishes.[1]

The alchemist, for the various reasons we have noted, drew the logical conclusions: that the scientific mysteries should be revealed only to the initiates. In so doing he was making the best of a bad job: for certainly in the Ptolemaic and Roman periods any attempt to practise and to teach in public would have meant prosecution for counterfeiting and for meddling in matters strictly reserved for the State. For quite different reasons the State and the alchemist were concerned with gold, considered the purest of metals. The State because of its worldly economic value; the alchemist because of its unworldly spiritual-and-scientific value as the supposed highest level of matter.

In our first chapter we sketched out the main attitudes, the underlying and unquestioned preconceptions, of the world from which the alchemist arose. Let us glance afresh at the limitations of the classical outlook. Aristotle's synthesis had been specially weak, almost blank, on mechanics, as men like Archimedes and Hipparchos could not but grow aware. The Greeks were able to deal only with combinations of forces or motions that were in the same straight line or were parallel, as with levers. Without something like the calculus no notion of instantaneous velocity could be worked out; hence Aristotle's inability to deal effectively with planetary motion or free fall. In the Hellenistic age, Archimedes made the first step towards the infinitesimal calculus and Hipparchos was feeling his way towards the modern concept of momentum; but these explorations could not be carried further in their society. The Aristotelean categories of motion held the dominant position, and were inherited by the medieval world. In the sublunar sphere all natural motion was rectangular, light things rising from the earth's centre, heavy things falling down to it. As that centre was a fixed point, there was no problem about defining up and down, lightness or heaviness.[2] All deviations from the rectilinear were thus seen as the result of violent motion, with some force deflecting the light or heavy body from its natural straight line. In the celestial spheres above the moon, however, motion was natural, in a circle, as on earth rest was natural, violated only by the application of force. Aristotle did not state the proposition that the application of a constant force imparts a constant velocity to a body, but it was implied in all pre-Galilean mechanics.

Special cases where the Aristotelean system did not apply kept coming up, but it was not till the advent of projectiles (*i.e.*, gunpowder and its blast-power) that such a case proved so difficult as to break the whole system down. Already, however, among the Greeks there had been much strain on Aristotle's two main dynamical principles: that movement required a continuous efficient cause to keep it going, and that space had an organised qualitative structure with different natural directions for different substances.[3] As a result, the geometrical space-systems ended by having so little relation to the accepted system of dynamics that a distinction came to be drawn between mathematical and physical theories, with two criteria (stated by Ptolemaios) for choosing which was to be used: the one that saved the phenomena most accurately and with the smallest number of necessary assumptions. This distinction was taken up afresh in the West in the 12th -13th centuries.

Gunpowder, ballistics and projectiles were the force that blew up the ancient systems inherited by the medieval world; but the discovery and use of gunpowder did not arise technologically in a social vacuum. That discovery and its concomitant problems were the expression of the new bourgeois forces slowly breaking through the old balances: the interlocked feudal system of hierarchies which had replaced the ancient system of freeman and slave interlocked in what was more or less a technological impasse. For the systems which fundamentally resisted any deep going change, the world existed in a condition of "natural rest", which was only disturbed by directly interfering (and in their sense, unnatural) forces. The Aristotelean tradition held that the interfering forces resided in the medium (air, water, etc.) where the motion took place. The medium did not move but was charged with the capability of moving; it resisted movement but was locally and temporarily defeated by the application of a constant force, though it still expressed its nature by limiting the attainable velocity; it thus had a contradictory effect, reducing a body to rest, yet protracting movement after the force's effects had ended.

A little thought will bring out the way in which the Aristotelean scheme of things ideally represented the problems of movement and change in a slave-society. And it could in turn become the expression of a feudal society, which, though discarding slavery, reposed on an equally stubborn and inert basis, serfdom.

However, in late antiquity the glimmerings of a different system appeared in a thinker like John Philoponos of Byzantion (6th century). Men began to argue that when a stone was thrown or slung, the efficient cause maintaining the velocity was an inner tendency imparted by the thrower to the stone. Behind the new conception there lay the considerable social changes which had gone on in the Byzantine world, the shaking of the ancient bases without the ability to break through into new forms, and so on-historical changes we cannot probe here, though we may note the accompanying growth of new projectile mechanisms culminating in Greek-Fire, the precursor of gunpowder and cannon. Philoponos' notion of the Impetus reached the West in the 14th century through men like Jean Buridan, and eventually, linked with the technological advances of the 15th -16th centuries (especially the complex of physical, mechanical, chemical developments centred on gunpowder), issued in Galilean mechanics and Newtonian physics. "The classical scientists had studied bodies at rest, or bodies acting in each other with relatively steady forces. The new world was to consider the problem of bodies in violent motion, and on this basis was to found a new and much more comprehensive mechanics. [4]

There then is the dilemma of ancient science considered from new angle. We have seen that the Aristotelean systems did not carry on without various challenges, of which the main one was the Stoic concept of *pneuma* as a tensional force pervading the whole universe. But this concept, however fruitful in a general way, could not develop effectively a system of physics to supplant the Aristotelean. Similarly Plato's ideas of symmetry-asymmetry as the source of movement or development, and his triadic schemes of vital structure, could not do other than impact m general ideas on a stubborn world of "natural rest". Galen had remarkable sense of growth as a continual reassertion of structure in new conditions of tension. "This nature which shapes and gradually adds to the parts is most certainly extended throughout their whole substance. Yes, indeed, she shapes and nourishes and increases them through and through, not on the outside only.'' [5] But he saw this process only in terms of the individual (isolated) organism and thus could not apply the symmetry-asymmetry principle in terms of fused inner-and-outer tensions at work.

Where, then, do our alchemists come in? They took over many ideas from Aristotle about the elements, metals and the like, but in effect they brushed his physics aside. They accepted the Stoic idea of a unitary process and proceeded to see where it led them, not merely as a general or a moral idea, but as a guide to scientific action. Thus they were able to apply the Platonic triads in a concrete way and to discard the whole notion of natural rest. They attained at least a partial consciousness of the revolutionary step they had made, as we see from Zosimos' account of the unity of all processes, his insistence on the use of the triadic formula in a way that embraced theory and practice in a dynamic unity, and his rejection of both the empirical and the magical-mystical way. We see it again in Olympiodoros' rejection of the notion of the absolute, of a changeless reality. But these men could not possibly have comprehended anything like all the implications. For one thing they were not interested in the speculations that finally led to the impetus theory. They were not interested in the mechanical aspects of the world at all.[6]

In this fact lay both their weakness and their strength. They contributed nothing to the line of ideas which led through Philoponos into Buridan and Galileo; and on the whole they would have considered that this was an incorrect line for science to take. Clearly they could not have denied the new grasp of phenomena that was thereby made possible, but they would have argued that the grasp had been obtained at too great a cost, or that the results it brought had been misapplied. The consequences, in the alchemic view, were to divorce man from nature, to give mechanistic aspects a vastly undue importance in the scheme of things, and to lose sight of the flashpoints of change or development.

What the alchemists took over from classical Greek thought was the concrete sense of the object, the concentration on its qualities; but they attempted at the same time to break through the limitations of this attitude, not by ignoring qualities and concerning themselves solely with the quantitative mechanics and dynamics of objects in interrelation, but by putting the objects into interaction with one another as units composed of qualities. Their problem was that they could not effectively explore and extend this method without quantitative systems to provide a secure basis for their experimentations; the only way historically open for the creation of those systems lay through Philoponos and Galileo. Men were not able, as they still are not able, to deal simultaneously with the abstract world of quantities and the concrete world of qualities.

History shows that the feasible way forward was through Philoponos; but that does not simply wipe out the alchemists as misguided enthusiasts. On the one hand there is the mere pragmatic defence of their work. However fantastic the theory, the work itself did draw attention to problems of chemistry. In its development or expansion over the centuries, especially through the Arabs and various western alchemists like Paracelsus, it made many incidental discoveries of great importance. And finally in the issues it raised in its declining years, in the transitional schools (such as that of the Phlogiston Theory) which it evoked, it led the way to chemistry on a quantitative basis--chemistry without the vision of unitary process and of nodal points of qualitative change. (Modern chemistry was not just alchemy without the nonsense; it was alchemy tamed, reduced wholly to a quantitative level, and thus giving up its ghost.)

On the other hand we can put up a defence that would have been more to the taste of the alchemists themselves. We can admit the weaknesses, the enormous scope of the aims and hopes in comparison with the technical resources on which they were to be realised. We can admit that without precise forms of control-those afforded by quantitative methods or checks, and by much more effective apparatus--the art was doomed to go round for the most part in wasteful circles, unable to find firm ground on which to advance step by step. We can admit that fantasy an intuitive guesswork played an inordinate part in the art. And yet we can still hold that the alchemists were on the track of something that still eludes scientific method and inquiry. Something that nowadays becoming more and more relevant to the scientific comprehension of reality. Just as thermodynamics in the 19th century brought physics back in some respect to underlying idea that owned certain affinities with classical Greek ideas, so the advent of atomic physics and quantum mechanics brings science up against problems that remind us of both stoic field-theory and alchemy. It might be argued that the unifying theses which are so badly needed by the physics of our day will turn out, when and if they are found, to be closer to Zosimos than to Galileo in some fundamental aspects.

The unity of human and natural process, as set out by th alchemists, may have many fantastic elements; yet it may vet well hold an essential truth which was lost with the appearance of Galilean mechanics and its method of excessive abstraction The reduction of the world to quantitative elements banishes mar from the scene, for it banishes all concrete objects with their essentially qualitative existence.

Fig. 71. Alchemical resurrection (from *The Rosary*)

Life becomes the ghost in the machine. True, the gap is partly bridged by biology and its connected disciplines; but in a world of thought dominated by quantitative mechanisms, biological issues can only be realised in limited aspects or through a distorting mirror. The problem posed by the alchemists, that of rounding a truly human science, without the abstraction thrusting between man's senses and the external world, is still to be solved. In this sense the alchemists were not daydreamers of a confused moment of the past; they were the prophets of a future yet to be realised.

I have spoken of the final role played by alchemy in the transitional schools that lead up to the chemistry of Priestley, Lavoisier, Dalton. The role of alchemy in the 17th century still needs to be fully assessed. It is a noteworthy point that more alchemic books appeared in English between the years 1650-80 than in all the time before and after that period. [7] The effect on culture appears strongly in the poetry of the 17th century, in our so-called Metaphysical Poets. But the point I should like to make here is the way in which a new sort of attention was paid to *Colour* after the triumph of the new mechanics in Newton. The Romantic Movement was rounded by the poetry of Thomson and Savage, in which appears *a new dynamic sense of colour, of light as a sort of formative principle*. These ideas were developed by the romantic poets, with special attention to the changes of light, colour and tone at morning and evening. Ann Radcliff called the dusk "the transforming hour"; and the way in which the poets used dusk-imagery to express the merging of vast elemental and human changes was in a pure alchemic idiom. In Smart's *Jubilate* the conscious defiance of Newton breaks out in a paean to colour as the creative force, a denial of the Lockean position that the qualities derived from sense-experience were subjective and unreal when set next to the laws of mechanics and the quantitative analysis; in Blake this anti-Newtonism reaches a matured philosophic position. In turn these romantic positions beget the great colour-art of Turner and Delacroix, the increasing concentration on light which culminates in the Impressionists. There is no space here to elaborate these points; but it is highly significant that just as the alchemists developed their belief in the primary importance of colour in their reaction against purely geometrical and arithmetical notions of matter, so the romantics developed their retort of colour-arts to the Newtonian mechanism. We may adz that the last word has by no means been scientifically spoken of the nature of colour and its function in the universe.

Now to return to the more direct problems raised by alchemy, we might say that what happened with Galileo was not the over-coming of the problems raised by the Aristotelean schema; it was rather simply the reversal of the situation. In the classical Greek view, man was cut off inside his own qualities; in the post-Galilean view, he is cut off outside the world of quantities. The alchemist sought to work outwards from the isolated bundle of qualities into the grasp of processes where objects remained whole and yet fused with one another into new unities. He failed in his objectives, because he tried to do too much with too little in hand; and with all his vast hopes he had far too limited a view of what the problems of material transformation involved. With his newly-found faith in the possibilities of transformation he had no sense at all of the stabilities or symmetries of organised matter of the depths to which he must penetrate before he could touch the levels and the systems of transformation, of the minute and fugitive complexity of those systems. Despite the many tribute; paid to Demokritos, no attempt was made to consider transformation at the atomic level. With the poor means of measurement a the disposal of scientists in ancient days we could not indeed expect any attempts to define elements at that level; but we ma, still wonder at the lack of any general theorising on this point especially as Plato had given a basis for the discussion of differing geometrical structures among the atoms.[8]

However, when the worst is said, the remarkable nature of the alchemic aim remains. We may definitely claim that the alchemist were the first scientists in the full sense of the word. That is, they did not merely contemplate phenomena and seek to deduce regularities from them; they did not merely make models on mathematical principles to reflect the operation of phenomena. They took a fully active attitude. They sought to grasp the nature of process itself and to test out their ideas in the laboratory, to recreate and repeat phenomena under controlled conditions. That their controls were too often inadequate and crude is beside the point. They did make the attempt to grasp and recreate processes, and that is the crucial thing.

In this they show their link with the craft-world; for there the question of understanding processes so as to be able to repeat them is the essence of the whole business. The alchemists thus reveal the breakthrough of the craftsman into the world of scientific contemplation and model-making. Contemplation becomes the theoretical side of the active effort to control and change matter; model-making becomes the practical work of grasping, modifying and changing reality. The alchemist accepts nature for what it is, in order to change it into what it might be; accepts himself for what he is, in order to change himself into what he might be. The lonely struggle with substances in still or alembic becomes the struggle of all men to free themselves from existing fetters and to advance into a qualitatively new sphere of experience, a new social union. Zosimos in announcing the indissoluble link of theory and practice has brought something quite new into culture; and it is this more than anything else that sounds the doom of the ancient world with its bias towards contemplation and its sense of the active sphere (apart from war and government) as servile.

In the last resort it is this *unity of craft-process with theoretical thought* which is the great revolutionary mark of alchemy and which explains why it could find no accepted place in the systems of the ancient world. When in the 17th century an assured scientific method was at last established with a mixture of the particular and the general, with an appeal to experimental method, this was not the same as the alchemic unity; for the concept of nature in perpetual qualitative change was omitted and in its place was put the concept of perpetual quantitative movement. Therefore the question of directions and of values was not present. For the exponents of post-Galilean science this lack has seemed a proof of virtue and of objectivity. The alchemist would reply that if you exclude humanity (the concrete object of qualities), you exclude reality in any essential sense and your results have a limited and ultimately anti-human aspect. This book is not the place to argue such problems out; but I should be failing in my love and respect for the alchemists if I did not add that in this matter I am on their side. That is, I consider a true and complete science to be one which includes the alchemic viewpoints, but with the addition of the various methodological precisions which are the great achievement of post-Galilean developments. The complete science I visualise would then be one capable of dealing with more than symmetries in nature, the stable states which quantitative analysis can compass; it would know how to grasp and define at the same time all crucial points of change, in which new qualities emerge; and it would vitally link its inquiries into natural process with the needs of a humanity that knew where it was going.

What is implied by these comments may perhaps be made clearer by a passage from the writings of a great critic of the unconscious assumptions and preconceptions of modern science:

> The assumption, that cause equals effect, dominated the later phases of Greek philosophic thought, and

> determined the entire development of exact science. Plato asked "how can that be real which is never in the same state?" Aristotle held that "in pursuing the truth one must start from things that are always in the same state and never change". Greek atomism and, until recently, modern atomic theory found the real basis of nature in permanent and unchanging constituent units. Quantitative physics abstracted ideal reversible processes from observed phenomena and constructed quantitative energy-functions which were conserved in the processes which it treated as isolable. J. R. Mayer based his formulation of the principle of the conservation of energy on a general law of the quantitative indestructibility of cause.
>
> So remarkable has been the success of this assumption that few have noticed that it is an assumption, and fewer still have seen grounds to question its adequacy... [But] the invariant factor in process need not itself be timeless, but may consist in a universal tendency towards a defined end-condition. The clue to the order of nature may not be a principle of permanence, but a universal pattern of process displaying an invariant one-way tendency. For it is not change, but only arbitrary change, which eludes the rational intellect. (L. L. Whyte.)[9]

This, in my opinion, is the sort of science that the alchemists glimpsed; and it is perhaps a heartening thought that the men who rounded the unity of scientific theory and practice in consistent laboratory-work had such a system in their minds, however inadequate were their methods for realising it that their essential positions were opposed to mechanist assumptions which, in place of the real universe of irreversible process, put an abstract symmetrical construction where action and reaction are equal and opposite. With all their limited applications they yet saw reality as unitary, concrete, involving critical or nodal points of change, and consisting of interrelated hierarchical levels of organisation; and they wanted a method above all which brought all these aspects together. They saw human values as implicated in every phase of the work and as determining the direction of research from within the processes, not merely as a system of ends imposed from without.[10]

(Conclusion to *The Origins of Alchemy in Graeco-Roman Egypt* by Jack Lindsay 1970:382-392)

Notes

CHAPTER I: GREEK SCIENTIFIC THOUGHT BEFORE ALCHEMY

1. Tannery (3) 3 10 thinks it the organising period; Burnet, the opposite. "Hesiod's conviction that he lives in the decadent Iron Age now becomes in E. the belief that his own human existence is wedged in between a Golden Age of the past, when Love prevailed, and a brighter future when that Age shall come again, only to be vanquished by the reign of Hate," Jaeger, *Theology of Early Gr. Philosophers*, 1967, 143.

For rel. of E. and Anaxagoras, and notion of the Elements, O'Brien.

2. Santillana, 115 f.
3. Cherniss (z) argues that A. overstates the role of opposites in earlier stages; but he does not grasp the deep primitive roots.
4. See for example JL (2) and (3). In a more abstract way, Levi-Strauss in his Totemism, etc.
5. Cornford 25 f.
6. Demok. fr. 164; Cornford 35
7. *Peri phys. paid*. xvii (Litrée vii 496); Cornford 36 f.
8. CH iii 91, no. xxii; cf. Aetlos v II (DieIs 422a 13); Ps.-Galen, *hist phil*. 115 (612d), cf. Aet. v 3-19, Stob. 1 42 (i, 294-6 W.); Gal. iv 603, 607, 609, 613, 626 (Kühn), Wellmann, *Pneum. Sch.* 100 ff; Tert. *de an.* V 4, XXV 9 (Wasz. comment. 128 f, 333 f); Scott iii 405-70, Ferguson iv 447 f; J- Kroll (2) 249-51.
9. *Tim.* 63c; Cornford 38 f. See also Bochner (I) 155 on Arist. *phys*. iv and *topos* of a body as the inner boundary of what it contains; 152-60 for concepts of space in Plato and Aristotle, and A.'s concepts as viewed from thermodynamic angle, 159; further Bochner (2).
10. *Tim*. 81a.
11. *De gen. et corr*. 323 b10; Joachim *ad loc*.; Theophr., *de sens*.
12. Sext., *adv. math*. vii 11 6; Arist. *de anima* 409 b 24. Diog. of Apol. had soul = air, primary element, so the soul could know all things on the like-to-like principle; *Tim*. 27; Theophr. *de sens*. i. For general principle, Plato, *Lysis* 215c; Arist. *E.N*. viii I, *met*. 984b 23
13. *Enn*. iv 4, 40, cf. ii 4, 5, "The eye, which is luciform, extending itself to the light, and to colours which are illuminations, says that what is under colours is dark and material and concealed by the colours."
14. Bochner (I) 167 f. Galileo of course had his predecessors (M. Clagett, *The Science of Mechanics in the Middle Ages*, 1959) but was nonetheless decisive in his advance.
15. Arist. *phys*. vii and *de caelo* iii; 0) 65 f; Themist., *phys*. 208, 13.
16. Garnsey, 3 & 24; Plout, *mor*. 719 bc; Farringdon (I) 29 f.
17. *De re rep*. i 43.

18. Sambursky (2) 92-5; breakdown of Aristot. concept of topos, 95. Greek maths. failed to get beyond idealisation, a process of abstraction from "direct actuality." Bochner 18.
19. *Mechanikë: post. analyt*. 78b 37; Heath (I) II f. Aristotle, *phys*. (193b 22, 194a 15), wonders if astronomy, *optikë*, and *harmonikë* can be distinguished from maths.; but here, as in *Metaph*., is sure that physike is distinct: Bochner 144 f.
20. A. N. Whitehead, *Concept of Nature*, 1930, 24; Bochner 180 f: see 145 ff for Aristotle; also Solmsen and W. D. Ross.
21. *Phys.* 225b 16 to 226a 23: "nor becoming of becoming, nor in general change of change."
22. Bochner 168. Eudoxos established the volumes of cone and pyramid: the first form of integral calculus. "Lacking a kinematics, the Greeks had little inducement to develop a corresponding different calculus," Santillana 236. But both lack and no-inducement came from the same socio-intellectual basis.
23. Sambursky (I) 48 f; Iambl. *de cormm. math*. se. xxxii (93,11).
24. *Tim*. 87 cd. For Philolaos: Plato, *Phaid.* 61d; Apollod. (Diog. L. ix 38); Diog. L. iii 6; Cicero mentions him as Pythag. teacher of Plato, d. *Interpr*., DL iii 6; Iambl. *V. Pyth*. 23 and 31; Porph. *V.P*. 40. Said be first Pythag. to publish doctrines; his works were said to be called *Bacchai* (prob. name given by an admirer). For demiurge: Dield, *Vors*. i 301, it seems possible then that Demiurge was a general Pythag. idea. Demokritos had also the concept of symmetry and a-symmetry: "Some (atoms) rebound in random directions, while others interlock because of the symmetry of their shapes, positions, and arrangements, and remain together. This is how compound bodies were begun," Santillana 146.
25. *Tim.* 58de. Aristotle wanted to explain perceptible things by perceptible principles; saw maths. as merely such things abstracted from their qualifies; never asked if math. elements (e.g. geom. shapes) could be used as symbols to describe physical realities; never grasped that Plato did not attribute weight etc. to his triangles. Thus both Plato and Demokritos came under his censure. S (1) 29-31.
26. *Tim*. 59 be. Various kinds of fire, 58ce. Fifth element: Lloyd (2) 103 f, 134-9. 160 f; F (I) ii 251 f; Epinomis has the five elements. Stephanos speaks of the 5th element, which in medieval days became the Quintessence.
27. *Tim*. 50ab.
28. *Tim.* 59ab.
29. *Tim*. 37c. *Paradeigma*: Rep. vi 500de; *Theait*. 176e, 3. Note play on words, *ëgasthë*, rejoiced, and *agalma* (thing-of-joy).
30. *Tim*. 50e.
31. *Tim.* 52e. Note passage of Demok. quoted above. Cf. example of blowing through pipe into bladder of sand and lead filings, Cornford 37.
32. *Tim*. 55d, cf. *Phileb*. 17e. There is metaphor of joiner and wood, Tim. 69a (*hyle* = both wood and matter); also in same sentence a metaphor from weaving.
33. *Tim*. 31b; 35b, cf. *Soph*. 244 f, greatest kinds or main categories: Storey. I have no room here to discuss the many dialectical ideas in Plato. Note that to pan, the whole, appears often in *Tim*., a term much loved by alchemists.
34. *De caelo* iii-iv; *de gen. et corr*.; *met*. etc.
35. Holmyard (4) 17 f.
36. *Met.* iii 6, 378c; 378a 26 if; 388a 13 (included silver, tin, and prob. lead); 389a. Realgar, ochre, ruddle all used as red pigments.
37. Joachim (1); S (2) 12.
38. Olymp., *comm. in Met*. (Stüne 270, 24 f) ; Eicholz, 28 ft. Alchemists identified dry vapour with sulphur, moist with mercury; developed theory all metals made up of mercury and sulphur.
39. Eicholz 15 if; 20 f on filtering in *Tim*. 60bc. Fire, *de lap*. 54; Eicholz 38; *Tim*. 67c on. I would like to discuss here and elsewhere in the book Greek views on light, colour, vision, but can only refer to the account in Theophr. *de sensu*.
40. Arist. *met.* 341, 16 and 340b 29. *De sensu* 443a 21 f, 27 f. Hard to envisage: *Met.* 34qb 15. Gradings of colour: Plin. xxxiii 59; Lippmann (1) i 7; Eicholz 118-120.
41. *De lap*. 58-60. Kermes: from which red dye, really an insect though the ancients did not know it. Distempering: Hdt. iii 8; Thouk. iii 20. Silvermines: Laurion. Date of invention, c. 405. No doubt K. had rented a holding at mines, but after Spartan occupation of Dekeleia, 412, he migrated to Asia Minor, hoping for gold in river-valleys. Eicholz, 8-12, 127; Thorndyke (2) errs to date, 7 f. Theophr. says whitelead, verdigris, cinnabar, all produced by imitation of nat. process of separation, *ekkrisis* (Arist. *meteor*. 381 b8).
42. S (2) ch.i, 1, and his discussion of the idea of the elements. For early use of "breath", Anaximenes, see Croissant on ultimate mechanistic basis. Heidel notes how even in Hippok. treatises [on] physiological processes are conceived in terms of inanimate nature. Cannot go further into the pneuma of the Stoics and allied Iranian concepts; sperm and *pneuma*, CH iii p. lxxxiv on; *dynamis pneumatikë* or sperm, Galen, *ib* xcv. *Asthma*: Edsman (I) 221; Bidez (I) ii 155; Cumont (6) 407 n 2 etc.
43. DL vii 156; Galen, *nat. fac*. i H, 25; ii 4, 89; S (2) 3 f; Cic. *nat. deor*. ii 23-8.
44. Galen, *de loc*. aft. v 1; Plout. *stoic. repug*. 1034d. Sleep as relaxation of sensory tension, DL vii 158. For *pneuma*: add H. Thesleff, *Intro. to Pythag. Writers of the Hellenistic Period* 1961 68 f; G. Verbeke, *L'Evolution de la Doctrine du Pneuma* 1945 (esp. 119 f; 156f); F. Bréhier (I) 152 and 211 (*pneuma* characteristic of Middle Stoa).
45. S (2) 7 f with refs.
46. S (2) 9; Galen, *nat. fac*. ii 3, 82.
47. S (2) 22 and 18-20. *Dynamis of pneuma*: Stob. i 37x, 22; Simplik. *categ*. 165, 52-166, 29, and Gal. *meth. med.* i 6 (Arnim ii 494). Plot. *enn*, ii 7, t. 52-2, 2. Chrysippos: Plout., *stoic*. rep. 1078e. For cosmic god: F (I) ii 238-47. All is One: perhaps going back to Xenophanes of Kolophon (c. 570--460), DieIs *Dox*. III, 3 to H2, 2; also 565, 24 and 604, 18; Vors. ft. i, 40, 25; Plato *soph*. 242d; Norden 247 (1965 ed.); Orphic frag., Clement *strom* vi 259; gnostics, *ib*. iii 524.
48. Zaehner 200 ff claims for Zoroastrianism a kind of evolutionary concept: no ref. to creator, everything seen as a process of becoming from a unitary infinite and eternal Timespace (primal matter). Four stages lead to the full cosmos.
In general, for the nuances in the stress on the importance of the theoretic life and the weak form taken by the "mixed lie": R. Joly, *Le Thème philosophique de Genres de Vie* 1956. Relations of slavery to all this: P. M. Schuhl, *Machinisme et philosophic* ch. i, 1938; A. Aymard, *J. de Psychologie* 1948 3 29 if; G. Vlastos, *Philosoph. Rev*. 1941 289-304 etc.

(Jack Lindsay, *The Origins of Alchemy in Graeco-Roman Egypt*, 1970:393-395)

CHAPTER XIX: CONCLUSIONS

1. Dion xii 33 f; vii 31, cf. Plout.*de tranq*. xx; Cic. *leg.* ii II; Phil.*spec*. i 66 Idea of maths, (and star-contemplation) as initiation: *Epinom*. 986b-8d4. Sen QN vii 3 x.

2. Toulmin, *Listener* Feb. 11 1960 & *Philosophy of Sc.* 1953.

3. A. C. Crombie *discovery* (Aug. 1962) 24. on Aristotelian law of motion giving the proportional relation of velocity to force or power of the moving agent; this could not explain a projectile's velocity after it left the agent of propulsion or what increase in power occurred to make a heavy body accelerate as it fell. See A. Lejeune for virtues and limits of ancient method, esp. 184-6. Carcurio for struggle of the Greeks towards the integral calculus.

4. Bernal 238 f, *Science in History* 1954. Philoponos: Sheldon-Williams 477 ff, with refs.

5. *Nat. Fac*. ii 3 (82).

6. Weight: Browne (1) 211.

7. Lloyd on Plato and esp. relation to medical science. Medicine needed to refer to practice and actual cases, but did not attempt to re-create phenomena under tested conditions. With the new dynamical concepts of the Stoics we feel that could have got past the geometrical outlook of Plato; but the "swerve" of Epikouros (introduced into the atoms for moral reasons) seems the only addition made. See Sambursky (1) 70 ff on Impetus; Hipparchos and storage of power, 71, 74. Note how Philoponos links his concept of Impetus with colour-tincting. "Indeed, we see from the colours which stain corporeal bodies exposed to them, that the forces of an incorporeal form are emitted when the sun's rays pass through transparent coloured object... It is thus evident that certain forces can reach be in an incorporeal way from other bodies." *Phys*. 642, 9.

8. See my *Sunset Ship* and Lives of Turner and Cezanne. 1650-80: J. Ferguson, *J. of the Alchemical Soc*. 1914 ii 5.

9. Whyte, *Unitary Principle in Physics and Biology* 1949, 15 f.

10. As I type this last chapter, I note the comment by E. H. Hutton (*New Scientist*, 21 Dec.1967), "The investigation of elementary particles lies outside the scope of quantum mechanics. It has more resemblance to the ways in which the internal structure of living cells is revealed. Comparison between physics and biology, at the present stage of development, should be useful. It may help us in constructing a new model for the elementary particle, just as previously we learned a new meaning for 'atomicity' through quantum mechanics, going beyond the simple concept chemical atom."

(Jack Lindsay, *The Origins of Alchemy in Graeco-Roman Egypt*, 1970:432)