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Notes and Records of the Royal Society of London, Vol. 21, No. 2 (Dec., 1966), 108-143.

Stable URL:
http://links.jstor.org/sici?sici=0035-9149%28196612%2921%3A2%3C108%3ANAT%27OP%3E2.0.CO%3B2-3

Notes and Records of the Royal Society of London is currently published by The Royal Society.

NEWTON AND THE 'PIPES OF PAN'

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> What is it, by means of wch, bodies act on one another at a distance. And to what Agent did the Ancients attribute the gravity of their atoms and what did they mean by calling God an harmony and comparing him & matter (the corporeal part of the Universe) to the God Pan and his Pipe. Can any space be without something in it & what is that something in space void of matter (& what are its properties & operations on matter).
> Draft of Query 27 of *Opticks* (1)

NEWTONIAN scholars have long been aware of a set of draft Scholia to Propositions IV to IX of Book III of the *Principia* (2). These were composed in the 1690's, as part of an unimplemented plan for a second edition of the work. Since they describe supposed anticipations of Newton's doctrines in the thought of Graeco-Roman antiquity, they have become known as the 'classical' Scholia (3). The analogies and parallels drawn in them are so strained, as judged by modern standards of scholarship, that it is tempting to consider them as merely literary embellishments of a scientific work.

However, the sheer bulk of the manuscripts, the number of copies and variants, their relation to Newton's other writings, and the testimony of Newton's associates together with their publication of some of the materials, all make it certain that he considered the arguments and conclusions of the Scholia an important part of his philosophy.

It would perhaps be possible to interpret the Scholia, with their discussions of legendary figures and their references to a 'mystical' philosophy, as the work of the 'magical' (and hence aberrant) Newton—as eccentric productions that possess little significance for the reconstruction of his genuinely scientific work, but merely throw light on his esoteric and occult interests. To us, however, this interpretation appears untenable. It is now amply clear that Newton's serious enquiries were not restricted to natural philosophy, investigated by an experimental-mathematical method. His studies of theology and ancient chronology were of equal importance to him, and were pursued in as rigorous a fashion as his scientific work (4). There is sufficient evidence, even in his published writings, to show that he did not regard these different sorts of enquiry as unrelated exercises. Rather, he shared the belief, common in the seventeenth century, that natural and divine knowledge could be harmonized and shown to support each other.

We shall first describe the contents of these Scholia, and interpret them in the light of the statements of Newton's associates, and of other works by Newton. These materials will provide the basis for a re-examination of parts of the *General Scholium* and the *Opticks*. At that time, as is well known, Newton believed that he knew how God's agency operated in His created world, particularly in the cause of gravitation. Our analysis of the Scholia will show that Newton held (at least at the time of their composition) an equally firm belief about his own place among the *prisci theologi* who had possessed such knowledge. He believed, in brief, that God had once revealed these and other truths, but they had soon been obscured and had been partially rediscovered by certain antique sages. In this respect, Newton's work has close similarities with that of the Cambridge Platonists. These similarities may be more significant than the well-known similarity between Newton's doctrine of absolute space and that of Henry More. In re-examining Newton's relation to the Cambridge Platonists, we shall see that he did not merely borrow ideas from them, but was engaged in a private dialogue whose terms were set by a certain intellectual tradition.

The study of the 'classical' Scholia should therefore deepen our understanding of the Newton's philosophical endeavour, and make it possible to relate his work to its contemporary English natural-philosophical and theological context with greater precision.

I

The first public hint of Newton's studies of the *prisca* seems to have been contained in a letter from Fatio de Duillier to Huyghens on 5th February 1691/2. Fatio had just then begun his work of preparing a second edition of the *Principia*, the task having been entrusted to him after his return from Holland the previous September. He wrote:

> Monsieur Newton croit avoir decouvert assez clairement que les Anciens comme Pythagore, Platon &c. avoient toutes les demonstrations qu'il donne du veritable Systeme du Monde, et qui sont fondées sur la Pesanteur qui diminue reciproquement comme les quarrez des distances augmentent. Ils faisoient dit il un grand mystere de leurs connoissances. Mais il nois reste divers fragmens, pa où il paroit, à ce qu'il pretend, si on les met ensemble, qu'effectivement ils avoient les mêmes idées qui sont repandues dans les Principia Philosophiae Mathematica. Quand Monsieur Newton se seroit trompé il marque toujours beaucoup de candeur de faire un aveu comme celui la (5).

It seems most likely that the letter was sanctioned by Newton and designed

to test Huygens' reaction. Newton would hardly have countenanced the mention of these studies without his permission, and the last sentence of the quotation expressly invites Huygens' comments. Hugyens' reply was courteous but negative (6). He doubted that such ancients as the Pythagoreans could have demonstrated elliptical orbits, although he was willing to credit them with knowledge of certain general principles (like the heliocentric system and the balance of weight and centrifugal force for maintaining the moon in orbit). He used Borelli's failure to demonstrate elliptical orbits as evidence for the uniqueness of Newton's achievement, and then passed rapidly on to praise Newton's mathematical discoveries and urge their publication.

In May 1694, David Gregory visited Newton in Cambridge, and made 'Annotations Physical, Mathematical and Theological' from their conversations. Notes on the three topics follow each other in an indiscriminate sequence. Concerning the *prisca*, Gregory records:

> He will spread himself in exhibiting the agreement of this philosophy with that of the ancients, and principally with that of Thales. The philosophy of Epicurus and Lucretius is true and old, but was wrongly interpreted by the ancients as atheism.
>
> It is clear from the names of the planets given by Thoth (the Egyptian Mercury)—he gave them, in fact, the names of his predecessors whom he wished to be accepted as Gods—that he was a believer in the Copernican system (7).

There can be no doubt that Newton intended to incorporate such material into the revised version of the *Principia*; in July 1694 a memorandum of Gregory described the extensive changes planned by Newton, and mentioned:

> By far the greatest changes will be made to Book III. He will make a big change in Hypothesis III. page 402. He will show that the most ancient philosophy is in agreement with this hypothesis of his as much because the Egyptians and others taught the Copernican system, as he shows from their religion and hieroglyphics and images of the Gods, as because Plato and others—Plutarch and Galileo refer to it—observed the gravitation of all bodies towards all (8).

Some of the materials which Newton then intended for inclusion in the revised edition of the *Principia* have survived in a reasonably complete state. The main body of text is a set of fifteen folio sheets in Newton's hand, in the Library of the Royal Society. Their contents are Scholia on Propositions IV to IX of the Third Book of the *Principia*, where the essentials of Newton's

doctrine of gravitation are set out. The material includes many references to, and quotations from, the ancients on the nature of the physical world. There is not space to present the material of these 'classical' Scholia *in extenso*. We shall, however, give an indication of its character, and present important passages which he took to support these key propositions of the Third Book. Newton gave the manuscript to Gregory, probably on the visit of May 1694, either as a gift or as a loan. Gregory drew from it extensively for the preface to his *Astronomia Physicae et Geometricae Elementa*, some paragraphs being almost identical with the manuscript (9).

The Propositions of Book III, for which the Scholia were intended, exhibit a carefully developed structure. The Book starts with six solar Phaenomena, obtained through astronomical observation and calculation. Then the first three Propositions state that the circumjovial planets, the primary planets, and the moon, are all retained in their orbits by a force which is mathematically described by the inverse-square law. The proof of this is supplied by the first four Propositions of the First Book.

So far we are at the level of the mathematical description of the phenomena. But Proposition IV states that the forces mentioned in the first three Propositions are the force of gravity. Thus it is a statement about a real force in the physical world, embodying the famous proof that the gravitational force which pulls terrestrial objects to the Earth is the same as that which pulls the moon from its inertial path. By induction and by appeal to Rules 1 and 2, Propositions V and VI extend the reasoning to cover the primary planets and then all celestial bodies. Proposition VI also introduces the proportionality of gravity to the quantity of matter in a body, which leads to a discussion of the interstitial void in the corrollaries. But more importantly, Proposition VI not only asserts the generality of the action of gravity in affecting all sensible bodies, but it implies that sub-sensible particles gravitate as well. This latter doctrine is explicitly treated in Proposition VII. The inverse-square law of attraction is shown, in Proposition VIII, to apply not only to celestial bodies but also to their component particles. Finally, Proposition IX asserts the law of action of the real force of gravity *within* celestial bodies. Thus, by this series of extensions, gravity is concluded to be a completely universal force.

The central purpose of the 'classical' scholia was to support the doctrine of universal gravitation as developed in these Propositions, and to enquire into its nature as a cosmic force. This doctrine is shown by Newton to be identifiable in the writings of the ancients. As will become clear, he is not using this historical evidence in a random fashion, or merely for literary

ornamentation. Rather, the evidence is used in a serious and systematic fashion, as support for, and justification of, the components of Newton's theory of matter, space and gravitation. The evidence is used to establish four basic theses, which correspond to the matter of the Propositions IV to IX. These are, that there was an ancient knowledge of the truth of the following four principles: that matter is atomic in structure and moves by gravity through void space; that gravitational force acts universally; that gravity diminishes in the ratio of the inverse square of the distance between bodies; and that the true cause of gravity is the direct action of God. We shall analyse these in turn, using supporting texts from some associates of Newton, and from Newton's other writings.

It will be recalled that Propositions VI and VII are concerned with gravity as a real physical force, moving both perceptible and imperceptible bodies in a non-resisting void. In the Scholium to Proposition VI, which includes 62 lines from Lucretius, Newton says:

> Even the ancients were aware that all bodies which are round about the Earth, air and fire as well as the rest, have gravity towards the Earth, and that their gravity is proportional to the quantity of the matter of which they consists. Lucretius thus argues in proof of the void (10).

Newton then quotes twelve lines from Book I of *De Rerum Natura* which state that void exists, and that of any bodies which are equal in magnitude, difference in weight is explained by more or less interstitial void. This doctrine is discussed in the Corollaries to Proposition VI. Newton's comment on this passage is important:

> Lucretius here relates gravity to the function of the body, or its nature by which it is distinguished from Void, which has no gravity, and from this concludes that weight is always proportional to body. In this argument he includes all bodies, both imperceptible and perceptible. For he attributes this gravity even to those atoms of which other things consist. For he affirms that fire, and other bodies which are designated weightless, rise upwards not of their own accord but by a force which drives from below, just as wood, which is a body with gravity, rises up in water, whereas all bodies are being borne downwards through void space (11).

Newton follows this with a passage of twenty-two lines from Book II of Lucretius, which shows his commentary to be, in part, a paraphrase. For the conclusion of this Lucretian passage states, after giving the same example of things which seem to rise upwards naturally:

> We do not doubt, but that all these things, as far as in them lies, are borne downwards through the empty void (12).

Thus it is clear from his commentary and from the passages quoted, that Newton regards Lucretius as holding in the manner of the *Principia* that all matter whatsoever gravitates in a non-resisting void. Another quotation of twenty-eight lines from Book II further supports this conclusion.

Newton then turns to the historical succession of the atomical hypothesis, which is implicit in the *Principia* and explicit in the Lucretian passages:

> This Lucretius taught from the mind of Epicurus, Epicurus from the mind of the more ancient Democritus. For certain persons, assuming the equality of the atoms, would have it that the gravity of bodies is in proportion to the number of the atoms of which they consist. Others, to whom the atoms were unequal taught that gravity is proportional not to the number of the solids but to the quality of the solid.

This distinction is supported by a quotation from Aristotle on the atomists, and by a reference to Simplicius, who places Leucippus and Democritus in the second position. For them, the 'quality' of the body is measured by the ratio of solid parts to void interstices, which together make up the body:

> But by the levity of the void these philosophers did not understand any positive quality of the void, as Aristotle's opinion is, but merely absence of gravity.

Newton concludes by bringing the 'Italic' philosophers into the succession:

> Among the philosophers therefore who have held that bodies are composed of atoms, it was a received opinion that gravity accrues both to atoms and to composite bodies, and that in individual bodies it is proportional to the quantity of matter. That bodies are compound of atoms was the view of both Ionic and Italic philosophers. *The followers of Thales and Pythagoras*, Plutarch observes, *deny that the section of those bodies which are subject to movement proceeds to infinity but ceases at those things which are individual and are called atoms* (13).

In Proposition VII, Newton is explicitly concerned with the doctrine that the gravity of any composite body is the sum of its component parts which are held together by mutual gravitation. By analogy, he concludes that it follows that all celestial bodies mutually gravitate as the inverse square of the distance with respect to their components. Apart from the draft scholia in the Royal Society manuscript, there is another in the Portsmouth collection which is, in part, a summary of the longer set of scholia and which was probably intended as an alternative. Both documents are concerned with the absolute universality of gravitation. In the Royal Society manuscript there is

a passage directly relevant to the main doctrine of Proposition VII, namely, that the quantity of matter of any body is a function of its parts:

> Therefore just as the attractive force of the whole Magnet is composed of the attractive forces of the individual particles of which the Magnet consists, even so the ancient opinion was that Gravity towards the whole Earth arises from the gravity towards its individual parts. For that reason, if the whole Earth were divided into several globes, gravity, by the mind of the ancients, would have to be extended towards each several globe, in the same way as magnetic attraction is extended towards individual fragments of the magnet. And the ratio of gravity is equally towards all bodies whatever.
>
> Hence Lucretius teaches that there exists no centre of the universe, and no lowest place, but that there are in infinite space worlds similar to this of ours, and in addition to this he argues for the infinity of things in these terms (14).

Following this is another passage from Lucretius, containing an argument for the infinity of the universe:

> . . . if all the space in the universe stood contained within fixed boundaries on all sides and were limited, by this time the store of matter would by its solid weight have run together from all sides to the bottom . . .

Newton's comments on this passage are similar in the two manuscripts. The Royal Society manuscript reads:

> The force of the argument is that if the nature of things were bounded in any direction, the remotest bodies, since they would have no bodies beyond them into which to have gravity, would not stand in equilibrium but would by their own gravity make their way towards the things inside, and by flowing together from all quarters since infinite time would long ago have settled down in the midst of the whole as it were in a lowest place. Therefore, to the mind of Lucretius, each several body has gravity towards the matter situated round about it, and by virtue of overpowering gravity is carried into the region where matter is more copious, and all worlds whatsoever have mutual gravity towards one another, and by their own gravity towards worlds which are in our direction are precluded from falling on to worlds which are in another direction (15).

An historical succession is added in the Portsmouth manuscript:

> This Lucretius records from Epicurus' philosophy, Book I line 983, and Book II lines 1064 and 1074. Now it is likely enough that Epicurus

had learned all this from the mystical philosophers, seeing that Heraclides and the Pythagoreans and the followers of Orpheus said that all the stars were worlds in the infinite aether, as Plutarch has it in Book II, chapter 13, of the Beliefs of the Philosophers. This opinion also was held by Anaximander, who no doubt learned it from Thales, his teacher (16).

In the same document, Newton dates the atomic succession back to Moschus the Phoenician.

> That all matter consists of atoms was a very ancient opinion. This was the teaching of the multitude of philosophers who preceded Aristotle, namely Epicurus, Democritus, Ecphantus, Empedocles, Zenocrates, Heraclides, Asclepiades, Diodorus, Metrodorus of Chios, Pythagoras, and previous to these Moschus the Phoenician whom Strabo declares older than the Trojan war. For I think that same opinion obtained in that mystic philosophy which flowed down to the Greeks from Egypt and Phoenicia, since atoms are sometimes found to be designated by the mystics as monads. For the mysteries of numbers equally with the rest of hieroglyphics had regard to the mystical philosophy (17).

Newton goes on to say that such 'immutable seeds' account for the fact that 'the species of objects are conserved in perpetuity'.

It may be difficult for the modern reader to imagine Sir Isaac Newton being serious about such supposed 'anticipations' of his views. Indeed, were it not for the testimony of Fatio and Gregory, one would most naturally interpret them as adding a classical flourish to a scientific treatise. But the draft Scholium to Proposition VIII cannot be interpreted in such a fashion. For here Newton asserts unequivocally that Pythagoras discovered by experiment an inverse-square relation in the vibrations of strings (unison of two strings when tensions are reciprocally as the squares of lengths); that he extended such a relation to the weights and distances of the planets from the sun; and that this true knowledge, expressed esoterically, was lost through the misunderstanding of later generations. This is an instance of a fully developed *prisca sapientia*, and as such merits extended quotation.

> By what proportion gravity decreases by receding from the Planets the ancients have not sufficiently explained. Yet they appear to have adumbrated it by the harmony of the celestial spheres, designating the Sun and the remaining six planets, Mercury, Venus, Earth, Mars, Jupiter, Saturn, by means of Apollo with the Lyre of seven strings, and measuring the intervals of the spheres by the intervals of the tones. Thus

they alleged that seven tones are brought into being, which they called the harmony diapason, and that Saturn moved by the Dorian phthong, that is, the heavy one, and the rest of the Planets by sharper ones (as Pliny, bk. 1, ch. 22 relates, by the mind of Pythagoras) and that the Sun strikes the strings. Hence Macrobius, bk. 1, ch. 19, says: 'Apollo's Lyre of seven strings provides understanding of the motions of all the celestial spheres over which nature has set the Sun as moderator.' And Proclus on Plato's Timaeus, bk. 3, page 200, 'The number seven they have dedicated to Apollo as to him who embraces all symphonies whatsoever, and therefore they used to call him the God the Hebdomagetes', that is the Prince of the number Seven. Likewise in Eusebius' Preparation of the Gospel, bk. 5, ch. 14, the Sun is called by the oracle of Apollo the King of the seven sounding harmony. But by this symbol they indicated that the Sun by his own force acts upon the planets in that harmonic ratio of distances by which the force of tension acts upon strings of different lengths, that is reciprocally in the duplicate ratio of the distances. For the force by which the same tension acts on the same string of different lengths is reciprocally as the square of the length of the string.

The same tension upon a string half as long acts four times as powerfully, for it generates the Octave, and the Octave is produced by a force four times as great. For if a string of given length stretched by a given weight produces a given tone, the same tension upon a string thrice as short acts nine times as much. For it produces the twelfth, and a string which stretched by a given weight produces a given tone needs to be stretched by nine times as much weight so as to produce the twelfth. And, in general terms, if two strings equal in thickness are stretched by weights appended, these strings will be in unison when the weights are reciprocally as the squares of the lengths of the strings. Now this argument is subtle, yet became known to the ancients. For Pythagoras, as Macrobius avows, stretched the intestines of sheep or the sinews of oxen by attaching various weights, and from this learned the ratio of the celestial harmony. Therefore, by means of such experiments he ascertained that the weights by which all tones on equal strings . . . were reciprocally as the squares of the lengths of the string by which the musical instrument emits the same tones. But the proportion discovered by these experiments, on the evidence of Macrobius, he applied to the heavens and consequently by comparing those weights with the weights of the Planets and the lengths of the strings with the distances of the Planets, he understood by means of the harmony of the heavens that the

weights of the Planets towards the Sun were reciprocally as the squares of their distances from the Sun.

But the Philosophers loved so to mitigate their mystical discourses that in the presence of the vulgar they foolishly propounded vulgar matters for the sake of ridicule, and hid the truth beneath discourses of this kind. In this sense Pythagoras numbered his musical tones from the Earth, as though from here to the Moon were a tone, and thence to Mercury a semitone, and from thence to the rest of the Planets other musical intervals. But he taught that the sounds were emitted by the motion and attrition of the solid spheres, as though a greater sphere emitted a heavier tone as happens when iron hammers are smitten. And from this, it seems, was born the Ptolemaic system of solid orbs, when meanwhile Pythagoras beneath parables of this sort was hiding his own system and the true harmony of the heavens (18).

There is a piece of personal testimony which confirms Newton's belief in the wisdom of Pythagoras: that of Conduitt.

Sir. I thought Pythagoras's music of the spheres was intended to typify gravity & as he makes the sounds & notes to depend on the size of the strings, so gravity depends on the density of matter (19).

Moreover, Newton's most brilliant disciple, Maclaurin, expressed the same view, though with a slight but significant reservation:

A musical chord gives the same notes as one double in length, while the tension or force with which the latter is stretched is quadruple: and the gravity of a planet is quadruple of the gravity of a planet at a double distance. In general, that any musical chord may become unison to a lesser chord of the same kind, its tension must be increased in the same proportion as the square of its length is greater; and that the gravity of a planet may become equal to the gravity of another planet nearer to the sun, it must be increased in proportion as the square of its distance from the sun is greater. If therefore we should suppose musical chords extended from the sun to each planet, that all these chords might become unison, it would be requisite to increase or diminish their tensions in the same proportions as would be sufficient to render the gravities of the planets equal. And from the similitude of those proportions the celebrated doctrine of the harmony of the spheres is supposed to have been derived (20).

He goes on to say that:

these doctrines of the *Pythagoreans*, concerning the diurnal and annual motions of the earth, the revolutions of the comets . . . and the harmony

of the spheres, are very remote from the suggestions of sense, and opposite to vulgar prejudices; so we cannot but suppose that they who first discovered them must have made a very considerable progress in astronomy and natural philosophy.

Gregory too quotes this; his description makes it clear that Pythagoras used sound Newtonian method for his discovery:

Pythagoras afterwards applied the proposition he had thus found by experiments, to the heavens, and thus learned the harmony of the spheres (21).

The same theme was mentioned in a draft variant to Query 23 of the Latin edition of the *Opticks* of 1706:

By what means do bodies act on one another at a distance? The ancient Philosophers who held Atoms and Vacuum attributed gravity to atoms without telling us the means unless in figures: as by calling God Harmony representing him & matter by the God Pan and his Pipe, or by calling the Sun the prison of Jupiter because he keeps the Planets in their Orbs. Whence it seems to have been an ancient opinion that matter depends upon a Deity for its laws of motion as well as for its existence (22).

This passage serves us as a bridge to the material of the Scholium intended for Proposition IX. We notice that at the end, Newton states the *cause* of gravity, for the ancients, was God. In this draft variant, Newton develops the idea further. After stating that matter is passive and non-active, he says:

These are passive laws and to affirm that there are no others is to speak against experience. For we find in ourselves a power of moving our bodies by our thought. Life and will are active principles by which we move our bodies and thence arise other laws of motion unknown to us.

And since all matter duly formed is attended with signes of life and all things are framed with perfect art and wisdom and nature does nothing in vain; if there be an universal life and all space by the sensorium of a thinking being who by immediate presence perceives all things in it, as that which thinks in us, perceives their pictures in the brain: those laws of motion arising from life or will may be of universal extent. To some such laws the ancient Philosophers seem to have alluded when they called God Harmony and signified his actuating matter harmonically by the God Pan's playing upon a Pipe and attributing musick to the spheres made the distances and motions of the heavenly bodies to be harmonical, and represented the Planets by the seven strings of Apollo's Harp (23).

The personal testimony of David Gregory confirms the importance of this set of ideas for Newton's philosophy. His memorandum of 21 December 1705 tells us that Newton would answer the question, 'What cause did the ancients assign to gravity?' (in the projected Latin edition of the *Opticks*) by saying that, 'they reckoned God the cause of it, nothing else, that is no body being the cause; since every body is heavy'. Thus we have in the intended Query, an expression of the Newtonian distinction between passive and active principles in an orderly universe, and the complete dependence of matter, for its existence and motion, on the will of God; and all of this expressed by the ancients through the idea of 'Harmony'.

The draft Scholium to Proposition IX develops the same theme in greater detail. It starts with Newton's customary abjuring of causal explanations, and concludes with an eloquent passage in which the ancient dieties are assimilated into the one true God.

> So far I have expounded the properties of gravity. Its cause I by no means recount. Yet I shall say what the ancients thought about this subject. Thales regarded all bodies as animate, deducing that from magnetic and electrical attractions. And by the same argument he ought to have referred the attraction of gravity to the soul of matter. Hence he taught that all things are full of Gods, understanding by Gods animate bodies. He held the sun and the Planets for Gods. And in the same sense Pythagoras, on account of its immense force of attraction, said that the sun was the prison of Zeus, that is, a body possessed of the greatest circuits. And to the mystical philosophers Pan was the supreme divinity inspiring this world with harmonic ratio like a musical instrument and handling it with modulation, according to that saying of Orpheus 'striking the harmony of the world in playful song'. Thence they named harmony God and soul of the world composed of harmonic numbers. But they said that the Planets move in their circuits by force of their own souls, that is, by force of the gravity which takes its origin from the action of the soul. From this, it seems, arose the opinion of the Peripatetics concerning Intelligences moving solid globes. But the souls of the sun and of all the Planets the more ancient philosophers held for one and the same divinity exercising its powers in all bodies whatsoever, according to that of Orpheus in the Bowl.
>
> Cylennius himself is the interpreter of divinity to all:
> The nymphs are water. Ceres corn, Vulcan is fire.
> Neptune is the sea striking the foaming shores.
> Mars is war, kindly Venus is peace, the Bull-born

Horned Bacchus frequenting gladsome feasts
Is to mortals and to gods relief of mind from care.
Golden Themis is guardian of Justice and right
Next Apollo is the Sun, hurling his darts
From afar, circling round, the Divines and the Soothsayers
The Epidaurian God is the expeller of diseases: these things
All are one thing, though there be many names (24).

For the material of this passage, Newton drew heavily on Macrobius, Cicero, Virgil, Porphyry, and the Orphic hymns. In it, he completes the view of nature which was developed in the earlier Scholia. In those, the universe was seen as comprising innumerable worlds, composed of immutable atoms, held together by gravity, moving in an absolute void. Now the immaterial, 'immechanical' cause of it, is seen to be God himself. Newton states this conception clearly in another manuscript intended for the same unimplemented edition of the 1690's:

> . . . those ancients who more rightly held unimpaired the mystical philosophy as Thales and the Stoics, taught that a certain infinite spirit pervades all space *into infinity*, and contains and vivifies the entire world. And this spirit was their supreme divinity, according to the Poet cited by the Apostle. In him we live and move and have our being (25).

Thus the more ancient philosophers, such as Orpheus, who were closer to the true philosophy, held that gravity was a direct result of the exercise of divine power. Later philosophers such as the Ionics, the Italics and Plato reveal themselves to have partial knowledge of this, if their utterances are properly interpreted. For instance, Newton says of Plato:

> Hence after Plato has, by succession from Pythagorean doctrine and by the divine profundity of his own genius, shown that apart from these ratios (i.e. musical ratios) there can be no possibility of conjunction: in his Timaeus, he constitutes the soul of the world by means of the composition of those ratios, by the ineffable providence of God the craftsman. Consequently the soul of the world, which propels into movement this body of the universe visible to us, being constructed of ratios which created from themselves a musical concord, must of necessity produce musical sounds from the movement which it provides by its proper impulse having found the origin of them in the craftsmanship of its own composition (26).

There is little doubt that Newton saw in analogy to musical harmony, the principles of law and order in the natural world. Such harmony was the profoundest expression of cosmos. But for Newton, nature operating accord-

ing to these divine ratios, could scarcely be dependent on the guidance of an intermediate world soul. Rather (as we shall soon see) the exquisite structure of things immediately bespoke the providential governance of a Divine power actually present in the world.

II

It seems clear from the 'classical' Scholia, and from the testimony of his intimate friends, that Newton considered it necessary to complement his endeavours in natural philosophy by an investigation of the sources of the ancient knowledge that he believed himself to be re-discovering; and also that in that ancient tradition God was conceived as being in the most intimate relation with His creation. The draft Scholia, running parallel to the Propositions of Book III of the *Principia*, begin with classical views on matter, void, and gravity, and culminate in an affirmation of the ancient knowledge of the divine harmony by which God moved all bodies in the cosmos. Since a 'classical' edition of the *Principia*, incorporating these annotations, was never published, it may plausibly be argued that Newton considered these enquiries too speculative, or too incongruous with his inductive natural philosophy, to be made public.

Newton's thoughts on these matters were not, however, kept completely concealed. He permitted David Gregory to use the material extensively in a long historical preface to his *Astronomia physicae et geometricae elementa* (1702), if without attribution. (It was also available to Maclaurin for his much later work.) More important, the basic thesis of the Scholia is set out, more or less explicitly, in important sections of his two most important scientific works. These passages enable us to conclude that Newton was convinced of the importance of the *prisca* tradition for his philosophy, and that he believed his inductive method would yield as much certainty in historical and theological as in natural-philosophical studies. In both the *General Scholium* to the second edition of the *Principia* (1703) as well as the concluding pages of the *Opticks* (1704), a discussion of God's causal agency in the natural world ends with allusions to the suppressed material of the 'classical' Scholia.

In the *General Scholium*, Newton's special doctrines of the near-identification of infinite space with God and the assertion of His continuous intervention in His Creation end, not with a characteristic disclaimer, but with the affirmation:

> And thus much concerning God, to discourse of whom from the appearance of things does certainly belong to natural philosophy (27).

This extension of the scope of natural philosophy is significant. It implies that the sequence of ever more fundamental causes in nature does not stop short of the First Cause, but includes Him as a legitimate part of a natural-philosophical inquiry. That is already implicit in the use of God's attributes to establish the properties of atoms; and it justifies the attempt to define the mode of God's causal agency, as in the 'harmony' mentioned in the *Scholium* to Proposition IX.

Newton's belief in a *prisca* tradition is expressed in the same passages. In the *General Scholium*, a lengthy discussion of the divine attributes is concluded with the remarks:

> And from his true dominion it follows that the true God is a living, intelligent, and powerful Being; and, from His other perfections, that He is supreme, or most perfect. God is the same God, always and everywhere. He is omnipresent, not *virtually* but also *substantially*; for virtue cannot subsist without substance. In Him are all things contained and moved (28).

Newton's marginal note to the passage cites some of the main sources of the 'classical' Scholia:

> This was the opinion of the Ancients. So *Pythagoras*, in Cicer. *de Nat. Deo.* Lib. I. *Thales*, *Anaxagoras*, *Virgil* Georg. Lib. IV. Ver. 220; and the *Aeneid*, lib. VI, ver. 721. *Philo Allegor*, at the beginning of Lib. I. *Aratus*, in his *Phaenom*, at the beginning. So also the sacred writers: as *St. Paul*, *Acts* xvii, ver. 27, 28. *St. John*'s Gosp. Chap. xiv, ver. 2. *Moses*, *Deut.* iv, ver. 39; and x, ver. 14. *David*, *Psal.* cxxxix, ver. 7, 8, 9. *Solomon*, I *Kings*, viii, ver. 27. *Job*, xxii, ver. 12, 13, 14. *Jeremiah*, xxiii, ver. 23, 24. The Idolators supposed the sun, moon, and stars, the souls of men, and other parts of the world, to be parts of the Supreme God, and therefore to be worshipped; but erroneously.

Newton is asserting here a *prisca theologia*, an original conception of divinity from which 'the Idolators' had departed. A parallel *prisca* is described in a concluding passage of the *Opticks*. After examining the attributes of God and emphasizing His power to vary the laws of nature in different parts of the universe, he seems to pass by an abrupt transition to a review of his method of Analysis and the manner in which it was employed in the treatise. He then reverts to theological considerations, for

> . . . if Natural Philosophy in all its parts, by pursuing this method, shall at length be perfected, the bounds of Moral Philosophy will be also enlarged. For so far as we can know by Natural Philosophy what is the first cause, what power He has over us, and what benefits we receive

> from Him, so far our duty towards Him, as well as that towards one another, will appear to us by the Light of Nature. And no doubt, if the worship of false gods had not blinded the heathen, their Moral Philosophy would have gone farther than to the four cardinal virtues; and instead of teaching the transmigration of souls, and to worship the sun and moon and dead heroes, they would have taught us to worship our true Author and Benefactor, as their ancestors did under the government of Noah and his sons before they corrupted themselves (29).

The *prisca sapientia* and the *prisca theologia* is implicit in the closing passage of Newton's great scientific treatise. A true natural philosophy must lead to a surer knowledge of God, and thence to a firmly-grounded moral philosophy. The curious reference to Noah and his sons can be explained only by the assumption that, if true religion follows from true natural philosophy, then the latter must have served as the foundation for the former in the pristine age before the corruption of Noah and his sons (30). The supporting evidence from the unpublished material would appear to make that conclusion certain.

Finally, certain stylistic features of the concluding section of the *Opticks*, quoted above, make it plain that when Newton undertook to 'discourse' of God within natural philosophy, he believed that could be done by the same rigorous methods as those employed in mathematics and experimental philosophy. As mentioned above, in the last pages of the *Opticks*, a dicsussion of God's attributes and power is interrupted by a discussion of Newton's method of 'Analysis', consisting in a careful sequence of inductions from observations and experiment. The sequence of causes yielded by this method, could be pursued 'Till the argument end in the most general'. Newton seems to be alluding here to the First Cause or God. That interpretation is strengthened by the succeeding passage, quoted above. The perfection of natural knowledge must lead to a more perfect knowledge of God, with its attendant moral benefits (31).

More direct evidence for Newton's confidence in his method as yielding certainty in theology, as in natural philosophy in the narrower sense, is provided by the qualifications with which he introduces his assertions. In Queries notorious for the cautions with which they are hedged, it is most significant that Newton's theological asseverations are introduced by 'must be allowed', 'nothing else but', and 'no doubt' (32). It is inconceivable that Newton would have publicly claimed such certainty for these propositions unless they were grounded as firmly for him as the inverse-square law of gravitation and the composite nature of white light.

The published texts discussed above confirm our interpretation of the

'classical' Scholia as constituting a serious investigation for Newton. We see that Newton was prepared to make a public avowal of his belief that he believed in God's direct intervention in His creation; that theological and historical knowledge could be obtained by the sure method of inductive analysis; that there was a *prisca* in theology and philosophy which could be recovered; and that the deepest problem of natural philosophy, the cause of gravitational attraction, could only be explained within such a historical-theological framework. In the light of these assumptions, Newton would have every confidence in his interpretation of ancient sources for his 'classical' Scholia, finding there atoms, gravity and the void, the Copernican System and the inverse-square law.

In these principles, there is a direct link with Newton's immediate predecessors, the Cambridge Platonists. Newton's dialogue with the Cambridge Platonists, and his concern with the theological implications of fundamental natural philosophy, were not a passing interest of his troubled middle years. A passage from *de Gravitatione et Aequipondio Fluidorum*, written about 1670, confirms his continuing concern:

> . . . some may perhaps prefer to suppose that God imposes on the soul of the world, created by him, the task of endowing definite spaces with the properties of bodies, rather than to believe that this function is directly discharged by God. Therefore the world should not be called the creation of that soul but of God alone, who created it by constituting the soul of such a nature that the world necessarily emanates from it. But I do not see why God himself does not directly inform space with bodies; so long as we distinguish between the formal reason of bodies and the act of divine will.

Newton's Platonism was not entirely the Platonism of More and Cudworth, with their stress on such intermediaries as the Hylarchichal Principle; but it was also a Platonism in the spirit of the early Church Fathers. Still, as in More, Cudworth and the Fathers, the basic world picture of the 'classical' Scholia emerges from what Newton took to be an 'entire and genuine philosophy' which had been lost. Newton, and the Cambridge Platonists, saw as their task the unification and restoration of this philosophy. It will be one of the main tasks of the remainder of this paper to characterize further the origin and nature of this distinctively English tradition of natural philosophy.

The apparent contradiction between such a traditional Neo-Platonic philosophy, and the stern inductivism of the *Principia*, dissolves when we examine more closely how Newton modified the 'mechanical' philosophy of

nature which was current earlier in the century. In one sense he expanded it, by allowing unexplained forces into his explanations of the phenomena; but in a deeper sense he restricted it, especially in its pretensions to knowledge of the natural world. A sign of this restrictive approach appeared in his early work in optics. There, he rejected the arbitrarily formulated hypotheses of such philosophers as Descartes and Hooke; for they could not from these deduce the phaenomena of nature, and their pictorial mechanisms were incompatible with the laws of such phaenomena. For Newton, the source of their error was that they did not sufficiently appreciate that the mechanical philosophy, rigorously conceived, was simply the estimation of forces in nature by geometrical calculation in terms of matter in motion. This conception was secured by the brilliant achievements of the *Principia*.

At times Newton certainly hoped that he could extend this approach to include the behaviour of the insensibly small particles of matter. But he realized that the most the 'analogy of nature' would allow was the transference of his system of quantitative laws to the motions of such invisible particles. That is, they applied only to the *atomical* part of his system, to *vis inertiae*: 'a passive Principle by which Bodies persist in their Motion or Rest, receive Motion in proportion to the Force impressing it, and resist as much as they are resisted!' But the heart of Newton's philosophy of nature, the world of forces and active principles, lay categorically beyond the systems of the *Opticks* and the *Principia*. How these principles were to be explained was a great, though hidden, problem of Newton's work. There is evidence that he tried different approaches to it at different periods; and the material of the 'classical' Scholia comes from a time when he seems to have largely abandoned earlier attempts at a quasi-material explanation of forces, and of gravity in particular. However, even when in his later years he again entertained the possibility of an 'aetherial medium', this did not obviate the 'necessity of conceiving and recruiting it (motion) by active principles, such as are the cause of Gravity . . .'. Newtonian forces were never such as to be explained away by aetherial mechanisms; by nature immaterial, they required a different categoy of existence for their explanation.

Thus the ontological problem of causation, conceived in the classical neoplatonic framework, was central to Newton's thought (33). His failure to solve it is less significant than his attempt to investigate it through a unique combination of methods: a rigorously inductive philosophy, using controlled experiment and elaborate mathematics; complemented by an historical approach, reconstructing the *prisca sapientia* of the laws of God's agency in the world.

In the light of this interpretation of Newton's programme for philosophy, we may re-examine the significance of the published *Queries*. It may well be that their hints and suggestions for further experimental and theoretical work were taken by Newton's successors to be guides to the complete achievement of the new natural philosophy within the mathematical framework of the *Principia*. But in his private thoughts, certainly in the period of the 'classical' Scholia and probably throughout his life, Newton knew that the programme was incomparably more vast. For he saw the task of natural philosophy as the restoration of the knowledge of the complete system of the cosmos, including God as the creator and as the ever-present agent (34).

The dream of a *science universelle* was not unique to Newton; it motivated the deepest philosophers of the seventeenth century, as Descartes and Leibniz. Where Newton stands out is in his choice of materials and methods for such a science, drawing partly on a neoplatonic tradition which flourished in England long after it had declined among leading philosophers on the Continent. That tradition will be examined in the following section.

III

The weight attached by Newton to his historical Scholia must appear curious and anachronistic in the light of the generally-accepted view of the intellectual milieu in late seventeenth- and early eighteenth-century England. The 1690's witnessed a decisive confrontation in England in a literary battle that had raged through much of the century: the 'battle of books' between those who championed and those who contested the superiority of the moderns over the ancients. In 1694 the young William Wotton published his *Reflections on Ancient and Modern Learning*, a work which gave a careful account of the scientific achievements of the century, and, while on the whole acknowledging the superiority of the ancients in literature, insisted that the moderns had far surpassed them in natural philosophy. Wotton's work was a reply to Sir William Temple's defence of the ancients in his *Essay upon the Ancient and Modern Learning* (1690). The controversy has been regarded as an indication of the extent to which the idea of progress had permeated the general intellectual consciousness by this time, as compared with Temple's circular view of history (35). Newton's defence of his *systema mundi* by representing it as no more than a return to the views of the ancients appears reactionary against that background, and not easily reconcilable with the idea of progress.

The discrepancy seems most glaring in Newton, since his system of the world came to be regarded as the most important argument for the

superiority of the moderns over the ancients. Was Newton, in poring over the fragments of the ancients and elaborating dubious genealogies for his doctrines, reflecting a backward-looking attitude peculiar to him and his circle of intimates at Cambridge? It would be misleading to accept such a view of Newton's relations to the general intellectual currents of his time. Though a new conception of human progress had been gaining ground through the seventeenth century, there were other conceptions of the development of human knowledge whose rôle can easily be overlooked or minimized if we fix our gaze wholly on the 'idea of progress'. Through them Newton is linked to a certain Renaissance tradition, and, beyond the thinkers of the Renaissance, to the early Greek Church Fathers on whom he relied so considerably in discovering intimations of his physical doctrines among the ancients.

'Rebirth', 'rediscovery', not absolute originality but a return to truths well known to men in earlier ages, corrupted and obscured through the centuries: that is recognized as a cardinal characteristic of the Italian Renaissance. The broad similarity of Newton's scholia with that approach is immediately obvious. A more precise understanding of various *prisca* traditions and their modifications is necessary before we can place Newton's views in their historical context.

During the Renaissance, the ideal of classical antiquity aided the emergence and legitimation of a new sensibility and a new view of the world and of man. Innovation and experiment, the break with the traditional culture of the time, could be justified by a doctrine of the 'imitation' of the ancients, whose civilization typified the perfect models of conduct, arts, philosophy and polity. By the sixteenth century, the 'prisca' concept served, at least for the more critical humanists as a way of drawing attention to the undoubted superiority which classical antiquity had enjoyed over medieval Europe in civilization and refinement (36). But there were other thinkers who interpreted the concept much more literally. They wished to demonstrate that the best of pre-Christian thought owed its excellence to the fact that it represented fragments of the only major non-Christian revelation which a Christian could acknowledge, the Mosaic one enshrined in the Old Testament. Others postulated a series of partial revelations to humanity, preceding the Christian one, through a chain of *prisci theologi* (37). It is not surprising that the most elaborately developed Renaissance *prisca* doctrine is to be found in the works of leading thinkers of the Platonic Academy at Florence in the late fifteenth century, Marsilio Ficino (1433-1499) and Pico della Mirandola (1463-1494), since their interest was centred upon writings and

practices which the Church had traditionally regarded as heretical and diabolic: the magical works of late antiquity, and especially the newly-recovered *Corpus Hermeticum*. Through Ficino's Latin translation of the *Poemander* and *Asclepius* of Hermes Trismegistus, supposedly an Egyptian contemporary of Moses, these opinions came to be widely diffused in the sixteenth and seventeenth centuries (38).

Tracing pagan wisdom back to Moses was far more cautious and compatible with orthodoxy than postulating a series of partial revelations, since the unique status of Old Testament was thus safeguarded. In practice, the two approaches were not kept quite distinct. Ficino, for example, had accused the Neo-Platonists of having stolen from the apostles and apostolic disciples 'anything sublime that they have said about the divine mind, angels, and other things pertaining to theology' (39). But the tendency was pursued to such an extreme by other thinkers that every great pagan philosopher, including Plato, was placed in the debt of 'Egyptian wisdom'. The attribution was not original. The cult of 'Egyptian wisdom' found many votaries at Hellenistic Alexandria in late antiquity. Jewish thinkers of the Alexandrian school sought to reconcile their own religious traditions with the Greek doctrines to which they had been exposed by attributing a Hebraic origin to Greek philosophy (40). Even before Philo, a host of treatises had convicted the Greek philosophers of having stolen from the Hebrews, until Plato (in a famous saying attributed to Numneius) became nothing but 'an Attic Moses'. The Egyptian priests themselves began to claim an Egyptian origin for the doctrines, arts and institutions of the Greeks. Pythagoras had derived his theory of numbers, and Democritus his supposed knowledge of astronomy from the Egyptians and had transmitted these to the Hellenes (41). The Alexandrian Christians gave the Hebraic tradition an important place in Christian apologetics.

Foremost among these was Clement of Alexandria (d. *c.* 213 A.D.), founder of the famous Catechetical School, whose authority was regarded as supreme by Newton in his biblical studies. Clement accepted the necessity of the heritage of Greek philosophy for Christianity. In defending Christianity and seeking the conversion of pagan intellectuals, Clement employed two basic techniques. One was allegorism. The Old Testament was represented as embodying the moral law; it was inferior to the Gospel, since it worked by fear and not by love. The rest of it revealed Christ throughout, but in riddles and symbols for those who could read it aright (the postulate adopted by Newton in his studies of the prophetical books). The other Clementine technique consisted of tracing Hellenic wisdom to borrowings from the

Hebrew prophets, Plato being simply ὁ ἐξ βρχίω φιλόσφος, and Clement's *Stromata* served through the centuries as he chief handbook of those who claimed an Hebraic origin for Greek scienc and philosophy (42). In Clement, as in other Christian apologists like Lactantius, Eusebius, Justin, and St. Augustine, the attribution was supported by the testimony of the mysterious Hermes Trismegistus, regarded as an Egyptian *priscus* who prefigured the Christian revelation of the future (43).

In the sixteenth century, the many authors who adhered to these *prisca* traditions drew upon the authority of these patristic works. By a curious shift, a tactic originally employed to secure the authority of the Christian revelation against pagan philosophy was now used by Renaissance apologists for pagan philosophy. Since what was best in the philosophy of Greece and Rome was borrowed from the Mosaic revelation, Christianity had nothing to fear from the study of pagan doctrines.

The history of *prisca* doctrines in the sixteenth century is complicated by the Reformation and Counter-Reformation, and the doctrinal strife between Protestants and Catholics and among the various Protestant sects. The Protestant stress on the Bible at the expense of the mediating Church may be expected to have diminished Catholic enthusiasm for the naked text of the Scripture as the sole repository of God's revelation to mankind. It is certainly true that Catholic writers who continued to concern themselves with the *prisca* in the post-Reformation period came to be regarded with increasing suspicion by the orthodox. An over-emphasis on the *prisca* could lead to a depreciation of the uniqueness of the Christian revelation. In the closing years of the sixteenth century, two heretic south-Italian Dominicans, each in his own way, conceived it as their mission to restore the true Hermetic religion. One of these was Tommaso Campanella (1558-1639), who spent twenty-five years in the prison of the Inquisition for his part in a Calabrian revolt aiming to set up an Hermetic 'City of the Sun' (44). The other was Giordano Bruno (1548-1600), burnt at the stake in Rome, who planned to restore the true Egyptian 'religion of the world', Christianity having been a falling away from that true religion (45). That is probably the reason for Francesco Patrizi's much less socially revolutionary ideas in his *Nova de universis philosophia* (1591) being placed on the Index in 1594 (46).

The *prisca* doctrines discussed so far were not without significance for natural philosophy, in as much as its adherents wished to substitute a Neo-Platonic explanation, based on secret sympathies and antipathies, stellar virtues, and the microcosm-macrocosm analogy, for the Aristotelian qualitative physics (47). A *prisca* variant more directly concerned with natural

philosophy made its appearance in the late sixteenth century. There was a growing interest in the teachings of the earliest Greek natural philosophers, the Pre-Socratics of the Ionic and Milesian schools, and ancient atomic doctrines were attracting greater attention. Even in antiquity atomism had been associated with atheism, and its assimilation into a basically religious framework raised special difficulties. The Democritean universe of jostling atoms, bereft of all qualities save the purely quantitative characteristics of size, figure and motion, needed no Creator, nor special act of creation. Becoming entangled by chance, they gave birth to bodies and universes, and served to explain all phenomena.

During the late sixteenth century, the diffusion of the works of Strabo, Sextus Empiricus, Diogenes Laertius, and Plutarch revived a certain tradition about the origins of atomism, which, in turn, suggested a *prisca* doctrine to clothe it in respectability and reconcile it with orthodoxy (48). Relying on a now lost work of Posidonius, these authorities named a certain Moschus, a Phoenician, who lived before the Trojan war, as the first expositor of atomism. In 1598, Arcerius, a Friesian philologist, identified Moschus with Mochus, another Phoenician, whose successors Pythagoras (according to Iamblichus) had encountered and conversed with during a sojourn at Sidon. But Arcerius went much farther: he suggested that Moschus-Mochus was no other than Moses himself (49). It was a momentous identification which proved popular and influential through the seventeenth century. Many leading Protestant scholars lent their support to it. The great Isaac Casaubon (1559-1614) confirmed that Mochus was the Tyrian name for Moses. John Selden (1584-1654) accepted the identification. Gerardus Vossius (1577-1649) discussed Strabo's account of Moschus's natural philosophy (50).

Although Arcerius's identification of Moschus with Moses was not universally accepted, the derivation of Democritean atomism from the Hebrews is reflected in such authors as Daniel Sennert (1572-1637), the well-known German iatrochemist, in 1636 (51), Robert Boyle (52), and Pierre Gassendi(53).

But the most sustained attempt to develop these *prisca* doctrines into a justification for a new and revolutionary natural philosophy by tracing it to the Mosaic revelation, was undertaken in mid-seventeenth-century England by certain thinkers at Cambridge, grouped familiarly as the Cambridge Platonists. Newton was at Cambridge when their influence was considerable. He early became acquainted with their writings. There are striking similarities between their approach and his, to the relation between revelation and natural philosophy. The views of the Cambridge Platonists must therefore be discussed here in some detail.

Joseph Glanvill, who was admitted to Exeter College at Oxford in 1652, regretted having entered Oxford rather than Cambridge where he believed the 'new philosophy' was held in greater esteem (54). It seems certain that the proponents of the 'new' (by which he means the Cartesian) philosophy whom Glanvill had in mind were the Cambridge Platonists. At Oxford, the scientific group which came together from the late 1640's concentrated its attention on the more purely scientific aspects of the work of Descartes, Gassendi, and other Continental natural philosophers. The Cambridge Platonist approach to these philosophers was guided by different problems and preoccupations. Henry More (1614-1687) had early saluted Descartes as the prince of philosophers, but his deepest interests did not lie in Descartes' more purely technical and scientific output (55). For him Descartes' main achievement lay in providing a rational demonstration of the existence of incorporeal substance, and in offering a grand synthesis reconciling theology and natural philosophy. More saw Descartes as making an enormous contribution towards building an 'exteriour Fortification about Theology', to repel 'gigantic batteries raised against the belief of the *existence of a God*, and of a *Reward in the World to come* . . . ' (56). More was writing during the turbulent decades of the Puritan Revolution, when these dangers were felt to have reached unprecedented heights in England. They could be refuted by resorting to the Cartesian *cogito* argument, and by showing that acceptance of the Cartesian postulate of the material world as dead and inert involved the metaphysical necessity of an immaterial principle to set it into motion and preserve its motion.

In attempting to introduce the Cartesian postulate of a dead world of matter into Neo-Platonism, the Cambridge Platonists were embarking on a formidable task, running counter to the historical tendencies of that philosophy. The hylozoistic magical philosophies of nature in the sixteenth century had drawn inspiration from late-antique Neo-Platonism, and the 'enthusiasts' in Civil-War England had urged the teaching of these philosophies of nature at English universities in place of the 'rubbish' of scholastic learning (57). Reacting against them, as well as against Deists, Hobbists and Socinians, the Cambridge Platonists adopted a sharp distinction between matter and spirit, although the distinction lost its Cartesian clarity in their emphasis on a 'hylarchic principle', which was in effect a restatement of Neo-Platonic world-soul as intermediary between God and the universe. In order to assimilate the Cartesian natural philosophy to their Christianized Neo-Platonism, the Cambridge Platonists read Platonic innate ideas into the Cartesian *cogito* argument, the 'aetherial vehicle' (58) into his First and

Second Matter, and, most important, developed an historical thesis about the origins of the Cartesian philosophy. Since the true revelation in religion as in natural philosophy had been vouchsafed to Moses, Descartes had only *rediscovered* the true natural philosophy. But that natural philosophy was to be found not in Plato, but as glimmerings in the atheistic Leucippus and Democritus. How was the paradox to be resolved? Greatly expanding Arcerius's suggestion, More proposed that the Mosaic philosophy had passed to the Greeks in two divided streams, the religious part being received by Plato, the natural philosophical part (through Pythagoras) by Leuccipus and Democritus, who had developed it in an atheistic manner. Now, after many vicissitudes, the two had again been welded into the Mosaic whole by Descartes. It is

> Therefore very evident to me, That the ancient *Pythagorick*, or Judaick Cabbala did consist of what we now call *Platonism* and *Cartesianism*, the latter being as it were the *Body*, the other the *Soul* of Cartesianism; the unhappy disjunction of which, has been a great evil to both (59) . . . *Moses* has been aforehand with *Cartesius* (60).

Henry More's enthusiasm for Cartesianism did not last. Already by 1659 he was urging exceptions to the principle that all natural phenomena could be solved in mechanical terms, instancing gravitation as a phenomenon not susceptible of a Cartesian or Hobbist explanation (61). Later he came to reject Cartesianism as paving the way for atheism. More faithful to Cartesianism and to More's sketch of its historical origins was Henry More's fellow-Platonist, Ralph Cudworth (1617-1688), in his influential *True Intellectual System of the Universe*, first published in 1678. Cudworth conducted his discussion on the basis of a natural philosophy 'called by some *Atomical* or *Corpuscular*, by others *Mechanical*' (62), and admitted that in driving out 'all Final and Mental Causality' from the universe, Descartes increased the danger of atheism (63). The central weakness of Descartes' approach was that he would not accept causes other than mechanical causes; for Cudworth, over and above purely mechanical processes, there was a 'plastic nature', 'that which makes all things thus to conspire every where, and agree together into one harmony' (64). Cudworth was no more successful than More in attempting to combine the Neo-Platonic concept of nature with the atomical and mechanical concepts of the new physics in a coherent synthesis, as shown by the fact that theological explanations were introduced by him when the phenomena in question did not easily seem to admit of a mechanical explanation. But he was convinced that the mechanical philosophy, 'if rightly understood . . . is the most effectual Engin against Atheism than can be' (65).

If matter was utterly dead and passive, and there was no motion in the world save that which resulted from contact-action ('heterokinesis'), then it was self-evident that there must be something else in the world besides body or matter. The ancients had rightly apprehended that truth, and had a 'clear and distinct' conception of two basic entities, passive matter, and active power, vigour or virtue—what they had termed 'the *Active Principle*' (66).

Although Cudworth is primarily concerned with formulating the favourable theological and moral consequences of a 'rightly understood' mechanical philosophy, it is noteworthy that throughout his treatise he relies on an historical mode of exposition, based on the fundamental presupposition that the true religious, moral and natural philosophy flowed to the Gentiles from the Hebrews, and came to be fragmented and corrupted in the course of time.

The belief in a *prisca theologia* and in the Hebraic origin of Greek learning, was not restricted to the inner circle of the Cambridge Platonists. It was widely accepted in theological discussions. A striking example is to be found in the theological writings of John Wallis (1616-1703), a distinguished scientific contemporary of Newton and Savilian Professor of Geometry at Oxford. Wallis entered the Trinitarian controversy in the last decades of the century, as a champion of the dogma. In his *Three Sermons Concerning the Sacred Trinity* (1691) he wrote:

> 'Tis well-known (to those conversant in such Studies) that much of the Heathen Learning (their Philosophy, Theology and Mythology) was borrowed from the Jews; though much Disguised, and sometimes Ridiculed by them. Which things though they are Fabulous, as disguised in a Romantick Dress: yet they are good Evidence that there was a *Truth in History*, which gave occasion to those Fables.
>
> None doubt but *Ovid*'s Fable of the *Chaos* (of which all things were made) took its rise from *Mose*'s of the *Creation*: And *Deucalion*'s *Flood*, from that of Noah: and the *Titan*'s fighting against the Gods, from the Builders of *Babel*'s Tower: And that of Two-faced *Janus*, from *Noah*'s looking backward and forward to the World before and since the Flood. And many the like, of which we may see in *Natalis Comes*, in *Bochartus*, and others: And of which we have a large Collection in *Theophilus Gales*'s *Court of the Gentiles*. And in Dr. Duport's *Gnomologia Homerica*: wherein is a Collection of *Homer*'s *Sayings*, which look like Allusions to like Passages in Sacred Scripture; and seem to be borrowed (most of them) from those Books of it, which were written before Homer's time; who yet is one of the most Ancient and most Famous of Heathen Writers.

Plato hath borrowed so much of his Philosophy, History, and Theology, from the *Jewish* Learning, as that he hath obtained the Title of *Moses Atticus, Moses disguised in a Greek dress* . . .

And I am so far from thinking (as the *Socinians* would have us) that *St. John* did but *Platonize*, and borrowed his ὁλόγος from Plato's Trinity; that I rather think, that *Plato* borrowed his *Trinity* (as he did many other things) from the *Jewish Doctrine*, though by him disguised . . .

Aristotle, in the last Chapter of his Book, *De Mundo*; which is *de Dei Nominibus*: He tells us that *God, though he be but One, hath many Names*: And amongst these *many*, he reckons that of the *Tres Parcae* . . . or as we call them, the *Three Destinities* . . . to be one of these names. Which though Numbered as *Three*, are but this *One God* . . . So that it seems that both *Plato* and *Aristotle* were of opinion, that *Three Somewhats* may be *One God*. And this, in likelihood, they derived from the Jewish Learning.

IV

Newton's earliest commonplace-book at Cambridge shows him imbibing the mechanical philosophy not only from the works of Descartes, but also from other works which presented it as part of a long historical tradition, in contradistinction to Descartes' own exposition, which acknowledged no historical debts (67). Walter Charleton's *Physiologia Epicuro-Gassendo-Charltoniana* (1654) introduced him to the Gassendist approach, sifting the opinions of the ancients to establish their concordance with his own philosophy. At the same time, the early writings of Henry More would have acquainted him with a much more fundamentalist *prisca*, tracing the new mechanical philosophy to Moses, and making it an essential part of a new theological synthesis.

Much later, when Newton was developing his 'classical' annotations, he drew considerably on Cudworth's erudite *True Intellectual System*. His extant notes on the *System* reproduce almost verbatim Cudworth's account of Moschus and of the atomic succession from him (68). There was a large body of shared assumptions between Newton and Cudworth. From the earliest period of his intellectual development, Newton held a view of the world as comprising both active and passive principles, with the technique later presented in the *Principia* applying only to inert matter. He believed that conceiving matter as independent of God, or endowed with self-activity, led to atheism (69). Like Cudworth, he seems to have had the mechanical

philosophies of Hobbes and of Descartes, and the 'hylozoistic atheism' of various English free-thinkers in mind.

Despite these similarities, Newton did not borrow a great deal from Cudworth's learned account in his historical annotations. Cudworth had necessarily confined himself to a very general account of the mechanical philosophy, and buttressed it with his historical learning, while Newton needed support for the details of his own system of the world; and his own classical knowledge was sufficient for the purpose. Besides such standard authorities in his own time as Diogenes Laertius's *De vita philosophorum* and the Pseudo-Plutarchian *Placita Philosophorum* (supplemented by Suidas, Pliny, Galen, the *Ecologae* of Stobaeus, and the *Academic Questions* of Cicero), he cited Plato's *Timaeus*, *Apology*, and *Laws*, as well as Poclus's *Commentary* on the *Timaeus*. The strongly Platonic bias in his authorities was reinforced by his extensive use of Macrobius's *Commentary on Cicero's Dream of Scipio*, a work which had served virtually as a handbook of Neo-Platonism during the Christian middle ages, and discussed ancient arithmetologies in great detail (70). Besides Macrobius, Lucretius served as the principal authority on the most ancient natural philosophy. Besides the Greek and Roman authors, the early Greek church fathers, whose works were very familiar to Newton in the course of his biblical studies, were prominently represented, including Clement, Origen, and Eusebius, as well as Cyril and Julian (71). The only modern author cited was Natalis Conti (*c.* 1520–1582), an influential sixteenth-century mythographer, who links Newton with a Renaissance tradition attributing a hidden theological, moral, and natural-philosophical meaning to all the classical myths (72).

Our treatment so far has stressed the similarities between the early More, Cudworth, and Newton, in order to show that Newton's historical annotations are by no means as bizarre as they may now appear, but follow a certain intellectual tradition very much alive in Newton's own day. It must also be pointed out that Newton disagrees with the two other authors on certain important points of interpretation. His notes on Cudworth show that he was not merely transcribing his conclusions, but questioned some of them, for example, his condemnation of the 'Egyptian' account of creation as atheistical (73). A more important divergence would lie in Newton's anti-trinitarianism. *Prisca* theories, in the Renaissance as in More, Cudworth, and the industrious Theophilus Gale (74), had generally emphasized the presence of the notion of the Trinity among the *prisci*. Since Newton was vehemently opposed to the Trinitarian dogma, which he held to be a comparatively late corruption, these arguments would be uncongenial to him (75).

Nor would he accept More's and Cudworth's characterization of Epicurus and Lucretius as atheistic. As he had told Gregory: 'The philosophy of Epicurus and Lucretius is true and old, but was wrongly interpreted by the ancients as atheism . . . ' (76).

The most important difference between More and Cudworth on the one hand, and Newton on the other, lay in Newton's conviction that not the Cartesian philosophy (as More had once held), nor the 'mechanical philosophy' (in Cudworth's basically Cartesian interpretation), but his own system of the world represented the restoration of the true and original natural philosophy, as revealed by God even before the Flood.

In concluding this outline of the main points of agreement and disagreement between Newton and the Cambridge Platonists, attention must again be drawn to the fact that the terms of the dialogue were set by a certain theological-philosophical tradition. Only against that tradition can Newton's 'classical' endeavour be understood and explained. Newton's relation to that tradition becomes clearer if we remember that his interpretation of the texts of ancient natural philosophy was not the only 'exegetical' exercise which had engaged his attention. He had spent much time and labour on two other fields which demanded highly-developed techniques of interpretation. One was alchemy, whose practitioners wrapped up their supposed knowledge in a complex symbolism, designed to obscure it from the uninitiated. During the early seventeenth century, Michael Maier (1568-1622), whose works were deeply studied by Newton, had undertaken a survey of the entire Greek mythology to demonstrate that they represented alchemical secrets (77). Newton's interpretation of the 'harmony of the spheres' is analogous, in that it sees it as a symbolical representation of 'physical' secrets. The other major field employing exegetical techniques was that of biblical studies, which absorbed Newton throughout his life. In interpreting the prophetical books of the Old Testament, Newton attempted to show that the prophecies had been fulfilled down to the minutest details.

Both alchemy, as well as biblical exegetics, rested on the assumption that a true body of knowledge had been available to wise men in the remotest antiquity, and that the knowledge was couched in an enigmatical, symbolical form to conceal it from the vulgar. It is evident that the same assumptions underlie Newton's exegesis of the natural philosophy of the ancients. His tortuous interpretation of the Lyre of Apollo, the Pipes of Pan, and the 'Harmony of the Spheres' rests on the belief that the true system of the world was known to the ancients, but had been turned into 'a great mystery' which only the initiates could penetrate. In his studies of the Old Testament

prophecies, Newton was tracing the pristine knowledge of the historical events of future ages; in his alchemical studies, the pristine knowledge of the constitution of things; in his studies of ancient natural philosophy, the pristine knowledge of physical nature and the system of the world. The true meaning of the Old Testament prophecies would only become clear in retrospect, in the light of historical experience. In the same way, the authentic meaning of the ancient natural philosophy would only be revealed when the truths it embodied had been independently discovered by experimental investigation; it was thus that Pythagoras—and Newton—had unravelled the mystery of the most ancient 'harmony of the spheres'.

It should be quite clear that Newton's textual analysis of ancient natural philosophy was not based on a consciously *post hoc* procedure: reading into ancient texts truths arrived at in the course of his scientific work. For him, they represented a deeper penetration into the *prisca sapientia*, possible only when the preliminary work had been accomplished through experience. Besides this overriding justification, these investigations could perform a number of different functions. They could provide a pedigree for his own doctrines, to legitimate them for an audience which still widely accepted the idea of a *prisca sapientia*. He could use them as a direct defence for his own doctrines, as he does in the *Opticks* (78), and, on one occasion, during the controversy with Leibniz (79). Furthermore, the documents dealt with in this paper do not tell us whether his own adoption of the doctrines he ascribes to the ancients preceded his textual studies. Such basic problems as the existence of the void, the properties of matter, and the character of the divine agency lay beyond the experimental procedures he could deploy. Newton's solutions to some of these problems are explained and defended by the analogical reasoning whose patterns he defined in the *Regulae*. But the possibility that the ancient texts might have provided clues, and guided his thoughts in one direction or another, can by no means be excluded.

It is also possible to discern the function of the *prisca* arguments in Newton's more general philosophical concerns. Like Cudworth, he wished to confute 'Hobbists', Deists, and 'hylozoistick atheists', on the basis of *prisca* arguments (80). His own variant of the history of the original natural philosophy, with its insistence on absolutely dead matter, would be his contribution to the debate. On the struggle which was taking place on another front, concerning the authenticity and reliability of the Old Testament, Newton's demonstration of a pre-Noachian *prisca sapientia* would again be a weighty argument. When we recall how deeply Newton was committed to the vindication of the Old Testament account, both in regard to the prophecies

and the chronology of the ancient kingdoms (81), it is evident that it would have been a positive act of abstention on his part to fail to extend this approach to the origins of natural philosophy.

For Newton, all the truths of God's creation were once revealed, as an interconnected whole which comprised natural, moral and divine knowledge. Though they soon became obscured, they could be recovered by a disciplined method of analysis of experience. 'Hypotheses' were not to be feigned in any of these enquiries: just as the properties of light were to be induced from experiments, so the meaning of the sacred prophecies could be ascertained from those which had already been fulfilled, and the true natural philosophy of the ancients was to be deciphered on the basis of experimental knowledge already arrived at. A sequence of inductions could therefore lead naturally from Kepler's laws and the radial acceleration of the moon, through the principle of universal gravitation, to the unveiling of the true meaning of the Pipes of Pan.

Conclusion

In the course of our analysis of the 'classical' Scholia in this paper, we have traced the intellectual ancestry of Newton's 'historical' assumptions and methods, and their development in connection with a distinctive English 'mechanical philosophy'. The analysis has shown Newton's adherence to a particular approach to theological and philosophical problems, influential among many of his contemporaries. The conclusion may be suggested, that it is not really profitable to consider Newton either as 'the last of the magicians' or 'the first of the scientists'. It is equally unhistorical to try to resolve the problem by imagining a multiplicity of Newtons, one engaging in 'science' and the others dabbling in theology, chronology, and other similar pursuits.

It is certainly difficult for us in the twentieth century to conceive one whose scientific achievements were so great, pursuing with equal interest and energy such other studies, especially when his efforts in those fields produced so little of enduring value. It is even more difficult for us to imagine the mechanics and cosmology of the *Principia* being influenced by Newton's theological views and his belief in a pristine knowledge. Sir Isaac Newton, however, was not a 'scientist' but a Philosopher of Nature. In the intellectual environment of his century, it was a legitimate task to use a wide variety of materials to reconstruct the unified wisdom of Creation.

That was the task which Newton attempted. We cannot fully understand his scientific successes, without appreciating his endeavour in problems which for him, as for many of his contemporaries, constituted the ultimate problems.

ACKNOWLEDGEMENTS

The final version of this paper owes a great deal to the generous help and criticism of Dr J. R. Ravetz. The authors would also like to thank Professor A. R. Hall for allowing them to consult his copy of Newton's notes on Cudworth from the William Andrews Clark Library, and to the Reverend Dr E. Evans for providing the basic translations of the main passages quoted from the Royal Society manuscript.

NOTES

(1) University Library, Cambridge, Ad. MS. 3970.f.292^{v}.

(2) The first notice of the Gregory Manuscript (note 3) seems to have appeared in James Crauford Gregory's 'Notice concerning an Autograph Manuscript by Sir Isaac Newton . . . ', *Trans. R. Soc. Edinb.* **12**, 1834, pp. 64-76. Professor I. Bernard Cohen has announced his intention of publishing an edited version of the Newton MS. as well as Gregory's copy, ' "Quantum in se est": Newton's Concept of Inertia in relation to Descartes and Lucretius', *Notes and Records Roy. Soc. Lond.* **19**, 1964, p. 148.

(3) Gregory MS. 247 at the Royal Society, in Newton's hand. It is plain that both Fatio and Gregory had access to these Scholia. Gregory's notes on Newton's *Principia* contain the entire Scholia, copied in a careful hand and placed in a systematic order by Gregory. The Scholia must have been composed in the 1690's, most probably before 1694 (the year of Gregory's extended visit to Cambridge), and not later than 1697 (the date of Gregory's last note on the *Principia*). There are many alternative versions of the Newton autograph in the MSS. of the Portsmouth Collection, Ad. 3965.6 Folios 640^{r}-640^{v} and 278^{r} (University Library, Cambridge) contain substantially the same quotations and ideas as the R.S. autograph, although only Propositions IV, VI, VII, and VIII are dealt with. There are many other stray sheets in this section which probably represent even earlier attempts by Newton to construct his ideas. Folios 270^{r} 271^{r} and 272^{r} contain a long Scholium to Proposition VII, containing all of the ideas developed at greater length in the R.S. autograph, and was probably intended as another and more condensed version of it. Folio 14^{a} contains three paragraphs of interest. The first two embody some of the ideas of the General Scholium of 1713; the second paragraph contains ideas which only appeared in the Scholium to the last edition of the *Principia* in 1726; the last criticizes the existence of a fluid aether. It is plain therefore that the theological ideas in the *General Scholium* had been sketched by the early 1690's, and that Newton saw these being compatible with the philosophy presented in the scholia to the key propositions of Book Three. For a discussion of these passages, consult James Crauford Gregory, *loc. cit.* See also 'Fragment on the Law of Inertia', in Hall and Hall (note 23), pp. 309-311.

(4) See Frank E. Manuel, *Isaac Newton Historian*, Cambridge, 1963; H. McLachlan, *Newton: Theological Manuscripts*, Liverpool, 1950.

(5) *The Correspondence of Isaac Newton*, ed. H. W. Turnbull, Cambridge, 1961, Vol. 3, p. 193.

(6) *Ibid.* pp. 196-198, letter of 29 February 1692.

(7) *Ibid.* p. 338.

(8) *Ibid.* p. 384.

(9) That was shown by J. C. Gregory, *loc. cit.*; the *Elementa* was first published in 1702.

(10) Gregory MS. Folio 2. The quotations have been translated from the Latin.
(11) *Ibid.*
(12) *Ibid.* folio 7.
(13) *Ibid.* folio 8.
(14) *Ibid.* folio 9.
(15) *Ibid.* folio 10.
(16) U.L.C. Ad. MS. 3965.6, folio 271^{r}.
(17) *Ibid.* folio 270^{r}.
(18) Gregory MS. 247, folios 11-12; the account of Pythagoras is taken directly from *Macrobius' Commentary on the Dream of Scipio*, pp. 184-189 in W. H. Stahl's translation, New York, 1952.
(19) Keynes MS. 130, King's College Library, Cambridge.
(20) Colin MacLaurin, *An Account of Sir Isaac Newton's Philosophical Discoveries*, London, 1750, p. 34. MacLaurin is here discussing 'hints concerning the gravitation of celestial bodies in what is related of the doctrines of *Thales* and his successors: but *Pythagoras* seems to have been better acquainted with it, and is supposed to have had a view to it, in what he taught concerning the harmony of the spheres'. The authorities cited follow those given by Newton: Pliny, Macrobius (Lib. ii, cap. i), Plutarch, and Plato's *Timaeus*.
(21) *Elementa*, last page of 'Praefatio Auctoris': 'Proportionem his experimentis inventam *Pythagoras* applicuit ad Coelos, & inde didicit Harmoniam Sphaerarum'.
(22) U.L.C. Ad. 3970, folio 619^{r}; the passage was written between 1704, the date of the first edition of the *Opticks*, and 1706, the date of the second.
(23) There are many other references in the draft Queries to life and will as active principles, acting harmoniously upon matter; that knowledge is clearly attributed to the ancients. The analogy between man's moving his body by volition and God's moving matter in His sensorium was developed as early as 1670 in the *De Gravitatione*, A. R. Hall and M. B. Hall, *Unpublished Scientific Papers of Isaac Newton*, Cambridge, 1962, p. 141
(24) Gregory. MS 247, folio 13. Newton also cites 'On the same subject Hermesianax: Pluto Persephone, Ceres and kindly Venus and the Loves, the Tritons, Nereus, Thetis, Neptune and Mercury, Juno, Vulcan, Jupiter and Pan (,) Diana and Phoebus the dartsman are one God'.
(25) U.L.C. Ad. 3965.12, folio 269.
(26) Gregory MS. 247, folio 3.
(27) *Mathematical Principles of Natural Philosophy*, ed. F. Cajori, Berkeley, 1934, p. 545.
(28) *Ibid.* p. 545.
(29) Dover edition, based on the 4th London edition, 1952, pp. 405-406. In the first edition, the concluding passage ends with '. . . they would have taught us to worship our true Author and Benefactor'. Newton's autograph addendum to that passage, in a copy of the *Opticks* in the Babson Institute Library (No. 133, reproduced as Plate 10, in Manuel, *op. cit.*), reads: 'as their ancestors did before they corrupted themselves. For the seven Precepts of the Noachides were originally the moral Law of all nations; & the first of them was to have but one Supreme Lord God & not to alienate his worship; the second was not to profane his name; & the rest were to abstain from blood or homicide & from fornication (that is from incest adultery & all unlawful lusts), & from theft & all injuries, & to be merciful even to bruet beasts, & to set up magistrates for putting these laws in execution. Whence came the moral Philosophy of the ancient Greeks'.

(30) *Cf. The Chronology of the Ancient Kingdoms Amended*, London, 1728, pp. 186–190.
(31) *Opticks*, edition cited in note 29, p. 404.
(32) *Ibid.* p. 402, p. 403, p. 405.
(33) F. Van Steenberghen, *Aristotle in the West*, Louvain, 1955, pp. 8–22.
(34) For a different view, see H. Guerlac, 'Where the Statue Stood: Divergent Loyalties to Newton in the 18th Century', *Aspects of the Eighteenth Century*, 1965, p. 333: Newton was setting forth only the *mathematical principles* of natural philosophy, although that philosophy was still to come, 'the work of other hands, though here and there Newton offers hints and suggestions as to what it may contain'; that new natural philosophy 'must be erected . . . inside the boundaries that he (Newton) had marked out by his mathematical laws'.
(35) Wotton discusses 'the Learning of *Pythagoras*, and the most Ancient Philosophers of *Greece*' (Ch. viii), and concludes that from the reputation he enjoyed in antiquity 'one can no more conclude from thence, That *Pythagoras* knew as much as *Aristotle* or *Democritus*, than that Friar *Bacon* was as great a Mathematician as Dr. *Barrow*, or Mr. *Newton* . . . (p. 93, 3rd edition, 1705).
(36) F. A. Yates, *Giordano Bruno and the Hermetic Tradition*, London, 1964, pp. 159–166.
(37) D. P. Walker, 'The *Prisca Theologia* In France', *J. Warburg & Courtauld Insts*, 1954, **17**, pp. 204–259.
(38) Yates, *op. cit.*, pp. 1–61; the standard edition and translation of the *Corpus Hermeticum* is the French one, Nock & Festugière, Paris, 3 vols., 1945–1964. References to the *Poemander* and *Asclepius* in Ficino's edition are to be found in Newton's hand in his notes from the works of Michael Maier (about 50,000 words on 82 pages), Keynes MS. 32, at King's College, Cambridge.
(39) Walker, quoting Champier, in *op. cit.*, p. 218.
(40) C. Bigg, *The Christian Platonists of Alexandria*, new ed., Oxford, 1913; for a summary and bibliography of the vast secondary literature on this subject, see J. Quasten, *Patrology*, Vol. 2, Utrecht-Antwerp, 1953.
(41) Eduard Zeller, *A History of Greek Philosophy*, Eng. tr., London, 1889, Vol. I, pp. 27–28.
(42) Zeller, p. 28; also, C. Merk, *Clemens Alexandrianus u. seine Abhängingkeit der griechischen Philosophie*, 1879; bibliography in Quasten, pp. 12–15.
(43) Yates, *op. cit.*, pp. 7–12.
(44) *Ibid.* pp. 360–397; L. Blanchet, *Campanella*, Paris, 1920, esp. pp. 70ff.
(45) *Ibid. passim.*
(46) On Patrizi, see bibliography in P. O. Kristeller, *Eight Philosophers of the Italian Renaissance*, London, 1965, pp. 186–187.
(47) See Blanchet, esp. pp. 146–163, 193–207; Patrizi, *Nova*, 'Panarchia', Books xii and xvi. The *prisca* chains usually excluded Aristotle; those who did include him (like Pico and Steuchus) relied on pseudo-Aristotelian works like the *de mundo*.
(48) G. Aspelin, 'Cudworth's Interpretation of Greek Philosophy', *Göteborgs Högskolas Arsskrift*, **49**, 1943; D. Sailor, 'Moses and Atomism', *J. Hist. Ideas*, **25**, 1, 1964; H. Guerlac, *Newton et Epicure*, Paris, 1963, pp. 13–22.
(49) Arcerius, edition of Imablichus' *De vita Pythagorae*, note to p. 33.
(50) These authorities are cited by Henry More in his 'Defence of the Philosophic Cabbala', pp. 110–111, in *A Collection of Several Philosophical Writings*, 4th edition, 1711. The Selden work referred to is *De Jure Naturali juxta Hebros*, London, 1640; Vossius, *De historicis Graecis*, lib. 3, Leyden, 1624.
(51) Daniel Sennert, *Hypomnemata physica*, Francfort, 1636, p. 89.

(52) *The Sceptical Chymist* (1661), Everyman edition, 1949, p. 75.
(53) *Philosophiae Epicuri Syntagma*, 3rd edition, Lugduni, 1675, **I**, p. 101.
(54) Anthony à Wood, *Athenae Oxonienses*, 2nd edition, London, 1721, **2**, p. 662.
(55) *A Collection*, 'Epistolae Quatuor Ad Renatum Des-Cartes', letter of December 1648, p. 61.
(56) More, *op. cit.*, Preface General, p. vi.
(57) P. M. Rattansi, 'Paracelsus and the Puritan Revolution', *Ambix*, **II**, 1963, pp. 24-32.
(58) More, *op. cit.*, 'The Immortality of the Soul' (1659), Bk. II, Ch. xii, p. 124.
(59) *Ibid.* Preface General, p. xvii.
(60) *Ibid.* 'Defence of the Philosophic Cabbala', Ch. I, p. 80.
(61) *The Immortality of the Soul*, London, 1659, Preface $b7^{v}$-$b8^{v}$; also *Remarks upon Two late Ingenious Discourses*, London, 1676.
(62) Chapter 1.
(63) *Ibid.* pp. 680-681.
(64) *Ibid.* p. 167.
(65) *Ibid.* p. 12.
(66) *Ibid.* p. 27.
(67) *Questiones quaedam Philosphicae*, U.L.C. Ad. 3996ff. 88-135; discussed by R. S. Westfall, 'The Foundations of Newton's Philosophy of Nature', *Br. J. Hist. Sci.* **1**, pp. 171-182, 1962. Charleton distinguished between the innovators, who 'ponder the Reasons of all, but the Reputation of none', and included Tycho, Kepler, Galileo, Scheiner, Kircher, Harvey, and 'the Epitome of all, *Des Cartes*' (p. 3); the renovators, like Ficino, Copernicus ('reviver' of Aristarchus' system), Magnenus, and 'the greatest antiquary among them, the immortal *Gassendus* . . . ' (p. 4). Moschus is cited as originator of atomism on p. 87. On Gassendi's method, see F. Bernier, *Abrege de la Philosophie de Gassendi*, Paris, 1675, 'Av Lectevr', 'Car à proprement parler, Gassendi est une Biblioteque entiere; mais une Biblioteque qui en rapporant les diverses Opinions des Anciens, nou sçait toujours doucement insinüer la plus probable'.
(68) The notes comprise unnumbered folio pages, now at the William Andrews Clark Memorial Library of the University of California, Los Angeles. Passages from pages 16-17 of the first edition of 1678 have been copied almost verbatim. On the origin of the atomic philosophy, he has transcribed Cudworth's opinion word for word: 'Posidonius, an ancient and learned philosopher, did (as both Strabo and Empiricus tell us) avouch it for an old tradition, that ye first inventor of the atomical philosophy was one Moschus a Phoenician, who lived before the Trojan war'. Cudworth's identification of Moschus and Moses does not seem to be accepted by Newton. On Mochus, Moschus and Moses, see J. L. Mosheim's edition of Cudworth's *System*, trans. J. Harrison, London, 1845, **I**, p. 21. Newton's reference to atoms being designated 'by the mystics as monads' is clarified by the note: 'The Pythagorite monads were atoms' (p. 13 of the *System*).
(69) See esp. *De Gravitatione* in Hall & Hall, *op. cit.*, pp. 142-144.
(70) See W. H. Stahl's introduction to his translation of Macrobius's work, cited in note 18 above.
(71) These sources cannot be discussed in any detail here, although the historical sketch of *prisca* doctrines in the text should help to clarify the significance of some of these citations.
(72) Conti's *Mythologiae sive explicationis fabularum libri decem*, Venice, 1551, was based on the assumption that from the earliest times, thinkers, first in Egypt and then in Greece,

hid the great truths of science and philosophy under the veil of myth to secure them against vulgar profanation. Francis Bacon made extensive use of Conti in his *De sapientia veterum liber* . . . (1609). Conti is discussed by Jean Seznec, *The Survival of the Pagan Gods* (Eng. tr.), New York, 1953, Bk. 2, ch. 1.

(73) See note 68 above. Commenting on Cudworth's interpretation of the Egyptian account of creation on p. 21 of the *System*, Newton says: 'By night understand invisible Deity whome the Egyptians call (blank space) & paint with an Egg in his mouth & by Love ye spirit wch moved on ye face of ye waters. Dr. Cudworth therefore is much mistaken when he represents this Philosophy as Atheistical.'

(74) Gale published *The Court of the Gentiles*, in four volumes, Oxford and London, 1669-1677, the most comprehensive seventeenth-century attempt to show that all the human arts and sciences originated in the Scriptures and the Jewish Church.

(75) Manuel, *op. cit.*, p. 156; on trinitarian controversies in 17th century England, J. Hay Colligan, *The Arian Movement in England*, Manchester, 1913.

(76) See note 7. *Cf.* Cudworth on 'the Fraud and Juggling of *Gassendus*' in praising Epicurus, *op. cit.*, p. 462.

(77) Michael Maier, *Arcana Arcanissima*, 1616, attempted to interpret the whole of Greek mythology in alchemical terms; also *Atlanta Fugiens*, 1618. J. Tollius continued the attempt in his *Fortuita* &c., Amsterdam, 1687. See John Read, *Prelude to Chemistry*, London, 1936, pp. 228-246; W. Pagel, *Paracelsus*, Basel-New York, 1958, p. 233 and note 108.

(78) *Op. cit.*, Query 28, p. 369, 'And for rejecting such a Medium, we have the Authority of those the oldest and most celebrated Philosophers of *Greece* and *Phoenicia*, who made a *Vacuum*, and Atoms, and the Gravity of Atoms, the first Principle of their Philosophy; tacitly attributing Gravity to some other Cause than dense Matter'. The adjective 'dense' was first inserted in the 1717 English edition; see Guerlac, *Newton et Epicure*, pp. 30-31.

(79) A. Koyré and I. Bernard Cohen, 'Newton and the Leibniz-Clarke Correspondence', *Archs Int. Hist. Sci.* **15**, 1962, pp. 63-126: Newton's draft letter to Conti, p. 73, complains that Leibniz 'falls foul upon my Philosophy as if I (and by consequence the ancient Phenicians & (or) Greeks) introduced Miracles & (or) occult qualities'. The final version was dated 26 February 1715/16 o.s.

(80) Hall and Hall, *op. cit.*, on Newton's view that matter conceived as independent of God or with self-activity leads to atheism, pp. 142-144.

(81) See Manuel, *op. cit.*, esp. Ch. VI.