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Geometrical Atomism – Flux and Language

Plato's geometrical atomism is in my view somewhat undervalued. Pyle's magisterial *Atomism and its Critics* gives little mention to it, and concentrates on the tradition of Leucippus, Democritus and Epicurus.[1] This is a shame, as geometrical atomism is an important and interesting theory in itself, as well as having important relationships to the earlier theories of Leucippus and Democritus and later theories such as those of Descartes. It is interesting that Plato presents geometrical atomism using a letters and syllables analogy, as Aristotle tells us that for the atomists the differences between bodies are caused by the atoms and are due to:

> shape, arrangement and position; being, they say, differs only in 'rhythm, touching and turning', of which 'rhythm' is shape, 'touching' is arrangement, and 'turning' is position; for A differs from N in shape, AN from NA in arrangement, and Z from N in position.[2]

We shall also see something very akin to Empedocles' four-element theory under attack, as well as the ideas of the atomists and the Milesians. As we shall see, there are interesting parallels between the use of the letters and syllables analogy in the *Timaeus* and other late works, notably the *Theaetetus* and the *Philebus*.

Examining geometrical atomism will also involve questions concerning the nature of the receptacle, the degree to which the world can be said to be in flux and what we can say about the world around us. So far, I have argued that in the *Timaeus* the heavens move in an entirely regular manner and are entirely stable.[3] One might feel that runs against the general tenor of some passages in the *Timaeus* and creates a significant tension, in particular with 27d where a radical disjunction is made between what always is and never becomes, and what always becomes and never is. There are several possible strategies for resolving this tension. First, we might look to *Timaeus* 29c, where after arguing that we can only expect a likely account of a likeness *Timaeus* says that if we cannot produce an entirely consistent account we should not be surprised but should gladly accept the most likely account and not seek any further. So we might shrug our shoulders and accept that such tension is inevitable.

With passages where several interpretations are possible, we might look to reduce this tension by interpreting them so as to produce the greatest overall harmony. We saw an example of this in Chapter 4 where I gave an interpretation of the relation between reason and necessity which would allow for regular and stable celestial motion. A second strategy would be to argue that there is sufficient difference between the nature of the heavens and the rest of the cosmos to allow for the stability of the heavens. Clearly the fact that all the celestial bodies are gods will be significant here, though there are some other important differences as well. If this fails to release the tension entirely, then we can fall back on the first strategy having at least dissolved some more of the tension. The third, and by far the most radical strategy, is to counter-attack. If one can harmonise a sufficient number of passages with the idea of regular and stable celestial motion, then one might become suspicious of the orthodox interpretation of any remaining recalcitrant passages. That is something I shall explore in Chapter 9. In this chapter and the following one I shall argue that it is possible to produce a reading of geometrical atomism, the receptacle and flux that underpins the stability of the heavens and allows us to talk in an informative manner about the physical cosmos.

As commented in the general introduction, I take a different line on the relation of the receptacle to geometrical atomism to most commentators. Commonly, the receptacle is treated on its own, or geometrical atomism is interpreted such that it fits conclusions drawn from an analysis of the receptacle. As will become clear in this chapter and the next, I believe there are serious problems with the receptacle which can be resolved by the introduction of geometrical atomism and a reformulation of the nature of the receptacle. So in effect I take geometrical atomism as the dominant theory to which we need to fit an interpretation of the receptacle, rather than vice versa.

I. The receptacle and language

There are many problems with the *Timaeus'* account of the relation of the basic constituents of the world to each other and to the receptacle, but here I wish to focus on three. There might be insufficient stability to underwrite the stability of the heavens, there might be problems with how we ought to refer to anything physical, and there is the matter of the relation of the account of the *Timaeus* on these matters to that given in the *Theaetetus*. At 49b Timaeus introduces the problem of the relation of language to things that are in flux, initially taken to be earth, air, fire and water by:

> Speaking of each of these, to say which ought really to be termed water rather than fire, and which by any name rather than each and all, so as to employ language which is sound and secure, is hard (*pisto kai bebaio chresasthai logoi, chalepon*).[4] We see, so we suppose, water congealing and

> becoming stones and earth, and this same thing when dissolved or dispersed becoming air, and air becoming fire by combustion ... and thus, it appears, they pass into each other in a cycle of birth.

The problem we face in attempting to construct a secure logos is that the elements that we refer to appear to change into one another.[5] Along with others, I take this to be a problem concerning identifying references.[6] If we identify some stuff as water, and it changes into air, should we now identify the same stuff as air? If we do, what happens to any distinction between the elements – what name, 'rather than one and all' ought to be applied to each? If so, this will then function as a critique of anyone holding any of these substances to be basic, which will certainly include Empedocles, anyone who holds that there are fire atoms and even the Milesians. The key passage is perhaps the following, which has been the subject of much debate concerning both its translation and interpretation. At 49d ff. Timaeus tells us:

> Since, then, each of these never appear the same, which of them can we assert with confidence and without shame to be this – whatever it is – and not something else? It is not possible, but much the safest way to speak of them is as follows. Whatever we perceive as always changing into something else, like fire, in each case we should not call fire 'this' but 'the suchlike' (*hos pur, me touto alla to toiouton hekastote prosageurein pur*). Nor should we call water 'this' but always 'suchlike', nor anything else as this if it had some stability, among the things we indicate by the expressions 'this' or 'that', and think we indicate something; for they slip away and do not wait to be described as 'this' or 'that' or any term which attributes permanence to them.[7]

The central debate concerns the phrase, *me touto alla to toiouton hekastote prosageurein pur*.[8] The traditional reading is that *touto* 'this' and *to toiouton* 'suchlike' are competing predicates for the subject *pur*, fire. The phrase then concerns ways in which we may talk of fire, one proper and one improper. So we ought not to call fire 'this', but we can call it 'suchlike'. The alternative reading takes *touto* and *toiouton* to be competing subjects for the predicate *pur*, the sense now being that words such as fire which we now apply to transient phenomena are better applied to more stable entities. So if we are to use 'fire' properly, we should only use it to refer to entities which are 'this', and not those which are 'suchlike'.

Both of these interpretations are acceptable renderings of the Greek.[9] Which we choose to accept, however tentatively, will be dependent on more general considerations.[10] As we shall see, this is not the only issue related to the question of flux where there is such a choice. As indicated in the introduction to this chapter, my concern is whether these passages can support the regular and stable motions of the heavens. So too as Gill comments, the decision which reading to adopt:

> reflects a decision about the status Plato grants to physical phenomena. On the traditional reading he legitimates talk about such objects. On the alternative he proscribes it.[11]

So on strategic grounds I opt to explore the first of these alternatives. This is not to say that the alternative reading is not a viable one, nor is to say there is not a great deal of interest to be said for the alternative reading, both in relation to the rest of the *Timaeus* and other works, notably the *Theaetetus*. I do have concerns about the alternative reading in that it seems in many versions to generate four types of entity for *Timaeus* 48e-53b where the text is adamant there are three.[12] I also have worries as to how well the alternative view can account for the relation of the entities of geometrical atomism to the receptacle. I shall return to these matters a little later, but let us see what we can make of the traditional reading first.

A major concern over the traditional reading was the apparent discord between the *Timaeus* and the *Theaetetus*. It has been argued that the *Theaetetus* post-dates and corrects the *Timaeus'* view on the relation of flux and language.[13] It is surely true, so Owen argued, that if everything is in radical flux, then we cannot successfully refer to anything at all, and this is a better position than the 'lame plea' of *Timaeus* 49d ff. that we can refer to the four elements as 'the suchlike'.[14] The alternative view was pioneered by Cherniss,[15] possibly with the aim of defusing the argument concerning flux for dating the *Timaeus* before the *Theaetetus*. At *Theaetetus* 182c ff., Socrates and Theodorus have the following exchange concerning the Heraclitean position and its relation to language:

> *Socrates*: Let us ask them, are all things changing and in flux? ... Have they both kinds of change that we distinguished, of place and of quality?
>
> *Theodorus*: Of course; they must if they are to be completely in change.
>
> *So.*: If they only underwent change of place, and not of quality, then we would be able to say what the flowing things that change position are. Could we speak in this manner?[16]
>
> *Theo.*: We could.
>
> *So.*: But since not even this stays still, what flows flowing white, but changing, so that there is a flux of this very thing also, the whiteness, and a change of colour, lest it be convicted of staying still, is it possible to name a colour with the result that it is correctly named?
>
> *Theo.*: But how could one contrive that, Socrates? Or indeed for anything else of this sort, if it always slips out from under us as we speak, being in flux?

The flux described in this passage is a very radical one indeed. Not only is there nothing which is free from qualitative change, but everything changes in every respect at every successive instant, 'lest it be convicted of standing still'. The passage that is supposed to create problems for a late dating of the *Timaeus* is the following at *Theaetetus* 183a:

So.: If everything is changing, every answer to any question is equally correct, both to say 'thus' and 'not thus', or if you wish, 'becomes', if we are not to employ any expression that will bring them to a standstill.

Theo.: You speak truly.

So.: Except this, Theodorus, I said 'thus' and 'not thus'. It is necessary, though, not even to say 'thus'. For 'thus' would no longer be changing, and nor would 'not thus'. Indeed, there is no motion in 'this', either. Those who hold this theory must establish some other phrase with which to express it, as by their own hypothesis they now have no words, unless 'nohow' is allowed. That might be the most fitting expression for them, as it is indefinite.

Similarly at *Cratylus* 439d8-12 one cannot say that anything in flux is either *ekeino* or *toiouton*. So according to the *Theaetetus* we cannot refer at all to items which are in a radical flux. It is important to note that at *Theaetetus* 182c9 above, if something only underwent *phora* and not *alloiosis* we would be able to say what it was. What then allows us to refer to things in flux in the *Timaeus*? The leading candidate here is the receptacle. There is no question that the receptacle can be called *touto*, and that it us supposed to be free from change, and perhaps it is this which gives a sufficient basis for being able to call the elements *to toiouton*. At 50b ff. *Timaeus* introduces the gold example to explicate this:

> If someone were to mould all the shapes out of gold and without stopping remodel each of these into the rest, then should he point one of them out and ask what it is, by far the safest answer in truth would be that it is gold, but as for the triangle and the other figures that occur, it would be wrong to describe them as having being, as they change even as we state them, and we should rest content if they willingly receive the description of the suchlike with some safety.

So where we have flux, and here we would seem to have a radical flux,[17] we can refer to what is changing by *to toiouton*. What is it about the receptacle that allows this, and does the *Timaeus* give us a coherent account of the receptacle?

II. Some paradoxes

I take the primary task of the receptacle to be to provide a licence for *to toiouton* expressions. If so, it would seem that the receptacle cannot be merely a theory of space. If something is changing, and I am attempting to make an identifying reference, it does not seem to be particularly helpful to say that this change is occurring in space. Space may well be unchanging and so be a suitable referent of *touto*, but could hardly be said to constitute or lend any stability to the phenomena occurring in it. If a chameleon changes colour, I need to know something about the constitution of the chameleon, not about the tree that it is sitting in.

In order to license *to toiouton* references to the things in flux, then, the receptacle must be related in some constitutive way to them. Certainly the metaphors of the receptacle being like gold, or a moulding-stuff, or an odourless base for scent would seem to invite some form of material interpretation of the receptacle.[18] We might discuss here whether Plato has one theory of a material receptacle, and whether that is a coherent theory. It is quite possible that shapes relate to gold in a different way from how scents relate to bases or mothers to offspring etc., and that at least some of these are incompatible when we come to consider how the receptacle relates to forms. An alternative to keep in mind though is that Plato may give us several conceptions and wishes us to consider theories of a material receptacle in general. As we saw with pre-cosmic chaos in Chapter 1, he may provide something more flexible and more powerful than a straightforward statement of cosmogony. Whatever degree of pre-cosmic chaos we might suppose, a teleological ordering is required. Here, however we conceive of a material receptacle there may be difficulties.[19]

In order for the receptacle to remain a proper referent of *touto*, it must remain changeless. At *Timaeus* 50d4-51b2 great emphasis is laid on the characterlessness of the receptacle. This is so in order that it does not distort what is in it, but also the receptacle needs to be characterless in order that it be changeless. As Prior comments, 'Its nature, one is tempted to say, is that it has no nature.'[20] Now we might frame a slightly different problem. In order to be entirely free from change the receptacle must be characterless. If it is entirely characterless, it is difficult to see how it relates to the things in it. Gill argues that in the gold example, the gold is not constitutive of the shapes as *shapes*.[21] I would rather put this as a dilemma. If the gold is constitutive, then the receptacle is in grave danger of changing as the shapes change, and so its status as the referent of *touto* is endangered. If it is not constitutive, then the receptacle cannot licence *to toiouton* references.

These problems are perhaps best exemplified by the struggle Timaeus has at 50bc to produce a coherent account of the receptacle and its relation to the things in it. This passage follows directly from the gold example where we have been told that the triangles moulded out of gold can be referred to as *to toiouton*. *Timaeus* 50b5-c2 then tells us:

> The same account applies concerning the nature of that which receives all bodies. It must always be called the same, for it never departs at all from its own character (*dunameos*). For since it always receives all things, in no way whatsoever does it assume a shape (*morphen*)[22] similar to any of the things which enter it.[23]

That seems quite reasonable for the receptacle in order to retain its status

as a referent of *touto*. However, immediately following this, at *Timaeus* 50c2-5 we are told:

> For in nature it is a moulding-stuff (*ekmageion*) for everything, changed and shaped (*kinoumenon te kai diaschematizomenon*) by the things which enter it, and because of this appears different at different times.

Timaeus cannot have this both ways and have a coherent account. This problem I shall refer to as the receptacle paradox. One might add that if the receptacle only appears to be changed (but is not changed), it is not really constitutive, and if it appears to be changed (and is changed) then it ceases to be a proper referent of *touto*. At *Timaeus* 50c4-6 we are told:

> The things entering and leaving the receptacle are copies of those ever existent, and are stamped (*tupothenta*) from them in some hard to explain and marvellous manner (*dusphraston kai thaumaston*), which we will shall follow up later (*hon eisauthis metimen*).

This Timaeus conspicuously fails to do in 48e-53b. All we are told is that the receptacle partakes in the intelligible in a most difficult and hard to grasp manner (*aporotata ...kai dusalotaton*) at 51a7, and at 51b and 52d that the receptacle is liquefied and ignified. Whether the geometrical atomism introduced at 53c ff. will help with these matters we shall see in a moment.

There is a further problem with considering the receptacle to be material on the basis of what we have seen of *Timaeus* 48e-53b. There would seem to be very little we can say about matter. Timaeus struggles to say anything positive about the receptacle, and of course there will be serious epistemological problems with anything so utterly characterless.[24] At *Timaeus* 49a3 it is something difficult and obscure (*chalepon kai amudron*), at 52b it is grasped without sensation by some bastard reasoning (*logismoi tini nothoi*) and is the subject of a dream.[25] Something that cannot be explained in terms of anything more basic and has no character seems in itself inexplicable. If it is not constitutive, it is hard to see how it helps to explain the phenomena, and anyway if it is characterless there would seem little that it can explain. It is difficult then to see matter, if we equate it with the receptacle, as anything which is explanatory or is itself subject to explanation. Perhaps *Timaeus'* dream, as McCabe comments, is as problematic as Socrates' dream in the *Theaetetus* (201e ff.), where the basic elements turn out to be unknowable.[26]

If we treat the receptacle as being in some way constitutive of the phenomena, we run into two major problems. It is not clear that the receptacle can play the role required of it in being so related to the changing phenomena that it can licence *to toiouton* expressions, and in being independent of them so as to preserve its own stability (the recepta-

cle paradox). If the receptacle is both inexplicable and non-explanatory, it seems a poor theory of matter. Can the introduction of geometrical atomism at *Timaeus* 53c help with these difficulties?

III. Geometrical atomism

In my view it is of the utmost importance to recognise that there are significant differences between the four-element theory put forward at *Timaeus* 48e-53c and the geometrical atomism introduced at 53c. In the theory of 48e-53c, there is no mention of any sub-structure to the elements. The only mention of *stoicheia* prior to 53c ff. is at 48b9 which explicitly denies these elements (earth, water, air, fire) are *stoicheia*. Each of the elements of 48e-53c may transmute into any other element. In the later theory, what we suppose we see here is contradicted by the ban on the transmutation of earth and the other elements.

Of considerable importance is the fact that at 48e-53c, the entire discussion of the elements is conducted at the perceptual level. This is emphasised very strongly in the opening passages. We see, so we believe (*hos dokoumen*, 49b9 *...horomen*, 49c1) the transmutation of earth, water, air and fire. They form a cycle 'so it appears' (*hos phainetai*, 49c9, cf. *phantazomenon*, 49d1), and we see things such as fire constantly changing (*kathoromen*, 49d4). This would seem to line up with the tripartite ontology of form, receptacle, and that which is perceptible, which is stressed at 48e3 ff., 50c7 ff. and 51a4 ff., and 51e6 ff. What is created by form and receptacle is visible (*horaton*, 49a1), sensible (*aistheton*, 52a5, cf. 52a7), and at 51a the mother and receptacle of the visible and sensible (*horatou kai pantos aisthetou*, 51a4) must not be called by any of the names of the elements. At 52b the receptacle is not accessible by perception (*anaisthesias*, 52b1). There is no discussion of anything which is below our perceptual threshold rather than in principle imperceptible.

Timaeus 56bc however is very specific. The atoms of the elements cannot be seen (*ouden horomenen*, 56c1-2) because of their smallness. Only when many of them are gathered together can a mass of them be seen (*horasthai*, 56c3). We can take it that the individual basic triangles and the complexes they form as the faces of atoms are also too small to be seen. These differences may have a significant bearing on Plato's intentions. He may well wish to show that the phenomena are in some sort of flux, requiring a reform of our references to them, without being committed to a theory where the ultimate constituents of the phenomena are in flux. The point being driven at by the first theory may then be a conditional one. If we operate only at the level of perception, and we equate changing phenomena, such as the four-elements, with the ultimate constituents of the world, then we will be unable to make any identifying references, or even any *to toiouton* references. This may be a criticism of current four element theories, and may be pushing a theoretical point about fundamental flux.

Empedocles may be a significant target here, though the point would apply to anyone who believes that earth, air, water and fire are basic. That such an attack is made on these elements for failing to be stable does not mean that the idea of a stable basis for phenomena is necessarily abandoned. If we suppose there to be some form of stable, amorphous substrate, such as the receptacle then we have the problems outlined in the last section. The later introduction of atomic sub-structure may be an attempt to rectify these difficulties by postulating stable physical entities at a level well below the threshold of human perception.

At 53d *Timaeus* postulates two sorts of triangle as the *archai* of the elements, but suggests that there are some higher *archai* than these. It is a reasonable assumption that these *archai* (or as Gill terms them, simples), will be stable. I doubt that anything that is not stable would qualify as an *arche* for Plato. We are also quite justified in using this assumption as an hypothesis to see what sort of account ensues. I would agree with Gill that: 'The important point is not *what* turns out to be basic but that there be ultimate simples.'[27] If there is something basic and simple, these simples can be called *to toiouton*, and this gives a sufficient basis for the elements to be called *to toiouton* as well. If so, then the problem of the relation to the *Theaetetus* is resolved. The objection there was to a flux where everything changed place and quality. In the *Timaeus* we have the foundation of some things which while they change place do not undergo *alloiosis*. While Gill is reticent about identifying the two fundamental types of triangles, which I shall call the stoicheic triangles, as these basic and simple entities, I am not.[28] I take one of the key points of the introduction of geometrical atomism to be precisely this, to introduce some basic physical constituents, and the stoicheic triangles are clearly strong natural contenders here. As I shall argue in the next few sections, there is a very strong case for considering the stoicheic triangles both as basic and as free from any change to their intrinsic order.

One might argue then that there is a case for the stoicheic triangles being called *touto*, if they are stable, the two standard objections being that they undergo *phora* or *alloiosis*. The very nature of the *stoicheia* (whether they be the stoicheic triangles or something else) precludes *alloiosis* being a problem. That they are in motion may not be a problem either, because at *Timaeus* 52de, 57c and 88de we are told that the receptacle moves, and is shaken like a winnowing-basket.[29] It is also interesting that at *Timaeus* 49e7 ff. we are told that only that which the four elements are created from or are dissolved into may be referred to as *touto*, and the elements ultimately are created from and dissolved into the stoicheic triangles. If the basic problem here is identifying references, again it would seem that the stoicheic triangles can quite safely be identified. To say that this is the position that the *Timaeus* adopts would probably be to push matters too hard, though it may be something that Plato is leading his readers to consider. However, it may be that the fact that the receptacle moves and

can be called *touto* is an oversight on Plato's part, or one might argue that Plato gives us several images of the receptacle and we should not push any of them too hard. That what the elements can be dissolved into can be called *touto* may be restricted to the elements and receptacle model, or perhaps the dependence of the stoicheic triangles on the receptacle prevents them being called *touto*.[30] Gill argues that the simples, whatever they may be, will be called *to toiouton* because they are distinct from their relevant forms and move around.[31]

IV. Letters, syllables and triangles

Are the stoicheic triangles the ultimate constituents of the physical world in the *Timaeus*, and are they free from change? Let us begin with a distinction which the *Theaetetus* makes between two sorts of change. At *Theaetetus* 181c Socrates says:

> What I want to enquire is this; do they say that there is only one kind of change (*kinesis*),[32] or, as it seems to me, that there are two? ... Do you call it change when something exchanges one place for another, or spins around in the same place? ... Let this then be one form of change. But when something remains in the same place, but grows old,[33] or becomes black instead of white or hard instead of soft, or undergoes any other sort of qualitative change (*alloiosis*), isn't it right to say that this is another form of change? ... There are then two forms of change, change of quality and change of position (*phoran*).[34]

Consider this in relation to the basic entities of the world, the *stoicheia*. That they move around is not in question. What is more intriguing is whether they undergo any change in themselves. Flux theories here come in many shapes and sizes. These changes might involve one, many or all of the properties of a basic entity and those changes might take place at any rate up to the radical flux of change every instant. One might contrast such flux theories with the idea that the basic entities are entirely stable. To put this in terms of a distinction I used in Chapter 1 for Plato's *stoicheia*, perhaps the *stoicheia* undergo no change in their intrinsic order even if their extrinsic order changes. The ancient atomists held such a theory, and we can compare an elementary modern physics view of the world. According to this there are three types of simple, uncompounded particles, electrons, protons and neutrons, which are the exhaustive physical constituents of more complex entities such as atoms and molecules. These elementary particles change velocity and position, and enter into bonding relations with each other, but do not undergo any change in themselves. Complex entities which are ensembles of these basic particles on the other hand, such as atoms or molecules or clouds on a windy day may indeed be said to be in some form of flux, without compromising the stability of the basic particles.

In the above passage from the *Theaetetus* I translated *alloiosis* as 'qualitative change', as the *Theaetetus* is concerned here with perceptible qualities. One might though, as in the two examples above, have a theory where the *stoicheia* are not perceptible so we will have to talk of their characteristics. We can then distinguish between two quite different theories of how things change. I shall term these theories of fundamental flux and of fundamental stability, depending upon whether the *stoicheia* undergo *alloiosis*. The position ascribed to Heraclitus in the *Theaetetus* is clearly one of fundamental (and indeed radical) flux.[35] At *Theaetetus* 181d Socrates poses a hypothetical question for the Heracliteans:

> *So.*: Do you hold that everything changes in both ways, changing both in place and in quality (*pheromenon te kai alloioumenon*), or that some things partake of both, and some only one?
>
> *Thes.*: By Zeus, I don't know what to say; I suppose they would say both.
>
> *So.*: If they did not, my friend, then it would seem that things are both in motion and standing still, and it would be no more correct to say that all things move than all things stand still ... then since it is necessary for them to change, and since it is not possible for something not to change in every way, all things are always suffering all kinds of change.[36]

So too, one might argue, the flux described in the *Cratylus* is a fundamental one.[37] I have no disagreement with this, but I shall argue that it is quite possible that the flux of the *Timaeus* as one of fundamental stability. A second way of setting up the contrast here would be to employ a distinction that the *Sophist* uses between change relative to itself and change relative to other things. This would bring us close to Irwin's distinction between aspect (a-) change and self (s-) change. The following arguments are intended to establish that in the *Timaeus* there are some entities which undergo no change of character, no change in relation to themselves and no s-change as defined by Irwin.[38] Let me outline where I believe these basic entities can be located. At 48b the *Timaeus* says concerning earth, air, fire and water:

> No one has as yet revealed their generation, but we speak as if we know what fire and each of them are, postulating them as the basic principles (*archas*) of the physical universe, although it is not fitting for them to be in any likelihood compared to syllables, even by a man of little insight.

This might be read as a rejection of the letters and syllables analogy which commonly occurs in later Plato.[39] However, if the two most basic types of triangle that the *Timaeus* postulates are taken as the letters, and the atomic faces they go to make up are the syllables, then the atoms will indeed not be syllables, although the letters and syllables analogy may still apply. The *Timaeus* refers to the two most basic types of triangle using the substantive *to stoicheion*.[40] This is important as *stoicheion* carries the

general sense of simplest component part, and a more specific sense in Plato of letter as opposed to *sullabe*, 'syllable'. I shall refer to these two basic types of triangles as the 'stoicheic triangles', and the compound triangles that are atomic faces as 'complex triangles' (see Figs 50 and 51).[41]

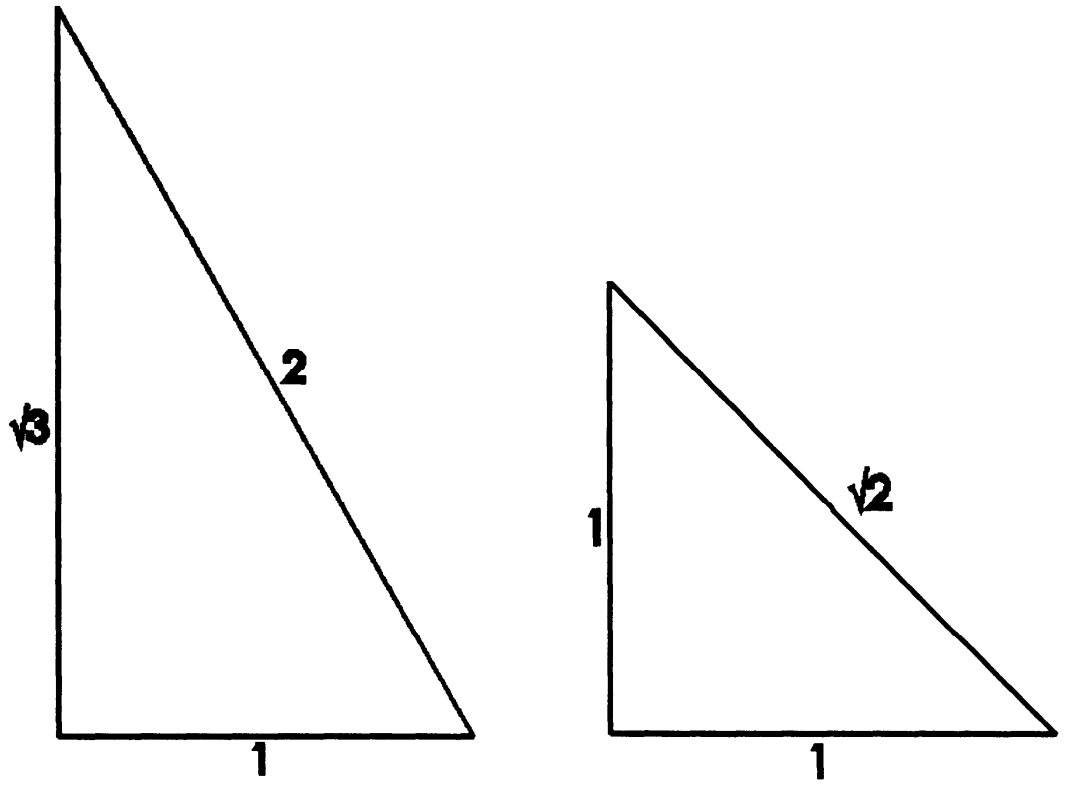

Fig. 50. Stoicheic triangles – the half-equilateral and the half-square. The *Timaeus* claims that earth, water, air and fire should not be called elements, not even syllables. The basic unit of the physical world would seem to be these two sorts of triangles, the half-equilateral and the isosceles, often referred to as *to stoicheion*. That the proportions chosen include 2 and 3 may have considerable significance for the history of cosmology and the question of how the world may be structured mathematically, as I discuss later.

The terminology I use for geometrical atomism is as follows:

I use elements to refer to earth, water, air, and fire.

I use atoms to refer to the individual cubes, octahedra, icosahedra and tetrahedra of the elements.

I use complexes or complex triangles to refer to the faces of the atoms.

I use stoicheic triangles to refer to the two basic triangles, the half-equilateral and the half-square.

Geometrical atomism has a further refinement, in that there are different types of each element. Friedlander, adding due caveats about the relation to modern atomism, has termed these 'isotopes'.[42] As Cornford has argued, this does not mean that there are different sizes of stoicheic triangles.[43] This would both strain the Greek of *Timaeus* 57d and would be extremely

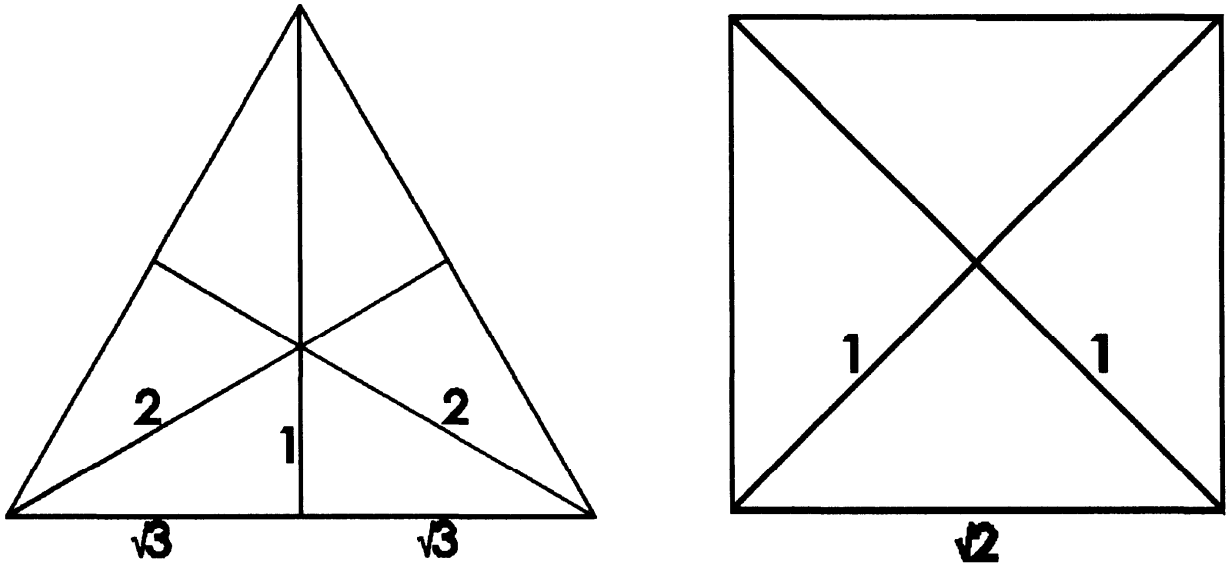

Fig. 51. Complex triangles and squares. In the specific arrangements discussed in the *Timaeus*, six half-equilateral stoicheic triangles form one complex triangle, and four isosceles stoicheic triangles form one square.

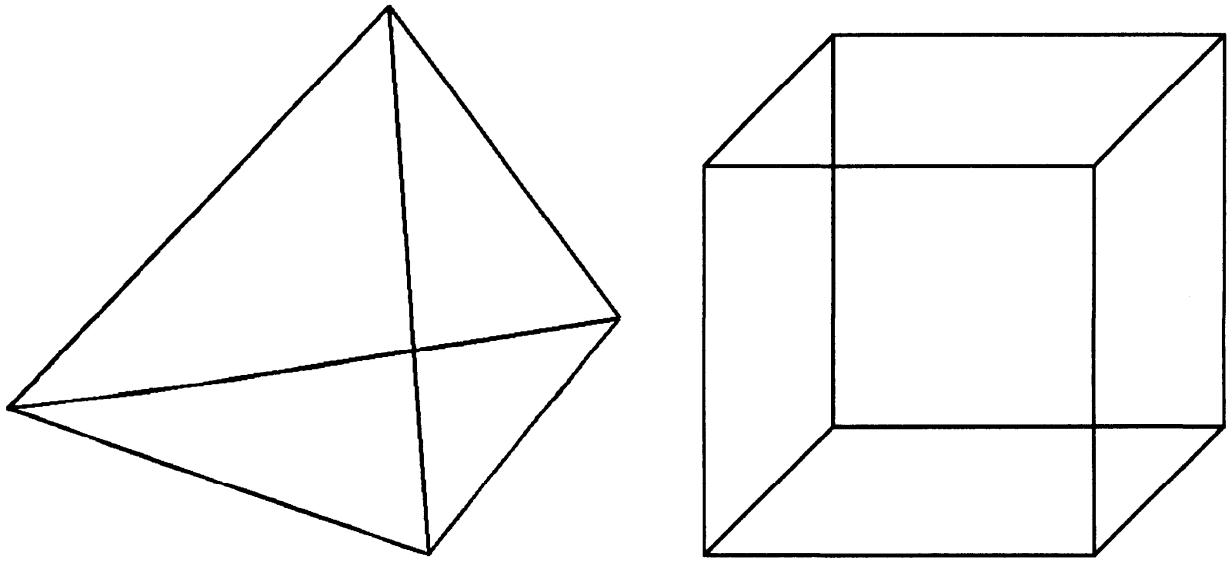

Fig. 52. Fire atom and earth atom. To form atoms, the complex triangles and the squares form into solid figures. Here we have fire, the tetrahedron and earth, a cube. Icosahedra of water an octahedra of air are also made from the complex triangles.

problematic for the theory of transmutation, both between types of one element and between elements.[44] Indeed it would be odd, given Plato's solution to Meno's paradox and his clear choice of specific shapes of the stoicheic triangles, if he supposed there to be many sizes of stoicheics when he has a simple means at his disposal of generating different varieties of the four elements. So the stoicheic triangles can form up in different ways to create different sizes of complex triangles and squares and so different sizes of atom, corresponding to the different classes of each element, and

we have the further factor that there can be different mixtures of elements and grades of each element in order to explain the diversity of the phenomena that we encounter (see Figs 53 and 54).

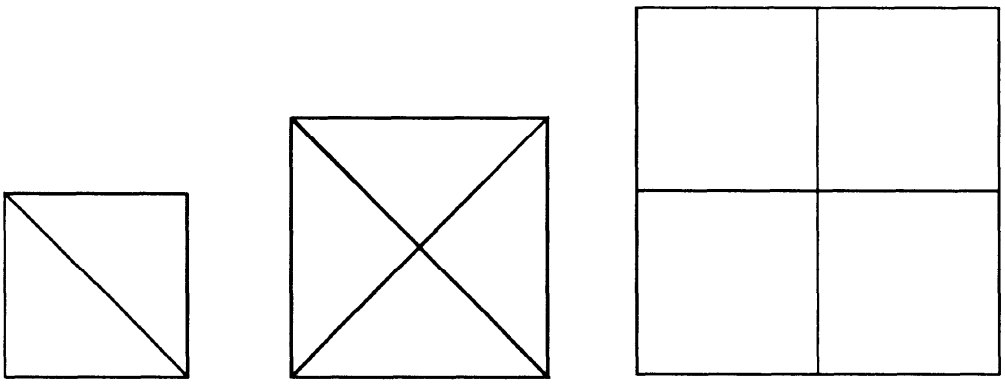

Fig. 53. 'Isotopes' – more complex planes, squares.

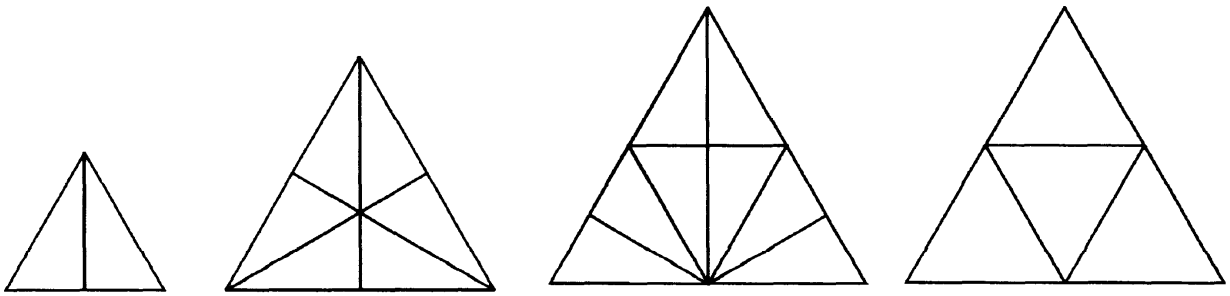

Fig. 54. 'Isotopes' – more complex planes, triangles.

The stoicheic triangles then undergo no change of character, no change in relation to themselves and no s-change, or to put it another way, incorporating the single size thesis for stoicheics, all half-equilateral triangles are congruent and remain so, and all half-square triangles are congruent and remain so.

V. The evidence of Aristotle

For the theory of change of *Timaeus* 53c ff. to work, no change in the stoicheic triangles is required and none is mentioned. Change is analysed solely in terms of the composition of stoicheic into complex triangles and these into atoms and aggregates of atoms, and the converse decomposition. At 59c, *Timaeus* is quite confident that all phenomena can be fully explained in this manner. It is perhaps important that while we are given an account of the relative abilities of the atoms to cut up what they encounter (cf. *Timaeus* 56b, 56d), we are not given such an account of the stoicheic

triangles. *Timaeus* 54c ff. is important in this context. We are told that while air, fire and water may transmute into each other, they may not transmute into earth, and vice versa, as the first three are constructed from half-equilateral triangles while earth is made from the half-square.[45] If the stoicheics come apart in some way, further transmutation would be possible. While the *Timaeus* specifies how atoms and complex triangles decompose, it does not do so for the stoicheic triangles. We might take that as an indication that they are not supposed to decompose into further physical elements.

If it is the case that the stoicheic triangles of the *Timaeus* are stable, then there are some interesting consequences. The theory of human ageing tells us that the bonds which hold the constituents of our bodies together have the power to last only for a certain time, and that as these begin to fail, so we slip into decrepitude.[46] The sort of flux to which the atoms and complex triangles are subject is not then the radical flux which would have them possessing a quality at time t and not possessing it at t + 1, but a rather gentler variant. This is important because it allows the physical world a large measure of stability, how much depending on how strong the 'power to last' is. In relation to this, if we examine what the *Timaeus* has to say on how human beings and the heavens are produced, we find something very interesting indeed. *Timaeus* 42d ff. tells us that the task appointed to the demigods is to fashion the bodies of human beings. At *Timaeus* 42e we are then told:

> Taking the immortal element of mortal creatures, imitating their own fashioner, and borrowing from the cosmos portions of fire, earth, water and air on the condition that this loan could be repaid, they cemented together what they had taken, though not with the indissoluble bonds (*alutois ... desmois*) with which they themselves were held together, but with well constructed bonds invisible because of their smallness, they fused them into one mass, creating out of all these one body for each, thus clothing the revolutions of the immortal soul in bodies subject to egress and ingress.

So while the constituents of our bodies are put together with dissoluble bonds, those of the demigods have indissoluble bonds. Our bodies will be subject to a gentle flux, while those of the demigods will be entirely exempt from flux in terms of qualitative change. The embodiment of these demigods though is in the heavenly bodies. Earlier in his discourse, at 38e *Timaeus* told us of the generation of the planets, and stated:

> When each of the bodies required to help in the production of time had been brought into its proper motion, as generated living creatures having their bodies bound with living bonds and having learnt their duties, they moved according to the motion of the different.

Now one might attempt to draw a distinction here between the planets as

living creatures and the fixed stars as demigods, but in fact the two terms are used interchangeably of each. *Timaeus* 40b talks of the fixed stars as living creatures while 40cd talks of the planets as demigods. The stability of the heavens is guaranteed by the qualitative stability of the stoicheic triangles allied with the 'indissoluble bonds' with which they are bound together. Through the mechanism of the variable durability of the bonds between the stoicheic triangles and between more complex entities,[47] the *Timaeus* theory can then account for any degree of qualitative flux at the perceptual level, up to and including the total stability of the heavens.

Aristotle's comments in *De Caelo* and *De Generatione et Corruptione* are interesting in relation to the nature of the stoicheic triangles. At *De Caelo* 306a9, Aristotle gives us an important general principle:

> Sensible things require sensible principles, eternal things eternal, and perishable things perishable, and generally something of the same kind underlies.

That of course is quite different from the atomism of Leucippus and Democritus, and, as the context makes clear, quite different in Aristotle's view from Plato as well. That geometrical atomism is Aristotle's target here at 306a ff. cannot be doubted. No one else held a theory of analysis into surfaces (306a1-4), that some but not all the elements could transmute into each other (306a4-6), and that earth was the odd man out (306a18-21). Those who 'resolve into surfaces', according to Aristotle have incorrect first principles (306a8-9).[48] Presumably those are that sensible things do not have sensible *archai* (though this is not stressed) and that perishable things have stable *archai*. These people stand on the truth of their *archai* and will not admit that their principles should be criticised in the light of their consequences.

Having discussed geometrical atomism in the latter part of *De Caelo* III.7, Aristotle opens III.8 by saying that in general it is unsound to try to give shapes to the simple bodies (*ta hapla somata*, 306b3 ff.). That is a very interesting phrase which would suggest that 'those who resolve into surfaces' do posit specifically shaped simple bodies. Aristotle goes on to raise the 'packing' problem, that such shapes could not form a plenum as, of the solids, only the square and the pyramid can do this and more shapes than these are required.

De Generatione et Corruptione is even more emphatic on these matters. At 315b25 ff. Aristotle poses what he feels is the key question, do things undergo change and growth (*alloioutai kai auxantai*) because of indivisible magnitudes (*megethos adiaireton*)? Those advocates of indivisible magnitudes are Leucippus and Democritus who suppose them to be bodies, and the *Timaeus* which supposes them to be surfaces. 316a2-4 is also important here, as Aristotle denies that putting surfaces together can account for any change of quality. Clearly he does not believe that the Platonic surfaces

undergo any sort of *alloiosis*. *De Generatione et Corruptione* 325b25 ff., as we saw in Chapter 1 states that Leucippus holds that the indivisibles (*ta adiaireta*) are solids and are unlimited in shape, and Plato holds that they are surfaces and definite in number. The evidence of Aristotle then is very much in favour of the idea that the stoicheic triangles do not undergo any sort of *alloiosis*.

VI. The ageing process

One objection to the idea that the stoicheic triangles undergo *phora* but not *alloiosis* might be based on the theory of ageing of *Timaeus* 81 ff. According to this, ageing and natural death are to be explained by the gradual deterioration and consequent loss of function of the particles which constitute the body. One interpretation is that it is change in (and indeed the loss of) the intrinsic order of the stoicheic triangles that is at the root of this sort of deterioration. There is an alternative interpretation, though, which is at least as plausible. This is that while the bonds between stoicheic triangles which form complexes may deteriorate, as may those between the complexes which form atoms, as may the complexes themselves, there is no deterioration in the intrinsic order of the stoicheic triangles. At 81b5-9 the *Timaeus* begins its discussion of ageing by saying:

> When the organisation (*sustasis*) of the whole animal is new, the triangles (*trigona*) which constitute the atoms being 'fresh off the stocks' (*ek druochon*), they have strong joins between one another (*pros allela*).

It is important that the bonds that the *Timaeus* describes here are *pros allela*. These must be bonds which bind either stoicheic or complex triangles to each other, rather then any bonds internal to the stoicheic triangles. That the stoicheic triangles undergo change in their bonding relations does not entail that they undergo any change of intrinsic order. At *Timaeus* 81c6-e1 we are subsequently told:

> When the sides of the triangles loosen (*he hriza ton trigonon chala*) due to having contested many battles in a great amount of time ... finally the bonds (*desmoi*) fitting the triangles of the marrow together no longer hold out against toil, but separate.

At this point death occurs. If these bonds are *pros allela*, then the ageing process can take place without any qualitative change of the stoicheic triangles. *he hriza ton trigonon chala* is undoubtedly a rather strange phrase. I would agree with Cornford that this 'curious metaphor' must contrast with *sunkleisin* at Timaeus 81b7 and that this strongly favours Taylor's view that *hriza* means side, in the sense of the side of a complex which will form one face of an atom.[49] I would agree with Taylor against Martin and Archer-Hind that *chala* means loosens (the sides) rather than

blunts (the angles).[50] Again, there is no need to suppose any change in the intrinsic order of the stoicheic triangles.

Returning to 81b5-9, one might take the view that as the triangles are *ek druochen* 'fresh off the stocks' they have been newly created.[51] However, if we build a wooden boat the wood does not undergo any change qua wood. It is merely reorganised from loose timber to a boat.[52] The wood may then be 'fresh off the stocks' without having undergone any qualitative change in itself, and so too perhaps with animals and stoicheic triangles. The verb that Plato uses in this context may support this approach. This is *sunistemi*, which has more of a sense of ordering that which is already existent than of creation de novo.[53] It is notable that this verb is used in the earlier discussion of atomism for the formation of atoms and complex triangles out of complex and stoicheic triangles respectively,[54] where no change in the stoicheic triangles is required or mentioned. So too at *Timaeus* 57c9, where as we saw there was the question of whether there were different sizes of stoicheics, the most reasonable interpretation would have *sunistemi* referring to how stoicheics are arranged in relation to each other, rather than their internal arrangement.

Even if we were to take *ek druochon* as signifying some qualitative change, it is not clear that it is stoicheic triangles that do the changing. If the referent of *trigona* at 81b6 is complex triangles, these can pass into and out of existence without prejudice to the stability of the stoicheics.[55] The correct referent of *trigona* is a problem which runs through the entire discussion of ageing. Certainly there are some uses here that can only be references to complex triangles, e.g. the *Timaeus* talks of 'the purest type of triangles, smoothest and oiliest' (82d). As there are only two types of stoicheics, and they could not be described as smoother or oilier than one another, this must be a reference to complex triangles.[56] So too at 81d, where we are told that the process of nutrition involves the triangles of the body cutting and assimilating incoming triangles. Conversely, when we age and the bonds between our triangles become weak, the incoming triangles cut up our own.[57]

Now it may be that the reference of *trigona* slips between stoicheic and complex triangles. However, in the earlier discussion of how the complex triangles are formed from the stoicheics at *Timaeus* 53c ff., Plato always has *Timaeus* carefully mark the distinction between the two, opening each discussion of the stoicheics with an explicit reference to their nature.[58] In this context *Timaeus* 57d and 61a are important, as in both of these passages there is a distinction made between the stoicheic and the complex triangles, the stoicheics being referred to in each case as *to stoicheion* triangles and the complex triangles simply as *trigona*. As some of the references of *trigona* in the discussion of ageing are clearly to complex triangles, and there is at no point any distinction drawn between these references and any other, one might conclude that all the references of *trigona* in the discussion of ageing are to complex triangles. We now

have two tools which work in harmony for analysing statements such as *Timaeus* 89c:

> For plainly in the beginning the triangles (*trigona*) of each animal are organised (*sunistatai*) with the power to last only up to a certain time.

In all likelihood *sunistemi* refers to the organisation of existent particles, and *trigona* to complex triangles. So it is complexes of stoicheics which undergo intrinsic change, which is consonant with the idea that it is the *pros allela* bonds that are subject to temporal limitations. That the triangles can 'last up to a certain time' (*Timaeus* 89d) might be a temporal limitation, or more likely in view of *Timaeus* 81b ff., a 'wear and tear' limitation. If we take the reference to be to complex triangles, neither require change in the stoicheic triangles. On this interpretation, the 'biochemical' processes of ageing and nutrition are merely specialised cases of the more general 'chemistry' that is discussed at *Timaeus* 53c ff. They require no more than the division and reconstitution of atoms and complex triangles. In this respect one might note the similarity of the battling imagery between *Timaeus* 53c ff. and 81b ff., as well as the similar uses of *sunistemi*. Compare *Timaeus* 56e where we are told:

> Whenever a small amount of fire is enclosed in a large amount of air, water or earth, moving within their movements, battling and breaking up upon being defeated, two units of fire are assembled to make one form of air.[59]

If we take the two images of battling to refer to the same sort of process, then it is the atoms being broken into their faces that constitutes old age, rather than any deterioration in the stoicheic triangles. If the theories of ageing and nutrition require something beyond the general theory of chemistry, one would expect this to be marked and discussed. There is no mention of change in the stoicheic triangles and good reason in the ban on the transmutation of the scalene and isosceles triangles to believe that no such change occurs.

VII. The gold example

Against this general line of thought, one might argue that the gold example explicitly denies any sort of permanence to shapes, and to triangles in particular. There are several strategies which one might employ against this view, though. The first is to argue, as I have above, that geometrical atomism introduces a quite different theory of the nature of the world and how we might solve the problem of referring to changing phenomena to that of *Timaeus* 48e-53b. It may well be the case that everything is transient except the receptacle in 48e-53b. That seems to run into difficulties though, and perhaps the determinate and stable shapes of

the *stoicheia* are introduced specifically to circumvent such problems. Ultimately these are different and incompatible theories which the readers may have to choose between, if they wish to have a coherent theory, and I shall say some more on the nature of that choice and other possible similar choices in the *Timaeus* in Chapter 9.

If one is seriously worried about what the gold example says about shapes, then it is possible to abandon the idea of stable shapes while still holding there to be some stable stoicheia, these being higher archai, perhaps lines, perhaps points. I would rather emphasise the conditional nature of the gold example though. So perhaps the key clause is at *Timaeus* 50b5-6:

> If (*ei gar*) someone were to mould all the shapes out of gold and without stopping remodel each of these into the rest ...

The conditional here may indicate that this is a thought experiment rather than a direct statement of cosmology. If someone were to do this remodelling, then we would appear to have something akin to a Heraclitean flux, where the only permanence would be found in the gold itself, and this is supposed to explicate the flux of the elements and their relation to the receptacle, and so the need for a reform of language. With that I have no quarrel, though one might wonder though what would be the case if this hyperactive character was not perpetually engaged in this remodelling. One reason for introducing this in conditional manner may be akin to the various descriptions of chaos and of the material nature of the receptacle we are given. Plato may wish to make some general comments on how we can talk about the world if we suppose there to be a receptacle, whatever degree of flux we suppose the world to be in, up to and including total flux. That does not commit Plato to the view that everything in the world is in such a radical flux, though if some things are we can still refer to them in a certain manner. Even with geometrical atomism it is quite possible that some things (including the shapes in the gold example, but not all things) may be in a rapid flux, but we are still able to refer to them though in a slightly different manner to that suggested in *Timaeus* 48e-53b.

The gold example presents us with a hypothetical manic remodeller of gold. We are not told within 48e-53b what natural processes this remodeller is an analogue for. Does he find a correlate in geometrical atomism? With the four-element theory, it is clear that there is a remodelling effect even if the cause of this is not specified. With geometrical atomism, though, we can perhaps be rather more specific. First, there is the effect which the atoms of each element have on each other, either as a general function of their shape (fire cuts more because of its size and sharp angles, 61d ff.), or the effect a much greater amount of an element has when it surrounds a smaller amount of another element (it assimilates it to its own kind, 57a-c). If we ask why these changes should come about, *Timaeus* has

two answers. At 57c the receptacle is still in motion and still separating out the elements by a like-to-like principle, so there is motion of the elements and hence contact and change. At 58a ff. we find that the revolution of the same has a compressing effect on the elements, such that atoms are pushed together and so again we have change. All this will produce a remodelling of the elements, but all this takes place within the standard theory of physical change, and there is no need here to suppose that anything remodels the stoicheic triangles.

Let me emphasise that I do not wish to deny that Plato has a theory of flux in the *Timaeus*. The world we see is in a constant flux with earth, water, air and fire all appearing to change into each other. The question is how radical that flux is at root. If earth, water, air and fire are the roots then that flux is indeed a radical one. Zeyl makes the interesting comment:

> All commentators agree that Plato intends to show (a) that the constituents of the physical world ('phenomena') are caught up in constant change (as is forcefully argued in the case of the 'elements' at 49b7-c7) and (b) that this fact necessitates a reform in the use of certain locutions as referring expressions.[60]

One might get the impression from Zeyl's remarks that for Plato the phenomena are all of the physical world, and that the elements of 49b ff. are the basic constituents of the phenomena. This may be so for the four-element theory of 49b ff., but is simply not the case for 53c ff. where the elements are decomposed to atoms, planes and stoicheic triangles, all of which are far below our perceptual thresholds, such that there is more to the physical world than the phenomena.[61] Surely one of the great glories of geometrical atomism is that it decouples the nature of what we see from the nature of the micro-world. Plato exploits this fact to great effect in his explanations of phenomena in the latter part of the *Timaeus*, and not least of course in the very essence of geometrical atomism itself, that the micro-world is populated by these geometrical entities. The most basic of these may well be qualitatively stable. That what persists through change should be different from that which we see changing is beyond doubt, but that does not imply what persists must be indeterminate, merely that it should be different, as geometrical atomism allows.[62] It is possible then to take a view of geometrical atomism, flux and the receptacle such that there is enough stability in the world to underwrite the complete stability of the heavens, if the stoicheic triangles are qualitatively stable and the bodies of the gods (i.e. the heavenly bodies, mostly fire) are put together with *alutois desmois*, indissoluble bonds, as at *Timaeus* 43a2, *desmoi* being what link the stoicheic triangles into planes and the planes into solid figures in geometrical atomism.

VIII. Geometrical atomism and Socrates' dream

One objection that has been raised against the idea that the stoicheic triangles are the basic physical entities for Plato is that this would deprive him of any analysis of matter.[63] In my view this is not so. While the stoicheic triangles may be the end of an analysis by physical decomposition, which might be taken as one sense of giving an account of a physical entity, there may be other sorts of account which we can have of the stoicheic triangles. Although *Timaeus* talks of the stoicheic triangles as the *archai* of the more complex triangles, he also goes on to talk of higher *archai*. At 48c3 he speaks of 'the *arche* or *archai* of everything', and later at *Timaeus* 53d, referring to the theory of stoicheic triangles he says:

> These we hypothesise (*hupotithemetha*) as the principle (*archen*) of fire and of the other bodies ... but the principles (*archas*) of these which are higher (*anothen*) are known only to God and whoever is friendly to him.

These higher principles need not refer to some more basic physical or mathematical entities, however. It is notable that *Timaeus* refers here to higher *archai*, principles or starting points, rather than to further *stoicheia*. At the termination of explanation in terms of analysis by decomposition into physical elements, one option for Plato is to switch to a teleological analysis. These higher *archai* then may be teleological explanations of why the stoicheic triangles are as they are. One interesting aspect of the passage at *Timaeus* 53d is that the use of *hupotithemi* and *anothen* is highly reminiscent of *Phaedo* 101d, the line allegory of the *Republic*, and the defence of hypotheses by higher hypotheses. One might compare here the uses of *anothen* at *Phaedo* 101d7, *Republic* 514b2 and 518b4, and the uses of *hupotithemi* at *Phaedo* 101d ff. and *Republic* 510b ff., and the *Republic* on line and cave, especially 511a5 where the soul must *ton hupotheseon anotero ekbainen*. One need hardly stress that the *Phaedo* and the *Republic* are not looking for further physical hypotheses at this point. The final clause concerning the man friendly to God might also suggest some intention to invoke explanations in terms of the good. When we look at the sort of arguments that *Timaeus* uses to justify his choice of stoicheic triangles this is borne out. At *Timaeus* 54a ff., we are told that while the isosceles triangle has but one form, the scalene has many and we must postulate the fairest, and teleological language permeates this entire section. It is likely then that the stoicheic triangles are the most elementary constituents of the physical world of the *Timaeus*, without being the ultimate explanatory *archai*.

The geometrical atomism of the *Timaeus* is very interesting in relation to the passage of the *Theaetetus* at 201d ff. known as 'Socrates' dream'. As with Meno's paradox, the dream poses wide and deep philosophical questions, much broader than the themes for science that I can tackle here, but

one issue for the study of the physical world posed by the dream is the question of letters and syllables and the accounts we can have of the simple and the complex. We can give an account of the complex in terms of its component parts, but we cannot give a similar account of the simple.

According to Socrates' dream at *Theaetetus* 201d ff., the regress is finite and terminates with basic elements, the stoicheia, which lack accounts. If they lack accounts, then they are perhaps unknowable. One problem for science that comes out of this is as follows. We can give an account of complex physical entities, such as the elements earth, water, air and fire, in terms of their component parts. Doubtless the dream has a good deal to say on the nature of that account, via the question of Hesiod's wagon at *Theaetetus* 207a, and whether a list of component parts is adequate, or an account of the interrelation of those parts, etc. There is a problem, though, with the physical stoicheia. However successful our physical analysis/account of complex physical entities, we cannot give the same sort of analysis/account of physical stoicheia.[64] As far as the physical world is concerned, it is notable that the *Timaeus* argues that there are basic elements, the stoicheic triangles, but at the termination of analysis from complex to simple these can be given teleological accounts.[65] It is interesting, and surely no coincidence, that the discussion of the *Timaeus* is presented with the same letters and syllables terminology. While letters and syllables may be inappropriate if we take the receptacle to be the key basic item, as argued in section I of this chapter that is not so if the stoicheic triangles are basic. They are the letters, the complexes of stoicheics the syllables, and the elements are neither letters nor syllables in line with *Timaeus* 48b.[66] But the *Timaeus* would want to deny that the elements of the physical world are perceptible, the contrary being claimed at *Theaetetus* 202b. It is important then that the *Timaeus* allows us some account of these stoicheia as otherwise we would have no access to them. There is not then a specific problem here with the physical world; the physical 'atoms', here taking 'atom' in its more literal sense as indivisible fundamental entity, can have accounts as well as names, though of course there may still be a problem with logical atomism, which would beset any claim to knowledge.[67] I do not wish to suggest that this is Plato's solution to the more general philosophical problems raised by the dream which run deeper than this, although it may point us in certain directions. What I do wish to bring out is that here we see a further epistemological reason for teleology, to add to the cosmological and nomological reasons we have seen, and of course the further epistemological reasons related to underdetermination and Meno's paradox.[68] In this sense, Plato's geometrical atomism is a long way removed from that of the Presocratics. So I would disagree with Vlastos when he compares Plato to Empedocles, Anaxagoras and the atomists, and says: 'So in offering us his own stoicheia Plato shows that he has enrolled in the same programme of physical elementarism.'[69] At one

level that is so, but Plato's atomism has a far richer structure both physically and philosophically.

The *Timaeus*, then, may have a teleological account of the stoicheic triangles at the end of an account of physical entities in terms of decomposition. To look forward to the *Philebus* for a moment, another sort of account of the stoicheic triangles may be available there. In the *Philebus*, we can think of points on a continuum as the imposition of limit on the unlimited.[70] If we take two points on a continuum, we can then define a specific quantity or distance between them. If we do this in two dimensions, we can then have an account of all the plane figures. So we arrive at a point where the *Timaeus* could take over with an account of how the physical world is constituted from two specific types of plane figures, the half-equilateral and the isosceles stoicheic triangles. I put this as generally as possible as there is a question as to what the triangles of the *Timaeus* are triangles of and so too a question in the *Philebus* concerning whether *peras* and *apeiron* are constitutive of things or an analysis of things. Whichever way we take these questions, the *Philebus* would be able to give a further account of the stoicheic triangles. It is worth noting that the *Philebus* accepts four-element theory, and that at *Timaeus* 53b we are told that when the demiurge orders the universe from its primordial chaos, where all is devoid of 'reason and measure' (*alogos kai ametros*) (53a9), he first 'created shapes by means of forms and numbers' (*eidesi te kai arithmois*) (53b4-5).[71]

Geometrical atomism would seem to leave us in a rather better position than the receptacle in terms of explanation. The stoicheic triangles are themselves explicable in terms of a further teleological account, in a way in which the characterless and basic receptacle was not. So too the stoicheic triangles are explanatory of the phenomena, as the *Timaeus* from 53c ff. goes on to show. They are constitutive of other things without imperilling their own stability in a way that the receptacle found difficult. We can have an account of how they fit together to make more complex entities, and how the particles of our bodies interact with other particles to create sensations.

IX. Geometrical atomism and language

One of the key consequences of there being some basic, stable entities in the *Timaeus* is that the problem of a collapse of discourse concerning the world around us is avoided. As Gill puts it, whatever turns out to be stable gives the world sufficient permanence for language to get a grip on it.[72] The receptacle appears to be fatally flawed as a candidate for this role. It cannot be both constitutive of the phenomena and unchanging as it is required to be in order to license *to toiouton* references to changing phenomena. If the stoicheic triangles are the basic, stable entities it would appear that they can be properly constitutive of changing phenomena, and

this does not imperil their stability. Thus reference can be made to the changing phenomena. That will be so for anything else which is qualitatively stable, which might well include the heavenly bodies. So as *Sophist* 262e demands, our sentences will have subjects, and I will say something more about false judgement in the *Timaeus* in Chapter 9.[73]

This may underestimate the grip that language can get on the world of the *Timaeus*, though. In several late works (*Theaetetus* 201d ff., *Politicus* 277d ff., *Sophist* 253a ff., *Philebus* 18b ff.) Plato employs the letters and syllables analogy to illustrate some points about the nature of language, and arguably in some or all of these cases about the nature of the world.[74] Plato is often interested in which letters do or do not combine to make syllables, and is concerned with the bonds (*desmoi*) between letters.[75]

Consider then what sort of problem geometrical atomism is introduced to solve, and how geometrical atomism is expressed. The original problem is a puzzle about the correct use of language and the structure of the world, and it is introduced using the letters and syllables analogy. Geometrical atomism is expressed in terms of *stoicheia* – we are given an account of which stoicheic triangles will combine with others, which will not, and how this combining occurs – and the bonds between the triangles are referred to as *desmoi*.[76] Indeed the *Timaeus* throughout seems very interested in the question of mathematical bonds, the bonds which hold men and gods together, the bonds which hold soul and body together and the bonds which hold the physical stoicheia together.[77]

The receptacle of 48e-53b might be thought to provide the ontological counterpart to a subject-predicate analysis of the world. Qualities appear in the receptacle and the proper description of these is that x is f-like, where x is the receptacle, f-like is the quality and F the form that this part of the receptacle is participating in. The receptacle always appears in the subject position and has no qualities in itself.[78] It halts the regress of Socrates' dream because it is ultimately basic ontologically, and is a pure subject linguistically (everything is predicated to the receptacle, it is predicated of nothing). The cost though is high, as we have seen. The receptacle is inexplicable (we can say nothing positive about the receptacle) and non-explanatory (its relation to what is in it is highly problematic).

With geometrical atomism though we have a different model of the world and perhaps a different conception of the way that language relates to the world.[79] What is not often recognised is how strong a reductive account of the world the *Timaeus* gives us. *Timaeus* 61c-68d gives an analysis of each of our senses in terms of geometrical atomism. Thus for instance white is the effect of the larger fire particles which dilate the visual stream (67e), and hot is due to the sharpness and rapid motion of the fire particles (61e). This then is no longer a simple subject-predicate arrangement as it might be if we were taking the receptacle to be the sole basic entity (i.e. (this part of) the receptacle is white, is hot). Hot and white

are now related to the motion and arrangement of certain types of atom, which in turn can be given analyses in terms of (the motion and arrangement of) complexes of stoicheics and ultimately stoicheic triangles themselves.

This brings us back to letters and syllables again. Instead of an isomorphism between a subject/predicate analysis of language and a substance/attribute ontology, we might look to an isomorphism between the way that the basic components of language can be arranged and structured into something meaningful and the basic components of the world can be arranged and structured into something beautiful and good. Can language pick out the basic components and relations of the world? That would seem eminently possible. In the same way that we might say that 'Theaetetus flies', and be wrong or right about that, we might say that '(this atom of) fire cuts (this earth atom)' or 'this stoicheic triangle forms a bond (with that one)'.

It is interesting to note that relative to the discussions of language in the *Theaetetus* and *Sophist* which are keen to stress that some words, letters and syllables do, or do not, fit together properly, so the *Timaeus* is keen to stress that some of the components of the world and some complexes of those components do, or do not, fit together properly. The *Philebus* is interested in the relationship between language and music at 17a ff. In both what is important in producing a meaningful result is how the components are linked and arranged together. An interesting link between the *Timaeus* and this passage is that *Philebus* 17e warns us, after the example of music but in a quite general manner, that an indeterminate plurality leaves you with an indeterminate account, while *Timaeus* 55c makes the same sort of remarks about the number of worlds and the number of elements.[80]

The links to other late works are of course rather speculative. However, if we are to link the various discussions of letters and syllables together, and that in itself seems a reasonable thing to do, then I see no reason why the *Timaeus* should not be included in that project, especially as the results are so interesting. Even if we stay within the *Timaeus*, geometrical atomism, if we take the stoicheic triangles to be the basic entities, can be seen to provide a different conception of the world and its relation to language to the receptacle passages, if we take the receptacle to be the basic entity. As indicated, this avoids the receptacle paradox and the problem of whether the receptacle is either explicable or explanatory, and language appears to be given a reasonable grip on the world. If we take this view, then geometrical atomism either replaces radically modifies the receptacle passages of 48e-53b. The further implications and advantages of that move, and whether we can justify it as a reading of this section of the *Timaeus*, will be the subject of the next chapter. If the *Timaeus* postulates the stoicheic triangles as stable, basic entities though, this has considerable ramifications for the nature

of flux envisaged (in relation to both the phenomenal and the micro worlds), and for nature of the relationship between language and the world.