Aristotle

Physics

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Book III:6

6

But on the other hand to suppose that the infinite does not exist in any way leads obviously to many impossible consequences: there will be a beginning and an end of time, a magnitude will not be divisible into magnitudes, number will not be infinite. If, then, in view of the above considerations, neither alternative seems possible, an arbiter must be called in; and clearly there is a sense in which the infinite exists and another in which it does not.
We must keep in mind that the word 'is' means either what potentially is or what fully is. Further, a thing is infinite either by addition or by division.
Now, as we have seen, magnitude is not actually infinite. But by division it is infinite. (There is no difficulty in refuting the theory of indivisible lines.)
The alternative then remains that the infinite has a potential existence.

But the phrase 'potential existence' is ambiguous. When we speak of the potential existence of a statue we mean that there will be an actual statue. It is not so with the infinite. There will not be an actual infinite. The word 'is' has many senses, and we say that the infinite 'is' in the sense in which we say 'it is day' or 'it is the games', because one thing after another is always coming into existence. For of these things too the distinction between potential and actual existence holds. We say that there are Olympic games, both in the sense that they may occur and that they are actually occurring.

The infinite exhibits itself in different ways – in time, in the generations of man, and in the division of magnitudes. For generally the infinite has this mode of existence: one thing is always being taken after another, and each thing that is taken is always finite, but always different. Again, 'being' has more than one sense, so that we must not regard the infinite as a 'this', such as a man or a horse, but must suppose it to exist in the sense in which we speak of the day or the games as existing things whose being has not come to them like that of a substance, but consists in a process of coming to be or passing away; definite if you like at each stage, yet always different.

But when this takes place in spatial magnitudes, what is taken perists, while in the succession of time and of men it takes place by the passing away of these in

such a way that the source of supply never gives out.

In a way the infinite by addition is the same thing as the infinite by division. In a finite magnitude, the infinite by addition comes about in a way inverse to that of the other. For in proportion as we see division going on, in the same proportion we see addition being made to what is already marked off. For if we take a determinate part of a finite magnitude and add another part determined by the same ratio (not taking in the same amount of the original whole), and so on, we shall not traverse the given magnitude. But if we increase the ratio of the part, so as always to take in the same amount, we shall traverse the magnitude, for every finite magnitude is exhausted by means of any determinate quantity however small.

The infinite, then, exists in no other way, but in this way it does exist, potentially and by reduction. It exists fully in the sense in which we say 'it is day' or 'it is the games'; and potentially as matter exists, not independently as what is finite does.

By addition then, also, there is potentially an infinite, namely, what we have described as being in a sense the same as the infinite in respect of division. For it will always be possible to take something ah extra. Yet the sum of the parts taken will not exceed every determinate magnitude, just as in the direction of division every determinate magnitude is surpassed in smallness and there will be a smaller part.

But in respect of addition there cannot be an infinite which even potentially exceeds every assignable magnitude, unless it has the attribute of being actually infinite, as the physicists hold to be true of the body which is outside the world, whose essential nature is air or something of the kind. But if there cannot be in this way a sensible body which is infinite in the full sense, evidently there can no more be a body which is potentially infinite in respect of addition, except as the inverse of the infinite by division, as we have said. It is for this reason that Plato also made the infinites two in number, because it is supposed to be possible to exceed all limits and to proceed ad infinitum in the direction both of increase and of reduction. Yet though he makes the infinites two, he does not use them. For in the numbers the infinite in the direction of reduction is not present, as the monad is the smallest; nor is the infinite in the direction of increase, for the parts number only up to the decad.

The infinite turns out to be the contrary of what it is said to be. It is not what has nothing outside it that is infinite, but what always has something outside it. This is indicated by the fact that rings also that have no bezel are described as 'endless', because it is always possible to take a part which is outside a given part. The description depends on a certain similarity, but it is not true in the full sense of the word. This condition alone is not sufficient:

it is necessary also that the next part which is taken should never be the same. In the circle, the latter condition is not satisfied: it is only the adjacent part from which the new part is different.

Our definition then is as follows:

A quantity is infinite if it is such that we can always take a part outside what has been already taken. On the other hand, what has nothing outside it is complete and whole. For thus we define the whole – that from which nothing is wanting, as a whole man or a whole box. What is true of each particular is true of the whole as such – the whole is that of which nothing is outside. On the other hand that from which something is absent and outside, however small that may be, is not 'all'. 'Whole' and 'complete' are either quite identical or closely akin. Nothing is complete (teleion) which has no end (telos); and the end is a limit.

Hence Parmenides must be thought to have spoken better than Melissus. The latter says that the whole is infinite, but the former describes it as limited, 'equally balanced from the middle'. For to connect the infinite with the all and the whole is not like joining two pieces of string; for it is from this they get the dignity they ascribe to the infinite – its containing all things and holding the all in itself – from its having a certain similarity to the whole. It is in fact the matter of the completeness which belongs to size, and what is potentially a whole, though not in the full sense. It is divisible both in the direction of reduction and of the inverse addition. It is a whole and limited; not, however, in virtue of its own nature, but in virtue of what is other than it. It does not contain, but, in so far as it is infinite, is contained.

Consequently, also, it is unknowable, qua infinite; for the matter has no form. (Hence it is plain that the infinite stands in the relation of part rather than of whole. For the matter is part of the whole, as the bronze is of the bronze statue.) If it contains in the case of sensible things, in the case of intelligible things the great and the small ought to contain them. But it is absurd and impossible to suppose that the unknowable and indeterminate should *contain and determine.*

Book IV:4

4

What then after all is place? The answer to this question may be elucidated as follows.

Let us take for granted about it the various characteristics which are supposed correctly to belong to it essentially. We assume then –

(1) Place is what contains that of which it is the place.
(2) Place is no part of the thing.
(3) The immediate place of a thing is neither less nor greater than the thing.
(4) Place can be left behind by the thing and is separable. In addition:
(5) All place admits of the distinction of up and down, and each of the bodies is naturally carried to its appropriate place and rests there, and this makes the place either up or down.

Having laid these foundations, we must complete the theory. We ought to try to make our investigation such as will render an account of place, and will not only solve the difficulties connected with it, but will also show that the attributes supposed to belong to it do really belong to it, and further will make clear the cause of the trouble and of the difficulties about it. Such is the most satisfactory kind of exposition.

First then we must understand that place would not have been thought of, if there had not been a special kind of motion, namely that with respect to place. It is chiefly for this reason that we suppose the heaven also to be in place, because it is in constant movement. Of this kind of change there are two species – locomotion on the one hand and, on the other, increase and diminution. For these too involve variation of place: what was then in this place has now in turn changed to what is larger or smaller.

Again, when we say a thing is 'moved', the predicate either (1) belongs to it actually, in virtue of its own nature, or (2) in virtue of something conjoined with it. In the latter case it may be either (a) something which by its own nature is capable of being moved, e.g. the parts of the body or the nail in the ship, or (b) something which is not in itself capable of being moved, but is always moved through its conjunction with something else, as 'whiteness' or 'science'. These have changed their place only because the subjects to which they belong do so.

We say that a thing is in the world, in the sense of in place, because it is in the air, and the air is in the world; and when we say it is in the air, we do not mean it is in every part of the air, but that it is in the air because of the outer surface of the air which surrounds it; for if all the air were its place, the place of a thing would not be equal to the thing – which it is

supposed to be, and which the primary place in which a thing is actually is.

When what surrounds, then, is not separate from the thing, but is in continuity with it, the thing is said to be in what surrounds it, not in the sense of in place, but as a part in a whole. But when the thing is separate and in contact, it is immediately 'in' the inner surface of the surrounding body, and this surface is neither a part of what is in it nor yet greater than its extension,

but equal to it; for the extremities of things which touch are coincident. Further, if one body is in continuity with another, it is not moved in that but with that. On the other hand it is moved in that if it is separate. It makes no difference whether what contains is moved or not.

Again, when it is not separate it is described as a part in a whole, as the pupil in the eye or the hand in the body: when it is separate, as the water in the cask or the wine in the jar. For the hand is moved with the body and the water in the cask.

It will now be plain from these considerations what place is. There are just four things of which place must be one – the shape, or the matter, or some sort of extension between the bounding surfaces of the containing body, or this boundary itself if it contains no extension over and above the bulk of the body which comes to be in it.

Three of these it obviously cannot be:

(1) The shape is supposed to be place because it surrounds, for the extremities of what contains and of what is contained are coincident. Both the shape and the place, it is true, are boundaries. But not of the same thing: the form is the boundary of the thing, the place is the boundary of the body which contains it.

(2) The extension between the extremities is thought to be something, because what is contained and separate may often be changed while the container remains the same (as water may be poured from a vessel) – the assumption being that the extension is something over and above the body displaced. But there is no such extension. One of the bodies which change places and are naturally capable of being in contact with the container falls in whichever it may chance to be. If there were an extension which were such as to exist independently and be permanent, there would be an infinity of places in the same thing. For when the water and the air change places, all the portions of the two together will play the same part in the whole which was previously played by all the water in the vessel; at the same time the place too will be undergoing change; so that there will be another place which is the place of the place, and many places will be coincident. There is not a different place of the part, in which it is moved, when the whole vessel changes its place: it is always the same: for it is in the (proximate) place where they are that the air and the water (or the parts of the water) succeed each other, not in that place in which they come to be, which is part of the place which is the place of the whole world.

(3) The matter, too, might seem to be place, at least if we consider it in what is at rest and is thus separate but in continuity. For just as in change of quality there is something which was formerly black and is now white, or formerly soft and now hard – this is just why we say that the matter exists – so place, because it presents a similar phenomenon, is thought to exist – only in the one case we say so because what was air is now water, in the other because where air formerly was there a is now water. But the matter, as we said before, is neither separable from the thing nor contains it, whereas place has both characteristics.

Well, then, if place is none of the three – neither the form nor the matter nor an extension which is always there, different from, and over and above, the extension of the thing which is displaced – place necessarily is the one of the four which is left, namely, the boundary of the containing body at which it is in contact with the contained body. (By the contained body is meant what can be moved by way of locomotion.)

Place is thought to be something important and hard to grasp, both because the matter and the shape present themselves along with it, and because the displacement of the body that is moved takes place in a stationary container, for it seems possible that there should be an interval which is other than the bodies which are moved. The air, too, which is thought to be incorporeal, contributes something to the belief: it is not only the boundaries of the vessel which seem to be place, but also what is between them, regarded as empty. Just, in fact, as the vessel is transportable place, so place is a non-portable vessel. So when what is within a thing which is moved, is moved and changes its place, as a boat on a river, what contains plays the part of a vessel rather than that of place. Place on the other hand is rather what is motionless: so it is rather the whole river that is place, because as a whole it is motionless. Hence we conclude that the innermost motionless boundary of what contains is place.

This explains why the middle of the heaven and the surface which faces us of the rotating system are held to be 'up' and 'down' in the strict and fullest sense for all men: for the one is always at rest, while the inner side of the rotating body remains always coincident with itself. Hence since the light is what is naturally carried up, and the heavy what is carried down, the boundary which contains in the direction of the middle of the universe, and the middle itself, are down, and that which contains in the direction of the outermost part of the universe, and the outermost part itself, are up.

For this reason, too, place is thought to be a kind of surface, and as it were a vessel, i.e. a container of the thing.

Further, place is coincident with the thing, for boundaries are coincident with *the bounded.*

Book V: 3-4

3

Let us now proceed to define the terms 'together' and 'apart', 'in contact', 'between', 'in succession', 'contiguous', and 'continuous', and to show in what circumstances each of these terms is naturally applicable.

Things are said to be together in place when they are in one place (in the strictest sense of the word 'place') and to be apart when they are in different places.

Things are said to be in contact when their extremities are together. That which a changing thing, if it changes continuously in a natural manner, naturally reaches before it reaches that to which it changes last, is between. Thus 'between' implies the presence of at least three things: for in a process of change it is the contrary that is 'last': and a thing is moved continuously if it leaves no gap or only the smallest possible gap in the material – not in the time (for a gap in the time does not prevent things having a 'between', while, on the other hand, there is nothing to prevent the highest note sounding immediately after the lowest) but in the material in which the motion takes place. This is manifestly true not only in local changes but in every other kind as well. (Now every change implies a pair of opposites, and opposites may be either contraries or contradictories; since then contradiction admits of no mean term, it is obvious that 'between' must imply a pair of contraries) That is locally contrary which is most distant in a straight line: for the shortest line is definitely limited, and that which is definitely limited constitutes a measure.

A thing is 'in succession' when it is after the beginning in position or in form or in some other respect in which it is definitely so regarded, and when further there is nothing of the same kind as itself between it and that to which it is in succession, e.g. a line or lines if it is a line, a unit or units if it is a unit, a house if it is a house (there is nothing to prevent something of a different kind being between). For that which is in succession is in succession to a particular thing, and is something posterior: for one is not 'in succession' to two, nor is the first day of the month to be second: in each case the latter is 'in succession' to the former.

A thing that is in succession and touches is 'contiguous'. The 'continuous' is a subdivision of the contiguous: things are called continuous when the touching limits of each become one and the same and are, as the word implies, contained in each other: continuity is impossible if these extremities are two. This definition makes it plain that continuity belongs to things that naturally in virtue of their mutual contact form a unity. And in whatever way that which

holds them together is one, so too will the whole be one, e.g. by a rivet or glue or contact or organic union.

It is obvious that of these terms 'in succession' is first in order of analysis: for that which touches is necessarily in succession, but not everything that is in succession touches: and so succession is a property of things prior in definition, e.g. numbers, while contact is not. And if there is continuity there is necessarily contact, but if there is contact, that alone does not imply continuity: for the extremities of things may be 'together' without necessarily being one: but they cannot be one without being necessarily together. So natural junction is last in coming to be: for the extremities must necessarily come into contact if they are to be naturally joined: but things that are in contact are not all naturally joined, while there is no contact clearly there is no natural junction either. Hence, if as some say 'point' and 'unit' have an independent existence of their own, it is impossible for the two to be identical: for points can touch while units can only be in succession. Moreover, there can always be something between points (for all lines are intermediate between points), whereas it is not necessary that there should possibly be anything between units: for there can be nothing between the numbers one and two.

We have now defined what is meant by 'together' and 'apart', 'contact', 'between' and 'in succession', 'contiguous' and 'continuous': and we have shown in what circumstances each of these terms is applicable.

4

There are many senses in which motion is said to be 'one': for we use the term 'one' in many senses.

Motion is one generically according to the different categories to which it may be assigned: thus any locomotion is one generically with any other locomotion, whereas alteration is different generically from locomotion.

Motion is one specifically when besides being one generically it also takes place in a species incapable of subdivision: e.g. colour has specific differences: therefore blackening and whitening differ specifically; but at all events every whitening will be specifically the same with every other whitening and every blackening with every other blackening. But white is not further subdivided by specific differences: hence any whitening is specifically one with any other whitening. Where it happens that the genus is at the same time a species, it is clear that the motion will then in a sense be one specifically though not in an unqualified sense: learning is an example of this, knowledge being on the one hand a species of apprehension and on the other hand a genus including the various knowledges. A difficulty, however, may be raised as to

whether a motion is specifically one when the same thing changes from the same to the same, e.g. when one point changes again and again from a particular place to a particular place: if this motion is specifically one, circular motion will be the same as rectilinear motion, and rolling the same as walking. But is not this difficulty removed by the principle already laid down that if that in which the motion takes place is specifically different (as in the present instance the circular path is specifically different from the straight) the motion itself is also different? We have explained, then, what is meant by saying that motion is one generically or one specifically.

Motion is one in an unqualified sense when it is one essentially or numerically: and the following distinctions will make clear what this kind of motion is.

There are three classes of things in connexion with which we speak of motion, the 'that which', the 'that in which', and the 'that during which'. I mean that there must he something that is in motion, e.g. a man or gold, and it must be in motion in something, e.g. a place or an affection, and during something, for all motion takes place during a time. Of these three it is the thing in which the motion takes place that makes it one generically or specifically, it is the thing moved that makes the motion one in subject, and it is the time that makes it consecutive: but it is the three together that make it one without qualification: to effect this, that in which the motion takes place (the species) must be one and incapable of subdivision, that during which it takes place (the time) must be one and unintermittent, and that which is in motion must be one – not in an accidental sense (i.e. it must be one as the white that blackens is one or Coriscus who walks is one, not in the accidental sense in which Coriscus and white may be one), nor merely in virtue of community of nature (for there might be a case of two men being restored to health at the same time in the same way, e.g. from inflammation of the eye, yet this motion is not really one, but only specifically one).

Suppose, however, that Socrates undergoes an alteration specifically the same but at one time and again at another: in this case if it is possible for that which ceased to be again to come into being and remain numerically the same, then this motion too will be one: otherwise it will be the same but not one. And akin to this difficulty there is another; viz. is health one? and generally are the states and affections in bodies severally one in essence although (as is clear) the things that contain them are obviously in motion and in flux? Thus if a person's health at daybreak and at the present moment is one and the same, why should not this health be numerically one with that which he recovers after an interval? The same argument applies in each case. There is, however, we may answer, this difference: that if the states are two then it follows simply from this fact that the activities must also in point of number be two (for only that which is numerically one can give rise to an activity that is numerically one),

but if the state is one, this is not in itself enough to make us regard the activity also as one: for when a man ceases walking, the walking no longer is, but it will again be if he begins to walk again. But, be this as it may, if in the above instance the health is one and the same, then it must be possible for that which is one and the same to come to be and to cease to be many times. However, these difficulties lie outside our present inquiry.

Since every motion is continuous, a motion that is one in an unqualified sense must (since every motion is divisible) be continuous, and a continuous motion must be one. There will not be continuity between any motion and any other indiscriminately any more than there is between any two things chosen at random in any other sphere: there can be continuity only when the extremities of the two things are one. Now some things have no extremities at all: and the extremities of others differ specifically although we give them the same name of 'end': how should e.g. the 'end' of a line and the 'end' of walking touch or come to be one? Motions that are not the same either specifically or generically may, it is true, be consecutive (e.g. a man may run and then at once fall ill of a fever), and again, in the torch-race we have consecutive but not continuous locomotion: for according to our definition there can be continuity only when the ends of the two things are one. Hence motions may be consecutive or successive in virtue of the time being continuous, but there can be continuity only in virtue of the motions themselves being continuous, that is when the end of each is one with the end of the other. Motion, therefore, that is in an unqualified sense continuous and one must be specifically the same, of one thing, and in one time. Unity is required in respect of time in order that there may be no interval of immobility, for where there is intermission of motion there must be rest, and a motion that includes intervals of rest will be not one but many, so that a motion that is interrupted by stationariness is not one or continuous, and it is so interrupted if there is an interval of time. And though of a motion that is not specifically one (even if the time is unintermittent) the time is one, the motion is specifically different, and so cannot really be one, for motion that is one must be specifically one, though motion that is specifically one is not necessarily one in an unqualified sense. We have now explained what we mean when we call a motion one without qualification. Further, a motion is also said to be one generically, specifically, or essentially when it is complete, just as in other cases completeness and wholeness are characteristics of what is one: and sometimes a motion even if incomplete is said to be one, provided only that it is continuous.

And besides the cases already mentioned there is another in which a motion is said to be one, viz. when it is regular: for in a sense a motion that is irregular is not regarded as one, that title belonging rather to that which is regular, as a straight line is regular, the irregular being as such divisible.

But the difference would seem to be one of degree. In every kind of motion we may have regularity or irregularity: thus there may be regular alteration, and locomotion in a regular path, e.g. in a circle or on a straight line, and it is the same with regard to increase and decrease. The difference that makes a motion irregular is sometimes to be found in its path: thus a motion cannot be regular if its path is an irregular magnitude, e.g. a broken line, a spiral, or any other magnitude that is not such that any part of it taken at random fits on to any other that may be chosen. Sometimes it is found neither in the place nor in the time nor in the goal but in the manner of the motion: for in some cases the motion is differentiated by quickness and slowness: thus if its velocity is uniform a motion is regular, if not it is irregular. So quickness and slowness are not species of motion nor do they constitute specific differences of motion, because this distinction occurs in connexion with all the distinct species of motion. The same is true of heaviness and lightness when they refer to the same thing: e.g. they do not specifically distinguish earth from itself or fire from itself. Irregular motion, therefore, while in virtue of being continuous it is one, is so in a lesser degree, as is the case with locomotion in a broken line: and a lesser degree of something always means an admixture of its contrary. And since every motion that is one can be both regular and irregular, motions that are consecutive but not specifically the same cannot be one and continuous: for how should a motion composed of alteration and locomotion be regular? If a motion is to be regular its parts ought to fit one another.

Book VI: 1-4, 6, 9

1

Now if the terms 'continuous', 'in contact', and 'in succession' are understood as defined above things being 'continuous' if their extremities are one, 'in contact' if their extremities are together, and 'in succession' if there is nothing of their own kind intermediate between them – nothing that is continuous can be composed 'of indivisibles': e.g. a line cannot be composed of points, the line being continuous and the point indivisible. For the extremities of two points can neither be one (since of an indivisible there can be no extremity as distinct from some other part) nor together (since that which has no parts can have no extremity, the extremity and the thing of which it is the extremity being distinct).

Moreover, if that which is continuous is composed of points, these points must be either continuous or in contact with one another: and the same reasoning applies in the case of all indivisibles. Now for the reason given above they cannot be continuous: and one thing can be in contact with another only if whole is in contact with whole or part with part or part with whole. But since indivisibles have no parts, they must be in contact with one another as whole with whole. And if they are in contact with one another as whole with whole, they will not be continuous: for that which is continuous has distinct parts: and these parts into which it is divisible are different in this way, i.e. spatially separate.

Nor, again, can a point be in succession to a point or a moment to a moment in such a way that length can be composed of points or time of moments: for things are in succession if there is nothing of their own kind intermediate between them, whereas that which is intermediate between points is always a line and that which is intermediate between moments is always a period of time.

Again, if length and time could thus be composed of indivisibles, they could be divided into indivisibles, since each is divisible into the parts of which it is composed. But, as we saw, no continuous thing is divisible into things without parts. Nor can there be anything of any other kind intermediate between the parts or between the moments: for if there could be any such thing it is clear that it must be either indivisible or divisible, and if it is divisible, it must be divisible either into indivisibles or into divisibles that are infinitely divisible, in which case it is continuous.

Moreover, it is plain that everything continuous is divisible into divisibles that are infinitely divisible: for if it were divisible into indivisibles, we should have an indivisible in contact with an indivisible, since the extremities

of things that are continuous with one another are one and are in contact.

The same reasoning applies equally to magnitude, to time, and to motion: either all of these are composed of indivisibles and are divisible into indivisibles, or none. This may be made clear as follows. If a magnitude is composed of indivisibles, the motion over that magnitude must be composed of corresponding indivisible motions: e.g. if the magnitude ABG is composed of the indivisibles A, B, G, each corresponding part of the motion DEZ of O over ABG is indivisible. Therefore, since where there is motion there must be something that is in motion, and where there is something in motion there must be motion, therefore the being-moved will also be composed of indivisibles. So O traversed A when its motion was D, B when its motion was E, and G similarly when its motion was Z.

Now a thing that is in motion from one place to another cannot at the moment when it was in motion both be in motion and at the same time have completed its motion at the place to which it was in motion: e.g. if a man is walking to Thebes, he cannot be walking to Thebes and at the same time have completed his walk to Thebes: and, as we saw, O traverses a the partless section A in virtue of the presence of the motion D. Consequently, if O actually passed through A after being in process of passing through, the motion must be divisible: for at the time when O was passing through, it neither was at rest nor had completed its passage but was in an intermediate state: while if it is passing through and has completed its passage at the same moment, then that which is walking will at the moment when it is walking have completed its walk and will be in the place to which it is walking; that is to say, it will have completed its motion at the place to which it is in motion. And if a thing is in motion over the whole KBG and its motion is the three D, E, and Z, and if it is not in motion at all over the partless section A but has completed its motion over it, then the motion will consist not of motions but of starts, and will take place by a thing's having completed a motion without being in motion: for on this assumption it has completed its passage through A without passing through it. So it will be possible for a thing to have completed a walk without ever walking: for on this assumption it has completed a walk over a particular distance without walking over that distance. Since, then, everything must be either at rest or in motion, and O is therefore at rest in each of the sections A, B, and G, it follows that a thing can be continuously at rest and at the same time in motion: for, as we saw, O is in motion over the whole ABG and at rest in any part (and consequently in the whole) of it. Moreover, if the indivisibles composing DEZ are motions, it would be possible for a thing in spite of the presence in it of motion to be not in motion but at rest, while if they are not motions, it would be possible for motion to be composed of something other than motions.

And if length and motion are thus indivisible, it is neither more nor less necessary that time also be similarly indivisible, that is to say be composed of

indivisible moments: for if the whole distance is divisible and an equal velocity will cause a thing to pass through less of it in less time, the time must also be divisible, and conversely, if the time in which a thing is carried over the section A is divisible, this section A must also be divisible.

2

And since every magnitude is divisible into magnitudes – for we have shown that it is impossible for anything continuous to be composed of indivisible parts, and every magnitude is continuous – it necessarily follows that the quicker of two things traverses a greater magnitude in an equal time, an equal magnitude in less time, and a greater magnitude in less time, in conformity with the definition sometimes given of 'the quicker'. Suppose that A is quicker than B.

Now since of two things that which changes sooner is quicker, in the time ZH, in which A has changed from G to D, B will not yet have arrived at D but will be short of it: so that in an equal time the quicker will pass over a greater magnitude. More than this, it will pass over a greater magnitude in less time: for in the time in which A has arrived at D, B being the slower has arrived, let us say, at E. Then since A has occupied the whole time ZH in arriving at D, will have arrived at O in less time than this, say ZK. Now the magnitude GO that A has passed over is greater than the magnitude GE, and the time ZK is less than the whole time ZH: so that the quicker will pass over a greater magnitude in less time. And from this it is also clear that the quicker will pass over an equal magnitude in less time than the slower. For since it passes over the greater magnitude in less time than the slower, and (regarded by itself) passes over LM the greater in more time than LX the lesser, the time PRh in which it passes over LM will be more than the time PS, which it passes over LX: so that, the time PRh being less than the time PCh in which the slower passes over LX, the time PS will also be less than the time PX: for it is less than the time PRh, and that which is less than something else that is less than a thing is also itself less than that thing. Hence it follows that the quicker will traverse an equal magnitude in less time than the slower. Again, since the motion of anything must always occupy either an equal time or less or more time in comparison with that of another thing, and since, whereas a thing is slower if its motion occupies more time and of equal velocity if its motion occupies an equal time, the quicker is neither of equal velocity nor slower, it follows that the motion of the quicker can occupy neither an equal time nor more time. It can only be, then, that it occupies less time, and thus we get the necessary consequence that the quicker will pass over an equal magnitude (as well as a greater) in less time than the slower.

And since every motion is in time and a motion may occupy any time, and the motion of everything that is in motion may be either quicker or slower, both quicker motion and slower motion may occupy any time: and this being so, it necessarily follows that time also is continuous. By continuous I mean that which is divisible into divisibles that are infinitely divisible: and if we take this as the definition of continuous, it follows necessarily that time is continuous. For since it has been shown that the quicker will pass over an equal magnitude in less time than the slower, suppose that A is quicker and B slower, and that the slower has traversed the magnitude GD in the time ZH. Now it is clear that the quicker will traverse the same magnitude in less time than this: let us say in the time ZO. Again, since the quicker has passed over the whole D in the time ZO, the slower will in the same time pass over GK, say, which is less than GD. And since B, the slower, has passed over GK in the time ZO, the quicker will pass over it in less time: so that the time ZO will again be divided. And if this is divided the magnitude GK will also be divided just as GD was: and again, if the magnitude is divided, the time will also be divided. And we can carry on this process for ever, taking the slower after the quicker and the quicker after the slower alternately, and using what has been demonstrated at each stage as a new point of departure: for the quicker will divide the time and the slower will divide the length. If, then, this alternation always holds good, and at every turn involves a division, it is evident that all time must be continuous. And at the same time it is clear that all magnitude is also continuous; for the divisions of which time and magnitude respectively are susceptible are the same and equal.

Moreover, the current popular arguments make it plain that, if time is continuous, magnitude is continuous also, inasmuch as a thing asses over half a given magnitude in half the time taken to cover the whole: in fact without qualification it passes over a less magnitude in less time; for the divisions of time and of magnitude will be the same. And if either is infinite, so is the other, and the one is so in the same way as the other; i.e. if time is infinite in respect of its extremities, length is also infinite in respect of its extremities: if time is infinite in respect of divisibility, length is also infinite in respect of divisibility: and if time is infinite in both respects, magnitude is also infinite in both respects.

Hence Zeno's argument makes a false assumption in asserting that it is impossible for a thing to pass over or severally to come in contact with infinite things in a finite time. For there are two senses in which length and time and generally anything continuous are called 'infinite': they are called so either in respect of divisibility or in respect of their extremities. So while a thing in a finite time cannot come in contact with things quantitatively infinite, it can come in contact with things infinite in respect of

divisibility: for in this sense the time itself is also infinite: and so we find that the time occupied by the passage over the infinite is not a finite but an infinite time, and the contact with the infinites is made by means of moments not finite but infinite in number.

The passage over the infinite, then, cannot occupy a finite time, and the passage over the finite cannot occupy an infinite time: if the time is infinite the magnitude must be infinite also, and if the magnitude is infinite, so also is the time. This may be shown as follows. Let AB be a finite magnitude, and let us suppose that it is traversed in infinite time G, and let a finite period GD of the time be taken. Now in this period the thing in motion will pass over a certain segment of the magnitude: let BE be the segment that it has thus passed over. (This will be either an exact measure of AB or less or greater than an exact measure: it makes no difference which it is.) Then, since a magnitude equal to BE will always be passed over in an equal time, and BE measures the whole magnitude, the whole time occupied in passing over AB will be finite: for it will be divisible into periods equal in number to the segments into which the magnitude is divisible. Moreover, if it is the case that infinite time is not occupied in passing over every magnitude, but it is possible to ass over some magnitude, say BE, in a finite time, and if this BE measures the whole of which it is a part, and if an equal magnitude is passed over in an equal time, then it follows that the time like the magnitude is finite. That infinite time will not be occupied in passing over BE is evident if the time be taken as limited in one direction: for as the part will be passed over in less time than the whole, the time occupied in traversing this part must be finite, the limit in one direction being given. The same reasoning will also show the falsity of the assumption that infinite length can be traversed in a finite time. It is evident, then, from what has been said that neither a line nor a surface nor in fact anything continuous can be indivisible.

This conclusion follows not only from the present argument but from the consideration that the opposite assumption implies the divisibility of the indivisible. For since the distinction of quicker and slower may apply to motions occupying any period of time and in an equal time the quicker passes over a greater length, it may happen that it will pass over a length twice, or one and a half times, as great as that passed over by the slower: for their respective velocities may stand to one another in this proportion. Suppose, then, that the quicker has in the same time been carried over a length one and a half times as great as that traversed by the slower, and that the respective magnitudes are divided, that of the quicker, the magnitude ABGD, into three indivisibles, and that of the slower into the two indivisibles EZ, ZH. Then the time may also be divided into three indivisibles, for an equal magnitude will be passed over in an equal time. Suppose then that it is thus divided into KL, LM,

MN. Again, since in the same time the slower has been carried over EZ, ZH, the time may also be similarly divided into two. Thus the indivisible will be divisible, and that which has no parts will be passed over not in an indivisible but in a greater time. It is evident, therefore, that nothing continuous is without parts.

3

The present also is necessarily indivisible – the present, that is, not in the sense in which the word is applied to one thing in virtue of another, but in its proper and primary sense; in which sense it is inherent in all time. For the present is something that is an extremity of the past (no part of the future being on this side of it) and also of the future (no part of the past being on the other side of it): it is, as we have said, a limit of both. And if it is once shown that it is essentially of this character and one and the same, it will at once be evident also that it is indivisible.

Now the present that is the extremity of both times must be one and the same: for if each extremity were different, the one could not be in succession to the other, because nothing continuous can be composed of things having no parts: and if the one is apart from the other, there will be time intermediate between them, because everything continuous is such that there is something intermediate between its limits and described by the same name as itself. But if the intermediate thing is time, it will be divisible: for all time has been shown to be divisible. Thus on this assumption the present is divisible. But if the present is divisible, there will be part of the past in the future and part of the future in the past: for past time will be marked off from future time at the actual point of division. Also the present will be a present not in the proper sense but in virtue of something else: for the division which yields it will not be a division proper. Furthermore, there will be a part of the present that is past and a part that is future, and it will not always be the same part that is past or future: in fact one and the same present will not be simultaneous: for the time may be divided at many points. If, therefore, the present cannot possibly have these characteristics, it follows that it must be the same present that belongs to each of the two times. But if this is so it is evident that the present is also indivisible: for if it is divisible it will be involved in the same implications as before. It is clear, then, from what has been said that time contains something indivisible, and this is what we call a present.

We will now show that nothing can be in motion in a present. For if this is possible, there can be both quicker and slower motion in the present. Suppose then that in the present N the quicker has traversed the distance AB. That being

so, the slower will in the same present traverse a distance less than AB, say AG. But since the slower will have occupied the whole present in traversing AG, the quicker will occupy less than this in traversing it. Thus we shall have a division of the present, whereas we found it to be indivisible. It is impossible, therefore, for anything to be in motion in a present.

Nor can anything be at rest in a present: for, as we were saying, only can be at rest which is naturally designed to be in motion but is not in motion when, where, or as it would naturally be so: since, therefore, nothing is naturally designed to be in motion in a present, it is clear that nothing can be at rest in a present either.

Moreover, inasmuch as it is the same present that belongs to both the times, and it is possible for a thing to be in motion throughout one time and to be at rest throughout the other, and that which is in motion or at rest for the whole of a time will be in motion or at rest as the case may be in any part of it in which it is naturally designed to be in motion or at rest: this being so, the assumption that there can be motion or rest in a present will carry with it the implication that the same thing can at the same time be at rest and in motion: for both the times have the same extremity, viz. the present.

Again, when we say that a thing is at rest, we imply that its condition in whole and in part is at the time of speaking uniform with what it was previously: but the present contains no 'previously': consequently, there can be no rest in it. It follows then that the motion of that which is in motion and the rest of that which is at rest must occupy time.

4

Further, everything that changes must be divisible. For since every change is from something to something, and when a thing is at the goal of its change it is no longer changing, and when both it itself and all its parts are at the starting-point of its change it is not changing (for that which is in whole and in part in an unvarying condition is not in a state of change); it follows, therefore, that part of that which is changing must be at the starting-point and part at the goal: for as a whole it cannot be in both or in neither. (Here by 'goal of change' I mean that which comes first in the process of change: e.g. in a process of change from white the goal in question will be grey, not black: for it is not necessary that that that which is changing should be at either of the extremes.) It is evident, therefore, that everything that changes must be divisible.

Now motion is divisible in two senses. In the first place it is divisible in virtue of the time that it occupies. In the second place it is divisible

according to the motions of the several parts of that which is in motion: e.g. if the whole AG is in motion, there will be a motion of AB and a motion of BG. That being so, let DE be the motion of the part AB and EZ the motion of the part BG. Then the whole DZ must be the motion of AG: for DZ must constitute the motion of AG inasmuch as DE and EZ severally constitute the motions of each of its parts. But the motion of a thing can never be constituted by the motion of something else: consequently the whole motion is the motion of the whole magnitude.

Again, since every motion is a motion of something, and the whole motion DZ is not the motion of either of the parts (for each of the parts DE, EZ is the motion of one of the parts AB, BG) or of anything else (for, the whole motion being the motion of a whole, the parts of the motion are the motions of the parts of that whole: and the parts of DZ are the motions of AB, BG and of nothing else: for, as we saw, a motion that is one cannot be the motion of more things than one): since this is so, the whole motion will be the motion of the magnitude ABG.

Again, if there is a motion of the whole other than DZ, say the the of each of the arts may be subtracted from it: and these motions will be equal to DE, EZ respectively: for the motion of that which is one must be one. So if the whole motion OI may be divided into the motions of the parts, OI will be equal to DZ: if on the other hand there is any remainder, say KI, this will be a motion of nothing: for it can be the motion neither of the whole nor of the parts (as the motion of that which is one must be one) nor of anything else: for a motion that is continuous must be the motion of things that are continuous. And the same result follows if the division of OI reveals a surplus on the side of the motions of the parts. Consequently, if this is impossible, the whole motion must be the same as and equal to DZ.

This then is what is meant by the division of motion according to the motions of the parts: and it must be applicable to everything that is divisible into parts. Motion is also susceptible of another kind of division, that according to time. For since all motion is in time and all time is divisible, and in less time the motion is less, it follows that every motion must be divisible according to time. And since everything that is in motion is in motion in a certain sphere and for a certain time and has a motion belonging to it, it follows that the time, the motion, the being-in-motion, the thing that is in motion, and the sphere of the motion must all be susceptible of the same divisions (though spheres of motion are not all divisible in a like manner: thus quantity is essentially, quality accidentally divisible). For suppose that A is the time occupied by the motion B. Then if all the time has been occupied by the whole motion, it will take less of the motion to occupy half the time, less again to occupy a further subdivision of the time, and so on to infinity. Again, the time

will be divisible similarly to the motion: for if the whole motion occupies all the time half the motion will occupy half the time, and less of the motion again will occupy less of the time.

In the same way the being-in-motion will also be divisible. For let G be the whole being-in-motion. Then the being-in-motion that corresponds to half the motion will be less than the whole being-in-motion, that which corresponds to a quarter of the motion will be less again, and so on to infinity. Moreover by setting out successively the being-in-motion corresponding to each of the two motions DG (say) and GE, we may argue that the whole being-in-motion will correspond to the whole motion (for if it were some other being-in-motion that corresponded to the whole motion, there would be more than one being-in-motion corresponding to the same motion), the argument being the same as that whereby we showed that the motion of a thing is divisible into the motions of the parts of the thing: for if we take separately the being-in-motion corresponding to each of the two motions, we shall see that the whole being-in-motion is continuous.

The same reasoning will show the divisibility of the length, and in fact of everything that forms a sphere of change (though some of these are only accidentally divisible because that which changes is so): for the division of one term will involve the division of all. So, too, in the matter of their being finite or infinite, they will all alike be either the one or the other. And we now see that in most cases the fact that all the terms are divisible or infinite is a direct consequence of the fact that the thing that changes is divisible or infinite: for the attributes 'divisible' and 'infinite' belong in the first instance to the thing that changes. That divisibility does so we have already *shown: that infinity does so will be made clear in what follows?*

9

Zeno's reasoning, however, is fallacious, when he says that if everything when it occupies an equal space is at rest, and if that which is in locomotion is always occupying such a space at any moment, the flying arrow is therefore motionless. This is false, for time is not composed of indivisible moments any more than any other magnitude is composed of indivisibles.

Zeno's arguments about motion, which cause so much disquietude to those who try to solve the problems that they present, are four in number. The first asserts the non-existence of motion on the ground that that which is in locomotion must arrive at the half-way stage before it arrives at the goal. This we have discussed above.

The second is the so-called 'Achilles', and it amounts to this, that in a race

the quickest runner can never overtake the slowest, since the pursuer must first reach the point whence the pursued started, so that the slower must always hold a lead. This argument is the same in principle as that which depends on bisection, though it differs from it in that the spaces with which we successively have to deal are not divided into halves. The result of the argument is that the slower is not overtaken: but it proceeds along the same lines as the bisection-argument (for in both a division of the space in a certain way leads to the result that the goal is not reached, though the 'Achilles' goes further in that it affirms that even the quickest runner in legendary tradition must fail in his pursuit of the slowest), so that the solution must be the same. And the axiom that that which holds a lead is never overtaken is false: it is not overtaken, it is true, while it holds a lead: but it is overtaken nevertheless if it is granted that it traverses the finite distance prescribed. These then are two of his arguments.

The third is that already given above, to the effect that the flying arrow is at rest, which result follows from the assumption that time is composed of moments: if this assumption is not granted, the conclusion will not follow.

The fourth argument is that concerning the two rows of bodies, each row being composed of an equal number of bodies of equal size, passing each other on a race-course as they proceed with equal velocity in opposite directions, the one row originally occupying the space between the goal and the middle point of the course and the other that between the middle point and the starting-post. This, he thinks, involves the conclusion that half a given time is equal to double that time. The fallacy of the reasoning lies in the assumption that a body occupies an equal time in passing with equal velocity a body that is in motion and a body of equal size that is at rest; which is false. For instance (so runs the argument), let A, A...be the stationary bodies of equal size, B, B...the bodies, equal in number and in size to A, A...,originally occupying the half of the course from the starting-post to the middle of the A's, and G, G...those originally occupying the other half from the goal to the middle of the A's, equal in number, size, and velocity to B, B....Then three consequences follow:

First, as the B's and the G's pass one another, the first B reaches the last G at the same moment as the first G reaches the last B. Secondly at this moment the first G has passed all the A's, whereas the first B has passed only half the A's, and has consequently occupied only half the time occupied by the first G, since each of the two occupies an equal time in passing each A. Thirdly, at the same moment all the B's have passed all the G's: for the first G and the first B will simultaneously reach the opposite ends of the course, since (so says Zeno) the time occupied by the first G in passing each of the B's is equal to that occupied by it in passing each of the A's, because an equal time is occupied by both the first B and the first G in passing all the A's. This is the argument,

but it presupposed the aforesaid fallacious assumption.

Nor in reference to contradictory change shall we find anything unanswerable in the argument that if a thing is changing from not-white, say, to white, and is in neither condition, then it will be neither white nor not-white: for the fact that it is not wholly in either condition will not preclude us from calling it white or not-white. We call a thing white or not-white not necessarily because it is be one or the other, but cause most of its parts or the most essential parts of it are so: not being in a certain condition is different from not being wholly in that condition. So, too, in the case of being and not-being and all other conditions which stand in a contradictory relation: while the changing thing must of necessity be in one of the two opposites, it is never wholly in either.

Again, in the case of circles and spheres and everything whose motion is confined within the space that it occupies, it is not true to say the motion can be nothing but rest, on the ground that such things in motion, themselves and their parts, will occupy the same position for a period of time, and that therefore they will be at once at rest and in motion. For in the first place the parts do not occupy the same position for any period of time: and in the second place the whole also is always changing to a different position: for if we take the orbit as described from a point A on a circumference, it will not be the same as the orbit as described from B or G or any other point on the same circumference except in an accidental sense, the sense that is to say in which a musical man is the same as a man. Thus one orbit is always changing into another, and the thing will never be at rest. And it is the same with the sphere *and everything else whose motion is confined within the space that it occupies.*

Book VI

6

Since there must always be motion without intermission, there must necessarily be something, one thing or it may be a plurality, that first imparts motion, and this first movent must be unmoved. Now the question whether each of the things that are unmoved but impart motion is eternal is irrelevant to our present argument: but the following considerations will make it clear that there must necessarily be some such thing, which, while it has the capacity of moving something else, is itself unmoved and exempt from all change, which can affect it neither in an unqualified nor in an accidental sense. Let us suppose, if any one likes, that in the case of certain things it is possible for them at different times to be and not to be, without any process of becoming and perishing (in fact it would seem to be necessary, if a thing that has not parts

at one time is and at another time is not, that any such thing should without undergoing any process of change at one time be and at another time not be). And let us further suppose it possible that some principles that are unmoved but capable of imparting motion at one time are and at another time are not. Even so, this cannot be true of all such principles, since there must clearly be something that causes things that move themselves at one time to be and at another not to be. For, since nothing that has not parts can be in motion, that which moves itself must as a whole have magnitude, though nothing that we have said makes this necessarily true of every movent. So the fact that some things become and others perish, and that this is so continuously, cannot be caused by any one of those things that, though they are unmoved, do not always exist: nor again can it be caused by any of those which move certain particular things, while others move other things. The eternity and continuity of the process cannot be caused either by any one of them singly or by the sum of them, because this causal relation must be eternal and necessary, whereas the sum of these movents is infinite and they do not all exist together. It is clear, then, that though there may be countless instances of the perishing of some principles that are unmoved but impart motion, and though many things that move themselves perish and are succeeded by others that come into being, and though one thing that is unmoved moves one thing while another moves another, nevertheless there is something that comprehends them all, and that as something apart from each one of them, and this it is that is the cause of the fact that some things are and others are not and of the continuous process of change: and this causes the motion of the other movents, while they are the causes of the motion of other things. Motion, then, being eternal, the first movent, if there is but one, will be eternal also: if there are more than one, there will be a plurality of such eternal movents. We ought, however, to suppose that there is one rather than many, and a finite rather than an infinite number. When the consequences of either assumption are the same, we should always assume that things are finite rather than infinite in number, since in things constituted by nature that which is finite and that which is better ought, if possible, to be present rather than the reverse: and here it is sufficient to assume only one movent, the first of unmoved things, which being eternal will be the principle of motion to everything else.

The following argument also makes it evident that the first movent must be something that is one and eternal. We have shown that there must always be motion. That being so, motion must also be continuous, because what is always is continuous, whereas what is merely in succession is not continuous. But further, if motion is continuous, it is one: and it is one only if the movent and the moved that constitute it are each of them one, since in the event of a thing's being moved now by one thing and now by another the whole motion will not be

continuous but successive.

Moreover a conviction that there is a first unmoved something may be reached not only from the foregoing arguments, but also by considering again the principles operative in movents. Now it is evident that among existing things there are some that are sometimes in motion and sometimes at rest. This fact has served above to make it clear that it is not true either that all things are in motion or that all things are at rest or that some things are always at rest and the remainder always in motion: on this matter proof is supplied by things that fluctuate between the two and have the capacity of being sometimes in motion and sometimes at rest. The existence of things of this kind is clear to all: but we wish to explain also the nature of each of the other two kinds and show that there are some things that are always unmoved and some things that are always in motion. In the course of our argument directed to this end we established the fact that everything that is in motion is moved by something, and that the movent is either unmoved or in motion, and that, if it is in motion, it is moved either by itself or by something else and so on throughout the series: and so we proceeded to the position that the first principle that directly causes things that are in motion to be moved is that which moves itself, and the first principle of the whole series is the unmoved. Further it is evident from actual observation that there are things that have the characteristic of moving themselves, e.g. the animal kingdom and the whole class of living things. This being so, then, the view was suggested that perhaps it may be possible for motion to come to be in a thing without having been in existence at all before, because we see this actually occurring in animals: they are unmoved at one time and then again they are in motion, as it seems. We must grasp the fact, therefore, that animals move themselves only with one kind of motion, and that this is not strictly originated by them. The cause of it is not derived from the animal itself: it is connected with other natural motions in animals, which they do not experience through their own instrumentality, e.g. increase, decrease, and respiration: these are experienced by every animal while it is at rest and not in motion in respect of the motion set up by its own agency: here the motion is caused by the atmosphere and by many things that enter into the animal: thus in some cases the cause is nourishment: when it is being digested animals sleep, and when it is being distributed through the system they awake and move themselves, the first principle of this motion being thus originally derived from outside. Therefore animals are not always in continuous motion by their own agency: it is something else that moves them, itself being in motion and changing as it comes into relation with each several thing that moves itself.

(Moreover in all these self-moving things the first movent and cause of their self-motion is itself moved by itself, though in an accidental sense: that is to say, the body changes its place, so that that which is in the body changes its

place also and is a self-movent through its exercise of leverage.) Hence we may confidently conclude that if a thing belongs to the class of unmoved movents that are also themselves moved accidentally, it is impossible that it should cause continuous motion. So the necessity that there should be motion continuously requires that there should be a first movent that is unmoved even accidentally, if, as we have said, there is to be in the world of things an unceasing and undying motion, and the world is to remain permanently self-contained and within the same limits: for if the first principle is permanent, the universe must also be permanent, since it is continuous with the first principle. (We must distinguish, however, between accidental motion of a thing by itself and such motion by something else, the former being confined to perishable things, whereas the latter belongs also to certain first principles of heavenly bodies, of all those, that is to say, that experience more than one locomotion.)

And further, if there is always something of this nature, a movent that is itself unmoved and eternal, then that which is first moved by it must be eternal. Indeed this is clear also from the consideration that there would otherwise be no becoming and perishing and no change of any kind in other things, which require something that is in motion to move them: for the motion imparted by the unmoved will always be imparted in the same way and be one and the same, since the unmoved does not itself change in relation to that which is moved by it. But that which is moved by something that, though it is in motion, is moved directly by the unmoved stands in varying relations to the things that it moves, so that the motion that it causes will not be always the same: by reason of the fact that it occupies contrary positions or assumes contrary forms at different times it will produce contrary motions in each several thing that it moves and will cause it to be at one time at rest and at another time in motion.

The foregoing argument, then, has served to clear up the point about which we raised a difficulty at the outset – why is it that instead of all things being either in motion or at rest, or some things being always in motion and the remainder always at rest, there are things that are sometimes in motion and sometimes not? The cause of this is now plain: it is because, while some things are moved by an eternal unmoved movent and are therefore always in motion, other things are moved by a movent that is in motion and changing, so that they too must change. But the unmoved movent, as has been said, since it remains permanently simple and unvarying and in the same state, will cause motion that is one and simple.

8

Let us now proceed to maintain that it is possible that there should be an infinite motion that is single and continuous, and that this motion is rotatory motion. The motion of everything that is in process of locomotion is either rotatory or rectilinear or a compound of the two: consequently, if one of the former two is not continuous, that which is composed of them both cannot be continuous either. Now it is plain that if the locomotion of a thing is rectilinear and finite it is not continuous locomotion: for the thing must turn back, and that which turns back in a straight line undergoes two contrary locomotions, since, so far as motion in respect of place is concerned, upward motion is the contrary of downward motion, forward motion of backward motion, and motion to the left of motion to the right, these being the pairs of contraries in the sphere of place. But we have already defined single and continuous motion to be motion of a single thing in a single period of time and operating within a sphere admitting of no further specific differentiation (for we have three things to consider, first that which is in motion, e.g. a man or a god, secondly the 'when' of the motion, that is to say, the time, and thirdly the sphere within which it operates, which may be either place or affection or essential form or magnitude): and contraries are specifically not one and the same but distinct: and within the sphere of place we have the above-mentioned distinctions. Moreover we have an indication that motion from A to B is the contrary of motion from B to A in the fact that, if they occur at the same time, they arrest and stop each other. And the same is true in the case of a circle: the motion from A towards B is the contrary of the motion from A towards G: for even if they are continuous and there is no turning back they arrest each other, because contraries annihilate or obstruct one another. On the other hand lateral motion is not the contrary of upward motion. But what shows most clearly that rectilinear motion cannot be continuous is the fact that turning back necessarily implies coming to a stand, not only when it is a straight line that is traversed, but also in the case of locomotion in a circle (which is not the same thing as rotatory locomotion: for, when a thing merely traverses a circle, it may either proceed on its course without a break or turn back again when it has reached the same point from which it started). We may assure ourselves of the necessity of this coming to a stand not only on the strength of observation, but also on theoretical grounds. We may start as follows: we have three points, starting-point, middle-point, and finishing-point, of which the middle-point in virtue of the relations in which it stands severally to the other two is both a starting-point and a finishing-point, and though numerically one is theoretically two. We have further the distinction between the potential and the actual. So in the straight line in question any one of the points lying between the two extremes is potentially a middle-point: but it is not actually so unless that which is in motion divides the line by coming to a stand at that point and

beginning its motion again: thus the middle-point becomes both a starting-point and a goal, the starting-point of the latter part and the finishing-point of the first part of the motion. This is the case e.g. when A in the course of its locomotion comes to a stand at B and starts again towards G: but when its motion is continuous A cannot either have come to be or have ceased to be at the point B: it can only have been there at the moment of passing, its passage not being contained within any period of time except the whole of which the particular moment is a dividing-point. To maintain that it has come to be and ceased to be there will involve the consequence that A in the course of its locomotion will always be coming to a stand: for it is impossible that A should simultaneously have come to be at B and ceased to be there, so that the two things must have happened at different points of time, and therefore there will be the intervening period of time: consequently A will be in a state of rest at B, and similarly at all other points, since the same reasoning holds good in every case. When to A, that which is in process of locomotion, B, the middle-point, serves both as a finishing-point and as a starting-point for its motion, A must come to a stand at B, because it makes it two just as one might do in thought.

However, the point A is the real starting-point at which the moving body has ceased to be, and it is at G that it has really come to be when its course is finished and it comes to a stand. So this is how we must meet the difficulty that then arises, which is as follows. Suppose the line E is equal to the line Z, that A proceeds in continuous locomotion from the extreme point of E to G, and that, at the moment when A is at the point B, D is proceeding in uniform locomotion and with the same velocity as A from the extremity of Z to H: then, says the argument, D will have reached H before A has reached G for that which makes an earlier start and departure must make an earlier arrival: the reason, then, for the late arrival of A is that it has not simultaneously come to be and ceased to be at B: otherwise it will not arrive later: for this to happen it will be necessary that it should come to a stand there. Therefore we must not hold that there was a moment when A came to be at B and that at the same moment D was in motion from the extremity of Z: for the fact of A's having come to be at B will involve the fact of its also ceasing to be there, and the two events will not be simultaneous, whereas the truth is that A is at B at a sectional point of time and does not occupy time there. In this case, therefore, where the motion of a thing is continuous, it is impossible to use this form of expression. On the other hand in the case of a thing that turns back in its course we must do so. For suppose H in the course of its locomotion proceeds to D and then turns back and proceeds downwards again: then the extreme point D has served as finishing-point and as starting-point for it, one point thus serving as two: therefore H must have come to a stand there: it cannot have come to be at D and departed from D simultaneously, for in that case it would

simultaneously be there and not be there at the same moment. And here we cannot apply the argument used to solve the difficulty stated above: we cannot argue that H is at D at a sectional point of time and has not come to be or ceased to be there. For here the goal that is reached is necessarily one that is actually, not potentially, existent. Now the point in the middle is potential: but this one is actual, and regarded from below it is a finishing-point, while regarded from above it is a starting-point, so that it stands in these same two respective relations to the two motions. Therefore that which turns back in traversing a rectilinear course must in so doing come to a stand. Consequently there cannot be a continuous rectilinear motion that is eternal.

The same method should also be adopted in replying to those who ask, in the terms of Zeno's argument, whether we admit that before any distance can be traversed half the distance must be traversed, that these half-distances are infinite in number, and that it is impossible to traverse distances infinite in number – or some on the lines of this same argument put the questions in another form, and would have us grant that in the time during which a motion is in progress it should be possible to reckon a half-motion before the whole for every half-distance that we get, so that we have the result that when the whole distance is traversed we have reckoned an infinite number, which is admittedly impossible. Now when we first discussed the question of motion we put forward a solution of this difficulty turning on the fact that the period of time occupied in traversing the distance contains within itself an infinite number of units: there is no absurdity, we said, in supposing the traversing of infinite distances in infinite time, and the element of infinity is present in the time no less than in the distance. But, although this solution is adequate as a reply to the questioner (the question asked being whether it is possible in a finite time to traverse or reckon an infinite number of units), nevertheless as an account of the fact and explanation of its true nature it is inadequate. For suppose the distance to be left out of account and the question asked to be no longer whether it is possible in a finite time to traverse an infinite number of distances, and suppose that the inquiry is made to refer to the time taken by itself (for the time contains an infinite number of divisions): then this solution will no longer be adequate, and we must apply the truth that we enunciated in our recent discussion, stating it in the following way. In the act of dividing the continuous distance into two halves one point is treated as two, since we make it a starting-point and a finishing-point: and this same result is also produced by the act of reckoning halves as well as by the act of dividing into halves. But if divisions are made in this way, neither the distance nor the motion will be continuous: for motion if it is to be continuous must relate to what is continuous: and though what is continuous contains an infinite number of halves, they are not actual but potential halves. If the halves are made actual,

we shall get not a continuous but an intermittent motion. In the case of reckoning the halves, it is clear that this result follows: for then one point must be reckoned as two: it will be the finishing-point of the one half and the starting-point of the other, if we reckon not the one continuous whole but the two halves. Therefore to the question whether it is possible to pass through an infinite number of units either of time or of distance we must reply that in a sense it is and in a sense it is not. If the units are actual, it is not possible: if they are potential, it is possible. For in the course of a continuous motion the traveller has traversed an infinite number of units in an accidental sense but not in an unqualified sense: for though it is an accidental characteristic of the distance to be an infinite number of half-distances, this is not its real and essential character. It is also plain that unless we hold that the point of time that divides earlier from later always belongs only to the later so far as the thing is concerned, we shall be involved in the consequence that the same thing is at the same moment existent and not existent, and that a thing is not existent at the moment when it has become. It is true that the point is common to both times, the earlier as well as the later, and that, while numerically one and the same, it is theoretically not so, being the finishing-point of the one and the starting-point of the other: but so far as the thing is concerned it belongs to the later stage of what happens to it. Let us suppose a time ABG and a thing D, D being white in the time A and not-white in the time B. Then D is at the moment G white and not-white: for if we were right in saying that it is white during the whole time A, it is true to call it white at any moment of A, and not-white in B, and G is in both A and B. We must not allow, therefore, that it is white in the whole of A, but must say that it is so in all of it except the last moment G. G belongs already to the later period, and if in the whole of A not-white was in process of becoming and white of perishing, at G the process is complete. And so G is the first moment at which it is true to call the thing white or not white respectively. Otherwise a thing may be non-existent at the moment when it has become and existent at the moment when it has perished: or else it must be possible for a thing at the same time to be white and not white and in fact to be existent and non-existent.

Further, if anything that exists after having been previously non-existent must become existent and does not exist when it is becoming, time cannot be divisible into time-atoms. For suppose that D was becoming white in the time A and that at another time B, a time-atom consecutive with the last atom of A, D has already become white and so is white at that moment: then, inasmuch as in the time A it was becoming white and so was not white and at the moment B it is white, there must have been a becoming between A and B and therefore also a time in which the becoming took place. On the other hand, those who deny atoms of time (as we do) are not affected by this argument: according to them D has become and so is

white at the last point of the actual time in which it was becoming white: and this point has no other point consecutive with or in succession to it, whereas time-atoms are conceived as successive. Moreover it is clear that if D was becoming white in the whole time A, the time occupied by it in having become white in addition to having been in process of becoming white is no more than all that it occupied in the mere process of becoming white.

These and such-like, then, are the arguments for our conclusion that derive cogency from the fact that they have a special bearing on the point at issue. If we look at the question from the point of view of general theory, the same result would also appear to be indicated by the following arguments. Everything whose motion is continuous must, on arriving at any point in the course of its locomotion, have been previously also in process of locomotion to that point, if it is not forced out of its path by anything: e.g. on arriving at B a thing must also have been in process of locomotion to B, and that not merely when it was near to B, but from the moment of its starting on its course, since there can be, no reason for its being so at any particular stage rather than at an earlier one. So, too, in the case of the other kinds of motion. Now we are to suppose that a thing proceeds in locomotion from A to G and that at the moment of its arrival at G the continuity of its motion is unbroken and will remain so until it has arrived back at A. Then when it is undergoing locomotion from A to G it is at the same time undergoing also its locomotion to A from G: consequently it is simultaneously undergoing two contrary motions, since the two motions that follow the same straight line are contrary to each other. With this consequence there also follows another: we have a thing that is in process of change from a position in which it has not yet been: so, inasmuch as this is impossible, the thing must come to a stand at G. Therefore the motion is not a single motion, since motion that is interrupted by stationariness is not single.

Further, the following argument will serve better to make this point clear universally in respect of every kind of motion. If the motion undergone by that which is in motion is always one of those already enumerated, and the state of rest that it undergoes is one of those that are the opposites of the motions (for we found that there could be no other besides these), and moreover that which is undergoing but does not always undergo a particular motion (by this I mean one of the various specifically distinct motions, not some particular part of the whole motion) must have been previously undergoing the state of rest that is the opposite of the motion, the state of rest being privation of motion; then, inasmuch as the two motions that follow the same straight line are contrary motions, and it is impossible for a thing to undergo simultaneously two contrary motions, that which is undergoing locomotion from A to G cannot also simultaneously be undergoing locomotion from G to A: and since the latter locomotion is not simultaneous with the former but is still to be undergone,

before it is undergone there must occur a state of rest at G: for this, as we found, is the state of rest that is the opposite of the motion from G. The foregoing argument, then, makes it plain that the motion in question is not continuous.

Our next argument has a more special bearing than the foregoing on the point at issue. We will suppose that there has occurred in something simultaneously a perishing of not-white and a becoming of white. Then if the alteration to white and from white is a continuous process and the white does not remain any time, there must have occurred simultaneously a perishing of not-white, a becoming of white, and a becoming of not-white: for the time of the three will be the same.

Again, from the continuity of the time in which the motion takes place we cannot infer continuity in the motion, but only successiveness: in fact, how could contraries, e.g. whiteness and blackness, meet in the same extreme point?

On the other hand, in motion on a circular line we shall find singleness and continuity: for here we are met by no impossible consequence: that which is in motion from A will in virtue of the same direction of energy be simultaneously in motion to A (since it is in motion to the point at which it will finally arrive), and yet will not be undergoing two contrary or opposite motions: for a motion to a point and a motion from that point are not always contraries or opposites: they are contraries only if they are on the same straight line (for then they are contrary to one another in respect of place, as e.g. the two motions along the diameter of the circle, since the ends of this are at the greatest possible distance from one another), and they are opposites only if they are along the same line. Therefore in the case we are now considering there is nothing to prevent the motion being continuous and free from all intermission: for rotatory motion is motion of a thing from its place to its place, whereas rectilinear motion is motion from its place to another place.

Moreover the progress of rotatory motion is never localized within certain fixed limits, whereas that of rectilinear motion repeatedly is so. Now a motion that is always shifting its ground from moment to moment can be continuous: but a motion that is repeatedly localized within certain fixed limits cannot be so, since then the same thing would have to undergo simultaneously two opposite motions. So, too, there cannot be continuous motion in a semicircle or in any other arc of a circle, since here also the same ground must be traversed repeatedly and two contrary processes of change must occur. The reason is that in these motions the starting-point and the termination do not coincide, whereas in motion over a circle they do coincide, and so this is the only perfect motion.

This differentiation also provides another means of showing that the other kinds of motion cannot be continuous either: for in all of them we find that there is the same ground to be traversed repeatedly; thus in alteration there are the

intermediate stages of the process, and in quantitative change there are the intervening degrees of magnitude: and in becoming and perishing the same thing is true. It makes no difference whether we take the intermediate stages of the process to be few or many, or whether we add or subtract one: for in either case we find that there is still the same ground to be traversed repeatedly. Moreover it is plain from what has been said that those physicists who assert that all sensible things are always in motion are wrong: for their motion must be one or other of the motions just mentioned: in fact they mostly conceive it as alteration (things are always in flux and decay, they say), and they go so far as to speak even of becoming and perishing as a process of alteration. On the other hand, our argument has enabled us to assert the fact, applying universally to all motions, that no motion admits of continuity except rotatory motion: consequently neither alteration nor increase admits of continuity. We need now say no more in support of the position that there is no process of change that admits of infinity or continuity except rotatory locomotion.