PART TWO

The Principles of Material Things

1. *The arguments that lead to the certain knowledge of the existence of material things.*

Everyone is quite convinced of the existence of material things. But earlier on we cast doubt on this belief and counted it as one of the preconceived opinions of our childhood.[1] So it is necessary for us to investigate next the arguments by which the existence of material things may be known with certainty. Now, all our sensations undoubtedly come to us from something that is distinct from our mind. For it is not in our power to make ourselves have one sensation rather than another; this is obviously dependent on the thing that is acting on our senses. Admittedly one can raise the question of whether this thing is God or something different from God. But we have sensory awareness of, or rather as a result of sensory stimulation we have a clear and distinct perception of, some kind of matter, which is extended in length, breadth and depth, and has various differently shaped and variously moving parts which give rise to our various sensations of colours, smells, pain and so on. And if God were himself immediately producing in our mind the idea of such extended matter, or even if he were causing the idea to be produced by something which lacked extension, shape and motion, there would be no way of avoiding the conclusion that he should be regarded as a deceiver. For we have a clear understanding of this matter as something that is quite different from God and from ourselves or our mind; and we appear to see clearly that the idea of it comes to us from things located outside ourselves, which it wholly resembles. And we have already noted that it is quite inconsistent with the nature of God that he should be a deceiver.[2] The unavoidable conclusion, then, is that there exists something extended in length, breadth and depth and possessing all the properties which we clearly perceive to belong to an extended thing. And it is this extended thing that we call 'body' or 'matter'.

2. *The basis for our knowledge that the human body is closely conjoined with the mind.*

By the same token, the conclusion that there is a particular body that is more closely conjoined with our mind than any other body follows from our clear awareness that pain and other sensations come to us quite unexpectedly. The mind is aware that these sensations do not come from itself alone, and that they cannot belong to it simply in virtue of its being a thinking thing; instead, they can belong to it only in virtue of its being joined to something other than itself which is extended and moveable—namely what we call the human body. But this is not the place for a detailed explanation of its nature.

3. *Sensory perception does not show us what really exists in things, but merely shows us what is beneficial or harmful to man's composite nature.*

It will be enough, for the present, to note that sensory perceptions are related exclusively to this combination of the human body and mind. They normally tell us of the benefit or harm that external bodies may do to this combination, and do not, except occasionally and accidentally, show us what external bodies are like in themselves. If we bear this in mind we will easily lay aside the preconceived opinions acquired from the senses, and in this connection make use of the intellect alone, carefully attending to the ideas implanted in it by nature.

4. *The nature of body consists not in weight, hardness, colour, or the like, but simply in extension.*

If we do this, we shall perceive that the nature of matter, or body considered in general, consists not in its being something which is hard or heavy or coloured, or which affects the senses in any way, but simply in its being something which is extended in length, breadth and depth. For as regards hardness, our sensation tells us no more than that the parts of a hard body resist the motion of our hands when they come into contact with them. If, whenever our hands moved in a given direction, all the bodies in that area were to move away at the same speed as that of our approaching hands, we should never have any sensation of hardness. And since it is quite unintelligible to suppose that, if bodies did move away in this fashion, they would thereby lose their bodily nature, it follows that this nature cannot consist in hardness. By the same reasoning it can be shown that weight, colour, and all other such qualities that are perceived by the senses as being in corporeal matter, can be removed from it, while the matter itself remains intact; it thus follows that its nature does not depend on any of these qualities.

5. *This truth about the nature of body is obscured by preconceived opinions concerning rarefaction and empty space.*

But there are still two possible reasons for doubting that the true nature of body consists solely in extension. The first is the widespread belief that many bodies can be rarefied and condensed in such a way that when rarefied they possess more extension than when condensed. Indeed, the subtlety of some people goes so far that they distinguish the substance of a body from its quantity, and even its quantity from its extension.[3] The second reason is that if we understand there to be nothing in a given place but extension in length, breadth and depth, we generally say not that there is a body there, but simply that there is a space, or even an empty space; and almost everyone is convinced that this amounts to nothing at all.

6. *How rarefaction occurs.*

But with regard to rarefaction and condensation, anyone who attends to his own thoughts, and is willing to admit only what he clearly perceives, will not suppose that anything happens in these processes beyond a change of shape. Rarefied bodies, that is to say, are those which have many gaps between their parts—gaps which are occupied by other bodies; and they become denser simply in virtue of the parts coming together and reducing or completely closing the gaps. In this last eventuality a body becomes so dense that it would be a contradiction to suppose that it could be made any denser. Now in this condition, the extension of a body is no less than when it occupies more space in virtue of the mutual separation of its parts; for whatever extension is comprised in the pores or gaps left between the parts must be attributed not to the body itself but to the various other bodies which fill the gaps. In just the same way, when we see a sponge filled with water or

[1] See Part 1, art. 4.

[2] Above, Part 1, art. 29.

[3] Cf. *The World*, above p. 92.

some other liquid, we do not suppose that in terms of its own individual parts it has a greater extension than when it is squeezed dry; we simply suppose that its pores are open wider, so that it spreads over a greater space.

7. *This is the only intelligible way of explaining rarefaction.*

I really do not see what has prompted others to say that rarefaction occurs through an increase of quantity, in preference to explaining it by means of this example of the sponge.[4] It is true that when air or water is rarefied, we do not see any pores being made larger, or any new body coming to fill them up. But to invent something unintelligible so as to provide a purely verbal explanation of rarefaction is surely less rational than inferring the existence of pores or gaps which are made larger, and supposing that some new body comes and fills them. Admittedly, we do not perceive this new body with any of our senses; but there is no compelling reason to believe that all the bodies which exist must affect our senses. Moreover, it is very easy for us to see how rarefaction can occur in this way, but we cannot see how it could occur in any other way. Finally, it is a complete contradiction to suppose that something should be augmented by new quantity or new extension without new extended substance, i.e. a new body, being added to it at the same time. For any addition of extension or quantity is unintelligible without the addition of substance which has quantity and extension. This will become clearer from what follows.

8. *The distinction between quantity or number and the thing that has quantity or number is merely a conceptual distinction.*

There is no real difference between quantity and the extended substance; the difference is merely a conceptual one, like that between number and the thing which is numbered. We can, for example, consider the entire nature of the corporeal substance which occupies a space of ten feet without attending to the specific measurement; for we understand this nature to be exactly the same in any part of the space as in the whole space. And, conversely, we can think of the number ten, or the continuous quantity ten feet, without attending to this determinate substance. For the concept of the number ten is exactly the same irrespective of whether it is referred to this measurement of ten feet or to anything else; and as for the continuous quantity ten feet, although this is unintelligible without some extended substance of which it is the quantity, it can be understood apart from this determinate substance. In reality, however, it is impossible to take even the smallest fraction from the quantity or extension without also removing just as much from the substance; and conversely, it is impossible to remove the smallest amount from the substance without taking away just as much from the quantity or extension.

9. *If corporeal substance is distinguished from its quantity, it is conceived in a confused manner as something incorporeal.*

Others may disagree, but I do not think they have any alternative perception of the matter. When they make a distinction between substance and extension or quantity, either they do not understand anything by the term 'substance', or else they simply have a confused idea of incorporeal substance, which they falsely attach to corporeal substance; and they relegate the true idea of corporeal substance to the category of extension, which, however, they term an accident. There is thus no correspondence between their verbal expressions and what they grasp in their minds.

10. *What is meant by 'space', or 'internal place'.*

There is no real distinction between space, or internal place,[5] and the corporeal substance contained in it; the only difference lies in the way in which we are accustomed to conceive of them. For in reality the extension in length, breadth and depth which constitutes a space is exactly the same as that which constitutes a body. The difference arises as follows: in the case of a body, we regard the extension as something particular, and thus think of it as changing whenever there is a new body; but in the case of a space, we attribute to the extension only a generic unity, so that when a new body comes to occupy the space, the extension of the space is reckoned not to change but to remain one and the same, so long as it retains the same size and shape and keeps the same position relative to certain external bodies which we use to determine the space in question.

11. *There is no real difference between space and corporeal substance.*

It is easy for us to recognize that the extension constituting the nature of a body is exactly the same as that constituting the nature of a space. There is no more difference between them than there is between the nature of a genus or species and the nature of an individual. Suppose we attend to the idea we have of some body, for example a stone, and leave out everything we know to be non-essential to the nature of body: we will first of all exclude hardness, since if the stone is melted or pulverized it will lose its hardness without thereby ceasing to be a body; next we will exclude colour, since we have often seen stones so transparent as to lack colour; next we will exclude heaviness, since although fire is extremely light it is still thought of as being corporeal; and finally we will exclude cold and heat and all other such qualities, either because they are not thought of as being in the stone, or because if they change, the stone is not on that account reckoned to have lost its bodily nature. After all this, we will see that nothing remains in the idea of the stone except that it is something extended in length, breadth and depth. Yet this is just what is comprised in the idea of a space—not merely a space which is full of bodies, but even a space which is called 'empty'.[6]

12. *The difference between space and corporeal substance lies in our way of conceiving them.*

There is, however, a difference in the way in which we conceive of space and corporeal substance. For if a stone is removed from the space or place where it is, we think that its extension has also been removed from that place, since we regard the extension as something particular and inseparable from the stone. But at the same

[4] Scholastic philosophers explained rarefaction in terms of a given amount of matter occupying a larger quantity or volume of space: for Descartes, however, this is unintelligible, since there is no real distinction between the notions of 'quantity', 'matter' and 'space'. See below, art. 8–12.

[5] The scholastics distinguished between *locus internus*, or 'internal place' (the space occupied by a body), and *locus externus*, or 'external space' (the external surface containing a body) Descartes employs the traditional terminology here and at art. 13 below, but puts it to his own use.

[6] Lat. *vacuum*. See below, art. 16.

time we think that the extension of the place where the stone used to be remains, and is the same as before, although the place is now occupied by wood or water or air or some other body, or is even supposed to be empty. For we are now considering extension as something general, which is thought of as being the same, whether it is the extension of a stone or of wood, or of water or of air or of any other body—or even of a vacuum, if there is such a thing—provided only that it has the same size and shape, and keeps the same position relative to the external bodies that determine the space in question.

13. *What is meant by 'external place'.*

The terms 'place' and 'space', then, do not signify anything different from the body which is said to be in a place; they merely refer to its size, shape and position relative to other bodies. To determine the position, we have to look at various other bodies which we regard as immobile; and in relation to different bodies we may say that the same thing is both changing and not changing its place at the same time. For example, when a ship is under way, a man sitting on the stern remains in one place relative to the other parts of the ship with respect to which his position is unchanged; but he is constantly changing his place relative to the neighbouring shores, since he is constantly receding from one shore and approaching another. Then again, if we believe the earth moves,[7] and suppose that it advances the same distance from west to east as the ship travels from east to west in the corresponding period of time, we shall again say that the man sitting on the stern is not changing his place; for we are now determining the place by means of certain fixed points in the heavens. Finally, if we suppose that there are no such genuinely fixed points to be found in the universe (a supposition which will be shown below to be probable[8]) we shall conclude that nothing has a permanent place, except as determined by our thought.

14. *The difference between place and space.*

The difference between the terms 'place' and 'space' is that the former designates more explicitly the position, as opposed to the size or shape, while it is the size and shape that we are concentrating on when we talk of space. For we often say that one thing leaves a given place and another thing arrives there, even though the second thing is not strictly of the same size and shape; but in this case we do not say it occupies the same space. By contrast, when something alters its position, we always say the place is changed, despite the fact that the size and shape remain unaltered. When we say that a thing is in a given place, all we mean is that it occupies such and such a position relative to other things; but when we go on to say that it fills up a given space or place, we mean in addition that it has precisely the size and shape of the space in question.

15. *How external place is rightly taken to be the surface of the surrounding body.*

Thus we always take a space to be an extension in length, breadth and depth. But with regard to place, we sometimes consider it as internal to the thing which is in the place in question, and sometimes as external to it. Now internal place is exactly the same as space; but external place may be taken as being the surface immediately surrounding what is in the place. It should be noted that 'surface' here does not mean any part of the surrounding body but merely the boundary between the surrounding and surrounded bodies, which is no more than a mode. Or rather what is meant is simply the common surface, which is not a part of one body rather than the other but is always reckoned to be the same, provided it keeps the same size and shape. For if there are two bodies, one surrounding the other, and the entire surrounding body changes, surface and all, the surrounded body is not therefore thought of as changing its place, provided that during this time it keeps the same position relative to the external bodies which are regarded as immobile. If, for example, we suppose that a ship on a river is being pulled equally in one direction by the current and in the opposite direction by the wind, so that it does not change its position relative to the banks, we will all readily admit that it stays in the same place, despite the complete change in the surrounding surface.

16. *It is a contradiction to suppose there is such a thing as a vacuum, i.e. that in which there is nothing whatsoever.*

The impossibility of a vacuum, in the philosophical sense of that in which there is no substance whatsoever, is clear from the fact that there is no difference between the extension of a space, or internal place, and the extension of a body. For a body's being extended in length, breadth and depth in itself warrants the conclusion that it is a substance, since it is a complete contradiction that a particular extension should belong to nothing; and the same conclusion must be drawn with respect to a space that is supposed to be a vacuum, namely that since there is extension in it, there must necessarily be substance in it as well.

17. *The ordinary use of the term 'empty' does not imply the total absence of bodies.*

In its ordinary use the term 'empty'[9] usually refers not to a place or space in which there is absolutely nothing at all, but simply to a place in which there is none of the things that we think ought to be there. Thus a pitcher made to hold water is called 'empty' when it is simply full of air; a fishpond is called 'empty', despite all the water in it, if it contains no fish; and a merchant ship is called 'empty' if it is loaded only with sand ballast. And similarly a space is called 'empty' if it contains nothing perceivable by the senses, despite the fact that it is full of created, self-subsistent matter; for normally the only things we give any thought to are those which are detected by our senses. But if we subsequently fail to keep in mind what ought to be understood by the terms 'empty' and 'nothing', we may suppose that a space we call empty contains not just nothing perceivable by the senses but nothing whatsoever; that would be just as mistaken as thinking that the air in a jug is not a subsistent thing on the grounds that a jug is usually said to be empty when it contains nothing but air.

18. *How to correct our preconceived opinion regarding an absolute vacuum.*

Almost all of us fell into this error in our early childhood. Seeing no necessary connection between a vessel and the body contained in it, we reckoned there was nothing to stop God, at least, removing the body which filled the vessel, and preventing any other body from taking its place. But to correct this error we should

[7] '. . . turns on its axis' (French version).

[8] The French version has 'demonstrable' instead of 'probable'. Cf. Part 3, art. 29, p. 252 below.

[9] Lat. *vacuum*, from *vacuus*, 'void', 'unoccupied'; cf. art. 18.

consider that, although there is no connection between a vessel and this or that particular body contained in it, there is a very strong and wholly necessary connection between the concave shape of the vessel and the extension, taken in its general sense, which must be contained in the concave shape. Indeed, it is no less contradictory for us to conceive of a mountain without a valley than it is for us to think of the concavity apart from the extension contained within it, or the extension apart from the substance which is extended; for, as I have often said, nothingness cannot possess any extension. Hence, if someone asks what would happen if God were to take away every single body contained in a vessel, without allowing any other body to take the place of what had been removed, the answer must be that the sides of the vessel would, in that case, have to be in contact. For when there is nothing between two bodies they must necessarily touch each other. And it is a manifest contradiction for them to be apart, or to have a distance between them, when the distance in question is nothing; for every distance is a mode of extension, and therefore cannot exist without an extended substance.

19. *The preceding conclusion confirms what we said regarding rarefaction.*

We have thus seen that the nature of corporeal substance consists simply in its being something extended; and its extension is no different from what is normally attributed to space, however 'empty'. From this we readily see that no one part of it can possibly occupy more space at one time than at another, and hence that rarefaction cannot occur except in the way explained earlier on.[10] Similarly, there cannot be more matter or corporeal substance in a vessel filled with lead or gold or any other body, no matter how heavy and hard, than there is when it contains only air and is thought of as empty. This is because the quantity of the parts of matter does not depend on their heaviness or hardness, but solely on their extension, which is always the same for a given vessel.

20. *The foregoing results also demonstrate the impossibility of atoms.*

We also know that it is impossible that there should exist atoms, that is, pieces of matter that are by their very nature indivisible <as some philosophers have imagined>. For if there were any atoms, then no matter how small we imagined them to be, they would necessarily have to be extended; and hence we could in our thought divide each of them into two or more smaller parts, and hence recognize their divisibility. For anything we can divide in our thought must, for that very reason, be known to be divisible; so if we were to judge it to be indivisible, our judgement would conflict with our knowledge. Even if we imagine that God has chosen to bring it about that some particle of matter is incapable of being divided into smaller particles, it will still not be correct, strictly speaking, to call this particle indivisible. For, by making it indivisible by any of his creatures, God certainly could not thereby take away his own power of dividing it, since it is quite impossible for him to diminish his own power, as has been noted above.[11] Hence, strictly speaking, the particle will remain divisible, since it is divisible by its very nature.

[10] See above, art. 6, p. 225.

[11] Cf. Part 1, art. 60, above p. 213.

21. *Similarly, the extension of the world is indefinite.*

What is more we recognize that this world, that is, the whole universe of corporeal substance, has no limits to its extension. For no matter where we imagine the boundaries to be, there are always some indefinitely extended spaces beyond them, which we not only imagine but also perceive to be imaginable in a true fashion, that is, real. And it follows that these spaces contain corporeal substance which is indefinitely extended. For, as has already been shown very fully, the idea of the extension which we conceive to be in a given space is exactly the same as the idea of corporeal substance.

22. *Similarly, the earth and the heavens are composed of one and the same matter; and there cannot be a plurality of worlds.*

It can also easily be gathered from this that celestial matter is no different from terrestrial matter.[12] And even if there were an infinite number of worlds, the matter of which they were composed would have to be identical; hence, there cannot in fact be a plurality of worlds, but only one. For we very clearly understand that the matter whose nature consists simply in its being an extended substance already occupies absolutely all the imaginable space in which the alleged additional worlds would have to be located; and we cannot find within us an idea of any other sort of matter.

23. *All the variety in matter, all the diversity of its forms, depends on motion.*

The matter existing in the entire universe is thus one and the same, and it is always recognized as matter simply in virtue of its being extended. All the properties which we clearly perceive in it are reducible to its divisibility and consequent mobility in respect of its parts, and its resulting capacity to be affected in all the ways which we perceive as being derivable from the movement of the parts. If the division into parts occurs simply in our thought, there is no resulting change; any variation in matter or diversity in its many forms depends on motion. This seems to have been widely recognized by the philosophers, since they have stated that nature is the principle of motion and rest. And what they meant by 'nature' in this context is what causes all corporeal things to take on the characteristics of which we are aware in experience.

24. *What is meant by 'motion' in the ordinary sense of the term.*

Motion, in the ordinary sense of the term, is simply the action by which a body travels from one place to another. By 'motion', I mean local motion; for my thought encompasses no other kind, and hence I do not think that any other kind should be imagined to exist in nature.[13] Now I pointed out above that the same thing can be said to be changing and not changing its place at the same time;[14] and similarly the same thing can be said to be moving and not moving. For example, a man sitting on board a ship which is leaving port considers himself to be moving relative to the shore which he regards as fixed; but he does not think of himself as moving relative to the ship, since his position is unchanged relative to its parts.

[12] Descartes here rejects the scholastic doctrine of a radical difference in kind between 'sublunary' or terrestrial phenomena and the incorruptible world of the heavens.

[13] See note to Part 1, art. 69, p. 217.

[14] Above, art. 13, p. 228.

Indeed, since we commonly think all motion involves action, while rest consists in the cessation of action, the man sitting on deck is more properly said to be at rest than in motion, since he does not have any sensory awareness of action in himself.

25. *What is meant by 'motion' in the strict sense of the term.*

If, on the other hand, we consider what should be understood by motion, not in common usage but in accordance with the truth of the matter, and if our aim is to assign a determinate nature to it, we may say that motion is the transfer of one piece of matter, or one body, from the vicinity of the other bodies which are in immediate contact with it, and which are regarded as being at rest, to the vicinity of other bodies. By 'one body' or 'one piece of matter' I mean whatever is transferred at a given time, even though this may in fact consist of many parts which have different motions relative to each other. And I say 'the transfer' as opposed to the force or action which brings about the transfer, to show that motion is always in the moving body as opposed to the body which brings about the movement. The two are not normally distinguished with sufficient care; and I want to make it clear that the motion of something that moves is, like the lack of motion in a thing which is at rest, a mere mode of that thing and not itself a subsistent thing, just as shape is a mere mode of the thing which has shape.

26. *No more action is required for motion than for rest.*

It should be noted that in this connection we are in the grip of a strong preconceived opinion, namely the belief that more action is needed for motion than for rest. We have been convinced of this since early childhood owing to the fact that our bodies move by our will, of which we have inner awareness, but remain at rest simply in virtue of sticking to the earth by gravity,[15] the force of which we do not perceive through the senses. And because gravity and many other causes of which we are unaware produce resistance when we try to move our limbs, and make us tired, we think that a greater action or force is needed to initiate a motion than to stop it; for we take action to be the effort we expend in moving our limbs and moving other bodies by the use of our limbs. We will easily get rid of this preconceived opinion if we consider that it takes an effort on our part not only to move external bodies, but also, quite often, to stop them, when gravity and other causes are insufficient to arrest their movement. For example, the action needed to move a boat which is at rest in still water is no greater than that needed to stop it suddenly when it is moving—or rather it is not much greater, for one must subtract the weight of the water displaced by the ship and the viscosity of the water, both of which could gradually bring it to a halt.

27. *Motion and rest are merely various modes of a body in motion.*

We are dealing here not with the action which is understood to exist in the body which produces or arrests the motion, but simply with the transfer of a body, and with the absence of a transfer, i.e. rest. So it is clear that this transfer cannot exist outside the body which is in motion, and that when there is a transfer of motion, the body is in a different state from when there is no transfer, i.e. when it is at rest. Thus motion and rest are nothing else but two different modes of a body.

28. *Motion in the strict sense is to be referred solely to the bodies which are contiguous with the body in motion.*

In my definition I specified that the transfer occurs from the vicinity of contiguous bodies to the vicinity of other bodies; I did not say that there was a transfer from one place to another. This is because, as explained above,[16] the term 'place' has various meanings, depending on how we think of it; but when we understand motion as a transfer occurring from the vicinity of contiguous bodies, then, given that only one set of bodies can be contiguous with the same moving body at any one time, we cannot assign several simultaneous motions to this body, but only one.

29. *And it is to be referred only to those contiguous bodies which are regarded as being at rest.*

I further specified that the transfer occurs from the vicinity not of any contiguous bodies but from the vicinity of those which 'are regarded as being at rest'. For transfer is in itself a reciprocal process: we cannot understand that a body AB is transferred from the vicinity of a body CD without simultaneously understanding that CD is transferred from the vicinity of AB. Exactly the same force and action is needed on both sides. So if we wished to characterize motion strictly in terms of its own nature, without reference to anything else, then in the case of two contiguous bodies being transferred in opposite directions, and thus separated, we should say that there was just as much motion in the one body as in the other. But this would clash too much with our ordinary way of speaking. For we are used to standing on the earth and regarding it as at rest; so although we may see some of its parts, which are contiguous with other smaller bodies, being transferred out of their vicinity, we do not for that reason think of the earth itself as in motion.

30. *Why, if there are two contiguous bodies which are separated from each other, motion is attributed to one of them rather than the other.*

The principal reason for this is that motion is understood to belong to the whole body in motion. Now it cannot be understood to belong to the whole earth, in virtue of the transfer of some of its parts from the vicinity of smaller contiguous bodies; for often we may observe several such transfers occurring on the earth in opposite directions. Let the body EFGH be the earth [see Fig. 1], and suppose that

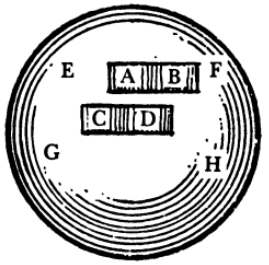

Fig. 1

[15] Lat. *gravitas*, literally 'heaviness'. In scholastic physics this term was used to refer to the supposed inherent tendency of terrestrial bodies to downward motion. For Descartes' own use of the term, and his purely mechanistic explanation of heaviness, see below Part 4, art. 20–3. It should be remembered that neither for the scholastics nor for Descartes did the term 'gravity' have its modern (post-Newtonian) connotation of a universal attractive force.

[16] See above, Part 2, art. 10, p. 227.

on its surface the body AB is transferred from E towards F, and simultaneously the body CD is transferred from H to G. Now this very fact means that the parts of the earth contiguous with AB are transferred from B towards A; and to produce this transfer, the action in these parts must be just as great as that in the body AB, and must be of an identical nature. But for all that, we do not understand the earth to be in motion from B towards A, or from east to west;[17] for, if so, the fact that those of its parts which are contiguous with the body CD are being transferred from C to D would, by the same reasoning, require us to understand the earth to be moving in the other direction, from west to east—which contradicts the former supposition. Hence, to avoid too great a departure from the ordinary way of speaking, we shall say in this case not that the earth moves, but merely that the bodies AB and CD move; and similarly in other cases. But meanwhile we will remember that whatever is real and positive in moving bodies—that in virtue of which they are said to move—is also to be found in the other bodies which are contiguous with them, even though these are regarded merely as being at rest.

31. *How there may be countless different motions in the same body.*

Each body has only one proper motion, since it is understood to be moving away from only one set of bodies, which are contiguous with it and at rest. But it can also share in countless other motions, namely in cases where it is a part of other bodies which have other motions. For example, if someone walking on board ship has a watch in his pocket, the wheels of the watch have only one proper motion, but they also share in another motion because they are in contact with the man who is taking his walk, and they and he form a single piece of matter. They also share in an additional motion through being in contact with the ship tossing on the waves; they share in a further motion through contact with the sea itself; and lastly, they share in yet another motion through contact with the whole earth, if indeed the whole earth is in motion. Now all the motions will really exist in the wheels of the watch, but it is not easy to have an understanding of so many motions all at once, nor can we have knowledge of all of them. So it is enough to confine our attention to that single motion which is the proper motion of each body.

32. *How even the proper motion unique to each body may be considered as a plurality of motions.*

The single motion that is the proper motion of each body may also be considered as if it were made up of several motions. For example, we may distinguish two different motions in a carriage wheel—a circular motion about the axle and a rectilinear motion along the line of the road. But that these are not really distinct is clear from the fact that every single point on the moving object describes only one line. It does not matter that the line is often very twisted so that it seems to have been produced by many different motions; for we can imagine any line at all—even a straight line, which is the simplest of all—as arising from an infinite number of different motions. Thus if the line AB travels towards CD [see Fig. 2], and at the same time the point A travels towards B, the straight line AD described by the point A will depend on two rectilinear motions, from A to B and from AB to CD, in just the same way as the curve described by any point of the wheel depends on a rectilinear motion and a circular motion. Although it is often useful to separate a single motion into several components in this way in order to facilitate our perception of it, nevertheless, absolutely speaking, there is only one motion that should be counted for any given body.

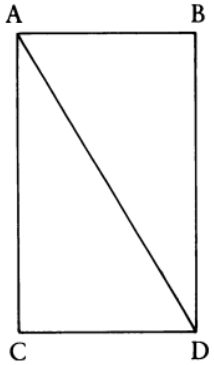

Fig. 2

33. *How in every case of motion there is a complete circle of bodies moving together.*

I noted above[18] that every place is full of bodies, and that the same portion of matter always takes up the same amount of space, <so that it is impossible for it to fill a greater or lesser space, or for any other body to occupy its place while it remains there>. It follows from this that each body can move only in a <complete> circle <of matter, or ring of bodies which all move together at the same time>: a body entering a given place expels another, and the expelled body moves on and expels another, and so on, until the body at the end of the sequence enters the place left by the first body at the precise moment when the first body is leaving it. We can easily understand this in the case of a perfect circle, since we see that no vacuum and no rarefaction or condensation is needed to enable part A of the circle [see Fig. 3] to move towards B, provided that B simultaneously moves towards C, C towards D and D towards A. But the same thing is intelligible even in the case of

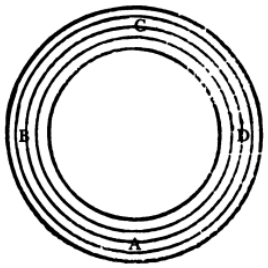

Fig. 3

an imperfect circle however irregular it may be, provided we notice how all the variations in the spaces can be compensated for by variations in speed. Thus all the

[17] The original texts (both Latin and French) have the terms 'east' and 'west' transposed throughout this article. The corrections adopted here and three lines lower down seem necessary to make sense of the diagram.

[18] Art. 18 and 19, pp. 230f.

matter contained in the space EFGH [see Fig. 4] can move in a circle without the need for any condensation or vacuum, and the part that is around E can move towards G while the part that is around G simultaneously moves towards E, with this sole proviso: if the space in G is supposed to be four times as wide as the space at E and twice as wide as the space at F and H, then the speed of the motion at E must be four times greater than that at G and twice as great as that at for H; and at every other location an increase in speed must similarly compensate for a narrower space. In this way, the amount of matter passing through any given part of the circle in any given time will always be equal.

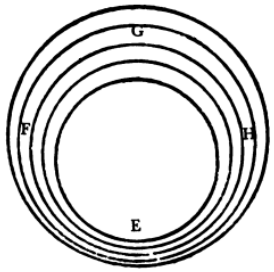

Fig. 4

34. *From this it follows that the number of particles into which matter is divided is in fact indefinite, although it is beyond our power to grasp them all.*

It must, however, be admitted that in the case of this motion we come upon something the truth of which our mind perceives, while at the same time being unable to grasp exactly how it occurs. For what happens is an infinite, or indefinite,[19] division of the various particles of matter; and the resulting subdivisions are so numerous that however small we make a particle in our thought, we always understand that it is in fact divided into other still smaller particles. For it is impossible for the matter which now fills space G successively to fill all the spaces between G and E, which get gradually smaller by countless stages, unless some part of that matter adjusts its shape to the innumerable different volumes of those spaces. And for this to come about, it is necessary that all its imaginable particles, which are in fact innumerable, should shift their relative positions to some tiny extent. This minute shifting of position is a true case of division.

35. *How this division comes about; and the fact that it undoubtedly takes place, even though it is beyond our grasp.*

It should be noted, however, that I am not here speaking of the whole of this matter, but merely of some part of it. We may suppose that two or three of its parts at G are as wide as the space at E, and that there are also several smaller parts which remain undivided; but nevertheless we can still understand them to move in a circle towards E, provided they have mixed up with them various other particles which somehow bend and change shape in such a way as to join onto them. Now the former group do not change their own shape, but merely adapt their speed depending on the place they are to occupy, while the latter group exactly fill all the crevices which the former do not occupy. We cannot grasp in our thought how this indefinite division comes about, but we should not therefore doubt that it occurs. For we clearly perceive that it necessarily follows from what we <already> know most evidently of the nature of matter, and we perceive that it belongs to the class of things which are beyond the grasp of our finite minds.

36. *God is the primary cause of motion; and he always preserves the same quantity of motion in the universe.*

After this consideration of the nature of motion, we must look at its cause. This is in fact twofold: first, there is the universal and primary cause—the general cause of all the motions in the world; and second there is the particular cause which produces in an individual piece of matter some motion which it previously lacked. Now as far as the general cause is concerned, it seems clear to me that this is no other than God himself. In the beginning <in his omnipotence> he created matter, along with its motion and rest; and now, merely by his regular concurrence, he preserves the same amount of motion and rest in the material universe as he put there in the beginning. Admittedly motion is simply a mode of the matter which is moved. But nevertheless it has a certain determinate quantity; and this, we easily understand, may be constant in the universe as a whole while varying in any given part. Thus if one part of matter moves twice as fast as another which is twice as large, we must consider that there is the same quantity of motion in each part; and if one part slows down, we must suppose that some other part of equal size speeds up by the same amount. For we understand that God's perfection involves not only his being immutable in himself, but also his operating in a manner that is always utterly constant and immutable. Now there are some changes whose occurrence is guaranteed either by our own plain experience or by divine revelation, and either our perception or our faith shows us that these take place without any change in the creator; but apart from these we should not suppose that any other changes occur in God's works, in case this suggests some inconstancy in God. Thus, God imparted various motions to the parts of matter when he first created them, and he now preserves all this matter in the same way, and by the same process by which he originally created it;[20] and it follows from what we have said that this fact alone makes it most reasonable to think that God likewise always preserves the same quantity of motion in matter.

[. . .]

64. *The only principles which I accept, or require, in physics are those of geometry and pure mathematics; these principles explain all natural phenomena, and enable us to provide quite certain demonstrations regarding them.*

I will not here add anything about shapes or about the countless different kinds of motions that can be derived from the infinite variety of different shapes. These matters will be quite clear in themselves when the time comes for me to deal with them. I am assuming that my readers know the basic elements of geometry already, or have sufficient mental aptitude to understand mathematical demonstrations. For I freely acknowledge that I recognize no matter in corporeal things apart from that which the geometers call quantity, and take as the object of their

[19] See above, Part 1, art. 26, pp. 201f.

[20] There is for Descartes no real distinction between God's action in creating the universe and his action in preserving it or maintaining it in existence. See below, art. 42, p. 243, and Med. III: vol. II, p. 33.

demonstrations, i.e. that to which every kind of division, shape and motion is applicable. Moreover, my consideration of such matter involves absolutely nothing apart from these divisions, shapes and motions; and even with regard to these, I will admit as true only what has been deduced from indubitable common notions so evidently that it is fit to be considered as a mathematical demonstration. And since all natural phenomena can be explained in this way, as will become clear in what follows, I do not think that any other principles are either admissible or desirable in physics.

[. . .]

PART FOUR

The Earth

[. . .]

187. *From what has been said we can understand the possible causes of all the other remarkable effects which are usually attributed to occult qualities.*

. . . Consider how amazing are the properties of magnets and of fire, and how different they are from the properties we commonly observe in other bodies: how a huge flame can be kindled from a tiny spark in a moment <when it falls on a large quantity of powder>, and how great its power is; or how the fixed stars radiate their light <instantly> in every direction over such an enormous distance. In this book I have deduced the causes—which I believe to be quite evident—of these and many other phenomena from principles which are known to all and admitted by all, namely the shape, size, position and motion of particles of matter. And anyone who considers all this will readily be convinced that there are no powers in stones and plants that are so mysterious, and no marvels attributed to sympathetic and antipathetic influences that are so astonishing, that they cannot be explained in this way. In short, there is nothing in the whole of nature (nothing, that is, which should be referred to purely corporeal causes, i.e. those devoid of thought and mind) which is incapable of being deductively explained on the basis of these self-same principles; and hence it is quite unnecessary to add any further principles to the list.

188. *What must be borrowed from [my proposed] treatises on animals and on man in order to complete our knowledge of material things.*

I would not add anything further to this fourth part of the Principles of Philosophy if, as I originally planned, I was going on to write two further parts—a fifth part on living things, i.e. animals and plants, and a sixth part on man. But I am not yet completely clear about all the matters which I would like to deal with there, and I do not know whether I shall ever have enough free time to complete these sections. So, to avoid delaying the publication of the first four parts any longer, and to make sure there are no gaps caused by my keeping material back for the two final parts, I shall here add a few observations concerning the objects of the senses. Up till now I have described this earth and indeed the whole visible universe as if it were a machine: I have considered only the various shapes and movements of its parts. But our senses show us much else besides—namely colours, smells, sounds and such-like; and if I were to say nothing about these it might be thought that I had left out the most important part of the explanation of the things in nature.

189. *What sensation is and how it operates.*

It must be realized that the human soul, while informing[21] the entire body, nevertheless has its principal seat in the brain; it is here alone that the soul not only understands and imagines but also has sensory awareness. Sensory awareness comes about by means of nerves, which stretch like threads from the brain to all the limbs, and are joined together in such a way that hardly any part of the human body can be touched without producing movement in several of the nerve-ends that are scattered around in that area. This movement is then transmitted to the other ends of the nerves which are all grouped together in the brain around the seat of the soul, as I explained very fully in Chapter Four of the *Optics*.[22] The result of these movements being set up in the brain by the nerves is that the soul or mind that is closely joined to the brain is affected in various ways, corresponding to the various different sorts of movements. And the various different states of mind, or thoughts, which are the immediate result of these movements are called sensory perceptions, or in ordinary speech, sensations.

190. *Various kinds of sensation. First, internal sensations, i.e. emotional states of the mind and natural appetites.*

The wide variety in sensations is a result, firstly, of differences in the nerves themselves, and secondly of differences in the sorts of motion which occur in particular nerves. It is not that each individual nerve produces a particular kind of sensation; indeed, there are only seven principal groups of nerves, of which two have to do with internal sensations and five with external sensations. The nerves which go to the stomach, oesophagus, throat, and other internal parts whose function is to keep our natural wants supplied, produce one kind of internal sensation, which is called 'natural appetite' <e.g. hunger and thirst>. The nerves which go to the heart and the surrounding area <including the diaphragm>, despite their very small size, produce another kind of internal sensation which comprises all the disturbances or passions and emotions of the mind such as joy, sorrow, love, hate and so on. For example, when the blood has the right consistency so that it expands in the heart more readily than usual, it relaxes the nerves scattered around the openings, and sets up a movement which leads to a subsequent movement in the brain producing a natural feeling of joy in the mind; and other causes produce the same sort of movement in these tiny nerves, thereby giving the same feeling of joy. Thus, if we imagine ourselves enjoying some good, the act of imagination does not itself contain the feeling of joy, but it causes the spirits[23] to travel from the brain to the muscles in which these nerves are embedded. This causes the openings of the heart to expand, and this in turn produces the movement in the tiny nerves of the heart which must result in the feeling of joy. In the same way, when we hear good

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[21] Lat. *informare*. Descartes occasionally employs this standard scholastic term, though of course he rejects the Aristotelian account of the soul as the 'form' of the body. The French version has simply 'while being united to the entire body'.

[22] *Optics*, above pp. 164ff; Cf. *Treatise on Man*, above pp. 100ff; *Passions*, below pp.340ff.

[23] I.e. the so-called 'animal spirits'; Cf. *Passions*, below, pp. 330ff.

news, it is first of all the mind which makes a judgement about it and rejoices with that intellectual joy which occurs without any bodily disturbance and which, for that reason, the Stoics allowed that the man of wisdom could experience <although they required him to be free of all passion>. But later on, when the good news is pictured in the imagination, the spirits flow from the brain to the muscles around the heart and move the tiny nerves there, thereby causing a movement in the brain which produces in the mind a feeling of animal joy. Or again, if the blood is too thick and flows sluggishly into the ventricles of the heart and does not expand enough inside it, it produces a different movement in the same small nerves around the heart; when this movement is transmitted to the brain it produces a feeling of sadness in the mind, although the mind itself may perhaps not know of any reason why it should be sad. And there are several other causes capable of producing the same feeling <by setting up the same kind of movement in these nerves.> Other movements in these tiny nerves produce different emotions such as love, hatred, fear, anger and so on; I am here thinking of these simply as emotions or passions of the soul, that is, as confused thoughts, which the mind does not derive from itself alone but experiences as a result of something happening to the body with which it is closely conjoined. These emotions are quite different in kind from the distinct thoughts which we have concerning what is to be embraced or desired or shunned. The same applies to the natural appetites such as hunger and thirst which depend on the nerves of the stomach, throat and so forth: they are completely different from the volition to eat, drink and so on. But, because they are frequently accompanied by such volition or appetition, they are called appetites.

191. *The external senses. First, the sense of touch.*

As far as the external senses are concerned, five are commonly listed corresponding to the five kinds of objects stimulating the sensory nerves, and the five kinds of confused thoughts which the resulting motions produce in the soul. First of all there are the nerves terminating in the skin all over the body.[24] These nerves may be touched, via the skin, by various external bodies; and these bodies, though remaining intact, stimulate the nerves in various different ways—in one way by their hardness, in another way by their heaviness, in another way by their heat, in another way by their humidity, and so on. Corresponding to the different ways in which the nerves are moved, or have their normal motion checked, various different sensations are produced in the mind; and this is how the various tactile qualities get their names. <We call these qualities hardness, heaviness, heat, humidity and so on, but all that is meant by these terms is that the external bodies possess what is required to bring it about that our nerves excite in the soul the sensations of hardness, heaviness, heat etc.>. Moreover, when the nerves are stimulated with unusual force, but without any damage being occasioned to the body, a pleasurable sensation arises <which is a confused thought in the soul and> which is naturally agreeable to the mind because it is a sign of robust health in the body with which it is closely conjoined <in so far as it can undergo the action causing the pleasure without being damaged>. But if there is some bodily damage, there is a sensation of pain <in the soul, even though the action causing the pain may be only marginally more forceful>. This explains why bodily pleasure and pain arise from such very similar objects, although the sensations are completely opposite.

192. *Taste.*

Then there <is the least subtle sense after that of touch, namely taste. Its organs> are other nerves scattered through the tongue and neighbouring areas. The same external bodies, this time split up into particles and floating in the saliva from the mouth, stimulate these nerves in various ways corresponding to their many different shapes <sizes or movements>, and thus produce the sensations of various tastes.

193. *Smell.*

Thirdly, there <is the sense of smell. Its organs> are two other nerves (or appendages to the brain, since they do not go outside the skull) which are stimulated by separate particles of the same bodies that float in the air. The particles in question cannot be of any kind whatsoever: they must be sufficiently light and energetic to be drawn into the nostrils and through the pores of the so-called spongy bone, thus reaching the two nerves. The various movements of the nerves produce the sensations of various smells.

194. *Hearing.*

Fourthly, there <is hearing, whose object is simply various vibrations in the ear. For there> are two other nerves, found in the inmost chambers of the ears, which receive tremors and vibrations from the whole body of surrounding air. When the air strikes the tympanic membrane it produces a disturbance in the little chain of three small bones attached to it; and the sensations of different sounds arise from the various different movements in these bones.

195. *Sight.*

Finally, there are the optic nerves <which are the organs of the most subtle of all the senses, that of sight>. The extremities of these nerves, which make up the coating inside the eye called the retina, are moved not by air or any external bodies entering the eye, but simply by globules of the second element <which pass through the pores and all the fluids and transparent membranes of the eye>. This is the origin of the sensations of light and colours, as I have already explained adequately in the *Optics* and *Meteorology*.[25]

196. *The soul has sensory awareness only in so far as it is in the brain.*

There is clear proof that the soul's sensory awareness, via the nerves, of what happens to the individual limbs of the body does not come about in virtue of the soul's presence in the individual limbs, but simply in virtue of its presence in the brain <or because the nerves by their motions transmit to it the actions of external objects which touch the parts of the body where the nerves are embedded>. Firstly, there are various diseases which affect only the brain but remove or interfere with all sensation. Again, sleep occurs only in the brain, yet every day it deprives us of a great part of our sensory faculties, though these are afterwards restored on waking. Next, when the brain is undamaged, if there is an obstruction in the paths by

[24] 'First there is the sense of touch, which has as its object all the bodies which can move some part of the flesh or skin of our body, and has as its organ all the nerves which are found in this part of the body and move with it' (French version).

[25] Cf. *Optics*, above pp. 167ff.

which the nerves reach the brain from the external limbs, this alone is enough to destroy sensation in those limbs. Lastly, we sometimes feel pain in certain limbs even though there is nothing to cause pain in the limbs themselves; the cause of the pain lies in the other areas through which the nerves travel in their journey from the limbs to the brain. This last point can be proved by countless observations, but it will suffice to mention one here. A girl with a seriously infected hand used to have her eyes bandaged whenever the surgeon visited her, to prevent her being upset by the surgical instruments. After a few days her arm was amputated at the elbow because of a creeping gangrene, and wads of bandages were put in its place so that she was quite unaware that she had lost her arm. However she continued to complain of pains, now in one then in another finger of the amputated hand. The only possible reason for this is that the nerves which used to go from the brain down to the hand now terminated in the arm near the elbow, and were being agitated by the same sorts of motion as must previously have been set up in the hand, so as to produce in the soul, residing in the brain, the sensation of pain in this or that finger. <And this shows clearly that pain in the hand is felt by the soul not because it is present in the hand but because it is present in the brain.>

197. *The nature of the mind is such that various sensations can be produced in it simply by motions in the body.*

It can also be proved that the nature of our mind is such that the mere occurrence of certain motions in the body can stimulate it to have all manner of thoughts which have no likeness to the movements in question. This is especially true of the confused thoughts we call sensations or feelings. For we see that spoken or written words excite all sorts of thoughts and emotions in our minds. With the same paper, pen and ink, if the tip of the pen is pushed across the paper in a certain way it will form letters which excite in the mind of the reader thoughts of battles, storms and violence, and emotions of indignation and sorrow; but if the movements of the pen are just slightly different they will produce quite different thoughts of tranquillity, peace and pleasure, and quite opposite emotions of love and joy. It may be objected that speech or writing does not immediately excite in the mind any emotions, or images of things apart from the words themselves; it merely occasions various acts of understanding which afterwards result in the soul's constructing within itself the images of various things. But what then will be said of the sensations of pain and pleasure? A sword strikes our body and cuts it; but the ensuing pain is completely different from the local motion of the sword or of the body that is cut—as different as colour or sound or smell or taste. We clearly see, then, that the sensation of pain is excited in us merely by the local motion of some parts of our body in contact with another body; so we may conclude that the nature of our mind is such that it can be subject to all the other sensations merely as a result of other local motions.

198. *By means of our senses we apprehend nothing in external objects beyond their shapes, sizes and motions.*

Moreover, we observe no differences between the various nerves which would support the view that different nerves allow different things to be transmitted to the brain from the external sense organs; indeed, we are not entitled to say that anything reaches the brain except for the local motion of the nerves themselves. And we see that this local motion produces not only sensations of pain and pleasure but also those of light and sound. If someone is struck in the eye, so that the vibration of the blow reaches the retina, this will cause him to see many sparks of flashing light, yet the light is not outside his eye. And if someone puts a finger in his ear he will hear a throbbing hum which comes simply from the movement of air trapped in the ear. Finally, let us consider heat and other qualities perceived by the senses, in so far as those qualities are in objects, as well as the forms of purely material things, for example the form of fire: we often see these arising from the local motion of certain bodies and producing in turn other local motions in other bodies. Now we understand very well how the different size, shape and motion of the particles of one body can produce various local motions in another body. But there is no way of understanding how these same attributes (size, shape and motion) can produce something else whose nature is quite different from their own—like the substantial forms and real qualities which many <philosophers> suppose to inhere in things; and we cannot understand how these qualities or forms could have the power subsequently to produce local motions in other bodies. Not only is all this unintelligible, but we know that the nature of our soul is such that different local motions are quite sufficient to produce all the sensations in the soul. What is more, we actually experience the various sensations as they are produced in the soul, and we do not find that anything reaches the brain from the external sense organs except for motions of this kind. In view of all this we have every reason to conclude that the properties in external objects to which we apply the terms light, colour, smell, taste, sound, heat and cold—as well as the other tactile qualities and even what are called 'substantial forms'—are, so far as we can see, simply various dispositions in those objects[26] which make them able to set up various kinds of motions in our nerves <which are required to produce all the various sensations in our soul>.

199. *There is no phenomenon of nature which has been overlooked in this treatise.*

A simple enumeration will make it clear that there is no phenomenon of nature which I have omitted to consider in this treatise. For a list of natural phenomena cannot include anything which is not apprehended by the senses. Now I have given an account of the various sizes, shapes and motions which are to be found in all bodies; and apart from these the only things which we perceive by our senses as being located outside us are light, colour, smell, taste, sound and tactile qualities. And I have just demonstrated that these are nothing else in the objects—or at least we cannot apprehend them as being anything else—but certain dispositions depending on size, shape and motion. <So the entire visible world, in so far as it is simply visible or perceivable by the senses, contains nothing apart from the things I have given an account of here.>

200. *I have used no principles in this treatise which are not accepted by everyone; this philosophy is nothing new but is extremely old and very common.*

I should also like it to be noted that in attempting to explain the general nature of material things I have not employed any principle which was not accepted by Aristotle and all other philosophers of every age. So this philosophy is not new, but the oldest and most common of all. I have considered the shapes, motions and sizes of bodies and examined the necessary results of their mutual interaction in accordance with the laws of mechanics, which are confirmed by reliable everyday experience. And who has ever doubted that bodies move and have various sizes

[26] '. . . in the shapes, sizes, positions and movements of their parts' (French version).

and shapes, and that their various different motions correspond to these differences in size and shape; or who doubts that when bodies collide bigger bodies are divided into many smaller ones and change their shapes? We detect these facts not just with one sense but several—sight, touch and hearing; and they can also be distinctly imagined and understood by us. But the same cannot be said of the other characteristics like colour, sound and the rest, each of which is perceived not by several senses but by one alone; for the images of them which we have in our thought are always confused, and we do not know what they really are.

201. *There are corporeal particles which cannot be perceived by the senses.*

I do consider, however, that there are many particles in each body which are <so small that they are> not perceived with any of our senses; and this may not meet with the approval of those who take their own senses as the measure of what can be known. <But to desire that our human reasoning should go no further than what we can see is, I think, to do it a great injustice.> Yet who can doubt that there are many bodies so minute that we do not detect them by any of our senses? One simply has to consider something which is slowly growing or shrinking and ask what it is that is being added or taken away hour by hour. A tree grows day by day; and it is unintelligible to suppose that it gets bigger than it was before unless we understand there to be some body which is added to it. But who has ever detected with the senses the minute bodies that are added to a growing tree in one day? It must be admitted, at least by those <philosophers> who accept that quantity is indefinitely divisible, that its parts could be made so tiny as to be imperceptible by any of the senses. And it certainly should not be surprising that we are unable to perceive very minute bodies through our senses. For our nerves, which must be set in motion by objects in order to produce a sensation, are not themselves very minute, but are like small cords made up of many smaller particles; hence they cannot be set in motion by very minute bodies. No one who uses his reason will, I think, deny the advantage of using what happens in large bodies, as perceived by our senses, as a model for our ideas about what happens in tiny bodies which elude our senses merely because of their small size. This is much better than explaining matters by inventing all sorts of strange objects which have no resemblance to what is perceived by the senses <such as 'prime matter', 'substantial forms' and the whole range of qualities that people habitually introduce, all of which are harder to understand than the things they are supposed to explain>.

202. *The philosophy of Democritus differs from my own just as much as it does from the standard view <of Aristotle and others>.*

It is true that Democritus also imagined certain small bodies having various sizes, shapes and motions, and supposed that all bodies that can be perceived by the senses arose from the conglomeration and mutual interaction of these corpuscles; and yet his method of philosophizing generally meets with total rejection. This rejection, however, has never been based on the fact that his philosophy deals with certain particles so minute as to elude the senses, and assigns various sizes, shapes and motions to them; for no one can doubt that there are in fact many such particles, as I have just shown. The reasons for the rejection are the following. First, Democritus supposed his corpuscles to be indivisible—a notion which leads me to join those who reject his philosophy. Secondly, he imagined there to be a vacuum around the corpuscles, whereas I demonstrate the impossibility of a vacuum. Thirdly, he attributed gravity to these corpuscles, whereas my understanding is that there is no such thing as gravity in any body taken on its own, but that it exists only as a function of, and in relation to, the position and motion of other bodies.[27] And lastly, Democritus did not show how particular things arose merely from the interaction of corpuscles; or, if he did show this in some cases, his explanations were not entirely consistent, if we may judge from those of his opinions which have survived. I leave others to judge whether my own writings on philosophy have up to now been reasonably consistent <and sufficiently fertile in the results that can be deduced from them. As for the consideration of shapes, sizes and motions, this is something that has been adopted not only by Democritus but also by Aristotle and all the other philosophers. Now I reject all of Democritus' suppositions, with this one exception, and I also reject practically all the suppositions of the other philosophers. Hence it is clear that my method of philosophizing has no more affinity with the Democritean method than with any of the other particular sects>.

203. *How we may arrive at knowledge of the shapes <sizes> and motions of particles that cannot be perceived by the senses.*

In view of the fact that I assign determinate shapes, sizes, and motions to the imperceptible particles of bodies just as if I had seen them, but nonetheless maintain that they cannot be perceived, some people may be led to ask how I know what these particles are like. My reply is this. First of all <I considered in general all the clear and distinct notions which our understanding can contain with regard to material things. And I found no others except for the notions we have of shapes, sizes and motions, and the rules in accordance with which these three things can be modified by each other—rules which are the principles of geometry and mechanics. And I judged as a result that all the knowledge which men have of the natural world must necessarily be derived from these notions; for all the other notions we have of things that can be perceived by the senses are confused and obscure, and so cannot serve to give us knowledge of anything outside ourselves, but may even stand in the way of such knowledge. Next> I took the simplest and best known principles, knowledge of which is naturally implanted in our minds; and working from these I considered, in general terms, firstly, what are the principal differences which can exist between the sizes, shapes and positions of bodies which are imperceptible by the senses merely because of their small size, and, secondly, what observable effects would result from their various interactions. Later on, when I observed just such effects in objects that can be perceived by the senses, I judged that they in fact arose from just such an interaction of bodies that cannot be perceived—especially since it seemed impossible to think up any other explanation for them. In this matter I was greatly helped by considering artefacts. For I do not recognize any difference between artefacts and natural bodies except that the operations of artefacts are for the most part performed by mechanisms which are large enough to be easily perceivable by the senses—as indeed must be the case if they are to be capable of being manufactured by human beings. The effects produced in nature, by contrast, almost always depend on structures which are so minute that they completely elude our senses. Moreover, mechanics is a division or special case of physics, and all the explanations belonging to the former also belong to the latter; so it is no less natural for a clock constructed with this or that

[27] See above, Part 2, art. 20; Part 4, art. 20–3.

set of wheels to tell the time than it is for a tree which grew from this or that seed to produce the appropriate fruit. Men who are experienced in dealing with machinery can take a particular machine whose function they know and, by looking at some of its parts, easily form a conjecture about the design of the other parts, which they cannot see. In the same way I have attempted to consider the observable effects and parts of natural bodies and track down the imperceptible causes and particles which produce them.

204. *With regard to the things which cannot be perceived by the senses, it is enough to explain their possible nature, even though their actual nature may be different <and this is all that Aristotle tried to do>.*

However, although this method may enable us to understand how all the things in nature could have arisen, it should not therefore be inferred that they were in fact made in this way. Just as the same craftsman could make two clocks which tell the time equally well and look completely alike from the outside but have completely different assemblies of wheels inside, so the supreme craftsman of the real world could have produced all that we see in several different ways. I am very happy to admit this; and I shall think I have achieved enough provided only that what I have written is such as to correspond accurately with all the phenomena of nature. This will indeed be sufficient for application in ordinary life, since medicine and mechanics, and all the other arts which can be fully developed with the help of physics, are directed only towards items that can be perceived by the senses and are therefore to be counted among the phenomena of nature.[28] And in case anyone happens to be convinced that Aristotle achieved—or wanted to achieve—any more than this, he himself expressly asserts in the first book of the *Meteorologica*, at the beginning of Chapter Seven, that when dealing with things not manifest to the senses, he reckons he has provided adequate reasons and demonstrations if he can simply show that such things are capable of occurring in accordance with his explanations.

205. *Nevertheless my explanations appear to be at least morally certain.*[29]

It would be disingenuous, however, not to point out that some things are considered as morally certain, that is, as having sufficient certainty for application to ordinary life, even though they may be uncertain in relation to the absolute power of God. <Thus those who have never been in Rome have no doubt that it is a town in Italy, even though it could be the case that everyone who has told them this has been deceiving them.> Suppose for example that someone wants to read a letter written in Latin but encoded so that the letters of the alphabet do not have their proper value, and he guesses that the letter B should be read whenever A appears, and C when B appears, i.e. that each letter should be replaced by the one immediately following it. If, by using this key, he can make up Latin words from the letters, he will be in no doubt that the true meaning of the letter is contained in these words. It is true that his knowledge is based merely on a conjecture, and it is conceivable that the writer did not replace the original letters with their immediate successors in the alphabet, but with others, thus encoding quite a different message; but this possibility is so unlikely <especially if the message contains many words> that it does not seem credible. Now if people look at all the many properties relating to magnetism, fire and the fabric of the entire world, which I have deduced in this book from just a few principles, then, even if they think that my assumption of these principles was arbitrary and groundless, they will still perhaps acknowledge that it would hardly have been possible for so many items to fit into a coherent pattern if the original principles had been false.

206. *Indeed, my explanations possess more than moral certainty.*

Besides, there are some matters, even in relation to the things in nature, which we regard as absolutely, and more than just morally, certain. <Absolute certainty arises when we believe that it is wholly impossible that something should be otherwise than we judge it to be.> This certainty is based on a metaphysical foundation, namely that God is supremely good and in no way a deceiver, and hence that the faculty which he gave us for distinguishing truth from falsehood cannot lead us into error, so long as we are using it properly and are thereby perceiving something distinctly. Mathematical demonstrations have this kind of certainty,[30] as does the knowledge that material things exist; and the same goes for all evident reasoning about material things. And perhaps even these results of mine will be allowed into the class of absolute certainties, if people consider how they have been deduced in an unbroken chain from the first and simplest principles of human knowledge. Their certainty will be especially appreciated if it is properly understood that we can have no sensory awareness of external objects unless these objects produce some local motion in our nerves; and that the fixed stars, owing to their enormous distance from us, cannot produce such motion unless there is also some motion occurring both in them and also throughout the entire intervening part of the heavens.[31] Once this is accepted, then it seems that all the other phenomena, or at least the general features of the universe and the earth which I have described, can hardly be intelligibly explained except in the way I have suggested.

207. *I submit all my views to the authority of the Church.*

Nevertheless, mindful of my own weakness, I make no firm pronouncements, but submit all these opinions to the authority of the Catholic Church and the judgement of those wiser than myself. And I would not wish anyone to believe anything except what he is convinced of by evident and irrefutable reasoning.

THE END

[28] '. . . are directed simply towards applying certain observable bodies to each other in such a way that certain observable effects are produced as a result of natural causes. And by imagining what the various causes are, and considering their results, we shall achieve our aim irrespective of whether these imagined causes are true or false, since the result is taken to be no different, as far as the observable effects are concerned' (French version).

[29] By 'moral certainty' is meant certainty sufficient for ordinary practical purposes. See first sentence of this article, where the French version runs: '... moral certainty is certainty which is sufficient to regulate our behaviour, or which measures up to the certainty we have on matters relating to the conduct of life which we never normally doubt, though we know that it is possible, absolutely speaking, that they may be false'.

[30] '. . . for we see clearly that it is impossible that two and three added together should make more or less than five; or that a square should have only three sides, and so on' (added in French version).

[31] '. . . from which it follows very evidently that the heavens must be fluid, i.e. composed of small particles which move separately from each other, or at least that they must contain such particles. For whatever I can be said to have assumed in Part 3, art. 46 can be reduced to the sole assertion that the heavens are fluid' (added in French version).