Principles of Philosophy

René Descartes

[Brackets] enclose editorial explanations. Small ·dots· enclose material that has been added, but can be read as though it were part of the original text. Occasional •bullets, and also indenting of passages that are not quotations, are meant as aids to grasping the structure of a sentence or a thought. The basis from which this text was constructed was the translation by John Cottingham (Cambridge University Press), which is strongly recommended. Each four-point ellipsis . . . . indicates the omission of a short passage that seemed to be more trouble than it is worth. Longer omissions are reported between square brackets in normal-sized type.—Descartes wrote this work in Latin. A French translation appeared during his life-time, and he evidently saw and approved some of its departures from or additions to the Latin. A few of these will be incorporated, usually without sign-posting, in the present version.—When a section starts with a hook to something already said, it's a hook to •the thought at the end of the preceding section, *not* to •its own heading. In the definitive Adam and Tannery edition of Descartes's works, and presumably also in the first printing of the *Principles*, those items were not headings but marginal summaries.

First launched: March 2008 Last amended: January 2012 (a confusion relating to II.15)

Contents

Part 2: The principles of material things

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

Everyone is quite convinced that there are material things; but earlier on I cast doubt on this belief, including it among the preconceived opinions of our childhood. So now we have to investigate the lines of thought that will give us certain knowledge of the existence of material things. Now, all our sensations undoubtedly come to us from something other than our mind. We can't *choose* what sensations to have, so obviously this is controlled by something ·external to us· acting on our senses. Are our sensations caused by God or by something different from God? Well, because of our sensory stimulation we have a vivid and clear perception of some kind of matter that is extended in three dimensions and has various differently shaped and variously moving parts that cause our different sensations of colours, smells, pain and so on. If God were himself immediately producing in our minds the idea of such extended matter, or even if he were causing it to be produced by something that wasn't extended, shaped, and moving, he would have to be regarded as a deceiver. For we have a lively understanding of this *matter* as something quite different from God and from ourselves or our mind; and we appear to see vividly that the idea of it comes to us from things located outside ourselves, which it—the idea—wholly resembles. And I have already pointed out that it is quite inconsistent with the nature of God that he should be a deceiver. So we are forced to the conclusion that there exists something extended in three dimensions and possessing all the properties that we clearly [*clare*] 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.

Our clear awareness that pain and other sensations come to us quite unexpectedly implies that one particular body is more closely conjoined with our mind than any other body. The reasoning here is like the reasoning in section 1. The mind is aware •that these sensations don't come from itself alone, and can't belong to it simply in virtue of its being a thinking thing; and •that it couldn't have them if it weren't joined to something other than itself—something extended and movable—namely what we call the human body. But this is not the place for a more detailed explanation of its nature.

3. Sense-perception doesn't show us •what really exists in things, but only •what is beneficial or harmful to man's composite nature.

All we need to note at the present stage is that human sensory perceptions are related exclusively to this body-mind complex. They normally tell us about how external bodies may harm or help this mind-body combination; they don't often show us what external bodies are like in themselves, and when they do it's only by accident. If we bear this in mind we'll find it easy to set aside prejudices acquired from the senses, and use the intellect alone, carefully attending to the ideas implanted in it by nature.

4. The nature of body consists just in extension—not in weight, hardness, colour or the like.

In doing this we'll see that the nature of matter (i.e. body considered in general) consists not in its being a thing that

> •is hard or heavy or coloured, or affects the senses in this or that way,

but simply in its being a thing that

•is extended in length, breadth and depth.

Why doesn't hardness enter into it? Well, what our senses tell us about hardness is just that the parts of a hard body stop our hands from moving through them. If bodies always moved away from in front of our hands, too fast for our hands to catch up, we would never have any sensation of hardness. And it doesn't make sense to suppose that bodies by moving in that way would lose their nature as bodies; from which it follows that hardness can't be any part of that nature. Similar reasoning can show that weight, colour, and all the other qualities that the senses perceive as being in corporeal matter, can be removed from it without stopping it from still being matter. It follows, therefore, that the nature of matter doesn't depend on any of these qualities.

5. This truth about the nature of body is obscured by old prejudices about rarefaction and empty space.

But there are still two possible reasons for doubting that the true nature of body consists solely in extension. **(1)** It is widely believed that many bodies can be •rarefied and •condensed, so that the same portion of matter can have more extension when it is rarefied than when it is condensed. Some people, indeed, slice things so finely that they distinguish the •substance of a body from its •quantity, and even its •quantity from its •extension! **(2)** Suppose we think that there's nothing in a certain place but extension in length, breadth and depth—we don't usually say 'There's a body there'. It is more usual to say 'There is a space there' or even 'There is an empty space there'—and almost everyone is convinced that empty space is a pure nothing.

6. How rarefaction occurs.

What *should* we then say about rarefaction and condensation? If you attend to your own thoughts, and refuse to accept anything that you don't openly and fully perceive, you won't think that rarefaction and condensation involve anything but change of shape. Specifically: rarefied bodies are the ones that have many gaps between their parts—gaps occupied by other bodies—and they become denser through the parts' coming together and reducing or eliminating the gaps. When the gaps are eliminated, the body B becomes so dense that the notion of its becoming even denser is outright self-contradictory. Now, the extension of B when it is utterly dense is just as large as its extension when it is ·rarer, i.e.· spread across more space because of the separation of its parts; because the extension of the pores or gaps between B's parts must be attributed not to B but to the various *other* bodies that fill the gaps. What do we think when we see a sponge is filled with water? *Not* that the sponge itself—the totality of its individual parts—has a greater extension than it had when dry; but rather its pores are open wider so that it spreads over a greater space.

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

When people say that rarefaction occurs through an increase in the quantity ·of extension that the given body has·, rather than explaining it on the analogy of the sponge, I don't know what has come over them! Admittedly, when air or water is rarefied we don't *see* any pores being made larger with new bodies flowing into them; but •making up something unintelligible so as to 'explain' rarefaction is less rational than •inferring the existence of pores or gaps that become larger with new matter pouring into them. We don't perceive this new matter through any of our senses, but what forces us to think that all the bodies that exist must affect our senses? Anyway, my account makes it easy to see *how* rarefaction could occur like this, which no other account does. The bottom line is that it's a flat contradiction to suppose that something might have quantity added to it, or extension added to it, without the addition of further extended substance, i.e. a new body. Adding extension or quantity without adding substance that *has* quantity and extension?—that doesn't make sense. I'll throw more light on this later.

8. A thing that has a certain quantity or number isn't •really distinct from the quantity or number—all that's involved is •distinctness of reason. [See 1:62.]

There is no *real* difference between quantity and the extended substance that has the quantity; the two are merely distinct in reason, in the way that the number three is distinct from a trio of things. ·Here's why they have a distinctness of reason·: Suppose there's a corporeal substance that occupies a space of 10 ft^3—-we can consider its entire nature without attending to its specific size, because we understand this nature to be exactly the same in the whole thing as in any part of it. Conversely, we can think of •the number ten, or •the continuous quantity 10 ft^3, without attending to this particular substance, because the concept of •the number ten is just the same in all the contexts where it is used, ten feet or ten men or ten anything; and although •the continuous quantity 10 ft^3 is unintelligible without some extended substance that *has* that size, it can be understood apart from this particular substance. ·And here's why they aren't really distinct·: In reality it is impossible to take the tiniest amount from the quantity or extension without also removing just that much of the substance; and conversely it is impossible to remove the tiniest amount from the substance without taking away just that much of the quantity or extension.

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

Others may disagree ·with this opinion about real distinctness·, but I don't think they have any alternative view of this matter. When they distinguish •substance from •extension or quantity, either they don't mean *anything* by the term 'substance', or else their meaning for it is just a confused concept of *in*corporeal substance, ·so that when they produce sentences of the type

> 'A corporeal substance is really distinct from its quantity of extension'

what they are really saying is that

> •An incorporeal substance is really distinct from ·any instance of· quantity of extension,

which is true but expressed in radically misleading language. Does the concept of corporeal substance play any part in their frame of thought? Yes, surprisingly it does.· They have the thought of corporeal substance, which they rightly equate with extension, which they wrongly classify as a mere quality!) There is thus no correspondence between their verbal expressions and what they grasp in their minds.

[A distinction that will run through sections 10–14 should be explained now. There are two things that could be meant by 'the place where you are at this moment'. **(1)** It could be your location in relation to other parts of the world—where you are in your room, or in the town you live in, or. . . and so on. **(2)** It could be the place you are *in*, the portion of space that snugly fits you at this moment. Of these two, **(2)** is what section 10 calls 'internal place'. These labels **(1)** and **(2)** will be used at certain points in what follows, relating bits of the text to the content of the present note.]

10. What space or (2) internal place is.

There is no real distinction between •space or internal place and •the corporeal substance contained in it; they differ only in how we usually think of them. In reality (·in contrast to 'In our thought. . . '·) the extension in length, breadth and depth that constitutes a space is exactly the same as the extension that constitutes a body. Our two ways of thinking about this extension differ as follows. **(2)** When we are thinking of it as a body, we regard the extension as something particular that moves when the body moves. **(1)** When we are thinking of this extension as ·a portion of· space, we attribute to the extension only a generic unity, i.e. we think of it not as one individual •thing but as one •set of specifications that might apply first to one thing and then to another. This thought of one body moving out of and another moving into the very same extension requires that the extension in question retains the same size and shape and keeps the same position relative to certain external bodies that we use to determine the space in question.

11. There's no real difference between space and corporeal substance.

It's easy for us to see that the extension that constitutes the nature of a body is exactly the same as the extension that constitutes the nature of a space. They don't differ any more than the nature of a genus or species differs from the nature of an individual ·belonging to that species or genus·. Let us attend to the idea we have of a pebble, leaving out everything we know to be non-essential to the nature of body: we will first exclude hardness, because if the pebble is melted or pulverized it will stop being hard but will still be a body; then we'll exclude colour, because we have often seen stones so transparent that they have no colour. Next we'll exclude weight, because 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 aren't thought of as being in the stone, or because changes in them aren't thought to deprive the pebble of its bodily nature. After all these exclusions we'll find that nothing remains in the idea of the pebble except its being something extended in length, breadth and depth. But that's just what is comprised in the idea of a space—and not merely a space full of bodies but even one that is called 'empty'.

12. The difference is only in our way of conceiving them.

Still, we think about space in a different way from how we think about corporeal substance. If a pebble is knocked off a table onto the floor, **(2)** we think that its extension has also been moved from table to floor, because we're thinking of the extension as something •particular and inseparable from the stone. But **(1)** we *also* think that the extension of the place on the table-top where the pebble used to be stays there, unchanged, although the place is now occupied by wood or water or air or some other body, or is even supposed to be empty. That's because we're now thinking of extension as something •general that is the same, whether it is the extension of a pebble or a bit of wood or whatever (or even of a vacuum, if there is such a thing), as long as 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 (1) external place is.

So the expressions 'the place of the pebble' and 'the space of the pebble' refer to *the pebble*; but they refer to it through its size, shape and position relative to other bodies. We fix the pebble's position in terms of **(1)** its relations to other bodies that we regard as immobile; and we can say of a single thing that it is at once •moving in relation to one set of bodies and •immobile in relation to another. Take the case of someone sitting still on a moving ship: his position doesn't change relative to the parts of the ship, but he is constantly changing his place relative to the neighbouring shores. . . . With that same example, let's suppose that the earth rotates and that in a given period of time it goes the same distance west-to-east as the ship travels east-to-west. In that case, our man is not changing his place relative to certain fixed points in the heavens. And if we suppose that there aren't any such genuinely fixed points to be found in the universe (and I'll show later that there probably aren't), we shall ·have to· conclude that nothing has a permanent place except as stipulated by us.

14. How (1) place differs from (2) space.

We speak of a body's 'place' and of its 'space', ·and between these two there is at least a strong difference of emphasis·. We use **(1)** 'place' when our primary interest is in position rather than size or shape, and we use **(2)** 'space' when our concern is with size and shape. **(1)** Remove a book from the centre of the table and put a bottle there instead: we say that the bottle is now 'in the place' where the book was, though of course the bottle doesn't have anything like the size and shape of the book. We would *not* say in this case that the bottle 'occupies the same space' that the book did. And we *do* say in this case that the book's place has changed, although its size and shape are unaltered. When we say 'The object is in place P' we're saying something only about its position relative to other things; but when we go on to say **(2)** 'The object fills up place P or space S', we mean in addition that it has precisely the size and shape of the space in question.

[Important note relating sections 10–14 to section 15. We have seen that Descartes marks the difference between

(1) position and **(2)** shape-and-size

in terms of the difference between

(1) external place and **(2)** internal place,
(1) 'place' and **(2)** 'space', and
(1) 'is in' and **(2)** 'fills up'.

Now in section 15 we are going to find him using some of the same terminology, specifically drawing a line between

external place and internal place,

but clearly *not* presenting yet again the distinction that has run through the preceding five sections. The second half of section 15 pretty clearly concerns **(1)** as we know it. The first half is in the general area of **(2)**, and is using 'internal' and 'external' to draw a line *within* **(2)**. It isn't transparently clear what line it is; it brings in some thoughts Descartes had about surfaces, and it looks as though his desire to bring that in led him to muddy the waters.]

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. As for •place: we sometimes consider it as internal to the thing that is in the place in question, and sometimes as external to it. Internal place is *space*; but external place can be taken as being the surface that immediately surrounds the body in the place. By 'surface' I don't mean any •part of the surrounding body but merely the •boundary between the surrounding and surrounded bodies, which is merely a mode. . . . This surface is always reckoned to be the same, provided it keeps the same size and shape: when body x surrounds body y, if x moves away taking its surface with it, that doesn't mean that y changes its place, provided that it keeps the same position relative to external bodies that are regarded as immobile. Consider a ship on a river being pulled one way by the current and in the opposite direction by the wind, so that it doesn't change its position relative to the banks; we'll all agree 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's no difference between •the extension of a space or internal place and •the extension of a body. A body's being extended in length, breadth and depth is enough to establish that it is a substance, because it's a flat-out contradiction to suppose that a *nothing* could have length, breadth and depth. And the same line of argument applies to any space that is supposed to be a vacuum, concluding that since there is extension in the space there must necessarily be substance in it as well.

17. The ordinary use of the term ‘empty’ doesn’t imply the total absence of bodies.

The term ‘empty’ in its ordinary use doesn’t refer to a place or space in which there is absolutely nothing at all, but simply to a place in which there are none of the things we think ought to be there. A water-jar is called ‘empty’ when it is 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. In the same way a space is called ‘empty’ if it contains nothing perceivable by the senses, despite its being full of created, substantial matter; that’s because normally we don’t give any thought to anything that isn’t detected by our senses. If we lose touch with what should be meant 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 at all. That would be on a par with thinking that there’s nothing substantial about the air in a water-jar because the jar is said to be ‘empty’ when it has air in it!

18. How to correct our old prejudice about absolute vacuum.

Most of us fell into this error in our early childhood. Seeing no necessary connection between a jar and the water contained in it, we thought that the water might be removed and not replaced by any other body—that God at least could bring this about. What was wrong with that line of thought? Well, although there’s no connection between •the jar and •this or that particular lot of water contained in it, there’s a very strong—indeed a wholly necessary—connection between •the concave shape of the jar vessel and •the extension—taken in its general sense—that must be contained in the concave shape. Indeed, to think of either of these:

(1) the concavity apart from the extension contained in it,

(2) the extension apart from a substance that is extended,

is just as contradictory as to think of

(3) highlands without any lowlands.

As regards **(2)**, I have made this point before: nothingness can’t have any extension! Well, then, what would happen if God took away every single body in the jar without allowing any other body to take its place? The answer has to be that in that case the sides of the vessel would be in contact. For when there is nothing between two bodies they must touch each other. And it is an obvious contradiction for them to be apart, i.e. 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. That conclusion confirms what I said about rarefaction.

So we have seen that the nature of corporeal substance consists simply in its being something extended; and its extension is just the same as what is normally attributed to space, however ‘empty’. This makes it easy to see •that no one portion of corporeal substance can possibly occupy more space at one time than at another, and hence •that rarefaction can’t occur except in the way I explained in section 6. Similarly, there can’t be more matter or corporeal substance in a box filled with gold than in the same box filled with air; because the quantity of a portion of matter depends not on its weight or hardness but solely on its extension, which is always the same for a given box.

20. Those results also prove that atoms are impossible. . .

We also know now that it's impossible for there to be atoms, i.e. bits of matter that are by their very nature indivisible. For if there were any atoms, however small, they would have to be extended; so we could *in our thought* divide each into smaller parts and hence recognize its divisibility. If something can be divided in our thought, this lets us know that it's divisible; if we judged it to be indivisible, our judgment would conflict with our knowledge. Couldn't God choose to bring it about that some particle of matter can't be divided into smaller particles? Yes, but that doesn't mean that this particle is strictly indivisible, because God could still divide it even if none of his creatures could do so. Not even God could make it indivisible by God himself, because that would involve lessening his power, and I have pointed out in section 1:60 that it is quite impossible for him to do that. So strictly speaking the particle will remain divisible, since it is divisible by its very nature.

21. . . . and that the extension of the world is indefinite. . .

We also recognize that this world—i.e. the whole universe of corporeal substance—has no limits to its extension. Given any supposed boundaries, there will always be some indefinitely extended spaces outside them—spaces that we don't merely imagine but also perceive to be . . . . real. And that means that there's corporeal substance outside them, because—as I have already shown very fully—the idea of the extension that we conceive to be in a given space *is* the idea of corporeal substance. Thus, there is corporeal substance outside any boundaries that we care to suppose, which means that the material world is indefinitely extended.

22. . . . and that the earth and the heavens are made of a single kind of matter; and that there can't be a plurality of worlds.

It's easy to see from all this that celestial matter is not different from terrestrial matter. And even if there were infinitely many worlds, they would have to be made of the very same ·kind of· matter, which means that there can't in fact be many worlds—there can only be one. For we see very clearly that the matter whose nature consists simply in its being an extended substance already occupies all the imaginable space in which 'other worlds' would have to be located; and we can't find within us an idea of any other sort of matter.

23. All the variety in matter, all the different forms it takes, depend on motion.

So the universe contains the very same matter all through, and it's always recognized as matter simply in virtue of its being extended. All the ·different· properties that we vividly perceive in it come down to its being divisible into parts that move, so that it can have all the different states that we perceive as derivable from the movement of the parts. No change in a portion of matter comes from our dividing it merely in our thought; all qualitative variety in matter comes from differences in how its parts move. Philosophers seem to have recognized this when they have said that 'motion and rest' are what drives nature—meaning by 'nature' in this context 'whatever causes all material things to take on the qualities we experience them as having'. [The sentence starting 'No change. . . ' may need to be explained. Descartes holds that whenever two portions of matter are qualitatively unalike in some way, this comes purely from differences in *structure*, i.e. in how the constituent parts of each portion are put together—for example, portion x has the structure of an array of little •spheres with liquid filling the gaps between them, while portion y has the structure of an array of little •cubes with liquid between them. How *can* there be this difference of structure? Each portion is wall-to-wall matter, with no gaps or vacua; and Descartes can't say that what marks off one sphere or cube from the surrounding liquid is that the material making up the sphere or cube is qualitatively different from the matter making up the liquid. Why not? Because this is offered as an account of *all* qualitative variety in matter; it can't help itself to some underlying qualitative variety that lies outside the scope of the explanation. Well, the various sub-portions of x and of y are conceptually different from one another: we can divide x *in our thought* into •spheres etc. and can divide y *in our thought* into •cubes etc.; but that difference is merely in our thought—it's a mere matter of how we choose to conceptually carve up x and y—it couldn't explain why or how x actually is qualitatively different from y. (Descartes: 'No change in a portion of matter comes from our dividing it merely in our thought. . . ') The only way left for him to differentiate one portion of matter from another is to suppose that they *move in different ways*, e.g. a sphere is differentiated from the liquid surrounding it by the fact that it rotates in a certain way while the liquid jigs around in a quite different way. (Descartes: '. . . all qualitative variety in matter comes from differences in how its parts move'.)]

24. What the ordinary sense of 'motion' is.

Motion, in the ordinary sense of that word, is simply the action by which a body travels from one place to another. . . . As I pointed out in section 13, a thing can be said to be changing and not changing its place at the same time; so a thing can be said to be moving and not moving at the same time. For example, a man sitting on a ship that is leaving port thinks he is moving relative to the shore which he regards as fixed; but he doesn't think of himself as moving relative to the ship, because his relations to its parts remain unchanged. We ordinarily think of motion as involving action, and of rest as the stopping of action, ·and by that standard· the man sitting on deck is more properly said to be at rest than in motion because he isn't aware of any action in himself.

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

That was about what 'motion' means in common usage; but if we want to understand what motion really actually *is* then we can say:

> A piece of matter or body *moves* if it goes from being in immediate contact with •some bodies that are regarded as being at rest to being in immediate contact with •other bodies.

I count as 'one body' or 'one piece of matter' anything that is transferred all together, even if it has many parts that are moving relative to one another. Note that motion in my account is •the transfer, not •the force or action that causes the transfer. . . . These two are usually not distinguished carefully enough. [Descartes goes on to explain what's at issue here, but he does it in too compressed a fashion. The point he wants to make is this: When something is *acting*, exerting force, or the like, it's easy to think of this action or exertion as a real thing or factor in the situation. Without endorsing that way of thinking about action, Descartes here wants to slap it down as a way of thinking about *motion*. A thing's being in motion, he says, is just a fact about the state it is in—like its being spherical. We aren't even slightly tempted to think that a thing's spherical shape is a real thing or factor in the situation!]

26. Motion doesn't require any more action than rest does.

We are gripped by a strong old prejudice that more action is needed for motion than for rest. We've been convinced of this since early childhood, because our bodies move by our will, of which we have inner awareness, but they remain at rest simply because their weight holds them to the earth, and we don't perceive the force of weight through the senses. And because weight and many other causes of which we are unaware produce resistance when we try to move our limbs, we think that more action or force is needed to start a motion than to stop one; for we equate •action with •the effort we expend in moving our limbs and moving other bodies by the use of our limbs. We'll easily get rid of this prejudice if we consider that the kind of effort we need to move external bodies is also often needed to stop them from moving, when weight and other causes aren't enough to do the job. For example, the action needed to move a boat which is at rest in still water is no greater than what's needed to stop it suddenly when it is moving. Well, anyway, not *much* greater (the difference being due to the weight of the water displaced by the ship and the viscosity of the water, both of which could gradually bring the boat to a halt).

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

I am not talking here about the action that is understood to exist in the body that starts or stops the motion, but simply about the transfer of a body, and with the absence of a transfer, i.e. rest. This transfer can't exist outside the moving body; and when there's a transfer of motion, the body is in a different state from when there is no transfer, i.e. when it is at rest. So motion and rest are just two modes of a body.

28. For a body to 'move', in the strict sense, is for there to be a change in what bodies it is in immediate contact with.

In my definition I specified that the transfer takes the moving body

> •from immediate contact with some bodies to immediate contact with others.

I did *not* say that the transfer takes the moving body

> •from one place to another.

That is because, as I explained in sections 10–14, the term 'place' has various meanings, ·so that the question of whether and how a given body is moving at a given time may have no unique answer if 'motion' is defined in terms of change of place·. But when we understand a body's motion as its transfer from being in immediate contact with certain other bodies, we have a single determinate account of whether it is moving, because the notion of 'bodies that are in immediate contact with x' is fixed, not floating and indeterminate like the notion of 'the place x is in'.

29. And motion is relative only to contiguous bodies that are regarded as being at rest.

I also specified that a body moves if it loses immediate contact (not with any bodies that it's in immediate contact with, but) with bodies that it's in immediate contact with *and that are regarded as being at rest*. Transfer, after all, is a reciprocal process: for a body x to be transferred from contact with a body y is for y to be transferred from immediate contact with x. Exactly the same force and action is needed on both sides. So if we want to characterize motion strictly in terms of its own nature, not bringing in anything extraneous, we'll have to say that when two touching bodies move apart there's as much motion in each as there is in the other. But this would clash too much with our ordinary way of speaking, ·which *does* bring in something extraneous·. We're used to standing on the earth and regarding it as at rest; and when we see (for example) a part of the earth lose immediate contact with my feet, we don't think that the earth moved!

30. When two bodies in contact with one another are separated, and one but not the other is said to move, why is this?

The principal reason for this is that our thought of something as moving is the thought of its *all* moving; and it's impossible that when I walk the whole earth is moving. [Descartes gives a rather heavy-handed explanation of why this is impossible, with help from a diagram. But its basic point is simple: if my walking eastward is said to involve the whole earth's moving westward, then what can we make of the fact that *while* I walk eastward you walk westward? We are obviously threatened with a contradiction. He continues:] Thus, to avoid too great a departure from the ordinary way of speaking, we say in this case not that •the earth moves but merely that •my feet and your feet move; and similarly in other cases. Still, let's bear in mind 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 that are in immediate contact with them, even though these are regarded as being at rest.

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

Each body has only one motion that is all its own, because it is understood to be moving away from only one set of bodies that are at rest and in immediate contact with it. But it can also share in countless other motions, by being a part of other bodies that have other motions. For example, you are walking along the deck of a ship with a watch in your pocket: the wheels of the watch have just one motion that is •only theirs, but they also •share in another motion because they're in contact with you as you walk, and they and you constitute a single piece of matter. They also •share in an additional motion through being in contact with the ship tossing on the waves, another through contact with the sea itself, and a final one through contact with the whole earth, if indeed the whole earth is in motion. Now all those motions really do exist in the wheels of the watch, but it's hard for us to hold them all in our minds at once, and indeed we can't know all of them. So we settle for confining our attention to the single motion that the given body has all to itself. [Phrases like 'all to itself' translate the Latin *proprium*, which means 'proper' in a sense of that word that is now obsolete except in the phrase 'proper name'.]

32. How the motion that any body has all to itself can be considered as a plurality of motions.

The single motion that each body has all to itself can also be seen as being made up of several motions. The wheel of a moving carriage, for example, can be seen as having a circular motion around the axle and a straight line motion along the road. ·You may want to object: 'That example is a special case. *That* movement clearly *is* a mixture of two movements; but plenty of movements are not.' Not so!· You can see that there aren't two distinct movements here from the fact that every single point on the wheel follows only one line. It's a twisted line that might still seem to you to be the upshot of several different motions, but that's not essential. Sketch for yourself a rectangle with corners labelled A and B at the top and C and D at the bottom. Think of this as representing a physical set-up in which a straight bar A-to-B moves steadily to the bottom while, in exactly that same interval of time, an object on the bar moves steadily from its A end to its B end. What line will the object follow? A straight (diagonal) line from A to D! Thus, the simplest possible motion, namely motion in a straight line, can be seen as the upshot of two straight-line movements, just as the curve followed by any point on the carriage-wheel can be seen as the upshot of a straight-line motion and a circular one. It is often useful to separate a single motion into several components in this way, so as to make it easier to grasp; but absolutely speaking only one motion should be attributed to any given body.

33. How every case of motion involves a closed loop of bodies moving together.

[In every context where this doctrine is in play, '(closed) loop' will be used to translate *circulus*. The literal meaning of *circulus* is 'circle', but in these contexts Descartes certainly didn't mean it literally.] I noted in sections 18–19 that every place is full of bodies, and that the same portion of matter always takes up the same amount of space. It follows from this that a body can move only in a closed loop of matter, a ring of bodies all moving together at the same time: a body entering a given place expels another, which moves on and expels a third body, and so on, until finally a body closes the loop by entering the place left by the first body *at the precise moment when the first body is leaving it*. It's easy to grasp this if you think of it in terms of a liquid flowing around a uniform closed-loop pipe. Now think about it in terms of liquid flowing through a closed-loop pipe that is narrower in some places than in others. Here as in the other case the liquid passing any point in the pipe during any second must have exactly the same volume as the liquid passing any other point during that second. This is achieved, despite unevennesses in the pipe's diameter, by corresponding differences in the speed with which the liquid moves at different points in its journey around the loop—the narrower the faster. So this conforms to the pattern I have described, with no need for rarefaction or condensation of any matter.

34. It follows from this that matter is divided into indefinitely many particles, though this is something we can't really grasp.

We can see *that* the liquid moves uniformly through the uneven pipe, but can't grasp exactly *how* it can do so. [The rest of this important and brilliantly insightful passage is a bit harder to understand than it needs to be. Descartes's point in it is this: At a place where the pipe changes *uniformly* from one diameter to a smaller one, the liquid has to squeeze through; this requires small parts of it to change their relations with other small parts of it. How small? Indefinitely small! If you suppose that the liquid has parts that have sizes and that can't be further divided, you won't be able to tell a story about how the liquid gets itself along a *continuously* narrowing length of pipe. Now let Descartes take over:] It's impossible for the liquid that now fills a wide stretch of the pipe to enter the *continuously* narrowing pipe that lies ahead unless some part of it adjusts its shape to the countless different volumes of pipe that lie ahead. And this can happen only if all the countless particles of the liquid change (ever so slightly) their positions relative to one another. This minute shifting of position is a true case of division.

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

This division doesn't have to occur all through the liquid, just in some parts of it. Some of the liquid near the centre of the stream could flow from wide-pipe to narrow-pipe without any change in how its parts are inter-related, as long as parts of the liquid out near the edge made the indefinitely many adjustments that are needed for them to fill exactly all the crevices that the nearer-to-the-centre liquid doesn't occupy. We can be sure that this indefinite division of matter does occur, because it's obvious to us that it necessarily follows from what we know for sure about the nature of matter. And we shouldn't be deterred by our inability to get our minds around *how* it occurs, because we can see that this is just the *kind* of thing that is ·bound to be· beyond the grasp of our finite minds. ·I'll come at this more directly in 3:51·.

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

So much for the •nature of motion—now for its •cause. This is a two-part story: as well as •the universal and primary cause, the general cause of all the motions in the world, there is •the particular cause that produces in an individual piece of matter some motion which it previously lacked. ·The second of these will be my topic in sections 37–53. As for the first·: It seems clear to me that the general cause is no other than God himself. In the beginning he created matter, along with its motion and rest; and now, merely by regularly letting things run their course, he preserves the same amount of motion and rest in the material universe as he put there in the beginning. ·You may want to protest: 'What's this about *amounts* of motion? We understand amounts of cheese or of water or of any other kind of substance; but you have insisted that motion is not a substance but merely a mode of a substance, a way of being that the substance has·.' Indeed, motion is simply a mode of the matter that moves; but it does have a definite quantity or amount: *how much* motion a body has at a given time is the product of its speed and its size. If x is twice the size of y, and is moving half as fast, then there's the same amount of motion in each. Now, the size of a body can't change, but the speed can; and we can easily understand the 'constancy of total motion thesis' through the thought that as some bodies speed up others correspondingly slow down. ·Why should we believe this thesis?· Because we understand that God's perfection involves his never changing in himself *or in his ways of operating*. Well, there do occur ·miracles·—changes in God's ways of operating—whose occurrence we know about from our own plain experience or from divine revelation; but our seeing or believing that these occur doesn't involve our thinking that God himself changes. And apart from those special cases we shouldn't suppose that any other changes occur in how God operates, because that might suggests some inconstancy in God. So it is absolutely reasonable for us to think that because •God set the parts of matter in motion in various ways when he first created them, •he now keeps the material world going in the same way (and by the same process) as when he originally created it, always preserving the same quantity of motion in matter.

37. The first law of nature: each thing when left to itself continues in the same state; so any moving body goes on moving ·until something stops it·.

From God's unchangingness we can also know certain rules or laws of nature, which are the secondary and particular causes of the various motions we see in particular bodies. ['Secondary': derived from God's actions, not •primary as his causation is. 'Particular': each concerned with some relatively specific kind of physical set-up, not bearing on the material world in •general, as God's action is.] The first of these laws is that each simple and undivided thing when left to itself always remains in the same state, never changing except from external causes. A cubic piece of matter will remain cubic for ever unless something from outside it changes its shape. If it is not moving, I maintain that it will never move unless something pushes it. And if it is moving, there's no reason to think it will ever slow down or stop of its own accord and without being blocked by something else. But the composition of the earth on which we live brings it about that all motions occurring near it are soon stopped, often by causes undetectable by our senses; and that's why it is that right from our infancy, seeing motions that were stopped by causes unknown to us, we have thought that they stopped of their own accord. This has produced a tendency to believe that what we have apparently experienced in many cases holds good in all cases—namely that it's in the very nature of motion to come to an end, or to tend towards a state of rest. This old prejudice is of course utterly at variance with the laws of nature. Rest is the contrary of motion, and nothing can *by its own nature* tend towards its contrary, i.e. tend towards its own destruction.

38. The motion of projectiles.

In fact our everyday experience of projectiles confirms this first rule of mine. If you discard the rule, you'll have no explanation for the fact that a javelin continues to fly through the air after leaving the hand that throws it. The javelin does eventually slow down, but that's because of the resistance of the air. *Does* air offer resistance? You know it does! Beat the air with a fan, or look at birds in flight! This general explanation for something's slowing down applies to every other case as well, often through a medium that is more obviously resistant than air is.

39. The second law of nature: each moving thing if left to itself moves in a straight line; so any body moving in a circle always tends to move away from the centre of the circle.

The second law is that every piece of matter . . . . tends to continue moving in a straight line. This is true despite •the fact that particles are often deflected by collisions with other bodies, and •the fact (noted in section 33) that when anything moves it does so as part of a closed loop of matter all moving together. The reason for this second rule is the same as the reason for the first rule, namely the unchangingness and simplicity of the operation by which God preserves motion in matter. [Descartes's way of linking this with the second law is harder than it needs to be, because it is so compressed. Its central thesis is the proposition P:

> •When God preserves the motion of a particle, he preserves *now* the motion that it has *now*, without attending to how it was moving a moment ago.

Actually, Descartes admits, in a single instant of time—a single *now*—no motion at all can occur, which means that P can't be quite what he wants. But he holds to its 'no attention to the immediate past' part of it, and contends that this has the upshot that God will always maintain, in each separate uninterfered-with particle, motion in a straight line and never in a curve. He illustrates this with the example of a stone being whirled around in a sling, using a rather complex diagram that we don't need. He says:] When a stone is rotated in a sling, whirling around in a circle, at any given instant in its journey the stone is inclined to leave the circle and move along its tangent—·so that (for instance) at the bottom-most point of the circle it is inclined to shoot off straight ahead, parallel with the ground·. The suggestion that it is inclined at each instant to move in a circle is an impossible story: it involves the thought that the stone will be inclined to *go on moving in a circle*, but at any given instant the fact that it *has been* moving in a circle is a fact purely about the past; it's absurd to think that that past circular motion is somehow still with the stone, still in the stone, at this instant. And we know from experience that at the instant the stone is released from the sling, it shoots off in a straight line. So there we have it: any body that is moving in a circle constantly tends to move away from the centre of the circle that it is following. Indeed, when we are whirling the stone around in the sling, we can *feel* it stretching the sling and trying to move away from our hand in a straight line. I shall often make use of this point in what follows, so it should be noted with care. I'll explain it more fully later.

40. The third law: (a) if one body collides with another that is stronger than itself, it loses none of its motion; (b) if it collides with a weaker body, it loses the same amount of motion that it gives to the other body.

The third law of nature is this: **(a)** when moving body x collides with body y, if x's power of continuing in a straight line is less than y's resistance, x is deflected so that it moves in a new direction but with the same quantity of motion; but **(b)** if x's power of continuing is greater than y's resistance, x carries y along with it, and loses as much motion as it gives to y. Thus we find that when a hard projectile hits some other hard body, it rebounds in the contrary direction; whereas when a hard projectile encounters a soft body, it is immediately transfers all its motion to the soft body and comes to a halt. All the particular causes of the changes that bodies undergo are covered by ·one or other part of· this third law—or anyway all *corporeal* causes; I'm not here considering what (if any) powers to move bodies may be possessed by the minds of men or of angels. I'll come to that topic in a treatise *On Man* which I hope to produce.

41. Proof of part (a) of the third law.

(a) is proved by the fact that there is a difference between •how much a thing is moving and •in which particular direction it is moving; because the direction can be altered while the motion remains constant. As I said in section 37, anything that is not composite but simple, as motion is,always stays in existence and in the same intrinsic state as long as it isn't destroyed ·or altered· by an external cause. Now, if one body x collides with a hard body y that it can't push aside, y's resistance provides an obvious reason why x's motion won't continue in the same direction ·that it had before the collision·, but there's no reason why its motion should be stopped or reduced in amount, because it isn't removed by y or by any other cause, and because one motion is not the contrary of another motion. It follows, then, that x's motion ought not to diminish at all. [Descartes's puzzling clause about contrariety connects with his thesis (sections 37 and 44) that the contrary of motion is not motion but rest. This isn't really a *reason for* the thesis that x's motion isn't diminished; at most it's a reason for saying that that thesis is *consistent with* x's changing direction by 180º—i.e. a reason for the rather tame point that the reverse-direction motion doesn't quantitatively cancel out the pre-collision motion.]

42. Proof of part (b) of the third law.

(b) is proved from the unchangingness of God's ways of operating, •keeping the world in existence by the very same ·kind of· action through which he •brought it into existence in the first place. From the fact that the whole of space is filled with bodies and that every single body tends to move in a straight line, it's clear that when God created the world he didn't just •give various motions to different parts of the world but also •set up all the collisions and transfers of motion between the parts. Thus, since God preserves the world by the same ·kind of· action and in accordance with the same laws as when he created it, the motion that he preserves is not permanently fixed in each piece of matter but transferred from one piece to another when collisions occur. Thus the continual changes in the created world are evidence that God doesn't change at all.

43. The nature of the power that all bodies have to act on or resist other bodies.

What constitutes the *power* that any given body has to act on, or resist the action of, another body? It consists simply in the fact that everything tends (when left to itself) to persist in the same state, as laid down in the first law [section 37]. Thus

- •what is joined to something else has some power to resist being separated from it,
- •and what is separated from something has some power to remain separate,
- •what is not moving has some power to remain so, and thus to resist anything that may start it moving, and
- •what is moving has some power to persist in its motion, i.e. to continue to move with the same speed and in the same direction.

How much power a body x has to persist in its motion ·after a collision· is to be measured by •x's size, •the size of the surface that separates x from other bodies, •how fast x is moving, •the kind of collision that is involved and •the degree of contrariety to x's moving it involves.

44. The contrary of motion is not some other motion but a state of rest; and the contrary of a given direction of motion is motion in the opposite direction.

One motion is in no way contrary to another motion of equal speed. There are really only two sorts of contrariety to be found here. One is that between

•motion and •rest,

which brings with it the contrariety between

•speed and •slowness

(because slowness shares something of the nature of rest). The second is the contrariety between

•the direction in which a thing x is moving and •a collision that x enters into with another body that is at rest or moving in another direction.

How great this ·second· contrariety is depends on the direction in which x is moving when the collision occurs. [Descartes really does •say (in the summary) that motion in a certain direction is contrary to movement in the opposite direction, and then •say (in the body of the section) that motion in a certain direction is contrary to *a collision*. This oddity is there in the Latin, and is not an artifact of this version. The French version is incomprehensible.]

45. Rules will be given for calculating how much the motion of a given body is altered by collision with other bodies.

For us to use these results to work out how individual bodies speed up, slow down, or change direction as a result of collision with other bodies, all we need is •to calculate the power each body has to produce or resist motion, and •to accept as a firm principle that the stronger power always produces its effects. This would be easy to calculate for the special case of

•a collision between two perfectly hard bodies isolated from other bodies that might affect the outcome.

In that class of special cases the following rules would apply.

46. The first rule.

When two perfectly hard bodies, x and y,

•of the same size

•moving at the same speed

•in opposite directions along a single line

collide head-on, they will come out of the collision still moving at the same speed with the direction of each precisely reversed.

47. The second rule.

When two perfectly hard bodies, x and y, of which

•**x is slightly larger than y**,

•moving at the same speed

•in opposite directions along a single line

collide head-on, they will come out of the collision still moving at the same speed as before, both moving in the direction in which x had been moving before the collision; that is, y would bounce back but x wouldn't.

48. The third rule.

When two perfectly hard bodies, x and y,

•of the same size,

•**x moving slightly faster than y**,

•in opposite directions along a single line

collide head-on, they will come out of the collision both moving in the direction in which x had been moving before the collision, and moving at the same speed as one another, which means that some of x's speed will have been transferred to y. This transfer will have to happen, because x can't continue moving faster than y, since y is ahead of it.

49. The fourth rule.

When two perfectly hard bodies, x and y,

- **x slightly smaller than y**,
- **x moving and y entirely at rest**

collide, they will come out of the collision with x moving in the opposite of its previous direction. [Descartes follows this up with some complex argumentation which is more trouble than it is worth philosophically. The core of it is the claim that just because y is larger than x there must be 'more force in y to resist than in x to push on, however fast x is moving'.]

50. The fifth rule.

When two perfectly hard bodies, x and y,

- **x slightly larger than y**,
- x moving and y entirely at rest

collide, they will come out of the collision with x continuing to move in the same direction, taking y with it by transferring to y as much of its motion as is needed if they're to have the same speed. [Again Descartes argues for this in some detail, insisting that this rule holds good however slowly x is moving, because:] it is impossible for x to have so little force that it couldn't move y, because weaker motions must observe the same laws as stronger ones, and must produce proportionally the same ·type of· result. We often think we see the opposite on this earth, but that's because of the air and other fluids that always surround solid moving bodies and can greatly increase or decrease their speed, as we'll see later.

51. The sixth rule.

When two perfectly hard bodies, x and y,

- **of the same size**,
- x moving and y entirely at rest

collide, they will come out of the collision with •y to some extent driven forward by x and •x to some extent driven back in the opposite direction by y. [Descartes's argument for this has at its core:] Since x and y are equal ·in size·, so that there's no more reason for x to bounce back than there is for it to move y, it is obvious that these two effects must be equally shared—x must transfer half of its speed to y while retaining the rest and moving in the opposite of its previous direction.

52. The seventh rule.

When two perfectly hard bodies, x and y,

- **x smaller than y,**
- **travelling in the same direction along the same straight line,**
- **x moving faster than y,**

so that they collide when x catches up with y, there are three different upshots that such a collision might have, depending on whether the amount by which x's speed exceeds y's is

(1) greater than,
(2) less than, or
(3) exactly the same as

the amount by which y's size exceeds x's. In case **(1)**, x will transfer to y as much of its speed as is needed for them then to move at the same speed in the same direction. In case **(2)**, x will be driven back in the reverse of its previous direction, and will retain all its motion. In case **(3)**, x must transfer some of its motion to y and bounce back with the rest. . . . These matters don't need proof because they are self-evident.

53. It is hard to apply these rules because each body is in contact with many others all at once.

In fact, experience often seems to conflict with the rules I have just expounded, but it's obvious why this is so. To calculate how a collision affects the motion of a given body is much harder than those rules would suggest, because the rules are stated for colliding pairs of bodies that are •perfectly hard and •completely isolated from all other bodies; and no bodies in our part of the universe satisfy either of those conditions. Thus, to find out whether the given rules are observed in collisions of the sorts that actually occur, we have to take into account all the other bodies that are touching the colliding pair on every side, and how hard or fluid they are. Our next task is to look into what difference hard/soft makes to the outcomes of collisions.

54. What hard bodies are, and what fluid bodies are.

The evidence of our senses tells us that fluids are bodies whose parts easily move about, so that they don't resist ·much· when we put our hands into them; whereas the parts of hard bodies hold onto one another in such a way that it takes force to separate them. What brings it about that some bodies do,while others don't, readily give way to other bodies? It's easy to see that a body x already in motion doesn't prevent another body y from occupying the place that x is spontaneously leaving, ·i.e. leaving without being pushed out·; and that a body at rest can't be expelled from its place except by some force coming from outside, making it move. So this lets us infer that •fluids are bodies whose numerous tiny particles are agitated, moving in all directions, and that •hard bodies are ones whose particles are all at rest relative to each other.

55. The only 'glue' binding the parts of hard bodies together is the simple fact that they are at rest relative to each other.

We can't think up any glue that could bind the particles of two bodies any more firmly than they are fixed just by being at rest. What could such a glue be? It couldn't be a •substance, because ·for *any* substance the question arises as to what makes *its* parts stick together, and for a substantial glue· the question would arise about what made its outer parts stick to the bodies it was supposed to join. And if the 'glue' is a •mode, it must be the mode *being-at-rest*. What mode could be more contrary to the *being-in-motion* that would separate the particles than their being at rest? And ·that ends the discussion, because· we don't recognize any categories of things except •substances and their •modes.

56. The particles of fluid bodies move with equal force in all directions. And if a hard body is immersed in a fluid, the smallest force can get it moving.

The agitated particles of fluids are too small for us to observe them, but we can easily infer from their effects how they move. This holds especially for air and water, because they corrupt many other bodies [= 'make other bodies turn rotten or rusty in some other way spoiled']; corrupting is *acting* in a certain way; and no corporeal action can occur without motion. Yet there is a difficulty here, because the particles of fluids can't all move at the same time in every direction, which seems to be what's needed if the particles aren't to impede the movement of bodies coming from any direction. [Descartes's solution of this 'difficulty' is just to suppose that the particles of a fluid that hit on the surface of a hard body immersed in the fluid come from every direction and in equal quantity (presumably meaning: with equal force), so that they cancel out: if the hard body is motionless, it will remain so. If it receives even a faint push in one direction from something other than the particles of the fluid, that push will co-operate with the fluid-particle-pushes in that same direction, and the body will move. Descartes presents all this at some length, bringing in his theses that •rest is the contrary of motion and •that unimpeded motion always goes in a straight line; but none of this contributes to his basic solution of the announced 'difficulty'.]

57. The proof of the above.

[This long, strange section is less a demonstration than a clarification—'in order that this may be more clearly understood', as Descartes says. What it does, basically, is to take us again through the line of thought in section 56, this time presenting it in terms of what happens to various named individual particles of the fluid. Having done that, Descartes goes on to say that essentially the same story holds for all the particles of the fluid, and that even if none of them move in exactly the ways he has supposed for purposes of this illustration, they do move in *some* way whose over-all result is that any particles driving the hard body in one direction 'are opposed by an equal number driving it in the opposite direction'. This is just section 56 all over again.]

58. If any particles of a fluid move more slowly than a hard body that is immersed in it, the fluid in that area doesn't behave as a fluid.

Take the case ·mentioned in section 56·, where a hard body x immersed in a fluid moves in a certain direction because it is pushed that way by something y other than the particles of the fluid. The thesis •that y needn't exert much force on x to make it move was based on the idea •that the various pushes by the particles of the fluid cancel out, leaving y's effect on x unopposed. But if in the path of x there are fluid-particles moving in the same direction as x *but more slowly*, they will be an obstacle to y's moving of x in that direction, because some of y's force will be used up in pushing these slower particles to move faster or get out of the way. In that sense, the fluid that lies in the path of x doesn't behave in the typical fluid way. This explains why we often see that air, water, and other such fluids put up a lot of resistance to bodies that are moving very rapidly through them, yet yield without any difficulty to the same bodies when they are moving more slowly.

59. If a hard body x is pushed by another hard body y, x doesn't get all its ·post-collision· motion from y; it gets some of it from the surrounding fluid.

[This short section repeats and lightly illustrates the thesis announced in the above summary of section 56.]

60. But the fluid can't make x move faster than it would have moved if it had had only the hard body y pushing it along.

[Descartes's explanation of this, which he says also explains a detail—not included in this version—in a previous section, is just what we would expect. All the motions of the fluid-particles are used up, so to speak, just in counteracting one another; the only uncounteracted force acting on x is the push from y.]

61. When a fluid body is moving, as a whole, in a given direction, it necessarily carries with it any hard body that is immersed in it.

[Descartes's defence of this amounts to the following. His account of how

> an unmoving hard body immersed in a fluid is held in a kind of equilibrium by the fluid particles' pushing it in all directions and cancelling one another out

holds good whether or not the surrounding fluid is itself involved in a linear movement of the whole in addition to the every-which-way movements of the individual particles.]

62. When a hard body is carried along by a fluid in this way, that doesn't mean that it is itself in motion.

According to the absolute and true nature of motion, a body x *moves* when it is transferred out of the vicinity of the bodies y, z, etc. that it is in immediate contact with [see section 25]. When this happens, it's equally correct •to say that x moves and •to say that y, z, etc. move, though we don't usually talk in that way. [From here to the end of the section this version expands Descartes's cryptic words in ways that the ·small dots·

convention can't easily indicate. Some of the expansion is warranted by the French version, which Descartes probably approved.] Consider two scenarios involving a hard body x:

> **(1)** x is swept along by the current of the fluid it is immersed in.
>
> **(2)** x resists the current of the fluid it is immersed in, allowing it to flow on past it.

At a very superficial level we want to say that in **(1)** x moves while in **(2)** it doesn't; but when we focus on the really strictly correct way of talking about motion, we can see quite plainly that it is more correct to say that x moves in **(2)** than to say that it moves in **(1)**, because it's in **(2)**—not **(1)**—that x leaves the vicinity of the particles of matter that it was in immediate contact with.

63. Why some bodies are so hard that, despite their small size, we can't easily break them with our hands.

We know from experience that in many bodies that are much smaller than our hands, the particles are so strongly stuck together that we can't get enough force into our hands to break them apart. This looks like a flat refutation of the rules of motion that I presented a few sections back. Consider any small, very hard body, such as an iron nail. Its parts are joined together, and ·according to me· all that holds them together is their being contiguous and *at rest* [section 55]; and according to my fifth rule [section 50], any motionless body can be set in motion by a moving body which is larger than itself. Putting those two together, we get a result that seems to fly in the face of experience, namely that we can easily snap an iron nail into two with our hands. How does that seem to follow? Well, the nail can be thought of as two half-nail bodies held together by their being •in contact and •at rest; our hand is much larger than either half-nail, so it ought to be able easy to start one of the half-nails moving, thus breaking the two apart. But to see why that doesn't follow, after all, consider this: Our hands are very soft, more like water than like nails; and for that reason they don't get to act *as a whole* against a body that they are engaged in moving—only that part of our hand that touches the body brings all its pressure to bear upon it at the same time. Just as we have thought of the nail as two half-nails, and have discussed the attempt to move *one* of them, we are equally entitled to think of (say) your right hand as comprised of two bodies, **(a)** the part of the hand that is in immediate contact with the nail, and **(b)** the rest of your hand. Now, **(a)** is much *smaller* than the nail. Also, it is easier for **(a)** to be pulled apart from **(b)** than it is for the two half-nails to be pulled apart, and the separating of **(a)** from **(b)** is a painful process; and those facts explain why we can't break the nail in our hands. If we strengthen our hand by using a hammer, file, pair of cutters, or other tool larger than the half-nail that is to be moved, it will be easy to overcome the nail's hardness and pull the two half-nails apart.

64. Geometry and pure mathematics provide me with the only principles I need in my physics, and the only ones I'll accept. They explain all natural phenomena, and provide us with quite certain demonstrations regarding them.

I shan't go on here about shapes and the countless different effects they have on how things move. When it's time for me to deal with them, these matters will be quite clear in themselves. I am assuming that you already know the basic elements of geometry, or are intellectually capable of understanding mathematical demonstrations. For I freely acknowledge that the only *matter* that I recognize in corporeal things is whatever can be •divided, shaped, and moved in every possible way—which is what geometers call 'quantity' and take as the object of their demonstrations. Furthermore, the only aspects of this *matter* that I shall take into account are just these •divisions, shapes and motions; and even with regard to them I won't admit as true anything that hasn't been drawn from indubitable common notions in such an evident manner that it's fit to be regarded as a mathematical demonstration. And because all natural phenomena can be explained in this way, as you'll see later, I don't think that any other principles are either admissible or desirable in physics.