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.

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Contents

Part 1: The principles of human knowledge

1. The seeker after truth must once in his lifetime doubt everything that he *can* doubt.

We're bound to have many preconceived opinions that keep us from knowledge of the truth, because in our infancy, before we had the full use of our reason, we made all sorts of judgments about things presented to our senses. The only way to free ourselves from these opinions, it seems, is just once in our lives to take the trouble to doubt everything in which we find even the tiniest suspicion of uncertainty. [Here and throughout this work, 'preconceived opinion'—following Cottingham's translation—translates *praejudicatum*. Sometimes, for a change, it will be translated as 'prejudice', but always meaning something believed in advance, believed long ago and then hung onto. It lacks much of the force of 'prejudice' as we use that word today.]

2. What is doubtful should even be considered as false.

It will be useful ·to go even further than that·: when we doubt something we should think of it as outright *false*, because this will bring more thoroughly into the open truths that are certainly true and easy to know.

3. But this doubt shouldn't be carried over into everyday life.

While this doubt continues, it should be kept in check and used only in thinking about the truth. In ordinary practical affairs we often have to act on the basis of what is merely probable, not having time to hold off until we could free ourselves from our doubts. Sometimes we may—·for practical reasons·—even have to choose between two alternatives without finding either of them to be more probable than the other.

4. The reasons for doubt regarding sense-perceptible things.

When we're focussed on the search for truth, we'll begin by doubting the existence of the objects of sense-perception and imagination. There are two reasons for this. **(1)** We have occasionally found our senses to be in error, and it's not wise to place much trust in anyone or anything that has deceived us even once. **(2)** In our sleep we regularly *seem to* see or imagine things that don't exist anywhere; and while we are doubting there seem to be no absolutely reliable criteria to distinguish being asleep from being awake.

5. The reasons for doubting even mathematical demonstrations.

We'll also doubt other things that we used to regard as perfectly certain—even rigorous mathematical proofs, even principles that we used to regard as self-evident. ·There are two reasons for this too·. **(1)** We have sometimes seen other people make mistakes in such matters, accepting as utterly certain and self-evident propositions that seemed false to us. **(2)** More important: we have been told that we were created by a God who can do anything. Well, for all we know he may have wanted to make us beings of such a kind that we are *always wrong* in our beliefs, even ones that seem to us supremely evident. ·This may seem extravagant, but it shouldn't be brushed aside·. We have encountered *some* cases of error about something of which the person was perfectly certain, and it's equally possible that certainty is *always* accompanied by error. 'Mightn't we have been brought into existence not by a supremely powerful God but by ourselves or by some other creator?' Yes, but the *less* powerful our creator is, the *more* likely it is that we're an imperfect product that is deceived all the time!

6. We have free will, enabling us to avoid error by refusing to assent to anything doubtful.

Still, whoever created us and however powerful and however deceitful he may be, we experience within ourselves a *freedom* to hold off from believing things that aren't completely certain and thoroughly examined. So we can guard ourselves against ever going wrong.

7. We can't doubt that we exist while we are doubting; and this is the first thing we come to know when we philosophize in an orderly way.

In rejecting everything that we can in any way doubt, even pretending to think it false, we can easily suppose that there's no God and no heaven, that there are no bodies—so that we don't *have* bodies, hands and feet and so on. But we can't suppose that we, who are having such thoughts, are nothing! 'At a time when I am thinking, I don't exist'—that's self-contradictory. So this item of knowledge—*I'm thinking, so I exist*—is the first and most certain thing to occur to anyone who philosophizes in an orderly way.

8. In this way we discover how soul and body differ, i.e. what the difference is between a thinking thing and a corporeal one.

This is the best way to discover what sort of thing the mind is, and how it differs from the body. How does it do that? [Descartes answers this in terms of 'we'; this version uses the singular 'I' just for clarity's sake.] Well, here I am supposing that everything other than myself is unreal, while wondering what sort of thing I am. I can see clearly that *I* don't have any of the properties that bodies have—I don't have a spatial size or shape, and I don't move—because those properties all fall on the supposed-to-be-unreal side of the line, whereas we've just seen that I can't suppose that *I* am unreal. So I find that the only property I can ascribe to myself is *thought*. So my knowledge of my thought is more basic and more certain than my knowledge of any corporeal thing.

9. What is meant by 'thought'.

I take the word 'thought' to cover everything that we are aware of as happening within us, and it counts as 'thought' *because* we are aware of it. That includes not only understanding, willing and imagining, but also sensory awareness. ·To see some of the force of this, let's connect it with the thought-experiment I conducted in section 7·. Consider these two inferences:

I am seeing, therefore I exist.
I am walking, therefore I exist.

If I am using 'seeing' and 'walking' to name bodily activities, then neither inference is secure, because I might think I am seeing or walking in *that* sense at a time when my eyes are closed and I'm not moving about (this happens in dreams); I might even think that I am seeing or walking at a time when I don't have a body at all. But if I use 'seeing' and 'walking' as labels for the actual *sense of* or *awareness of* seeing or walking, then the inferences are perfectly secure, because they don't go beyond the mind, which senses or thinks that it is seeing or walking.

10. Logical definitions for very simple and self-evident matters only make them more obscure. Don't think of •such items of knowledge as hard to discover.

I'm not going to explain many of the other terms (·in addition to 'thought'·) that I have already used or will use later on, because they strike me as being sufficiently self-explanatory. I have often noticed that philosophers make the mistake of trying to explain things that were already very simple and self-evident, by producing logical definitions that make things worse! When I said that the proposition *I am thinking, therefore I exist* is 'the first and most certain thing to occur

to anyone who philosophizes in an orderly way', I wasn't meaning to deny that one must first know •what thought, existence and certainty are, and know •that it's impossible for something to think while it doesn't exist, and the like. But these are utterly simple notions, which don't on their own give us knowledge of anything that exists; so I didn't think they needed to be listed.

11. How our mind is better known than our body.

The knowledge of our mind is not simply prior to and **(1)** more certain than the knowledge of our body, but is also **(2)** more evident. [Descartes is here distinguishing **(1)** being rightly sure that P is true from **(2)** having a good grasp of *why* P is true.] To see why this is so, we need to take account of something that the natural light clearly shows us, namely that *nothingness doesn't have any attributes or qualities*. This implies that wherever we find some attributes or qualities there must be some thing or substance that they belong to; and the more attributes we discover in a single •thing or substance the more brightly open is our knowledge of •it. Well, we find more attributes in our mind than in anything else, because anything that gives me knowledge of something other than myself *has to* lead me to a much surer knowledge of my own mind. For example, if I think that the earth exists because I touch it or see it, this very fact supports even more strongly my belief that my mind exists; because my basis for thinking that the earth exists is compatible with the earth's not existing, but it isn't compatible with my mind's not existing! And that's just one example out of many.

12. Why not everyone knows this.

Some philosophers don't see this, but that's because they haven't done their philosophizing in an orderly way, and haven't carefully enough distinguished the mind from the body. They may have been more certain of their own existence than of the existence of anything else, but they haven't seen that this certainty required that 'they' were *minds*. Instead of that, they thought that 'they' were only bodies—the bodies that they saw with their eyes and touched with their hands, the bodies that they wrongly credited with the power of sense-perception. *That*'s what prevented them from perceiving the nature of the mind.

13. The sense in which knowledge of everything else depends on knowledge of God.

So the mind, knowing itself but still in doubt about everything else, casts about for ways to extend its knowledge. •First, it finds within itself ideas of many things; and it can't be mistaken about these ideas, as distinct from other things that may resemble them, ·i.e. other things that they may be ideas *of*·. •Next, it finds ·within itself· certain 'common notions', from which it constructs various proofs; and while it is attending to them the mind is completely convinced of their truth. [The phrase 'common notion' is an unavoidable translation of Descartes's *communis notio*. It's a technical term, referring not to notions or ideas but to whole propositions, specifically ones that are elementarily and self-evidently true. See section 49.] For example, the mind contains ideas of numbers and shapes, and also has such common notions as:

•If you add equals to equals the results will be equal;

from which it's easy to demonstrate that *the three angles of a triangle equal two right angles* and the like. So the mind will be convinced of the truth of this conclusion and others like it, for as long as it is *attending to* the premisses from which it deduced them. But it can't attend to them all the time, and ·during times when it is not doing so, doubts can start up again·. At such a time, the mind can think like this:

> 'I still don't know that I wasn't created with a nature that would make me go wrong even in matters that

seem to me most evident, so it's right for me to doubt such conclusions.'

So it's not possible for the mind to have certain knowledge ·that will remain certain even when the basis for it isn't being kept consciously and attentively in mind·—it's not possible, that is, until the mind comes to know the Author of its being.

14. Necessary existence is included in our concept of God—from which it follow that God exists.

Surveying its various ideas, the mind finds one that stands out from all the others—it's the idea of a supremely intelligent, supremely powerful and supremely perfect being. And unlike other ideas that convey at most that the things they are ideas of *may* exist *contingently*, this idea of God is clearly seen by the mind to involve God's *necessarily* existing *eternally*. ·There's nothing weird or deviant about inferring God's existence from the idea of God·. When the mind sees that the idea of *triangle* contains having-three-angles-equal-to-two-right-angles, it becomes convinced that any triangle *does* have three angles equalling two right angles. And the mind is arguing in the same way when, seeing that the idea of *supremely perfect being* contains existing-necessarily-and-eternally, it concludes that a supreme being *does* exist ·necessarily and eternally·.

15. None of our other concepts contains necessary existence in this way. All they contain is contingent existence.

The mind will be encouraged to accept this result if it considers that it can't find within itself any other idea that contains necessary existence in this way. And this leads it to grasp that the idea of a supremely perfect being, far from being something fanciful that the mind has invented, is ·a representation of· a true and immutable nature that can't not exist, since necessary existence is contained within it.

16. To some people it's not obvious that God must exist; that's because of preconceived opinions.

As I said, our mind will easily accept this if it first completely frees itself from preconceived opinions. We're accustomed to distinguishing **(1)** essence from **(2)** existence—·e.g. distinguishing **(1)** 'What makes a thing a triangle?' from **(2)** 'Are there any triangles?'·—in connection with all things other than God. We are also accustomed to sheerly *making up* various ideas of things that don't and never did exist anywhere. So at a time when we aren't focussing on ·the idea of· the supremely perfect being, we can easily suspect that the idea of God may be one of the ideas that we chose to invent, or anyway one of the ones that don't include existence in their essence.

17. The greater the representative perfection in any of our ideas, the greater its cause must be

When we reflect further on our ideas, we see that two or more ideas that aren't very different considered merely as modes of thinking [= 'psychological episodes'] may differ greatly in what they represent, i.e. what they are ideas *of*. And we also see that the greater the amount of representative perfection an idea contains, the more perfect its cause must be.

[Descartes means by

'Idea x contains perfection P representatively'

exactly the same as

'Idea x represents something as having perfection P'.

The terminology of adverbly *containing* P is potentially misleading; but we'll see in a moment that Descartes needs it for the claim he is making here to be plausible.] Suppose someone has an idea of a highly intricate machine. What caused him to have it? That's a legitimate question, which might be answered by:

'He once saw such a machine that had been made by someone else', or 'Being skilled in mechanics (or being just plain brilliant), he thought it up for himself.'

All the intricacy that the idea contains merely representatively—as in a picture—must be contained in its cause, whatever kind of cause it turns out to be; and it must be contained not merely •representatively but •actually, either straightforwardly or in a higher form.

[Three points about this paragraph: •Descartes adds '. . . at least in the case of the first and principal cause'. This seems to allow that an idea representing a certain perfection might be caused by something that has that perfection via a causal chain whose intermediate members *don't* have it; but that would destroy Descartes's argument; so perhaps it's not what he meant, though it's hard to read him any other way. Anyway, this is the only appearance of this thought, and we can safely forget it. •Descartes and others had the notion of something's having a property 'in a higher form' (Latin: *eminenter*) mainly so that, for example, God could cause something to be square or slippery without himself being straightforwardly square or slippery! •A widely misunderstood fact about Descartes's terminology: He distinguishes

(1) containing P representatively from **(2)** having P actually,

and *within* the 'actually' category he distinguishes

(2a) (actually) having P straightforwardly from **(2b)** (actually) having P in a higher form.

The trouble comes from his using one adverb, *formaliter*, usually translated by 'formally', sometimes to express **(2)** as against **(1)** and sometimes to express **(2a)** as against **(2b)**. In the present version, 'formally' will not occur.]

18. This yields a second reason for concluding that God exists.

So here we are, having within us an idea of God, or a supreme being, and we're entitled to ask 'What caused us to have this idea?' We find in the idea—·*representatively* in the idea·—such immeasurable greatness that we're convinced that it must have been placed in us by something that truly possesses the sum of all perfections, i.e. by a God who really exists. [Regarding the choice between 'God' and 'a God', or between 'the supreme being' and 'a supreme being': Latin has no such distinction. The choices made in this version express opinions about which is more suitable in the given case, but if you disagree in some cases, you won't be in conflict with the Latin.] That's because the natural light makes it very obvious not only that

•nothing comes from nothing,

but also that

•a thing can't have as its sole cause something that is less perfect than *it* is,

and furthermore that •when we have within us an idea or likeness of something, there has to be *somewhere* an original that actually has all the perfections belonging ·representatively· to the idea. And ·in the case of our idea of God· the 'somewhere' can't be inside us, because we plainly don't have the supreme perfections that our idea of God represents; so we're entitled to conclude that what does have them is something distinct from ourselves, namely God. At any rate, we can certainly infer that God *did* have those perfections when he gave us this idea; which clearly implies that he still has them.

19. Even if we don't grasp God's •nature, his •perfections have a more open place in our knowledge than anything else does.

Anyone who is used to pondering the idea of God and thinking about his supreme perfections will be sure enough about this, finding it obvious. We don't completely get our minds around these perfections, because we who are finite couldn't fully take in the nature of an infinite being; but we can understand them more vividly and clearly than we can any corporeal things. Why? Because they permeate our thought to a greater extent, being simpler and not obscured by any limitations.

20. We didn't make ourselves; God made us; so he exists.

Some people don't give any thought to this. Usually when someone has an idea of some intricate machine, he knows—·because he *remembers*·—where he got it from; but we have

always had our idea of God, so we have no memory of getting it from him, ·and one result is that for many people the question 'Where did I get this idea from?' doesn't even arise. But it *should* arise!· So let us now go on to inquire into the source of our being, given that we have within us an idea of the supreme perfections of God. The natural light makes it blindingly obvious that a thing which recognizes something more perfect than itself didn't bring itself into existence, for if it had done so it would have given itself all the perfections of which it has an idea. So the source of its being—·the cause of its existence·—must be something that does have within itself all these perfections, namely God.

21. The fact that we last through time is sufficient to demonstrate the existence of God.

To see how compelling this proof is, you have only to think about the nature of time, i.e. the nature of things' duration—specifically the fact that the parts of time are not mutually dependent .... From the fact that we exist *now* it doesn't follow that we shall exist a moment from now, unless some cause—the very one that originally produced us—continually *re*produces us, so to speak, i.e. keeps us in existence. We easily understand •that *we* have no power to keep *ourselves* in existence! Something else it is easy for us to see is •that he who has enough power to keep us in existence though we are distinct from him must be well equipped to keep himself in existence. Or rather (·to put it more accurately, and get away from this talk about *keeping* himself in existence·) he has so much power that he doesn't need anything else to keep him in existence. He is, in a word, God.

22. My way of coming to know of God's •existence brings with it a knowledge of all his •attributes (or all that can be known by the natural power of the mind).

This way of proving the existence of God—namely by means of the idea of God—has a great advantage: it gives us all the knowledge of *what he is* that our feeble nature is capable of. When we reflect on our in-born idea of God, we see that he is

> eternal, omniscient, omnipotent, the source of all goodness and truth, the creator of all things

—in short, that he has every attribute that we can clearly recognize as involving some perfection that is infinite, i.e. not limited by any imperfection.

23. God (1) is not corporeal, (2) doesn't perceive through the senses as we do, and (3) doesn't will the evil of sin.

In many things we recognize some perfection while also finding them to be imperfect or limited in some way; and none of *these* can belong to God. **(1)** ·It's a sort of perfection in bodies that they are extended in space·, but along with extension the nature of body includes *divisibility*, and since divisibility is an imperfection we can be sure that God isn't a body. **(2)** It's a sort of perfection in us that we have *sense*-perception, but this also involves the imperfection of being *acted on* by something else and thus being in states that depend on things other than ourselves. So there's no question of supposing that God •perceives by means of senses ·like ours; our account of his mental activities must be confined to saying that· he •understands and •wills. *Our* understanding and willing involve operations that are, in a way, distinct one from another; but in God there is always a single identical and perfectly simple act by means of which he understands, wills and accomplishes everything all at once. **(3)** When I say 'everything' I mean all *things*: for God doesn't will the evil of sin, which is not a thing.

24. In passing from knowledge of God to knowledge of his creation, we should bear in mind that he is infinite and we are finite.

Since God alone is the true cause of everything that does or could exist, it's clear that the best way to go about philosophizing [here = 'doing philosophy or natural science'] is to •start from what we know of God himself and •try to derive from that knowledge an explanation of the things created by him. That's the way to acquire the most perfect scientific knowledge, i.e. knowledge of effects through their causes. To minimize our chances of going wrong in this process, we must carefully bear in mind •that God, the creator of all things, is infinite, and •that we are altogether finite.

25. We must believe everything that God has revealed, even if it's more than we can get our minds around.

·Here's an example of the need for section 24's reminder·: Suppose God reveals to us something about himself or others that is beyond the natural reach of our mind—such as the mystery of the Incarnation or of the Trinity—we won't refuse to believe it although we don't clearly understand it. And we won't be *at all* surprised that our mental capacity is outstripped by much in the immeasurable nature of God and in the things created by him.

26. We should steer clear of arguments about the infinite. When we see something as unlimited—e.g. the extension of the world, the division of the parts of matter, the number of the stars, and so on—we should regard it ·not as *infinite* but· as indefinite.

That will spare us tiresome arguments about the infinite. Given that we are finite, it would be absurd for us to ·try to· establish any definite results concerning the infinite, because that would be trying to limit it and get our minds around it. When questions such as these are asked:

> Would half an infinite line also be infinite?
> Is an infinite number odd or even?

we shan't bother to answer. No-one has any business thinking about such matters, it seems to me, unless he thinks his own mind is infinite! What *we*'ll do is this: faced with something that so far as we can see is unlimited in some respect, we'll describe it not as 'infinite' but as 'indefinite'. •An example: we can't imagine a size so big that we can't conceive of the possibility of a bigger; so our answer to the question 'How big *could* a thing be?' should be 'Indefinitely big'. •Another: however many parts a given body is divided into, we can still conceive of each of those parts as being further divisible; so our answer to the question 'How many parts can a body be divided into?' is 'Indefinitely many'. •A third: no matter how numerous we imagine the stars to be, we think that God could have created even more; so we'll suppose that there's an indefinite number of stars. And the same will apply in other cases.

27. The difference between the indefinite and the infinite.

The point of using 'indefinite' rather than 'infinite' is to reserve 'infinite' for God, because he's the only thing that our understanding •positively tells us *doesn't* have any limits. The most we know about anything else is the •negative information that *we can't find* any limits in it.

28. It's not the •final but the •efficient causes of created things that we must investigate.

[In contemporary terms, that is equivalent to saying 'What we must investigate are not created things' •purposes but their •causes'.] We'll never explain natural things in terms of the purposes that God or nature may have had when creating them, [added in the French] and we shall entirely banish them from our natural science. Why? Because we shouldn't be so arrogant as to think that we can share in God's plans. We should bring

him in only as the *efficient* cause of everything that happens. He has allowed us to have some knowledge of his attributes, and we'll find that, starting from that knowledge and using our God-given natural light, we can draw conclusions about ·the causation of· events that we perceive by our senses. . . .

29. God is not the cause of our errors.

The first attribute of God that we must attend to is his being supremely truthful and the giver of all light. So 'God might deceive us' is a flat-out contradiction. And the same holds for the supposition that he might positively *cause* the errors that our experience shows us we are prone to. The •ability to deceive others may be seen as a sign of intelligence in a •man, but the •wish to deceive can only come from malice, or from fear and weakness, so it can't be a wish that •God has.

30. It follows that everything that we vividly perceive is true; and this removes the doubts mentioned earlier.

[Descartes includes under 'perception' not only perceiving by the senses but any kind of propositional thinking.] So the light of nature—our God-given faculty of knowledge—can't shine on any object that isn't true to the extent that this light reaches it, i.e. to the extent that it is vividly and clearly perceived. If the faculty that God gave us was so distorted that it took falsehoods to be truths ·even when we were using it properly·, God *would* merit the label 'deceiver'! This disposes of the worst of the doubts ·that I discussed in sections 4–5·, namely the one arising from the fear that for all *we* know we might find something to be utterly obvious and yet be wrong about it. Indeed, this argument ·from section 29· easily demolishes all the other reasons for doubt that I have mentioned. earlier. Mathematical truths should no longer be suspect, because they're utterly clear to us. As for our senses: if we notice *anything* here that is vivid and clear—whether we're awake or asleep—then provided we separate it from what is confused and obscure we'll easily recognize which are the aspects of it that may be regarded as true. I needn't go on about this here, because I have already dealt with it in the *Meditations*; and a more exact treatment of the topic would require knowledge of things that I'll be saying later on.

31. Our errors, considered in relation to God, are merely negations; considered in relation to ourselves they are privations.

Although God isn't a deceiver, we often fall into error. To understand the origin and cause of our errors, and to guard against them, we need to realize that they depend not so much on our intellect as on our will. Also, an error isn't a ·positive· *thing* that couldn't have come into existence unless God concurred in its doing so. Considered in relation to God, an error is a mere •negation, ·something that God did not prevent·, whereas in relation to ourselves, errors are privations, ·i.e. lacks of something that we ought to have·. [•'Privation' was a standard technical term. Example: not-being-able-to-see is a mere negation in a turnip, a privation in a blind man. •The root sense of 'concur' is 'go along with' or 'knowingly not prevent', but on this occasion Descartes must mean something stronger than that.]

32. We have only two ways of thinking: •perceiving with the intellect, and •willing.

The kinds of thinking that we experience within ourselves can be classified under two general headings: •perception, or the operation of the intellect, including sensory perception, imagination and pure understanding, and •volition, including desire, aversion, assertion, denial and doubt.

33. We don't commit errors except when make judgments about topics that we haven't looked into sufficiently.

Now, when we perceive something [see note at top of section 30], so long as we don't assert or deny anything about it, we avoid

error—obviously. And we equally avoid error when we confine our assertions or denials to what we vividly and clearly perceive *should* be asserted or denied. Error occurs only when we make a judgment about something without having an accurate perception of it—a common enough event!

34. Making a judgment requires •will as well as •intellect.

In order to make a judgment we must of course have some perception, so the intellect has to be involved; but the judgment itself—the assent—is an act of the will. Now, a sort of judgment can be made even when there is no complete and exhaustive perception of whatever-it-is, because we can assent to many things that we know only in a very obscure and confused manner.

35. The will has a wider scope than the intellect does, and that's why error occurs.

The perception of the intellect extends only to the few things that come before it, and they are *very* few. The will, on the other hand, can be called 'infinite' in a certain sense. That is because we realize that *we* could will anything that *anyone* could will, even God with his immeasurable will. So we have plenty of scope for •willing where we don't vividly •perceive—no wonder we go wrong!

36. Our errors can't be imputed to God.

It must emphatically *not* be supposed that God is the author of our errors because he didn't give us an omniscient intellect. It stands to reason that a created intellect is finite, and that a finite intellect has a limited scope.

37. The highest perfection of man is that he acts freely or voluntarily, and that's what makes him deserve praise or blame.

It is part of the very nature of the will to have a very broad scope; and it's a supreme perfection in man that he acts voluntarily, i.e. freely; this makes him in a special way the author of his actions and deserving of praise for what he does. We don't *praise* automata for moving in exactly the way they were designed to move, because it's necessary for them to do that. We do praise the designer for doing a good job, because in building the automata he was acting freely, not out of necessity. By the same principle, when we embrace something true, that's much more to our credit if we do it voluntarily than it would be if we couldn't help embracing it.

38. Our falling into error is bad behaviour, not the result of a bad nature. The faults of subordinates can often be attributed to their masters, but not when the master is God.

[Throughout this section, 'a cause' could instead be 'the cause'; Latin doesn't distinguish them.] Our falling into error is a defect in how we act, how we use our freedom; it's not a defect in our nature. Whether we judge correctly or incorrectly, our *nature* remains the same. It's true that God could have given us intellects so sharp that we never believed anything false, but we have no right to *demand* this of him. When one us men could but doesn't prevent some evil, we call him a 'cause' of the evil; but that way of talking about humans doesn't carry over to God; we mustn't regard him as a cause of our errors just because he could have but didn't bring it about that we never erred. Men were given power over one another to use in discouraging one another from evil; but God's power over all men is both absolute and totally free. [Those last four words gesture towards a view that Descartes expresses openly elsewhere, namely that God's actions are free even from the 'constraint' of there being better reasons for him to act in one way rather than in some other.] So we should thank him warmly for the goods he has so lavishly bestowed on us, instead of unjustly complaining that he didn't give us everything that he could have given us.

39. It's self-evident that there is free will.

There's freedom in our will, and we often have the power to give or withhold our assent at will—that's so obvious that it must be regarded as one of the first and most common notions [see note in section 13] that are innate in us. It showed up in sections 5–6 where, trying to doubt everything, we went so far as to entertain the thought of a supremely powerful creator who was trying to deceive us in every possible way. Even in the context of that supposition, we sensed within ourselves a freedom strong enough to enable us to abstain from believing anything that wasn't quite certain or fully examined. And what we saw to be beyond doubt even *then* is as self-evident and as transparently clear as anything can be.

40. It is also certain that everything was preordained by God.

Now that we have come to know God, and to see in him a power so immeasurable that we think it downright sinful to suppose that we could ever do anything that God hadn't preordained, we can easily get ourselves into a tangle if we try to reconcile •this divine preordination with •the freedom of our will, holding both things in our mind at once..

41. How to reconcile the freedom of our will with divine preordination.

But we'll get out of these difficulties if we bear in mind that our mind is finite, and that God has infinite power by which he not only knew from eternity everything that was or could be going to happen, but also willed it and preordained it. We can know enough about this power to perceive vividly and clearly *that* God has it; but we can't get our minds around it well enough see *how* it leaves men's free actions undetermined [here = 'not settled in advance']. As for our own liberty—our ability at a given moment to go *this* way or *that*—we're so intimately *aware* of this ·aspect of our nature· that we see it as clearly and comprehend it as fully as we do anything. When something is as intimately and securely grasped as that, it would be ridiculous to *doubt* it just because we don't grasp something else—·namely its relation to God's powers of knowledge·—that we know must by its very nature be beyond our comprehension.

42. Although we don't want to go wrong, nevertheless we go wrong by our own will.

Knowing that all our errors depend on the will, you may find it surprising that we should ever go wrong, because no-one ever *wants* to go wrong. But

> (1) wanting to go wrong

is one thing, and

> (2) choosing to assent to something that is in fact wrong, though one doesn't realize it

is quite another. No-one does (1), but (2) happens often enough with almost everyone. In fact the reason why people fall into error is that they are eager to find the truth and ignorant of the right way of finding it, which leads to their passing judgment on things that they don't properly understand.

43. We never go wrong when we assent only to things that we vividly and clearly perceive.

But if we assent only to what we vividly and clearly perceive, we'll certainly never take a falsehood to be a truth. Why 'certainly'? Because *God is not a deceiver*, so the faculty of •perception [see note in section 30] he gave us can't have a bias towards to falsehood; and that holds for our faculty of •assent (·i.e. our faculty of *judgment*·) too, provided it doesn't stray from what we have a bright, open perception of. Even if there were no proof of this, nature has shaped our minds in such a way that when we perceive something in that fashion we spontaneously assent to it and *can't* doubt its truth.

44. When we assent to something P without having a brightly open view of P's truth, this is a misuse of our ·faculty of· judgment, even if P happens to be true. Such an assent comes from our imagining that we had a good enough view of P's truth on some previous occasion.

It is also certain that when we assent to something without perceiving the reason for it, then either •we fall into error or •we stumble into something true but merely by accident, so we can't be sure that we aren't in error. The light of nature tells us not to make judgments about things we don't know, which is why we don't often assent to something that we are *aware* of not perceiving. What does very often lead us into error is this: We have a proposition committed to memory along with the belief that we did once perceive it ·adequately·; on the strength of that belief we assent to the proposition now, just as we would if we fully perceived it now; though in fact we have never perceived it, ·and it is false·.

45. What 'vivid perception' means, and what 'clear perception' means.

Many people, indeed, *never* perceive *anything* accurately enough to be able to make a judgment about it with certainty. For a perception to support a certain and indubitable judgment, it needs to be not merely •vivid but also •clear. I call a perception 'vivid' when it is present and accessible to the attentive mind—just as we say that we see something vividly when it is present to the eye's gaze and stimulates it with a sufficient degree of strength and accessibility. I call a perception 'clear' if, as well as being vivid, it is so sharply separated from all other perceptions that every part of it is vivid.

46. The example of pain shows that a perception can be vivid without being clear, but can't be clear without being vivid.

For example, when someone feels an intense pain, his perception of it is very vivid; but it isn't always clear, because people often get this perception muddled with an obscure judgment they make about something that they think exists in the painful spot—something they think resembles the sensation of pain. But in fact it is the sensation alone that they perceive vividly. Hence a perception can be vivid without being clear, but it can't be clear without being vivid.

47. In order to correct the prejudices [see note in section 1] of our early childhood we must consider the simple notions and what elements in each of them are vivid.

In our childhood the mind was so immersed in the body that it perceived many things vividly but nothing clearly. Yet the mind made judgments about many things, and that's the origin of the many prejudices that most of us cling to throughout life. To enable us to get rid of them, I shall here briefly list all the simple notions that are the basic components of our thoughts; and in each case I'll distinguish the vivid elements from those that are obscure or liable to lead us into error.

[It is time to confront the fact that Descartes's adjectives
clarus and *distinctus*
(and their French equivalents
clair and *distinct*),
translated here by
'vivid' and 'clear'
respectively, are handled differently in *every* other English translation, and by *all* the Descartes scholars who write in English. It has been assumed by all these that the right translation is
'clear' and 'distinct'
respectively. The physical similarity of the words favours the usual translation, but all the adult considerations go against it. **(1)** In ordinary English, there's no clear difference between 'clear' and 'distinct' (except in the notion, irrelevant here, of x's being *distinct from* y). In many contexts where *distinctus* occurs without *clarus*, it is natural and quite usual to translate it as 'clear'. **(2)** Descartes's separate explanations of the two words make much better sense with the present translation than

with the usual one. •Try for yourself how section 45 reads when you put 'clear' for 'vivid'. •Repeat the experiment with section 46, and ask yourself: What sane man could think there is always something *very clear* about pain? **(3)** In sections 47, 68 and 74 Descartes treats *clarus* and *obscurus* as opposites; remember that *obscurus* means 'obscure' in the sense of *dark*. The vivid/dark or bright/dark contrast makes better sense than clear/dark. Quite generally, just as Descartes customarily writes *clarus* and *distinctus* in that order, he customarily writes *obscurus* and *confusus* in that order (section 30 is an exception; see also 4:203). **(4)** The meaning of *clarus* is often—and the meaning of its French cousin *clair* is always—something like 'vivid'. You probably know this already: *au clair de la lune* means 'in the bright moonlight'; *lumière claire* is bright light.—It doesn't matter greatly, because except for these three sections of the *Principles* Descartes always treats *clarus et distinctus* as a single lump, not distinguishing its separate parts. In sections 22 and 25, and also in 2:1, *clare* is translated by 'clearly' because there is no stylistically acceptable alternative. Other uses of 'clear(ly)' in this version translate *disinctus* or some other word, but never *clarus*.]

48. The items that we can have perceptions of may be regarded either as (1) things or (2) states or properties of things or as (3) eternal truths. This section lists the things and some of the properties.

We classify the items we have perceptions of into **(1)** things, **(2)** states or properties of things and **(3)** eternal truths that don't exist outside our thought. . . . I recognize only two basic classes of things:

> **(1a)** intellectual or thinking things, i.e. ones having to do with mind or thinking substance;
>
> **(1b)** material things, i.e. ones having to do with extended substance or body.

We attribute to thinking substance: **(1a)** perception, volition and every specific kind of perceiving and of willing. We attribute to extended substance: **(1b)** size (i.e. extension in length, breadth and depth), shape, motion, position, divisibility of component parts and the like. But we also experience within ourselves certain other items that relate not to the mind alone or to the body alone, but to the close and intimate union of our mind with the body (I'll explain this later). This list includes: **(2)** •appetites like hunger and thirst; •emotions or passions of the mind that don't consist of thought alone, such as the emotions of anger, joy, sadness and love; and •all the sensations, such as those of pain, pleasure, light, colours, sounds, smells, tastes, heat, hardness and the other tactile qualities.

49. It isn't possible to give a similar list of eternal truths, but we don't need one.

Everything that I listed in section 48 is classified by us either as **(1)** a thing or as **(2)** a quality or mode of a thing. But ·other items that we perceive fall into neither of those categories·. When we recognize that

> •It is impossible for something to come from nothing,

we don't classify the proposition *Nothing comes from nothing* as **(1)** a really existing thing, or even as **(2)** a mode ·or quality· of a thing, but as **(3)** an eternal truth that exists ·only· in our mind. Such truths are called 'common notions' [see note in section 13] or 'axioms'. Here are some examples:

> •It is impossible for a thing to be and not be at the same time,
>
> •What is done can't be undone,
>
> •While someone is thinking he can't *not* exist,

and there are ever so many more. It would be hard to list them all; but ·without the help of any such list· we can't fail to know them when they come up in our thought, provided we aren't blinded by preconceived opinions.

50. Eternal truths are vividly perceived, but not by everyone (because of preconceived opinions).

In the case of these common notions, there is no doubt that

they *can* be vividly and clearly perceived; otherwise they wouldn't merit the title 'common notions'. Some of them, actually, don't merit it as well as the rest do, because not everyone perceives them as well as they do the rest. It's not that one man's faculty of knowledge extends more widely than another's, I think, but just that •the common notions in question conflict with the preconceived opinions of some people, making it harder for them to grasp •them. But those same notions are seen as utterly obvious by people who are free from such preconceived opinions.

51. What is meant by 'substance'—a term that doesn't apply in the same sense to God and his creatures.

Regarding the items that we classify as 'things' or 'qualities of things', it is worthwhile to examine them one by one. All we can mean by 'substance' is 'thing that exists in such a way that it doesn't depend on anything else for its existence'. Actually, there's only one substance that can be understood to depend on *nothing* else, namely God. We can see that all the other substances can exist only with God's help. So the term 'substance' doesn't apply in the same sense to God and to other things—meaning that no clearly intelligible sense of the term is common to God and to things he has created.

52. (1) The term 'substance' applies in the same sense to mind and to body. (2) How a substance itself is known.

(1) As for •corporeal substance and mind (i.e. created •thinking substance), they *can* be understood in terms of a single common concept, namely this one: *things that don't depend for their existence on anything except God*. **(2)** However, we can't initially become aware of a substance merely from its being something that exists, because the mere fact of its existence doesn't have any effect on us. But we can easily come to know ·that we are in the presence of· a substance by one of its attributes. This involves the common notion that *nothingness doesn't have any attributes, i.e. any properties or qualities*. If we see that we are in the presence of some attribute, this common notion entitles us to infer that we are also in the presence of some existing thing or substance that has the attribute.

53. Each substance has one principal attribute; (1) for •mind it is the attribute of •thought, (2) for body it is •extension.

A substance can be known through any attribute at all; but each substance has •one principal property that constitutes its nature and essence, all its other properties being special cases of that. **(1)** The nature of corporeal substance is *extension in length, breadth and depth*; and any other property a body has presupposes •extension as merely a special case of •it. For example, we can't make sense of *shape* except in an extended thing, or of *motion* except in an extended space. **(2)** The nature of thinking substance is *thought*; and anything else that is true of a mind is merely a special case of that, a way of thinking. For example, we can make sense of *imagination*, *sensation* and *will* only in a thinking thing, But we *can* make sense of *extension* without bringing in shape or movement, and to make sense of *thought* without bringing in imagination, sensation, or the like. Anyone who thinks hard about these matters will see that this is so.

54. How we can have vivid and clear notions of •thinking substance and of •corporeal substance, and also of •God.

Thus we can easily have two vivid and clear notions or ideas, one of •created thinking substance and the other of •corporeal substance, provided we are careful to distinguish all the attributes of thought from the attributes of extension. We can also have a vivid and clear idea of •uncreated and independent thinking substance, i.e. of God. ·There are two mistakes we must be careful not to make regarding this·. •We must avoid supposing that our idea adequately

represents the whole of God's nature; and •we must confine our idea to what we clearly perceive to belong to the nature of a supremely perfect being, not cramming into it any invented features beyond the ones that really belong there. Do we really have any idea of God? If you deny that we do, you'll have to maintain that there's absolutely no knowledge of God in the minds of men.

55. How we can also have a clear understanding of duration, order and number.

[This version of section 55 is rather free, but it expresses Descartes's line of thought faithfully enough.] We'll have a very clear understanding of **(1)** duration, **(2)** order and **(3)** number, provided we don't attach any concept of substance to them, i.e. as long as we don't think of duration, order and number as *things*. When we think about the durations that things have, or their orders, or their numbers, our thoughts are or should be of the types:

(1) that iceberg lasted for three months,
(2) the house is between the meadow and the road,
(3) there are three ships this side of the horizon.

This is to treat duration etc. as *modes* of substances—as adjectival on the substances, rather than being substances themselves.

56. What modes, qualities and attributes are.

The term 'mode' as used here means exactly the same as 'attribute' or 'quality', ·but their usage differs, as follows·. We use 'mode' when speaking of a substance as being affected or altered (·if you boil some water its heat is a mode of it·). We use 'quality' when speaking of facts about a substance that make it belong to such and such a kind (·water's fluidity is a quality of it·). And we use 'attribute' when talking in a more general way about what there is to a substance (·water's being extended in space is an attribute of it·). When we are speaking correctly we say that God has 'attributes' but not that he has any 'modes' or 'qualities', because it doesn't make sense to suggest that God might alter. . . .

57. Some attributes are in things and others in thought. What duration and time are.

Some attributes or modes are in the things they are said to be attributes or modes of, while others are only in our thought. **[**Descartes goes on to differentiate *duration* (which is in the thing that endures) from *time* (which is in our thought). His explanation and illustration of this is unmanageable, because it runs together three different ideas about 'time'. **(1)** 'Time' stands for

•measures of stretches of duration.

It seems correct to say that although the duration of a running race (for example) is a mode of or fact about the race itself, the race's *occupying less than four minutes* is a fact about how the race relates to *our* measuring system, which is in a straightforward sense 'in our mind'. **(2)** 'Time' stands for

•measured stretches of duration.

This is a more plausible account of the meaning of 'time', but it doesn't imply that *time* is 'in our minds'. **(3)** What Descartes actually says is that time is 'the measure of movement'; this seems to make 'time' synonymous with 'speed'. Somehow, it seems, a curdled mixture of **(1)** and **(3)** lies behind Descartes's inscrutable illustration: 'If two bodies are moving for an hour, one slowly and the other quickly, we don't reckon the amount of time to be different in the two, though the amount of movement may be much greater.' And a mixture of **(1)** and **(2)** probably explains his saying 'When we measure the duration of all things . . . . we call this duration "time". Yet this doesn't add anything to duration, taken in its general sense, except for a mode of thought.' The clearly true thing in this section is the statement that:**]** we assign

temporal measures to things and processes by comparing their duration with the duration of the greatest and most regular motions that give rise to years and days. [For a straight translation of this section, by John Cottingham, see page 21.]

58. Number and all universals are simply modes of thinking.

In the same way, number, when it is considered simply in the abstract or in general, and not in any created things, is merely a mode of thinking; and the same applies to all the other 'universals', as we call them.

59. How universals arise. The five common ·kinds of· universals: genus, species, differentia, property, accident.

The whole source of these •universals is this: we use a single idea for thinking of all individual items that resemble each other ·in some one respect·, that we can apply a single word to all the things that are represented by that idea, this word being a •universal term. When we see two stones, for example, and direct our attention not to their nature but merely to the fact that there are two of them, we form the idea of the number that we call 'two'; and when we later see two birds or two trees, and attend not to what they are but only to there being two of them, we return to that same idea. . . . Similarly, when we see a figure composed of three lines, we form an idea of it that we call the idea of *triangle*, and we go on to use that as a universal idea with which we represent all figures composed of three lines, ·treating triangles as a genus·. Then we notice that some triangles have one right angle while others don't, and form the universal idea of *right-angled triangle*; since this idea is a special case of the preceding one, it is called a species. What distinguishes this species from the rest of the genus is *right-angledness*, which is the differentia. Having one side whose square equals the sum of the squares on the other two sides is a property of right-angled triangles. Finally, if some right-angled ·or any other· triangle is *moving*, that is an accident of it. Hence five universals are commonly listed: genus, species, differentia, property and accident. [In this section, Descartes is using 'property' (Latin *proprium*) in a technical sense: a 'property' of the Fs, in this sense, is something that follows rigorously from the definition of F without itself being included *in* the definition. And an 'accident' of an F is a feature of it that it doesn't share with all Fs.]

60. What real distinctness is.

·My next topic connects with what I have just been talking about, namely *number*·. For there to be a number of things, the things must be *distinct from* one another; and *distinctness* is of three kinds: x may be •really distinct from y, x may be •modally distinct from y, or there may be a •distinctness of reason between x and y. [In this context, remember that 'real' comes from Latin *res* = 'thing'.] Strictly speaking, it's only substances that can be *real*ly distinct from one another. If we can vividly and clearly understand substance x apart from substance y, that tells us that x is really distinct from y. ·How does it tell us that?· Well, when we come to know God we become certain that *he can bring about anything that we clearly understand*; so that even if (for example) we don't yet know for sure that there exists any extended or corporeal substance, our having a ·clear· idea of such a substance enables us to be certain that ·God could create it, and thus that· it could exist. ·And now for some examples involving real distinctness·.We can be certain that if matter exists then every single part of a body that our thought singles out is really distinct from the other parts of the same substance. ·In case it's not obvious, here is the reasoning behind that claim. Given any part x of any material thing y, we can clearly understand a state of affairs in which x exists while the rest of y doesn't; so God could bring it about that x existed while the rest of y didn't; so x is really distinct from all the other parts of y·. Similarly, just from the fact that I ·clearly· understand myself to be

a thinking thing and can have a ·clear · thought of myself as not involving any other substance, whether thinking or extended, it is certain that I as a thinking thing am really distinct from every other thinking substance and from every corporeal substance. And of course this applies equally to *you* and to everyone. We might suppose this:

> God has joined some corporeal substance to a thinking substance like you or me, joining them as closely and tightly as any two things could possibly be joined, compounding them into a *unity*.

That could happen, but the soul and the body would still be really distinct from one another. However closely God had united them, he couldn't lay aside his previous power to separate them, keeping one in existence without the other; and things that God has the power to separate, or to keep in existence separately, are really distinct.

61. What modal distinctness is.

There are two kinds of distinctness that could be called 'modal'. **(1)** When a given substance has a certain mode ·or quality or property·, the mode is distinct from the substance—·for example, you are clever but your cleverness is not the same thing as you·. It's a characteristic mark of this kind of distinctness between x and y that x can exist without y but y can't exist without x. ·We can. for example, have a clear understanding of a state of affairs in which you exist and are not clever, but we can't make sense of the supposition that your cleverness might exist while you don't·. Thus the shape and movement of a body are modally distinct from the body itself; and affirmation and recollection are modally distinct from the mind. **(2)** One mode of a given substance is distinct from the other modes of the same substance. ·For example, you are clever and good-tempered, and these are two modally distinct qualities that you have·. It's a characteristic mark of this kind of modal distinctness between x and y that we can arrive at knowledge of x apart from y, and of y apart from x, whereas we can't know either of them apart from the substance that has them; if a cubic stone is moving, I can understand the cubic shape without the movement, and the movement without the shape; but I can't understand either that movement or that shape without the substance of the stone. . . .

62. What distinctness of reason is.

Finally, distinctness of reason ·can be either of two things·. **(1)** There is distinctness of reason between a substance and some attribute of it without which the substance is unintelligible. Consider, for example, •you and your attribute of •lasting through time. You can't exist without that attribute (for you to stop lasting through time is for you to go out of existence), so there is distinctness of reason between you and that attribute of yours. Quite generally, we recognize cases of this kind of distinctness through finding that we can't form a vivid and clear idea of the substance if we exclude from it the attribute in question. **(2)** There is distinctness of reason between any two *such* attributes of a single substance. What shows us that we are dealing with a distinctness of reason of this kind is our inability to perceive vividly the idea of one of the two attributes separated from the other. . . .

63. How thought and extension can be clearly recognized as constituting the nature of mind and of body.

Thought and extension can be regarded as constituting

> •the nature of thinking substance and •the nature of bodily substance;

and then they have to be considered as

> •thinking substance itself and •extended substance itself,

that is, as

> •mind and •body.

This will give us a very vivid and clear understanding of them. Actually, *extended substance* and *thinking substance* are easier for us to understand than is plain *substance* with 'thinking' or 'extended' left out. It's hard for us to grasp the abstract notion of *substance* with *thought* or *extension* sifted out from it, precisely because these notions are only distinct-in-reason from the notion of substance. A concept isn't made any clearer by our leaving things out of it; what makes it clearer ·to us· is our carefully distinguishing what we include from what we leave out.

64. How thought and extension may also be clearly recognized as modes of a substance.

Thought and extension can also be taken as modes of a substance, because one mind can have many different thoughts, and one body can be extended in many different ways (e.g. through changes in shape). [Descartes goes on to insist that thought be seen as something that is 'in' the substantial mind, rather than being thought of as itself a substance; and similarly for extension and the substance that *has* it. Then:] If we tried to consider thought and extension apart from the substances in which they inhere—·the substances that *have* them·—we would be regarding them as things that subsisted in their own right, and would thus be confusing the ideas of a mode and a substance.

65. How the modes of thought and extension are to be known.

There are various modes of thought such as understanding, imagination, memory, volition, and so on; and there are various modes of extension .... such as different shapes, lay-out of parts and movements of parts. And, just as with thought and extension themselves, we'll have our best understanding of these more detailed modes if we regard them simply as modes of the things that have them. As far as motion is concerned, we'll do best ·at this stage· to think of it as mere change of place, without inquiring into the force that produces the change (though I'll try to explain this later in the appropriate place).

66. How sensations, emotions and appetites can be vividly known, though we're often wrong in our judgments about them.

There remain sensations, emotions and appetites,which can be vividly perceived provided we're careful to include no more in our judgments about them than •what is strictly contained in our perception—i.e. •what we have inner awareness of. But it's hard to conform to this rule, at least with sensations, because ever since our early childhood we have all judged that our sense-perceptions are *of* things that •exist outside our minds and •closely resemble our perceptions. For example: whenever we saw a colour we supposed we were seeing a thing located outside us and closely resembling the idea of colour that we were experiencing within us. And because we had a *habit* of making such judgments we thought we saw vividly and clearly—so much so that we took it for something certain, something that couldn't be doubted.

67. We often make mistakes, even in our judgments about pain.

Everything of which we have sensory awareness is subject to this same kind of mistake—even pleasure and pain! We don't suppose that pleasures and pains exist outside us, but we do think of them as existing not purely in our mind but also in the hand or foot or in some other part of our body. [In this section 'pleasure' translates *titillatione*, which refers to such pleasures as that of slaking thirst with cold water, relieving an itch with scratching, and the like—i.e. to pleasures associated with specific parts of the body. In section 71, where the topic is pleasure in relation to the body, but not to specific parts of the body, Descartes uses a different word, *voluptas*.]

But our feeling a pain as though it were in our foot doesn't make it certain that the pain exists outside our mind and in the foot, any more than our seeing light as though it were in the sun makes it certain that the light exists outside us and in the sun. Both these beliefs are mere carry-overs from early childhood, as will become obvious below.

68. How to distinguish, in these matters, •what we brightly and openly know from •what can lead us astray.

In order to distinguish what is vivid ·or brightly lit· in this context from what is obscure ·= dark·, we must pay special attention to this: when pain and colour and their like are regarded merely as sensations or thoughts, they are vividly and clearly perceived; but when they are considered as real things existing outside our mind, we haven't the faintest idea of what sort of things they are. If someone says 'I see red in that cherry' or 'I feel pain in my wrist', all he is saying, really, is that he sees or feels something there of which he is wholly ignorant—which amounts to saying that he doesn't know what he is seeing or feeling! If he isn't thinking hard enough, he may well convince himself that he knows *something* about what he sees or feels, because he may think it is something *like* the sensation of colour or pain that he experiences within himself. But if he examines the nature of whatever it is that the sensation of colour or pain represents as existing in the cherry or his wrist, he'll realize that he is wholly ignorant of it.

69. How we know •size, shape etc. is quite different from how we know •colours, pains etc.

He'll realize this with special force if he considers the wide gap between our knowledge of

> •the features of bodies that we're vividly aware of (as I said earlier)—the size of the bodies we see, their shape, motion, position, duration, number and so on

and our knowledge of

> •the features that must be referred to the senses (as I have just pointed out)—colours, pain, tastes, smells and so on.

It's true that when we see a body, its visible colour does as much to convince us of its existence as its visible shape; but we have a much better grasp of what it is for a body to have a shape than we have of what it is for it to be coloured. Incidentally, when I write about 'motion' I mean movement from place to place. Philosophers who have fancied that there are other kinds of motion have merely made the nature of motion less intelligible to themselves.

70. There are two ways of making judgments about sense-perceptible things: one enables us to avoid error, the other doesn't.

It is evident that when we say that we perceive colours in objects, this amounts to saying that we perceive something in the objects whose nature we don't know but which produces in us a certain very obvious and easily recognizable sensation that we call the sensation of colour. But when we make our judgment, either of two *very* different things can be going on. **(1)** If we merely judge that there is in the objects (i.e. in the things, whatever they turn out to be, that our sensations come from) something whose nature we don't know, there's no error in that. Indeed it's a shield against error, because our recognition that we are ignorant of something reduces the chances of our making any rash judgment about it. **(2)** But the scene changes when we suppose that we perceive colours *in the objects*. Of course, we don't really know what it is that we're calling a colour; and we can't make any sense of the idea of something in the objects *resembling* our sensation. But we ride rough-shod over this fact; ·and there's another fact that encourages us in our error·: There are plenty of features—size, shape and number etc.—that actually *are* or

at least *could be* present in objects in the same way that we sense or understand them; and we vividly perceive this to be the case. That makes it easy for us to fall into the error of judging that so-called 'colour' in objects is exactly like the colour that we're aware of through our senses, wrongly thinking we have a brightly open perception of something that we don't perceive at all.

71. The prejudices of childhood are the chief causes of error. This is the first and main cause of all our errors. In our infancy, the mind was so closely tied to the body that it couldn't make room for any thoughts other than ones involving sensory awareness of what was happening in the body. It didn't connect these thoughts to anything outside itself, but merely felt pain when something was harming the body and felt pleasure when the body received some benefit. And when nothing very beneficial or harmful was happening to the body, the mind had various sensations corresponding to where and how the body was being stimulated—i.e. it had the sensations of tastes, smells, sounds, heat, cold, light, colours and so on, sensations that don't represent anything located outside our thought. Also in infancy, the mind perceived sizes, shapes, motions etc. that were presented to it not as sensations but as things, or qualities of things, that did or at least could exist outside thought, though the mind wasn't yet aware of the difference between things and sensations. Background to the next step: The mechanism of the body is so constructed by nature that it can move in various ways by its own power, whirling around in its attempts to pursue the beneficial and avoid the harmful. Now, the mind that was fixated on the body began to notice that the things it was trying to get or avoid had an existence outside itself; and **(1)** it credited them with having not only •sizes, shapes, motions etc., which it perceived as things or qualities of things, but also •tastes, smells etc., the sensations of which were, the mind realized, produced by the objects in question. Moreover, because it judged everything in terms of its usefulness to the body in which it was immersed, **(2)** the mind assessed the amount of reality in each object by how greatly it was affected by it. That led it to suppose that there is more substance—more *body*—in rocks and metals than in water or air. . . . Indeed, in a moderate temperature with no wind, the mind regarded the air as a mere nothing. And because the light coming from the stars appeared no brighter than that produced by the meager glow of an oil lamp, **(3)** the mind didn't imagine any star as being any bigger than this. And because it did not observe that the earth turns on its axis or that its surface is curved to form a globe, **(4)** the mind was apt to suppose that the earth is immobile and its surface flat. Right from infancy our mind was swamped with a thousand such prejudices; and in later childhood, forgetting how little basis there had been for adopting them, it regarded them as known by the senses or implanted by nature, and accepted them as utterly true and utterly obvious.

72. The second cause of error is that we can't forget our prejudices.
When we are grown up, the mind is no longer a total slave to the body and doesn't relate everything to it. Indeed, it inquires into the truth of things considered in themselves, and learns that very many of its previous judgments are false. Yet the mind finds it hard to erase these false judgments from its memory; and as long as they stay there they can cause various errors. For example, in our early childhood we imagined the stars as being very small; astronomical arguments now clearly show us that they are enormous; but our prejudice is still so strong that we can't easily imagine them differently from how we did as children.

73. The third cause of error: we find it exhausting to think about things that aren't present to our senses; so our judgments about them are usually based not on •present thinking but on •preconceived opinions.
Our mind finds it difficult and tiring to stay focussed on anything, and especially to stay focussed on things that aren't present to the senses or even to the imagination. (Why ·this bias in favour of image-bound thinking·? Perhaps it's built into the mind as a result of its being joined to the body. Or perhaps it's because the mind has had much more practice in image-bound thinking, because that's the only thinking it did in our earliest years.) One upshot of this is that many people's understanding of *substance* is still limited to what they can imagine or even to what they can perceive by their senses. They don't realize that the only things •imagination gets a grip on are ones have extension, motion and shape, and that many *other* things can be tackled through the •understanding. And they suppose further that the only independently existing things are bodies, and that all bodies can be perceived by the senses. ·This means that they turn their backs on the truth about the world, because·, as I shall make obvious later on, we don't perceive the true nature of *anything* by the senses alone! That's why most people have only confused perceptions throughout their entire lives.

74. The fourth cause of error is that we attach our concepts to words that don't precisely correspond to real things.
Language-use has us •tying all our concepts to the words used to express them, and when we store the concepts in our memory •storing corresponding words along with them. Then we find the words easier to recall than the things; and because of this our concept of a •thing is seldom sharp enough for us to separate it totally from our concept of •the words involved. Most peoples' thoughts are concerned with words more than with things; with the result that people often assent to *words*—words they don't understand—thinking that •they used to understand them, or that they got them from someone who did understand them. I can't go into this in careful detail *here*, because I haven't yet dealt with the nature of the human body—indeed I haven't proved that there are any bodies! Still, what I have said up to here may be understandable enough to help you to sort out your concepts into •those that are vivid and clear from •those that are obscure and confused.

75. Summary of the rules to be observed in order to philosophize correctly.
If we are to philosophize seriously and search out the truth about everything that *can* be known, we must first dislodge all our prejudices, or at least take care not to trust any of our old opinions without first re-examining them to check on their truth. Next, we must focus in an orderly way on the notions that we have within us, identifying the ones whose truth we vividly and clearly recognize when we focus intently on them, and accepting as true *those and only those*. By doing this ·we'll come to be in possession of some secure truths with which we can start to theorize soundly. Specifically·, we'll come to realize **(1)** that we exist as thinking beings, **(2)** that there is a God, and **(3)** that we depend on him, and also **(4)** that by attending to God's attributes we can investigate the truth about other things, because God is their cause. Finally, we'll see that we have within us, along with notions of God and of our mind, knowledge of many eternally true propositions, e.g. **(5)** that nothing comes from nothing. We'll also learn **(6)** that we have knowledge both of a corporeal or extended nature that is divisible, movable, etc. and also of certain sensations such as those of pain, colours, tastes and so on (though we don't yet know what causes them or why). When we contrast all this knowledge

with the confused thoughts we had before, we'll get the habit of forming vivid and clear concepts of all the things that can be known. These few instructions seem to me to contain the most important principles of human knowledge.

76. Divine authority must be put before our own perception; but apart from that the philosopher should give his assent only to what he has perceived.

Above all else we must impress on our memory the overriding rule that whatever God has revealed to us must be accepted as more certain than anything else. And although the light of reason may, with the most shining obviousness, appear to suggest something different, we must still put our entire faith in divine authority rather than in our own judgment. But on matters where divine faith has nothing to say, it is unworthy of a philosopher to accept anything as true if he hasn't ever established its truth by thorough scrutiny; and he should never rely on the senses—i.e. on the ill-considered judgments of his childhood—in preference to his mature powers of reason.

Straight translation of section 57:

Now some attributes or modes are in the very things of which they are said to be attributes or modes, while others are only in our thought. For example, when time is distinguished from duration taken in the general sense and called the measure of movement, it is simply a mode of thought. For the duration which we understand to be involved in movement is certainly no different from the duration involved in things which do not move. This is clear from the fact that if there are two bodies moving for an hour, one slowly and the other quickly, we do not reckon the amount of time to be greater in the latter case than the former, even though the amount of movement may be much greater. But in order to measure the duration of all things, we compare their duration with the duration of the greatest and most regular motions which give rise to years and days, and we call this duration 'time'. Yet nothing is thereby added to duration, taken in its general sense, except for a mode of thought.

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.

Part 3: The visible universe

1. We cannot over-estimate the vastness of the works of God. The principles of material things that I have so far discovered have been derived not from the old prejudices of the senses but from the light of reason, so that their truth can't be doubted. Next question: Are these principles, unaided, sufficient for us to explain all natural phenomena, i.e. all the effects that we perceive through our senses? Let's start with the general structure of the entire visible world, because all the other phenomena depend on that one. In thinking about this, we must bear in mind two things. **(1)** One is the infinite power and goodness of God; we mustn't be afraid of over-estimating the vastness, beauty and perfection of his works. What we *should* be afraid of is appearing to *under*-estimate the magnificence of God's creative power by positing limits that we don't know for certain to exist.

2. Let's not be so presumptuous as to think we understand the ends God aimed at in creating the world. The second thing we must bear in mind is **(2)** that our mental capacity isn't up to much, and we shouldn't have too high an opinion of ourselves. One way of doing this would be to assign limits to the world in the absence of knowledge based on reason or divine revelation—as if our powers of thought could stretch beyond what God has actually made! And it would be the height of presumption for us to suppose that we have the mental power needed to grasp the ends that God aimed at in creating the universe—let alone supposing that he did it all for our benefit!

3. The sense in which it can be said that all things were created for man. In ethics it may be very right and proper to say that God made everything for our benefit, because this may stir us to thank him and burn with love for him all the more. And indeed there *is* a sort of truth in 'God made everything for our benefit', because we can make some use of all things, if only by thinking about them and being led by this to admire and wonder at God's marvellous works. But there isn't a chance that all things were *in fact* made for our benefit, if this means that's all they were for. . . . Obviously many things do or did exist that have never been seen or thought of by any man, and have never been of any use to anyone.

4. Empirical phenomena and their use in philosophy. The principles that I have so far discovered are so vast and so fertile that their consequences vastly outnumber the entire observed contents of the visible world. There are so many of them, indeed, that we could never in a lifetime survey them completely, even in our thought. But I'll offer a brief account of the principal phenomena of nature whose causes we must now examine. I don't mean to use these phenomena as the basis for proving anything; I plan to deduce an account of effects from their causes, not of causes from their effects. My aim ·in starting with the phenomena, the effects,· is simply to get us to focus on some effects rather than others from among the countless effects that I think could be produced by the very same causes.

5. The ratio between the distances and sizes of the sun, earth and moon. At first glance it seems that the earth is much larger than anything else in the world, and that the moon and sun are much larger than the other stars. But correcting his mistaken impression by infallible reasoning, we learn that the moon is separated from us by a distance of about thirty times the earth's diameter, and the sun by a distance six or

seven hundred times the earth's diameter. And by putting together •·what we know of· the distances from us the sun and the moon with •their apparent diameters, we learn that the moon is much smaller than the earth and the sun much larger.

6. How far the other planets are from the sun.
We also learn from observation aided by our reason that Mercury is more than two hundred earth-diameters from the sun, Venus more than four hundred, Mars nine hundred or a thousand, Jupiter more than three thousand, Saturn five or six thousand.

7. It is impossible to over-estimate how distant the fixed stars are.
As for the fixed stars, there's decisive empirical evidence that they aren't closer to the earth or the sun than Saturn is. But there's no such evidence that they aren't a truly enormous distance from us. Things I'll say later [section 40] about the movements of the heavens will imply that the fixed stars are so far from the earth that by comparison Saturn is a near neighbour.

8. Seen from the heavens, the earth would appear as a planet, smaller than Jupiter or Saturn.

9. The sun and the fixed stars shine by their own light.
The stars [here = 'the visible heavenly bodies of all kinds'] differ from one another not only in size but also in the fact that some shine by their own light while others only reflect light that comes to them from elsewhere. The sun first: if it were merely reflecting light that reached it from some other more brilliant body, we would be bound to see *that*; ·and we don't, so· it can't be doubted that the light with which the sun dazzles our eyes is its own .... Next the fixed stars: given how bright and glittering their rays are, although they are so far away from us and from the sun, it's easy to believe that they are like the sun in emitting their own light and that any one of them would appear as big and luminous as the sun if it were closer to us.

10. The light of the moon and the other planets is borrowed from the sun.
On the other hand, the Moon shines only on the side facing the sun, which tells us that it has no light of its own and merely reflects the rays it has received from the sun. The use of a telescope recently revealed the same thing to be true of Venus; and we can think the same about Mercury, Mars, Jupiter, and Saturn, because their light appears much weaker and less brilliant than that of the fixed stars, and because they are close enough to the sun to be illuminated by it.

11. There is no difference, with respect to light, between the earth and the planets.

12. The moon, when it is new, is illuminated by the earth.

13. The sun can be counted as one of the fixed stars, and the earth as one of the planets.
It's obvious that our earth, looked at from Jupiter, would appear smaller than Jupiter appears from here, but perhaps no less bright; and it would appear larger if viewed from some closer planet; but it couldn't be viewed at all from any of the fixed stars, because the distance would be too great. It follows from this that Earth is one of the planets, and the sun one of the fixed stars.

14. The fixed stars always keep the same distance from each other; the planets don't.

15. The observed motions of the planets can be explained by various hypotheses.
A man at sea in calm weather, looking at other vessels in the middle distance that seem to him to be changing their positions relative to one another, can't always tell whether a

given apparent change comes from the motion of •that ship or •that other one or •the one he is on. Similarly, looking from our Earth at the paths the planets follow, we don't always learn enough—just by looking—to know whether a given apparent change of position comes from the movement of this or that planet or the movement of the Earth, and ·it is made even harder to sort them out by the fact that· these changes are very unequal and complicated. If we're to understand them, it will have to be with help from some explanatory theory about the planets, and it's for us to select the theory. Astronomers have come up with three different hypotheses—i.e. suppositions that they have offered not necessarily as true but as sufficient to explain all the phenomena.

16. Ptolemy's hypothesis doesn't account for the appearances.

The first of these hypotheses is Ptolemy's. I shan't discuss this: no-one accepts it these days because it conflicts with many recent observations, especially the observation that the lunar phenomenon of full-moon/half-moon/crescent-moon also occurs with Venus..

17. There's no difference between the hypotheses of Copernicus and Tycho, considered simply as hypotheses.

The second hypothesis is that of Copernicus and the third that of Tycho Brahe. These two, considered simply as hypotheses, account for the appearances in the same way and don't differ much, except that the Copernican version is a little simpler and clearer. Tycho would have had no reason to change it if he hadn't been trying to unfold •the actual truth of things and not a •mere hypothesis.

18. Tycho says that he attributes less motion to the earth than Copernicus does, but actually he attributes more.

Copernicus had no hesitation in attributing motion to the earth; Tycho 'corrected' him about this, regarding it as absurd from the point of view of physics and in conflict with the common opinion of mankind. But he didn't attend carefully enough to the true nature of motion—despite his insistence that the earth doesn't move at all he actually attributed to it more motion to it than Copernicus did!

19. My denial that the earth moves is more careful than Copernicus's and more correct than Tycho's.

The only difference between my position and those of Copernicus and Tycho is that I don't attribute any motion to the earth, thus keeping closer to the truth than Tycho while also being more careful than Copernicus. I'll put forward the hypothesis that seems to be the simplest of all both for understanding the phenomena and for investigating their natural causes. Regard this, however, simply as •an hypothesis and not as •the real truth. [In presenting his 'hypothesis', Descartes marks off four parts of it as 'First' section 20, 'Second' sections 21–3, 'Third' sections 24–5, and 'Fourth' sections 26 to (probably) 29.]

20. The fixed stars must be supposed to be much, much further off from us than Saturn is.

Astronomers all agree that the fixed stars are further from us than Saturn is, but I propose that we go further than that. We don't know for sure how far away the fixed stars are, but no story about them could possibly put them so far away as to be in conflict with the phenomena; so let's not be content with merely putting them 'somewhere beyond Saturn', instead supposing them to be as far beyond Saturn as will serve our purpose. It doesn't matter if the distance we propose seems incredible by the standards of earthly distances, because the minimum distance that everyone agrees on—namely 'further off than Saturn'—is already incredible by earthly standards! And when we bear in mind the omnipotence of God who created the fixed stars, •the

greatest conceivable distance is at least as credible as •any smaller one. And I'll show later that we have to suppose an enormous distance between the fixed stars and the sphere of Saturn if we are to explain satisfactorily the empirical facts about the planets and the comets.

21. The sun, like a flame, is composed of extremely mobile matter, but that doesn't mean that it moves from place to place.

Because the sun gives off its own light, like •fire and like •the fixed stars, let us suppose that it resembles •fire in its motion and the fixed stars in its •situation. ·That means that there is motion in the sun—a great deal of motion—because· there's nothing more mobile than fire to be seen on the earth (as witness the fact that the bodies fire touches, if they aren't extremely hard, gradually disintegrate and allow their constituent particles to get caught up in the motions of the fire). But this motion consists only in each of its parts moving in relation to the others; the fire as a whole doesn't move from one place to another unless it is carried by some body to which it is adhering. So we can reasonably think that the sun is composed of very fluid and mobile matter which eats into the surrounding parts of the heaven, while judging that it resembles the fixed stars in not moving from place to place in the heaven. [By 'heaven' Descartes means a large spherical mass of rotating fluid material, having a fixed star at its centre. So there are as many heavens as there are fixed stars. This note comes from the translation of the complete work by V. R. and R. P. Miller (Reidel, 1983).]

22. The sun differs from a flame in not requiring fuel in the same way.

'Your comparison of the sun with fire doesn't hold good, because fire that we see here on earth always needs fuel, and the sun seems not to do so.' Not so. According to the laws of nature, *anything* once it has been formed continues to exist unless destroyed by some external cause—and that goes for fire as much as for everything else. Then why does fire on earth need fuel? Strictly speaking, it *doesn't*! That is, it doesn't need fuel in order to stay exactly as it is. But ·it can't unaided stay exactly as it is, because· its fluidity and mobility lead to its being constantly dissipated by the matter surrounding it; and the need for fuel comes from the need to create a new fire as the old one is extinguished. But the sun is not dissipated in that way by the heavenly matter surrounding it, so we have no reason to think that *it* needs to be fed like ·earthly· fire. . . .

23. The fixed stars don't all turn on the same sphere. Each is surrounded by a vast space that isn't occupied by any other star.

Some astronomers have thought that all the fixed stars are situated on the surface of a single sphere, but that can't be right if the sun is one of the fixed stars (or anyway is like the fixed stars in the facts about how it is situated). ·Why not? Because it's empirically obvious that the sun is much nearer to us than the fixed stars are, and therefore doesn't share a sphere-surface with them·. The real situation is that the sun is surrounded by a vast space with no fixed stars in it, ·and the same must be true of each fixed star·. So each fixed star must be very distant from all the others, and the fixed stars must vary widely in how far they are from the sun and from us. . . .

24. The heavens are fluid.

It's not just the sun and the fixed stars that are fluid; so also is every heaven. This is generally accepted by astronomers these days, because they can see that otherwise it's almost impossible to explain the observed facts about the planets.

25. The heavens carry along with them all the bodies that they contain.
Many of the astronomers regard a heaven as an entirely empty space—something that not only offers no resistance to the motion of other bodies but also lacks the force to carry other bodies along with it as it moves. [Descartes's wording of that seems to suggest that 'x is an empty space' goes further than 'x is fluid'—suggesting that emptiness is fluidity redoubled in spades, so to speak.] They are wrong about this, I think, because such a void cannot exist in nature. ·And a heaven's being fluid doesn't imply that it is a vacuum. The reason why **(1)** fluids offer so little resistance to the motions of other bodies is not that they contain so little matter but rather that **(2)** their constituent particles are in motion relative to one another; for an account of how **(1)** follows from **(2)** see section 2:56·. If this motion takes all the particles in some one direction, the fluid will have to—by the force of this motion—carry with it all the bodies that are immersed in it unless some external cause holds them back, even bodies that are very hard and are initially motionless. This follows obviously from what I said in 2:61.

26. The earth is at rest in its own heaven which nevertheless carries it along.
We see that the earth isn't supported by columns or held up by cables, but is completely immersed in a very fluid heaven. Let us assume that the earth is at rest, having no innate tendency to motion (because we don't see any such propensity). But let's not think that this prevents the earth from being carried along by the current of that heaven, following the motion of the heaven without itself *moving*. Compare this with an unanchored ship that isn't driven by the wind or by oars, floating motionlessly in the middle of the ocean, though it may be imperceptibly carried along by the ebb and flow of this great mass of water.

27. The same view should be taken of all the planets.
And just as the other planets resemble the earth in being opaque and reflecting the rays of the sun, there's reason to believe that they also resemble it in remaining at rest, each in its own part of the heaven, and that the observed variations in their positions results solely from the motion of the matter of the heaven in which they are immersed.

28. Strictly speaking the earth doesn't move, nor do the planets, though they're all carried along by the heaven.
Bear in mind what I said in section 2:25 about the nature of motion, namely: If we use the term 'motion' in the strict sense and in accordance with the truth of things, then motion is simply the transfer of one body away

- from contact with one set of bodies to contact with another set,

where the former set are regarded as being at rest. But quite often in accordance with ordinary usage people will label as 'motion' any event in which a body travels

- from one place to another place;

this being the sense in which a thing can be said to move and not to move at the same time, because of different choices we can make of what is to count as its 'place'. In the strict sense, the earth is not moving, nor are the other planets; because they are not transferred from the vicinity of those parts of the heaven with which they are in immediate contact, in so far as these parts are considered as being at rest. [Descartes's explanation of this is too compact to be easily followed. The basic point is his thesis that the earth and other planets revolve around the sun in what he calls 'a heaven', a closed-loop river of 'celestial material'; so that the earth (for example), although it moves around the sun in the ordinary language sense of 'moves', *doesn't* move at all in Descartes's 'strict' and 'in-conformity-with-the-truth' sense of 'move', because it doesn't move away from its immediate

neighbours but is herded along by them all the way. There's a slight complication because the tiny particles of the celestial fluid are constantly moving relative to one another, so that there *are* constant changes in exactly which bits of matter are in direct contact with the earth. But this doesn't conflict with the thesis that the earth doesn't strictly move, because] the motion of the particles should be attributed solely to the particles, not to the earth. In the same way, the partial transfers of water and air that occur on the surface of the earth are normally attributed not to the earth itself but to the parts of water and air which are transferred.

29. If 'motion' is taken in its loose ·ordinary-language· sense, it's correct to say that the planets other than the earth move, but it's still not correct to say that the earth moves.

If we use 'motion' in the ordinary way, then we should say that all the other planets and even the sun and fixed stars *move*; but it doesn't sound right to say that *the earth* moves, even when we are using 'move' in its ordinary informal sense. Here is why. The common practice is to determine the position of the stars from certain sites on the earth that are regarded as immobile: the stars are thought to move when they pass these fixed spots. This is convenient for practical purposes, and so it is reasonable. Indeed all of us since infancy have thought of the earth not as a globe but as a flat surface, so that 'up' and 'down' are everywhere the same, and the four directions—east, west, south and north—are the same for any point on the surface; and we have all used these directions for specifying the location of any other body. But what of a philosopher [here = 'scientist'] who realizes that the earth is a sphere immersed in a fluid and mobile heaven, and that the sun and the fixed stars always keep the same positions relative to each other? If he takes these bodies as immobile for the purpose of determining the earth's location, and thus says that the earth moves, his way of talking is quite unreasonable. On the one hand, 'location' in •the philosophical sense is settled in terms of bodies that are right next to the body that is said to move—not in terms of very remote bodies like the stars. And on the other hand, if we follow •ordinary usage, we have no reason to think that it's the stars that are at rest rather than the earth. Consider this possibility:

> **P**: There are other bodies even further away than the stars ·that we can see·, bodies from which •the stars are receding and with reference to which •they can be said (ordinary usage) to *move* and •the earth can be said (ordinary usage) to be at rest.

If **P** is true, then it isn't true (ordinary usage) that the earth moves. And to reject **P** is irrational. Our minds are so built that they don't recognize any limits in the universe; so anyone who thinks about God's immensity and the weakness of our senses will conclude that it is much more reasonable to suspect that ·**P** may be true, i.e. that· there may be other bodies beyond all the visible 'fixed' stars, and that with reference to *those* bodies the earth can be said to be at rest while all the ·visible· stars may be said to be in motion. This is surely more reasonable than to suppose that there can't possibly be any such bodies ·and thus that **P** *can't* be true·. [The French version added:] Someone who in this way thinks that the earth moves must be rejecting **P** on the grounds that the creator's power is not great enough. And if later on ·in this work· I seem to attribute motion to the earth, remember that this is an improper way of speaking—like saying of someone asleep on a ferry that he is 'moving' from Calais to Dover.

30. All the planets are carried round the sun by the heaven.

Let's stop worrying about the earth's motion and suppose that the whole of the celestial matter—·the heaven·—in which the planets are located turns continuously like a vortex with

the sun at its centre. Let us suppose further that the parts of the vortex nearer to the sun move faster than the parts further out from the sun, and that all the planets (earth included) always stay surrounded by the same portions of celestial matter. This single supposition lets us smoothly explain all the observed movements of the planets without bringing in any supplementary apparatus. At some places along a river the water twists around on itself and forms a whirlpool with bits of straw floating in it, ·and four features of this can help us to understand planetary motion·. **(1)** We see the straws carried around with the whirlpool. **(2)** Sometimes we see a straw also spinning around its own centre. **(3)** The straws nearer the centre of the whirlpool complete a revolution more quickly ·than the ones further out·. **(4)** Although such a straw always has a circular motion, it almost never follows a perfect circle—there are usually some deviations from that. We can easily imagine all this happening in the same way with the planets, so that this single account explains all the planetary movements that we observe.

31. How the individual planets are carried along.

32. The movement of sun spots.

33. How the earth rotates about its own centre, and the moon revolves around the earth.

34. The motions of the heavens are not perfectly circular.

35. The planets' deviations from the plane of the ecliptic.

36. Their longitudinal motion around the sun.

37. This hypothesis makes it easy to understand all the observations ·of the planets·.

38. According to Tycho's hypothesis the earth should be said to move about its own centre.

39. It should also be said to move annually around the sun.

40. The earth's movement ·around the sun· doesn't affect the apparent positions of the fixed stars because they are so far away.

You may want to object: 'Given that the sun always keeps the same position in relation to the fixed stars, the earth's great year-long circle around the sun must bring it nearer to any given fixed star at some times than it is at others; but this isn't confirmed by any observations that have been made.' The answer is that the fixed stars are too far away from the earth for these changes of distance to be observable ·by any means that we have·. The distance that I suppose there to be between the earth and any fixed star is so immense that the whole circle of the earth's path around the Sun should be counted as a mere point in comparison to it. Some people may find this incredible—I mean those whose minds aren't accustomed to contemplating God's mighty works, and who see the earth as the most important part of the universe because •it's where men live and (they think) •everything was created for men. But astronomers won't find it so strange, because they already know that the earth is like a mere point in comparison with the heaven.

41. The supposition that the fixed stars are very distant is also required to explain the motion of comets, which are now agreed to be celestial bodies.

42. All the things we see here on earth are among the phenomena ·to be explained·, but we needn't consider them all from the outset.

The phenomena ·to be covered· include not only these rather general ones but also many particular matters concerning the sun, the planets, the comets and the fixed stars, and also concerning the earth—*all* the facts about what we see happen on its surface. If we're to discover the true nature of this visible world [here = 'universe'], it's not enough to find

causes that explain what we see far off in the heavens; *those same causes* must also explain everything that we see right here on earth. We can discover the causes of more general things without first looking into all these terrestrial phenomena; but we'll know that we are right about those causes when we observe that serve to explain not only •the effects that we were initially trying to explain but •all these other phenomena that we hadn't even been thinking about.

43. If there's a causal story from which all the phenomena can be clearly deduced, then it's virtually impossible for it not to be true.

If •we use only principles that we see to be utterly evident, and •all our subsequent deductions follow by mathematical reasoning, and •what the deductions lead to are in precise agreement with all natural phenomena, wouldn't we be doing God an injustice if we suspected that the causal explanations reached in this way were false? It would imply that God had endowed us with such an imperfect nature that even the proper use of our powers of reasoning allowed us to go wrong.

44. Still, I want the causes that I shall set out here to be regarded simply as hypotheses.

When philosophizing about such important matters, however, it would be downright arrogant to claim that I have discovered the exact truth where others have failed; so I choose not to make such a claim, and to offer everything that I'm going to write simply as a hypothesis. And if you think the hypothesis is false, I'll still think that I have done something pretty worthwhile if everything deduced from it agrees with our observations; because in that case the hypothesis will be as useful as if it were true—useful, that is, in enabling us to manipulate natural causes so as to get the effects we want.

45. I shall even make some assumptions that are certainly false.

Indeed, to improve my explanation for things found in nature I shall take my investigation of their causes back to a time before (I think) those causes actually came into existence, ·which means that my explanatory scheme will include some things that are downright false·. It is beyond question that the world was created right from the start with all the perfection it now has: the sun and earth and moon and stars existed in the beginning, the earth contained not just seeds but full-grown plants, and Adam and Eve weren't born as babies but created as fully grown people. That's what the Christian faith teaches; and our natural reason also convinces us that it is true, because we can't think that God in his infinite power ever created anything that wasn't entirely perfect [partly meaning 'complete', 'finished'] of its kind. Still, if we want to understand the *natures* of plants or of men, it's much better to consider •how they might gradually grow from seeds than to consider •how they were created by God ·as going concerns· at the start of the world. In this spirit perhaps we can think up some very simple and easily grasped principles that can function as the seeds (so to speak) from which the stars, the earth and indeed everything we observe in this visible world demonstrably could have grown. We know for sure that they *didn't* arise in this way, but we'll be able to explain their nature much better in this way than if we merely described them as they now are or as we believe them to have been created. Well, I believe that I *have* found such principles, and I'll give a brief account of them here.

46. The assumptions that I am making here in order to explain all phenomena.

I have established that all the bodies in the universe are composed of a single ·mass of· matter that is •*divisible* into indefinitely many parts, and is in fact •*divided* into very many parts that move in different directions and have a sort of circular motion; and that the same quantity of motion is always preserved in the universe. But unaided reason won't tell us how big these pieces of matter are, how fast they move, or what kinds of looped path they follow. [See the note in 2:33.] There are countless configurations that God might have chosen, and experience will have to tell us which ones he actually chose. So we're free to make any assumption we like about this, provided that its consequences agree with our experience. Allow me then to suppose that God originally divided the matter of which the visible world is composed into particles of about the same size, a *moderate* size, between the biggest and smallest that now make up the heavens and stars. I'll also suppose that their total amount of motion was the same as what is now found in the universe; and that their motions were of two kinds, of equal force. **(1)** They moved individually and separately about their own centres, so as to form a fluid body such as we take the heavens to be. **(2)** They moved together in groups around certain other equidistant points corresponding to the present centres of the fixed stars, and around other more numerous points equalling the number of the planets, ... so as to make up as many different vortices as there are now heavenly bodies in the universe.

47. These suppositions are false, but that doesn't prevent the consequences deduced from them being true and certain.

These few assumptions, I think, are all we need as causes or sources from which all the effects observed in our universe would arise in accordance with the laws of nature that I presented in 2:37–40. And I don't think anyone could come up with any alternative sources for explaining the real world that are simpler, easier to understand, or more probable. It may be possible to start from primeval chaos and deduce from that, in accordance with the laws of nature, the precise organization now to be found in things; and I once undertook to do this. But •confusion seems less in accordance with the creator's supreme perfection than •proportion or order; and it is also harder for us to think about clearly. And if we are going to work ·not with chaos but· with proportion or order, the simplest and easiest to grasp is complete equality in every respect. That's why I am supposing at this point that all the particles of matter were initially equal in size and speed, and am allowing no inequality in the universe apart from the one that exists in the position of the fixed stars [presumably meaning 'the irregularity of the distribution of fixed stars through space'], which can't possibly be denied because any who looks at the night sky sees it staring him in the face. In fact it doesn't make much difference what initial suppositions are made, because:

> •all subsequent change must occur in accordance with the laws of nature; and •as long as those laws are followed, the same effects could be derived (perhaps more laboriously) from almost any supposition about the initial conditions.

That's because by the operation of these laws matter must successively assume all the forms of which it is capable; and if we consider these forms in order we'll eventually arrive at the form that characterizes the universe in its present state. So we have no reason to fear that in these matters we'll be led into error by starting with a false supposition.

48. How the particles of celestial matter become spherical.

To make a start on showing how the laws of nature work in the context of the hypothetical system I have proposed, I call your attention to this: The particles of matter of which the world is composed couldn't *all* have started out as spherical [*sphæricas*], because I have shown that our universe has no •empty spaces, and you can't completely •fill a space with spheres. But whatever shape these particles had at the outset, they *had to* become round [*rotundas*] in the course of time because of their various closed-loop [*circulares*] motions. ·Would the particles really have had enough force for all that rounding, all that knocking off of corners? Yes indeed!· At the outset the particles had enough force to separate them from one another; that's more than enough force for them subsequently to knock the corners off one another; and the total force present in the world doesn't lessen over the course of time. In this context, anything that protrudes beyond the spherical figure is called a 'corner', so that it obviously follows from this:

•the particles eventually grind down all one another's corners

that this is true:

•the particles eventually become spherical.

49. The spaces between these spherical particles must be filled by other more finely divided matter.

Because there can't be any empty space in the universe, and because spherical particles can't unite so closely as to leave no spaces around them, these spaces must be filled by scrapings of matter that are extremely tiny and able to change their shapes at any moment so as to fit into the spaces they enter. ·The scheme of things I am putting forward easily provides for these needed tiny and malleable chips of matter, because this is the story it tells·: Matter that is knocked off the corners of the particles of matter that are becoming spherical is gradually ground down to form particles that are so tiny and so fast-moving that through the sheer force of their motion they •come to have no exact shape and size and •can easily fill spaces that other parts of matter can't enter.

50. The particles of this more finely divided matter can be very easily divided.

The smaller these scrapings of other particles are, the more easily they can be •moved and •made even smaller still. That's because the smaller they are the more surface area they have in proportion to their bulk. ·For example,

•a cube of 8cm^3 has a surface area of 24cm^2;

(a cube with that volume measures 2cm along each side, so each side measures 4cm^2, and there are six sides); whereas

•a cube of 1cm^3 has a surface area of 6cm^2;

which means that reducing the bulk to one-*eighth* reduces the surface area only to one *quarter*·. The upshot of this is that as a particle is ground down to a smaller and smaller size,

•the area across which it can confront other bodies that can grind it down further

is not reduced as much as

•the bulk that enables it to resist such grinding-down.

51. And they move very quickly.

When a little bit x is knocked off a larger particle y that is on the way to becoming spherical, x gets all its motion from y and yet moves much faster than y and its like do. Why? Because y and its like travel by straight and open paths, pushing x and *its* like along zig-zag paths that are narrower. What does that have to do with *speed*? Well, think about how by closing a bellows •slowly we can force the air out of it •rapidly, because the opening the air has to go through is so

small.—You'll recall that in 2:33–5 I showed that for matter to move in closed loops at varying speeds, without allowing either rarefaction or empty space, there must be matter that moves extremely quickly and is divided into indefinitely many parts. I can't imagine how this theoretical need could be better met than it is by what I have said in these two sections about the size, speed and malleability of the 'scrapings'.

52. There are three elements of this visible world.

The two most basic elements of this visible universe are the following. **(1)** The first element is composed of matter that is so violently agitated that when it meets other bodies it splits into particles of indefinite smallness, adapting itself to the shapes needed for it to fill all the gaps between the larger particles. **(2)** The second element is composed of matter divided into spherical particles which are still much too small to be separately visible but have definite fixed sizes, though they can be divided into other much smaller particles. **(3)** The third element, which I'll expound soon, consists of particles that either •are much bulkier or •have shapes less suited for motion. I am going to show that all the bodies in this visible universe are composed of these three elements—

- •the sun and fixed stars are composed of the first element,
- •the heavens are composed of the second, and
- •the earth and planets and comets are composed of the third.

How will I show that? Well, the sun and the fixed stars **(1)** emit light, the heavens **(2)** transmit light, and the earth and the planets and comets **(3)** reflect light; and I'm going to argue that these three relations to light are explained by the threefold difference in the material components of the sun, the heavens etc.

53. Three heavens can also be distinguished in it.

54. How the sun and fixed stars were formed.

55. What light is.

It is a law of nature that any body moving in a circle will, if left to itself, move away from the centre of that circle—·see 2:39·. I shall now explain as carefully as I can the force by which the globules of the second element. . . .try to move away from their centres of motion; because that is the whole story about the nature of light (as I shall show later), and many other matters also depend on knowledge of this point. [Light is discussed in sections 64 and 77–81, but the 'later' passage Descartes is referring to is probably 4:28.]

56. How to understand an inanimate thing's 'trying' to move.

When I say that the globules of the second element 'try' to move away from the centres around which they revolve, don't take me to mean that they are trying on the basis of some thought that they have! All I mean is that their location and their state of arousal [*incitatos*] are such that they *will* travel in that direction unless some cause prevents them from doing so.

57. How one body can be said to try to move in different directions at the same time.

It often happens that a single body is subjected to many different causes at once, and these causes may interfere with one anothers' effects. So we can tell different stories about the direction a given body is tending or trying to move in, depending on which of the causes we are considering. Consider a stone that is being swung around a circular path in a sling. At the instant when it is at the bottom of the circle, how does it tend or try to move?

> **(1)** The stone tends or tries to continue upwards along the circle;

that's the right answer if all the relevant causes are taken into account, because that is the path that the stone does in

fact follow.

> **(2)** The stone tends or tries to shoot out along a tangent to the circle, parallel to the ground;

that's the right answer if we focus just on the power of moving that the stone itself has, because that's the line that the stone *would* travel if it were released from the sling at that instant. The sling prevents that from happening, but it doesn't eliminate the 'trying'.

> **(3)** The stone tends or tries to fall straight down to the ground;

that's the right answer if we focus on the part of the stone's total power of moving that is resisted by the sling, distinguishing this from the remaining part of its power that produces the actual result.

58. How bodies moving in a circle try to move away from their centre of motion.

59. The extent of the force of this trying.

60. This trying is found in celestial matter.

61. This is the cause of the sun and the fixed stars being round.

62. It is also the reason why celestial matter tries to move away from all the points of the circumference of each star or of the sun.

63. The globules of celestial matter don't hinder each other in this trying.

64. This trying explains all the properties of light. And as a result of it, light could be seen to emanate from the stars, despite the lack of any light-producing force in the stars themselves.

65. The poles of each celestial vortex touch the parts of other vortices which are remote from their poles.

66. There must be some deflection in the motion of the vortices so that they can move in harmony.

67. Two vortices cannot touch at their poles.

68. The vortices are of unequal size.

69. The matter of the first element flows from the poles of each vortex towards its centre, and from the centre towards the other parts.

70. The same thing cannot be supposed to occur with the matter of the second element.

71. The reason for this difference.

72. How the matter of which the sun is made moves.

73. There are various inequalities in the position of the solar body.

74. There are also various inequalities in the movements of its matter.

75. These inequalities don't prevent the shape of the sun from being round.

76. The motion of the first element as it travels between the globules of the second element.

77. How the light of the sun is diffused not only towards the ecliptic but also towards the poles.

78. How it is diffused towards the ecliptic.

79. The motion of one small body readily produces motion in other bodies which are so exceedingly remote from it.

80. How the light of the sun moves towards the poles.

81. Whether the strength of the light at the ecliptic is equal to that at the poles.

82. The globules of the second element that are near the sun are smaller and faster-moving than more distant ones. . . .

83. Why very remote globules move faster than ones that are somewhat nearer.

84. Why the globules closest to the sun move faster than ones that are slightly further away.

85. Why the globules nearest to the sun are smaller than ones that are further away.

86. The globules of the second element move in various different ways at the same time; and as a result they become completely spherical.

87. There are various degrees of speed in the tiny particles of the first element.

Having gone some distance towards explaining the nature of the first two elements, we should turn to the third, but I can't do that without first making some more points about the first element. [In fact, Descartes doesn't mention the third element until section 117, where he mentions in passing that sunspots belong to it. The third-element concept starts getting real work to do only in section 121.] The particles making up the matter of the first element don't all move at the same speed; it can often happen that a very small quantity of this matter has particles moving at countless different speeds. It's extremely easy to demonstrate this, on the basis of **(1)** the account I have given of what brought the first element into existence and of **(2)** the ongoing need for it to perform a certain function. [Descartes goes on to remind us of **(1)** his story about second-element particles gradually becoming spherical by having their corners knocked off, with the spaces between them being occupied by the chips and scrapings of the knocking-off procedure. And he adds that **(2)** there's an ongoing need for the tiny bits of (first element) matter to perform the space-filling role. He goes on from there to make his main point in this section: The space-filling job means that there is no limit to how small some first-element particles are, while the story about their origin gives no reason for thinking they are *all* indefinitely small. So they vary in size; so they vary in speed.]

88. The slowest tiny particles easily transfer what speed they have to other particles, and stick to one another.

So some of the first-element scrapings are less finely divided than the rest and less rapidly agitated. And since we are supposing these scrapings to have been knocked off the corners of second-element particles . . . ., they *have to* have extremely angular shapes, ill-adapted to movement. As a result, they easily stick to one another and transfer much of their agitation to other scrapings—the ones that are the tiniest and most rapidly agitated. . . .

89. Such clusters of tiny particles are chiefly found in the matter of the first element which is carried from the poles of the vortices to their centres.

Such slow-moving clustering particles are mainly found in first-element matter that is moved in straight lines from the poles of each heaven toward its centre. That's because straight-line movement requires less speed than the more crooked and diverse movements that occur in other places. Thus, when these particles are in such 'other places' they are usually expelled into the path of this straight movement, where they cluster together to form certain bodies—·larger than their constituent particles, of course, but still *small*·—the shape of which I wish to consider very carefully.

90. The shape of these 'striated particles', as I'll now label them.

They must be triangular in cross-section, of course, because they often pass through the narrow triangular spaces which that created when three second-element globules touch. It's not easy to determine the length of any particle, because that seems to depend solely on how much matter came together to form it; but all we need just now is to determine (not their •lengths but) their •shapes, which we must conceive as small fluted cylinders with three grooves or channels which

are twisted like the shell of a snail. This enables them to corkscrew their way through the little triangular spaces that always occur when three globes of the second element come together—curved-line triangles, ·of course, not straight-line ones·. [Descartes continues with a difficult account of why these particles need to be corkscrewed as they are. His use of this in the next section suggests that he thinks he has explained how the particles came to be grooved in that way.]

91. The particles coming from opposite poles are twisted in opposite ways.

Because they approach the centre of the heaven from opposite directions, i.e. some from its south pole and some from its north pole, while the vortex as a whole is spinning on its axis in only one direction, it's obvious that the particles coming from the south pole must be twisted in exactly the opposite direction from those coming from the north pole. This fact is pretty important, I think, because power of magnets depends on it, as I'll show later on, ·starting at 4:133·.

92. There are only three grooves in them.

93. The first element contains these striated particles, the tiniest particles, and other particles of various sizes.

94. How these particles produce spots on the surface of the sun and the stars.

95. This lets us discover the chief properties of these spots.

96. How the spots disintegrate, and new ones are produced.

97. Why the colours of the rainbow appear at the edges of some spots.

98. How spots are converted into bright areas, and vice versa.

99. The kinds of particles into which sunspots disintegrate.

100. How the ether round the sun and stars is produced from these particles. This ether and the spots belong to the third element.

101. The production and disintegration of spots depends on very uncertain causes.

102. How a single spot can cover an entire star.

103. Why the sun sometimes appears less bright, and why certain stars seem to change in size.

104. Why some fixed stars disappear or appear unexpectedly.

105. There are many passages in the spots through which the striated particles freely pass.

106. The arrangement of these passages, and why the striated particles can't return through them.

107. Why particles coming from one pole don't pass through the same passages as those coming from the opposite pole.

[Descartes's explanation of this, which is the central idea throughout sections 105–8, and in the Part 4 treatment of magnets, is the simple fact that a passage which snugly fits a right-handed corkscrew won't fit a left-handed one unless it approaches the passage from the other end.]

108. How the matter of the first element passes through these passages.

109. Other passages intersect them crosswise.

110. The light of such stars can scarcely pass through a spot.

111. Description of a star appearing unexpectedly.

112. Description of a star gradually disappearing.

113. In all spots there are many passages hollowed out by striated particles.

114. The same star can appear and disappear in turn.

115. It can happen that an entire vortex with a star at its centre is destroyed.

116. How it can be destroyed before many spots have gathered around its star.

117. How there can be many spots around a star before its vortex is destroyed.

118. How such a large number of spots is produced.

119. How a fixed star is changed into a comet or a planet.

120. The direction in which such a star moves when it first ceases to be fixed.

121. What we understand by the solidity of bodies, and their agitation.

[In this and the following few sections, Descartes introduces a new concept of 'solidity', defined in terms of 'the quantity of matter of the first element'. It would be unduly hard work to explain how it relates to other things he has said about solidity; and his use of it here suffers from being inextricably tied in with his theory about sun spots.]

122. Solidity depends not on matter alone but also on size and shape.

123. How celestial globules can be more solid than a whole star.

124. How they can also be less solid.

125. How some are more solid than a star and others less solid.

126. What sets a comet in motion.

127. The continuation of a comet's motion through various vortices.

128. Phenomena pertaining to comets.

129. The explanation of these phenomena.

130. How the light of a fixed star reaches the earth.

131. Whether the fixed stars are seen in their true locations; and what the firmament is.

132. Why comets are not seen by us when they are outside our heaven; and, incidentally, why coals are black and ashes white.

133. The tail of a comet and its various phenomena.

134. The type of refraction responsible for a comet's tail.

135. The explanation of this refraction.

136. The explanation of the appearance of the tail.

137. How beams of fire also appear.

138. Why the tail of a comet doesn't always appear in a direction directly opposite to the sun and doesn't always appear straight.

139. Why such tails don't appear around the fixed stars or planets.

140. What sets a planet in motion.

141–5. The five causes of deviations in planetary motions.

146. The initial formation of all the planets.

147. Why some planets are more remote from the sun; this doesn't depend on their size alone.

148. Why those nearer to the sun move faster, although the sun's spots move very slowly.

149. Why the moon revolves around the earth.

150. Why the earth rotates on its axis.

151. Why the moon moves faster than the earth.

152. Why very nearly the same face of the moon is always turned towards the earth.

153. Why the moon moves faster and diverges less from its mean motion in conjunction than in quadrature; and why its heaven is not round.

154. Why the secondary planets around Jupiter move so fast, while those around Saturn move so slowly if at all.

155. Why the poles of the equator and the ecliptic are so far apart.

156. Why they are gradually moving closer to one another.

157. The basic and most general cause of all the inequalities in the motions of the bodies in the universe.

Lastly, we shan't be surprised at the fact that all the planets, despite their constant tendency to move in a circular fashion, never follow perfect circles but are always subject to slight deviations of all kinds, both longitudinal and latitudinal. For all the bodies in the universe are contiguous and interact with each other, a vacuum being quite impossible, so that the motion of any one body depends on the motion of all the others, and hence is subject to countless variations. I think I have here given a satisfactory explanation of absolutely every phenomenon that we observe in the heavens above us. It remains for us to deal next with the phenomena we see here on earth.

Part 4: The earth

1. The false hypothesis that I have been using must be retained to provide an explanation of the true natures of things.

I gave you clear notice that I don't actually *believe* my hypothesis about how the bodies in this visible universe were first produced, but I'm still holding onto it as an aid to explaining what we observe here on earth. I hope to show clearly that this is the only way to supply causes for all natural objects; if I succeed in that, I'll be entitled to infer that although the world wasn't initially made like this but was created ready-made by God, the nature of these objects is exactly as it *would* have been if they *had* been produced in the way I have described.

2. How, according to this hypothesis, the earth was produced.

3–5. The division of the earth into three regions. Descriptions of them.

[The first region is the earth's innermost core, which is pretty much like the sun. The second is a very dense and opaque shell around that, entirely composed of third-element matter. The third region is the earth's outer crust. Descartes doesn't say how thick it is; but he does say that the first two regions won't concern him because 'no-one has ever reached them alive'. See also section 75.]

6. The particles of the third element that are in this third region must be fairly large.

7. These particles can be changed by the action of the first and second elements.

8. They are bigger than the globules of the second element but less solid and less agitated.

9. From the beginning they have formed successive layers around the earth.

10. Various gaps have been left around them, which are filled with matter of the first and second elements.

11. The globules of the second element were originally smaller, the nearer they were to the centre of the earth.

12. And they had narrower passages to pass through.

13. The thicker particles were not always below the thinner.

14. The original formation of various bodies in the third region of the earth.

15. The forces which caused these bodies to be produced. First, the general motion of the celestial globules.

·FIRST FORCE: MOTION·

16. The first effect of this first force is to make bodies transparent.

17. How a solid and hard body can have enough passages to transmit rays of light.

18. The second effect of this first force is to separate one body from another and to purify liquids.

19. The third effect is to make drops of liquid round.

·SECOND FORCE: WEIGHT·

20. Explanation of the second force, which is called 'weight'.

The force of weight doesn't differ much from the third action of the celestial globules. These globules, purely through their random motion in all directions, exert an equal pressure on all the particles of each drop of liquid, thus pressing them towards the centre of the drop and making the drop itself round. And through that same ·random· motion, when the

globules are prevented from moving in a straight line by encountering the entire mass of the earth, they propel all the earth's particles towards the centre, and that's what the 'weight' of terrestrial bodies consists in.

21. All the parts of the earth, taken individually, are not heavy but light.

Suppose that these two things were the case:

- All the spaces around the earth that don't have terrestrial matter in them are 'empty' in the sense of containing only bodies that wouldn't help or hinder the motion of other bodies

(that being the only way to make *any* sense of the term 'empty'),

- The earth turns on its axis, unaided, once every twenty-four hours.

If that were the case, all the terrestrial particles that weren't *very* firmly joined together would leap off in all directions towards the heavens. (You can see the same effect by throwing sand onto a spinning top.) Thus the earth would have to be called light rather than heavy.

22. What the lightness of the celestial matter consists in.

But those two suppositions are false: no spaces are 'empty', even in that special sense; and what drives the earth ·to spin on its axis· isn't its own motion but rather the celestial matter that surrounds it and fills all its pores; so that the earth's behaviour is that of a body at rest. Now, celestial matter considered as single mass that goes along with the earth as it drives it ·around the sun· has no force of weight or lightness. But the particles of celestial matter don't use up all their agitation in driving the earth; there is some left over, that is used in straight-line motions; and when these motions are blocked by an encounter with the earth, those celestial particles move away from the earth as far as they can, and that's what their lightness consists in. [Two ·dotted· interpolations in this section have implied that Descartes talks **(1)** about the earth's daily rotation on its axis and then silently switches to **(2)** its annual revolution around the sun. This is uncomfortable, but the connection with section 21 requires **(1)** and the phrase 'goes along with the earth' seems to require **(2)**.]

23. How all the parts of the earth are driven downwards by the celestial matter, and so become heavy.

The power that the individual particles of celestial matter have to move away from the earth can't achieve its effect unless the particles in moving upwards displace various terrestrial particles, thus pushing them downwards. Now all the spaces around the earth are occupied either by particles of terrestrial bodies or by celestial matter. The globules of the celestial matter have an equal tendency to move away from the earth, so no individual one of them has the force to displace any other. But the particles of terrestrial bodies don't have this tendency so strongly; so whenever any celestial globules have terrestrial particles above them they must exert all their force to displace them. Thus, the weight of any terrestrial body is not strictly produced by all the celestial matter surrounding it, but only by the portion of celestial matter that rises into the space left by the body as it descends, and hence equals it in size. [Descartes then goes through this again with a diagram of an example.]

24. How much heaviness there is in each body.

If we are correctly to calculate the weight of an individual body—let's call it 'B'—we must observe that **(1)** B's pores contain some celestial matter, which is opposed to an equal quantity celestial matter contained in the mass of air that is to take B's place; and **(2)** that this mass of air contains some terrestrial parts that are opposed to an equal number of the terrestrial parts of B. In respect of each of these, the matter

in the air and the corresponding matter in B cancel out, and have no effect on B's weight. What B's weight consists in is the action of the non-opposed celestial matter in the air on the non-opposed terrestrial matter in B.

25. Weight does not correspond to the quantity of matter in each body.

The **(1)** matter of the first element, other things being equal, has more force to drive terrestrial bodies downward than do **(2)** the globules of the second element, and **(2)** have greater force than ·a similar quantity of· **(3)** terrestrial particles of air that they move with them. The reason is the same in each case: **(1)** has more agitation than **(2)**, which have more agitation than **(3)**. So there's no easy way to estimate just from its weight how much terrestrial matter a body contains. . . .

26. Why bodies don't gravitate downwards when they are in their own natural places.

27. Weight pushes bodies down towards the centre of the earth.

·THIRD FORCE: LIGHT·

28. The third force, which is light. How it moves the particles of air.

·FOURTH FORCE: HEAT·

29. The fourth force, which is heat. What it is and how it persists even when light is removed.

30. Why it penetrates further than light.

31. Why heat rarefies almost all bodies and condenses some.

·DIFFERENT KINDS OF BODY·

32. How the highest region of the earth was first divided into two different bodies.

33. The three-part classification of principal kinds of terrestrial particle.

34. How a third body was formed in between the first two.

35. The particles contained in this body are of one kind only.

36. And they are of only two specific types.

37. How the lowest body was divided into many others.

38. The formation of another, fourth, body above the third.

39. The accretion of this fourth body, and the purification of the third.

40. How the bulk of this third body was reduced, so as to leave a space between it and the fourth body.

41. How there were many fissures produced in the fourth body.

42. How it was broken into many pieces.

43. How the third body has partly moved above the fourth and partly remained below.

44. This is the reason why mountains, plains, seas, etc. were produced on the surface of the earth.

·AIR·

45. The nature of air.

46. Why it is easily rarefied and condensed.

47. How it can be forcibly compressed in certain machines.

·WATER·

48. The nature of water, and how it easily turns either into air or into ice.

49. The ebb and flow of the tides.

50. Why the tide rises for 6.2 hours and falls for 6.2 hours.

51. Why the tides are greater when the moon is full or new.

52. Why they are greatest at the equinoxes.

53. Why air and water always flow from east to west.

54. Why regions having sea to the east are more temperate than others at the same latitude.

55. Why there is no ebb and flow in lakes or swamps; and why it occurs at different hours on different shores.

56. How we should investigate the particular causes of this on the individual shores.

·MISCELLANEOUS·

57. The nature of the earth's interior.

58. The nature of quicksilver.

59. The variation in the heat pervading the earth's interior.

60. The action of this heat.

61. The bitter juices and acids from which vitriol, alum etc. are formed.

62. The oleaginous matter of bitumen, sulphur etc.

63. The basic elements of the chemists; and how metals come up into mines.

64. The exterior of the earth, and the origin of springs.

65. Why the sea doesn't increase as a result of the rivers flowing into it.

·SALTS·

66. Why springs are not salt, and seawater doesn't become fresh.

67. Why the water in certain wells is brackish.

68. Why salt is also dug out of certain mountains.

69. Nitre, and other salts that are different from sea salt.

70. Vapours, acrid spirits and exhalations that come up and out from the earth's interior.

·MINERALS·

71. How the various mixtures of these produce different kinds of stones and other minerals.

72. How metals reach the exterior of the earth from its interior; and how minium is formed.

73. Why metals are not found everywhere on earth.

74. Why they are found especially at the base of mountains towards the south and east.

75. All mines are in the exterior of the earth; the interior can never be reached by digging.

76. Sulphur, bitumen, clay and oil.

·EARTHQUAKES AND VOLCANOES·

77. How an earthquake occurs.

78. Why fire erupts from certain mountains.

79. Why there are usually several tremors in an earthquake, so that it sometimes lasts for several hours or days.

·FIRE·

80. The nature of fire, and the difference between fire and air.

81. How fire is first kindled.

82. How it is kept going.

83. Why it needs fuel.

84. How fire is sparked off by striking flints.

85. How it is kindled from dry twigs. . .

86. . . . or by focussing the rays of the sun. . .

87. . . . or simply by very violent motion. . .

88. . . . or by the mixing of various bodies.

89. Fire in lightning and shooting stars . . .

90. . . . in things that shine and don't burn, such as falling stars. . .

91. . . . . in drops of seawater, in rotten wood and the like. . .

92. . . . in things that grow hot but don't shine, such as stored hay. . .

93. . . . in lime sprinkled with water, and other cases.

138. How the passages are made suitable for receiving striated particles coming from either direction.

139. The nature of a magnet.

140. How steel and any kind of iron is made by smelting.

141. Why steel is very hard, rigid and fragile.

142. The difference between steel and other iron.

143. How steel is tempered.

144. The difference in the passages found in a magnet, in steel, and in iron.

145. Enumeration of the properties of magnets.

146. How striated particles flow through the passages of the earth.

147. It is harder for them to move through the air, the water and the exterior part of the earth than through the interior.

148. It is easier for them to go through a magnet than through other bodies on the earth's exterior.

149. What the poles of a magnet are.

150. Why these poles turn towards the earth's poles.

151. Why they are also inclined at a certain angle towards its centre.

152. Why one magnet turns and inclines itself towards another magnet in the same way as it does towards the earth.

153. Why two magnets attract each other, and the sphere of action of each.

154. Why they sometimes repel each other.

155. Why the parts of the segments of a magnet which were previously joined also repel each other.

156. Why, if a magnet is broken up, two previously contiguous but now separated points are poles with opposite powers.

157. Why there is the same power in any part of a magnet as there is in the whole magnet.

158. Why a magnet imparts its power to a piece of iron that is made to touch it.

159. Why the piece of iron receives this power in various ways corresponding to the different ways in which it touches the magnet.

160. Why an oblong piece of iron can receive the power only along its length.

161. Why a magnet loses none of its power by imparting it to the iron.

162. Why this power is imparted to the iron very quickly, although it takes some time for it to be firmly fixed in it.

163. Why steel is better fitted to receive the power than baser types of iron.

164. Why more power is imparted by a more perfect magnet than by a less perfect one.

165. Why the earth itself imparts magnetic power to the iron.

166. Why the magnetic power in the earth is weaker than that in small magnets.

167. Why needles touched by a magnet always have their magnetic poles at their extremities.

168. Why magnetic poles do not always point accurately to the earth's poles, but diverge from them at various angles.

169. Why this divergence alters in time.

170. Why the divergence can be smaller when the magnet is made to stand on one of its poles than when its poles are equidistant from the earth.

171. Why a magnet attracts iron.

172. Why an armed magnet lifts much more iron than an unarmed one.

173. Why its poles, although they are mutual opposites, help each other in the lifting of the iron.

174. Why the rotation of an iron wheel is not hindered by the magnet from which it is hung.

175. How and why the power of one magnet increases or decreases the power of another.

176. Why a magnet, however strong, cannot pull iron from a weaker magnet if it is not touching the iron.

177. Why a weak magnet or iron can, if it touches a piece of iron, drag it away from a stronger magnet.

178. Why in these northern regions the south pole of a magnet is stronger than the north pole.

179. What can be observed if iron filings are scattered round a magnet.

180. Why an iron plate sticking to the pole of a magnet reduces its power of attracting or turning iron.

181. Why this power is not reduced when any other body is interposed.

182. Why the unsuitable position of a magnet gradually diminishes its strength.

183. Why rust, humidity and damp diminish its strength, and a vigorous fire destroys it.

184. The force of attraction in amber, wax, resin and similar things.

185. The cause of this attraction in glass.

186. The same cause can be observed in other cases too.

187. From all this we can understand how all the remarkable effects that are usually attributed to occult qualities can be explained in terms of ·plain down-to-earth· causes.
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 instantly flare up from a tiny spark, and how great its power is; •how great the distance is over which the fixed stars radiate their light; and all the other things for which I have given pretty obvious causal explanations through sources of power that are known and acknowledged by everyone, namely the shape, size, position and motion of particles of matter. Think about all this and you'll readily be convinced that these same power-sources can explain everything that occurs in material nature, leaving no powers of stones and plants that are so mysterious ·that we can only wonder at them·, and no marvels that we need to 'explain' in terms of influences of 'sympathy' and 'hostility'!

188. To complete our knowledge of material things we need some of the results in my ·planned· treatises on animals and on man.
I would have stopped this fourth part of my *Principles of Philosophy* right here if I had kept to my original plan to write two further parts—a fifth part on animals and plants, and a sixth part on man. But I'm not yet completely clear about all the matters I want to deal with in parts 5 and 6, and I don't know if I'll *ever* have enough free time to complete them. [He didn't. He lived for only six years after the completion of this work as we have it.] So as not to delay the publication of parts 1–4 any longer, and to make sure there are no gaps caused by my keeping material back for 5 and 6, I'll add here a few remarks about the objects of the senses. Up to this point in the present work 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 you might think I had left out the most important part of the explanation of the things in nature.

189. What sensation is and how it operates.

The human soul, while united to the entire body, has its principal seat in the brain. That is where it not only understands and imagines but also has sensory awareness. Sensory awareness comes about by means of nerves that stretch like threads from the brain to all the limbs, and are joined together so 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 my *Optics* chapter 4. The result of these movements' being set up in the brain by the nerves is that the soul or mind, being 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 (i.e. thoughts) that are the immediate result of these movements are called 'sense-perceptions', or in ordinary speech 'sensations'. [Remember that for Descartes *every* mental state or event is a 'thought'.]

190. Classifying the kinds of sensation, starting with internal sensations, i.e. emotional states of the mind and natural appetites.

The wide variety in sensations comes from differences in the nerves themselves and from differences in the sorts of motion that occur in individual nerves. It's not that each individual nerve produces a particular kind of sensation; indeed, there are only seven principal groups of nerves, two for internal sensations and five for external sensations. **(1)** The nerves that go to the stomach, oesophagus, throat, and other internal parts keep our natural wants supplied, and produce one kind of internal sensation, which is called 'natural appetite'. **(2)** The little nerves running to the heart and the surrounding area produce the other kind of internal sensation, a kind that includes 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 leading 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. When you imagine yourself enjoying something good, that act of imagination doesn't itself contain the feeling of joy, but it

- causes the ·animal· spirits to travel from the brain to the muscles in which these nerves are embedded;

which

- causes the openings of the heart to expand,

which in turn

- produces the movement in the tiny nerves of the heart

which inevitably

- results in the feeling of joy.

[Descartes accepted and helped to popularize the view that human physiology involves 'animal spirits'—an *extremely* finely divided fluid that transmits pressures through tiny cracks and tunnels—the body's 'hydraulic system', as it has been called.] In the same way, when you hear good news, what happens first is that

- your mind makes a judgment about it and rejoices with the kind of intellectual joy that occurs without any bodily disturbance

which is why the Stoics allowed that a wise man, though free of all passion, could experience joy of that kind). Later on when the good news is pictured in your imagination,

•the spirits flow from the brain to the muscles around the heart

and

•move the tiny nerves there,

which

•causes a movement in the brain,

which

•produces in the mind a feeling of animal joy.

Another example: Your blood is too thick, flows sluggishly into the ventricles of the heart, and doesn't expand enough inside it. This

•produces a different movement in those same small nerves around your heart;

and when this movement is transmitted to your brain it

•produces a feeling of sadness in your mind,

perhaps without your having the least idea of *why* you are sad. [Descartes might have quoted this::

> In sooth, I know not why I am so sad.
> It wearies me; you say it wearies you;
> But how I caught it, found it, or came by it,
> What stuff 'tis made of, whereof it is born,
> I am yet to learn.

(the opening lines of Shakespeare's *The Merchant of Venice*]

Various other causes could produce the same feeling by starting up the same kind of movement in these nerves. Other movements in these tiny nerves produce love, hatred, fear, anger and so on—I'm taking these to be merely emotions or passions of the soul, i.e. •confused thoughts that occur in the mind not through its own activity but through events in the body with which it is closely conjoined. Utterly different from these emotions are the •clear thoughts that we have concerning what is to be embraced or desired or shunned—·for example, the clear thought that it would be bad to be attacked by that tiger is different from the confused thought that consists in terror of being attacked by the tiger·. The same applies to the natural appetites such as hunger and thirst, which depend on the nerves of the stomach, throat etc. They're completely different from the volition to eat, drink and so on. . . .

191. The external senses, starting with (1) touch.

The external senses are standardly divided into five, corresponding to the five kinds of objects stimulating the sensory nerves, and the five kinds of confused thoughts that the resulting motions produce in the soul. First of all there are the nerves ending in the skin all over the body. •External bodies touch these nerves via the skin, stimulating the nerves in various different ways depending on whether •they are hard, heavy, hot, wet, and so on. Various different sensations are produced in the mind corresponding to the different ways in which movements are started or stopped in the nerves, and it's from those sensations that the various tactile qualities ·of external bodies· get their names. We call these qualities 'hardness', 'weight', 'heat', 'wetness' and so on, but all we mean by these terms is that the external bodies have whatever it takes to get our nerves to arouse in the soul the sensations of hardness, weight, heat and so on. Another point: When the nerves are stimulated with unusual force but without harming the body, this causes a kind of thrill [*titillatio*, literally = 'tickling'] which is naturally agreeable to the mind because it's a sign of robust health in the body with which it is closely conjoined. But when such an unusual stimulation does harm the body, there's a sensation of pain in the soul, even if the stimulus is only marginally stronger than one that causes pleasure. This explains why bodily pleasure and pain arise from such very similar objects, although the sensations are completely opposite.

192. (2) Taste.
Nerves scattered through the tongue and neighbouring areas are also affected by external bodies, but whereas with touch an external body acts as a whole, with taste it acts by being split up into particles that float in the saliva from the mouth. Such particles stimulate these nerves in various different ways, depending on their many different shapes, sizes or movements, thereby producing the sensations of various tastes.

193. (3) Smell.
The organs of the sense of smell are two other nerves (or appendages to the brain, because they don't go outside the skull) which are stimulated by separate particles of the same bodies, floating in the air. The particles have to be sufficiently light and energetic to be drawn into the nostrils and through the pores of the ethmoid bone, thus reaching the two nerves. The various movements of the nerves produce the sensations of various smells. [The ethmoid bone is a soft bone that separates the nasal cavity from the brain.]

194. (4) Hearing.
The object of hearing is simply various vibrations in the ear. 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 eardrum it produces a disturbance in the little chain of three small bones attached to it; and the sensations of different sounds arise—·via those two nerves·—from the various different movements in these bones.

195. (5) Sight
The optic nerves are the organs of the subtlest 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 terrestrial 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 my *Optics* and *Meteorology*.

196. The soul has sensory awareness because of its presence in the brain.
The soul's sensory awareness of what's going on in the body's individual limbs comes not •from its being present in those limbs but •from its being present in the brain, which registers, by means of motions along the nerves, the effects of external objects on the body. Here are four facts that jointly constitute decisive proof that the soul is in the brain. **(1)** Some diseases affect only the brain, yet remove or interfere with all sensation. **(2)** Sleep occurs only in the brain, but it always deprives us of most of our ability to sense things, though this is restored to us when we wake up. **(3)** When the brain is undamaged but something is blocking a path by which some nerve transmits effects from a limb to the brain, that is enough to destroy sensation in the limb in question. **(4)** We sometimes feel pain in a limb that actually has nothing wrong with it, the pain being caused by other parts of the body that the nerves pass through en route to the brain. [Descartes now reports an episode in which a girl complained of pains in individual fingers of a hand that had—though she didn't know this—been amputated. Then:] This must have been because the nerves that used to connect the brain with that hand were being agitated by the sorts of motion that had previously •been caused by ·damage to· the hand and •caused in the soul the sensation of pain in this or that finger.

197. It's just a fact about the mind 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 sorts of thoughts that aren't in any way *like* the motions that caused them. This is especially true of the confused thoughts we call 'sensations' or 'feelings'. We see that spoken or written words arouse all sorts of thoughts and emotions in our minds. With the same paper, pen and ink, •move the pen-nib across the page in one way and it will form letters that arouse in the reader's mind thoughts of battles, storms and violence, and emotions of indignation and sorrow; •move it in a slightly different way and the upshot will be thoughts of tranquillity, peace and pleasure, and emotions of love and joy. You may object:

> 'Speech or writing doesn't *immediately* arouse in the mind any emotions, or images of anything except the words themselves; it merely triggers various acts of understanding which then lead the soul to construct within itself the images of various things.'

But then what can you say about the sensations of pain and pleasure? A sword slashes your arm and pain follows just from that, ·without any mediating 'act of the understanding'·. The ensuing pain isn't remotely *like* any motion of the sword or of your arm—it's as different from them as is ·any sensation of· colour or sound or smell or taste. So it's clear that the sensation of pain is aroused in us merely by the motion of some parts of our body in contact with another body; from which we can 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 motions. [When Descartes says that 'the nature of our mind is such that' etc., he wants to get across that this is a *basic* fact about the mind, not something to be explained in terms of something broader and/or deeper.]

198. Our senses tell us nothing about external objects except their shapes, sizes and motions.

So far as we can tell, a nerve's effect on the brain depends purely on the motions that occur in the nerve—it's not a matter of special *kinds* of nerves delivering special kinds of input to the brain. And we see that this motion in the nerves produces not only sensations of pain and pleasure but also those of light and sound. You might see many sparks of flashing light because someone has punched you in the eye: there wasn't any light out there for you to see, just the vibrations in the nerve running from your retina to your brain. Put a finger in your ear and you'll hear a hum that comes from the movement of air trapped in the ear. And the same story holds for •heat etc. considered as qualities of external objects, and also for the basic nature of •fire etc., all of which we see consists merely in motions of particles. Now, we understand very well how the sizes, shapes and motions of the particles of one body can produce various motions in another body. But there's no way of making sense of the thesis **(1)** that size, shape and motion can produce such items as the •substantial forms and •real qualities that many philosophers think inhere in objects, or of the thesis **(2)** that these •qualities or •forms have the power to produce motions in other bodies. As well as being *unintelligible*, the notion of 'substantial form' or the like is idle, unnecessary, because we know that the nature of our soul is such that different motions suffice to produce all its sensations. . . . So we have every reason to conclude that the properties in external objects that we call 'light', 'colour', 'smell', 'taste', 'sound', 'heat', 'cold', other tactile qualities—and even 'substantial forms'!—seem to be simply various dispositions in those objects that enable them to trigger various kinds of motions in our nerves that are required to produce all the sensations in our soul.

199. No phenomenon of nature has been overlooked in this treatise.

There's no natural phenomenon that I have omitted to consider in this book—list them and you'll see! A list of natural phenomena can't include anything that isn't perceived by the senses. Well, I have dealt with all the various sizes, shapes and motions that are to be found in bodies; and the only other items that we perceive by our senses as being located outside us are light, colour, smell, taste, sound and tactile qualities. I have just demonstrated that these are nothing in the objects but certain dispositions depending on size, shape and motion, or anyway—or at least we can't perceive them [i.e. think of them] as anything but that.

200. I have used no principles in this treatise that aren't accepted by everyone; this philosophy is nothing new—it's extremely old and very common.

In trying to explain the general nature of material things I haven't used any principle that wasn't accepted by Aristotle and all other philosophers of every age. So this philosophy, far from being new, is the oldest and most common of all. I have considered the shapes, motions and sizes of bodies and examined what has to result from their interactions in accordance with laws of mechanics that are confirmed by reliable everyday experience. Who ever doubted that bodies move and have various sizes and shapes, and that how they move depends on their sizes and shapes. Who doubts that when bodies collide, the bigger bodies are split into many smaller ones and change their shapes? We pick up these facts through several senses—sight, touch and hearing; and we can also •depict them clearly in our imaginations and •understand them intellectually. ·I'm saying this about size, shape and motion·; it doesn't hold for colour, sound or the other characteristics each of which is perceived by only one sense, because our images of them are not clear but confused, and ·we have no intellectual understanding of them because· we don't know what they really are.

201. Some corporeal particles can't be perceived by the senses.

But I do allow that each body contains many particles that are too small to be perceived through any of our senses; and this may upset those who take their own senses as the measure of what can be known. But who can doubt that many bodies are too minute to be detectable by our senses? Think about a tree that is constantly growing larger: it doesn't make sense to say that it is larger now than it was this morning unless one means that some body was added to it during the day. And who has ever detected with his senses the tiny bodies that are added to a growing tree in one day? It must be admitted, at least by the philosophers who accept that quantity is indefinitely divisible—·implying that any portion of matter, however small, is divisible·—that the parts of a portion of matter could be made so tiny as to be imperceptible by any of the senses. And there's nothing surprising ·or suspect· about our inability to perceive very small bodies through our senses. Why not? Because we can't have a sensation unless our nerves are set in motion by external objects, and the nerves themselves are not very tiny, which implies that they can't be set in motion by bodies that *are* very tiny. I don't believe anyone who is really *thinking* will 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 that elude our senses merely because they are tiny.

This is much better than

> •explaining matters by inventing all sorts of strange objects with no resemblance to what is perceived by the senses

—objects such as 'prime matter', 'substantial forms' and the rest of the items in the absurd parade of qualities that people habitually introduce, all of which are harder to understand than the things they're supposed to explain.

202. The philosophy of Democritus differs from mine just as much as it does from the standard view of Aristotle and others.

Democritus also imagined certain small bodies having various sizes, shapes and motions, and supposed that every sense-perceptible body is the upshot of assemblage and mutual interaction of these little corpuscles; yet his method of philosophizing has met with total rejection ·by Aristotle and· by the general run of philosophers ·who have followed him·. Was that because it deals with particles so tiny as to elude the senses, and credits them with having sizes, shapes and motions? Of course not!—no-one can doubt that there are many such particles, as I have just shown. Here are the four reasons why the philosophy of Democritus has been rejected. **(1)** He supposed his corpuscles to be indivisible—a thesis that puts me in the 'rejection' camp. **(2)** He imagined there to be a vacuum around the corpuscles, whereas I show that there couldn't be. **(3)** He attributed weight to these corpuscles, whereas I think of a body's weight as •an upshot of its position and the motion of other bodies, not as •something the body has in isolation. **(4)** He didn't show how particular events arose purely from the interaction of corpuscles; or if he did explain some of them, his explanations didn't hang together properly—or so it seems, going by the little we know about his opinions. (I leave it to others to judge whether what I have written so far in philosophy [here mainly = 'science'] hangs together well enough, and is sufficiently fertile in the results that can be deduced from it.) As for the business of shapes, sizes and motions ·of corpuscles·: I agree with Democritus about that, but so did Aristotle and all the philosophers who came after him. I reject the rest of Democritus's philosophy, but then I also reject nearly everything in the systems of those other philosophers. So it's obvious that my way of philosophizing has no more affinity with the Democritean method than with any of the other philosophical sects.

203. How we know the shapes, ·sizes· and motions of imperceptible particles.

You may want to ask:

> 'Given that you are talking about particles that can't be perceived, how can you know what specific shapes, sizes, and motions to attribute to them? You write as though you had *seen* them!'

My reply is this. [The next two sentences are from the French version of the work.] I started by looking for all the vivid and clear notions that our understanding can have regarding material things, and all I found were •our notions of shapes, sizes and motions, and •the rules in accordance with which these three can be modified by each other—rules that are the principles of geometry and mechanics. This led me to the judgment that all human knowledge of the natural world *must* be derived from those three, because the only other notions we have of sense-perceptible things are confused and obscure, and so can only hinder—not help—us in our pursuit of knowledge of things outside ourselves. [Descartes or his translator here takes the antonym of the phrase *claires et distinctes* to be *confuses et obscures*, rather than *obscures et confuses*. Such occasional switches don't refute the thesis advanced in the long note at the end of 1:47.] Next, I took the simplest and most obvious principles—the ones that nature implants in our minds—and working from these I considered, in general terms, •what principal differences there can be between the sizes, shapes and positions of bodies that are too small to be perceptible by the senses, and •what observable effects would result from their various

interactions. When I later observed in sense-perceptible objects the very same effects ·that had been predicted by my theoretical approach·, I judged that they *were* indeed effects of just such an interaction of bodies that aren't sense-perceptible; and I was strengthened in this by the apparent impossibility of coming up with any other explanation for them. In thinking about these matters I was greatly helped by considering artefacts. I don't recognize any difference between artefacts and natural bodies except that artefacts mostly work through mechanisms that are big enough to be easily perceivable by the senses (they *have* to be, if humans are to be able to manufacture them!). In contrast with that, the effects produced in nature almost always depend on structures that are so tiny that they completely elude our senses. And anyway mechanics [*mechanica*] is just a division or special case of natural science [*physica*], and all the explanations belonging to the former also belong to the latter; so the fact that

> •a clock with such-and-such a mechanism of wheels will tell the time

is just as *natural* as the fact that

> •a tree that grew from such-and-such a seed will produce apples.

Men who've had experience dealing with machinery can take a particular machine whose function they know and by looking at •some of its parts easily guess at the design of •the other parts, the ones they can't see. That's the kind of thing I have been doing—noting the observable effects and parts of natural bodies and trying to work out their causes at the level of imperceptible particles.

204. It's enough to explain what the nature of imperceptible things might be, even if their actual nature is different.

This method may enable us to understand how all the things in nature *could* have arisen, but we shouldn't conclude that they *were* in fact made in that way. A craftsman could make two equally reliable clocks that looked completely alike from the outside but had utterly different mechanisms inside; so also, I freely concede, the supreme maker of everything could have produced all that we see in many different ways. I'll think I have achieved enough just so long as what I have written corresponds accurately with all the phenomena of nature. That's all that is needed for practical applications in ordinary life, because medicine and mechanics—and all the other arts that can be fully developed with the help of natural science—are directed only towards the phenomena of nature, i.e. towards items that are sense-perceptible. Do you think that Aristotle achieved more than this, or at least wanted to do so? If so, you are wrong. At the start of his *Meteorology* 1:7 he says explicitly, regarding his reasons and demonstrations concerning things not manifest to the senses, that he counts them as adequate so long as he can show that such things *could* occur in accordance with his explanations.

205. Nevertheless my explanations appear to be at least morally certain. . .

Something can be morally certain, i.e. sure enough for everyday practical purposes, while still being *un*certain in relation to the absolute power of God. Without having been to Rome (let's suppose), you are sure that it is a town in Italy, but it *could* be the case that everyone who has told you this has been lying. ·And here's another example·. You are trying to read a document written in Latin but encoded; you guess that every 'a' should be a 'b', every 'b' a 'c', and so on through the alphabet, and when you decode the document on that basis it makes good sense. You won't doubt that you have detected the code and understood the letter—·you'll be morally certain of that·. But it is *possible* that you are wrong, and that the document involves some other code and

means something different from what your decoding made it mean. •Possible, but hardly •credible—especially if the document is long. Well, now, look at all the many properties relating to magnetism, fire and the fabric of the entire world that I have derived in this book from just a few principles: you may think that my assumption of these principles was arbitrary and groundless, but perhaps you'll admit that if my 'principles' were false it would hardly have been possible for them to fit so many items into a coherent pattern.

206. . . . and indeed more than morally certain.
Besides, even in relation to nature there are some things that we regard as not merely •morally but •absolutely certain. (Being absolutely certain that P involves thinking that it's wholly impossible that P should be false.) This certainty has a metaphysical basis in the proposition that God is supremely good and in no way a deceiver, and hence that the faculty he gave us for distinguishing truth from falsehood can't lead us into error while we are using it properly and are thereby perceiving something clearly. Mathematical demonstrations have this kind of certainty, and so does the knowledge that material things exist, as does all evident reasoning about material things. If you think about how I have reached •my results, deriving them in an unbroken chain from the first and simplest principles of human knowledge, you may be willing to count •them among the absolute certainties. You are especially likely to do so if you have a proper grasp of two facts: **(1)** We can have no sensory awareness of •external objects unless •they make something move in our nerves; and **(2)** the fixed stars, owing to their enormous distance from us, can't produce such motion ·in our nerves· unless some motion is also occurring both in them and also throughout the entire intervening part of the heavens. [Strictly, the 'enormous distance' clause shouldn't occur in that sentence; Descartes's considered view is that something *six inches* from us can't stimulate our nerves unless there is motion in it and through the intervening space.] Once this is accepted, it seems that all the other phenomena, or at least the general features of the universe and the earth that I have described, can hardly be intelligibly explained except in my way.

207. I submit all my views to the authority of the Church.
Nevertheless, mindful of my own weakness, I make no firm pronouncements and submit all these opinions to the authority of the Catholic Church and the judgment of those wiser than myself. And I wouldn't want you to believe anything ·I have written· unless you are convinced of it by evident and irrefutable reasoning.