

RENÉ DESCARTES

The World
and Other Writings

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Treatise on Light and other principal objects
of the senses

3

Chapter 1

On the difference between our sensations¹ and the things that produce them²

In putting forward an account of light, the first thing that I want to draw to your attention is that it is possible for there to be a difference between the sensation that we have of it, that is, the idea that we form of it in our imagination through the intermediary of our eyes, and what it is in the objects that produces the sensation in us, that is, what it is in the flame or in the Sun that we term 'light'. For although everyone is commonly convinced that the ideas that we have in our thought are completely like the objects from which they proceed, I know of no compelling argument for this. Quite the contrary, I know of many observations which cast doubt upon it. 4

As you know, the fact that words bear no resemblance to the things they signify does not prevent them from causing us to conceive of those things,

¹ I have translated the term *sentiment* by 'sensation'. Although Descartes will include pains among our sensations in the *Treatise on Man*, the qualification that a sensation is formed 'through the intermediary of our eyes' restricts sensations to ideas caused by external objects. However, sensation should not be taken in the sense of mere sensation, as opposed to perception, something which involves judgement, for *sentiments* can involve judgement, and indeed typically involve judgements in the case of human sensations. The sensations of automata do not involve judgement, and cases of human sensation in which there is no attentiveness, such as our perception of objects at the extremes of our visual field, seem to be treated on a par with an automaton's sensation (see AT i. 413; CSM iii. 61–2).

² The chapter headings, and possibly even the division into chapters, were probably the work of Clerselier. I give the chapter headings of the 1677 edition; the 1664 chapter headings, which are probably the work of an early copyist, are given in the notes where these differ.

often without our paying attention to the sounds of the words or to their syllables. Thus it can turn out that, having heard something and understood its meaning perfectly well, we might not be able to say in what language it was uttered. Now if words, which signify something only through human convention, are sufficient to make us think of things to which they bear no resemblance, why could not Nature also have established some sign which would make us have a sensation of light, even if that sign had in it nothing that resembled this sensation? And is it not thus that Nature has established laughter and tears, to make us read joy and sorrow on the face of men?³

But perhaps you will say that our ears really only cause in us sensory awareness of the sound of the words, and our eyes only sensory awareness of the countenance of the person laughing or crying, and that it is our mind which, having remembered what those words and that countenance signify, represents this to us at the same time. I could reply to this that, by the same token, it is our mind that represents to us the idea of light
5 each time the action that signifies it touches our eye. But rather than waste time arguing, it is better to give another example.

Do you think that, when we attend solely to the sound of words with-

³ This is a key passage, but it is too compact for us to say with certainty exactly what Descartes has in mind. In discussing perceptual cognition in earlier works such as the *Rules*, Descartes focused on the 'perceptual' side of the question, whereas here he clearly wants to say something about the 'cognition' side. The former he construes in terms of mechanical-physiological process, as is clear from the *Treatise on Man*. Here he construes the latter in linguistic terms, so that visual cognition – knowing something by virtue of seeing it – is considered not in terms of seeing and understanding a picture but in terms of hearing and understanding a word or a sentence: any element of resemblance between the thing perceived and our cognitive representation of the thing is completely purged. What happens when we understand what another person says is that the idea in that person's mind is conveyed to our mind: the idea or thought is encoded in language and then decoded by our mind. The words that encode the idea clearly do not resemble it, but they just as clearly do represent it. So far so good, but once we apply this model to the visual perception of objects we immediately face a disanalogy. For in what sense is there an idea conveyed to our mind when we see something? Are there ideas in nature, which nature itself encodes, or which God has encoded there? We can think of the question in terms of Descartes' terminology of signs. For Descartes, language consists of conventional signs; these signs signify thoughts or ideas for the purpose of conveying those thoughts or ideas to another person who understands the signs. In the case of visual perception, what are the analogues of the speaker's thoughts, the conventional linguistic signs, and the hearer's thoughts? One might be tempted to say that they are, respectively, natural objects, the natural signs by which information about these natural objects is conveyed to us visually (namely light), and the perceiver's thoughts. But this is not consistent with the way in which Descartes construes what happens. He tells us that there is in nature a sign which is responsible for our sensation of light, but which is not itself light, and which does not resemble light: all there is in nature is motion. Motion is the sign, and what is signified is what is experienced in the perception, namely light. This makes it look as if what is signified in nature is something that exists only in our mind, a view we could hardly ascribe to Descartes.

out attending to their signification, the idea of that sound which is formed in our thought is at all like the object that is the cause of it? A man opens his mouth, moves his tongue, and breathes out: I see nothing in all these actions which is in any way similar to the idea of the sound that they cause us to imagine. And most philosophers maintain that sound is only a certain vibration of the air striking our ears.⁴ Thus if the sense of hearing transmitted to our thought the true image of its object, then instead of making us think of the sound, it would have to make us think about the motion of the parts of the air that are vibrating against our ears. But as not everyone will, perhaps, wish to follow what the Philosophers⁵ say, so I shall offer another example.

Of all our senses, touch is the one considered least deceptive and the most secure; so if I show you that even touch leads us to conceive many ideas which do not resemble in any way the objects that produce them, I believe you should not find it strange when I say that the same holds for sight. Now everyone knows that the ideas of tickling and pain which are formed in our thought when bodies from outside touch us bear no resemblance at all to these. One passes a feather lightly over the lips of a child who is falling asleep and he feels himself being tickled: do you think that the idea of tickling which he conceives resembles something in the feather? A soldier returns from battle. During the heat of the combat he could have been wounded without being aware of it. But now, as he begins to cool down he feels pain and believes that he has been wounded: a surgeon is called and examines him once his armour has been removed; in the end, it is discovered that what he was feeling was just a buckle or strap which, being caught under his armour, was pressing on him and causing his discomfort. If his sense of touch, in causing him to feel this strap, had impressed its image in his thought, there would not have been any need for the surgeon to show him what he was feeling.

Now I can see nothing which compels us to believe that what it is in objects that gives rise to the sensation of light is any more like that

⁴ An early version of the vibration theory had been held by the Coimbra commentators. See the texts given in Gilson, *Index scolastico-cartésien* (2nd edn, Paris, 1979), nos. 424 and 425. A related 'corpuscular' theory of sound had been developed by Descartes' early mentor Isaac Beeckman in the second decade of the seventeenth century, and Mersenne developed this approach in detail in the 1620s and 1630s. Here was a rare case of relatively common ground in natural philosophy.

⁵ The phrase 'les Philosophes' usually refers specifically to scholastic philosophers, and as often as not to the late scholastic Jesuit philosophers – Suárez, Toletus, Fonseca, and the Coimbra commentators – from whose commentaries Descartes had learned his philosophy at La Flèche.

sensation than the actions of a feather or a strap are like a tickling sensation and pain. Nevertheless, I have not adduced these examples to convince you absolutely that light is something different in objects from what it is in our eyes, but only to raise a doubt about it for you, to prevent you being biased in favour of the contrary view, so that we can examine together what light is.

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Chapter 2

What the heat and the light of fire consist in⁶

I know of only two kinds of bodies in the world in which light is found, namely the stars, and flame or fire.⁷ And because there is no doubt that stars are further from human knowledge than fire or flame, I shall first try to explain what I notice with respect to flame.

When it burns wood or other similar material we can see with our eyes⁸ that it moves the small parts of the wood, separating them from one another, thereby transforming the finer parts into fire, air, and smoke, and leaving the larger parts as ashes. Someone else may if he wishes imagine the 'form' of fire, the 'quality' of heat, and the 'action' of burning to be very different things in the wood.⁹ For my own part, I am afraid of going astray if I suppose there to be in the wood anything more than what I see must necessarily be there, so I am satisfied to confine myself to conceiving the motion of its parts. For you can posit 'fire' and 'heat' in the wood and make it burn as much as you please: but if you do not suppose in addition that some of its parts move or are detached from their neighbours then I cannot imagine that it would undergo any alteration or change.¹⁰ On the other hand, take away the 'fire', the 'heat', and keep
8 the wood from 'burning'; then, provided only that you grant me that

⁶ The heading in the 1664 edition is: *What it is in fire that burns, heats, and illuminates.*

⁷ The obvious omission here is phosphorescent phenomena.

⁸ That is, presumably, without the help of a magnifying glass. The phenomenon is macroscopic, even though it turns out that it must be explained in micro-corporcularian terms.

⁹ Descartes is referring here to the Aristotelian account of fire. Aristotle treats fire as one of the four elements in Book II of *De Generatione et Corruptione*, that element characterised by the qualities hot and dry. The elements can be transformed into one another by a change in their qualities, and he gives the example of fire and water being transformed into air and earth. The (qualitatively characterised) type of change involved in the transformation is the main subject of Aristotle's discussion. Nevertheless, it is not Aristotle's own account that Descartes has principally in mind here but that of the late scholastic commentators. Gilson traces reasonably direct sources in Suárez and Eustache de Saint Paul in his *Index*, nos. 211 and 392.

there is some power that violently removes its more subtle parts and separates them from the grosser parts, I consider that this alone will be able to bring about all those changes that we observe when the wood burns.

Now since it does not seem possible to conceive of a body moving another unless it itself is moving, I conclude from this that the body of the flame which acts against the wood consists of minute parts, which move independently of one another with a very quick and violent motion; and as they move in this way, they push against and move those parts of the body that they touch and which do not offer them too much resistance. I say that its parts move independently of one another because although often many of them act together to bring about a single effect, we see nonetheless that each of them acts on its own against the bodies they touch. I say also that their motion is very quick and very violent, for being so minute that we cannot distinguish them by sight, they would not have the force to act against other bodies if the quickness of their motion did not compensate for their lack of size.¹¹

I add nothing about the direction in which each moves. For when you consider that the power to move and the power that determines in what direction the motion must take place are two completely different things, 9 and can exist one without the other (as I have explained in my *Dioptrics*¹²), then you will have no difficulty recognising that each part moves in the manner made least difficult for it by the disposition of the bodies surrounding it.¹³ And in one and the same flame, there can be some parts going up, and others down, some in straight lines, some in circles; they can move in every direction without altering its nature at all. Thus if you see almost all the parts tending upwards, you need not think

¹⁰ Aristotle had maintained that local motion is involved in every other kind of change in his *Physics* (208^a32 and 260^b22). Descartes now moves from this relatively uncontentious claim to something more like the view that the other forms of change are reducible to local motion, something which Aristotle and the scholastic tradition completely reject.

¹¹ How the quickness of their motion can 'compensate' for their small size is not set out in the text. The simplest relation suggested by what Descartes says is that the force involved is to be measured by size \times speed, but Descartes thinks of force in so many different ways, and is normally so reluctant to consider speeds, that it is not possible to say just what the relationship here is.

¹² See translation of Discourse 2 of the *Dioptrics*, below.

¹³ The implicit principle that the part of the flame will always take the path which offers least resistance is problematic. On a literal reading of this principle, light (which will be treated on a par with fire) transmitted through air would always be reflected when it met an opaque surface, for the opaque surface would always resist its motion more than the air. This alone would rule out a literal reading. What the intended reading of 'least resistance' is in the present context is obscure.

that this is for any reason other than that the bodies touching them are almost always disposed to offer them greater resistance in any other direction.¹⁴

Once we appreciate that the parts of the flame move in this way, and that to understand how the flame has the power to consume the wood and to burn it, it is enough to conceive of their motions, I ask you to consider whether this is not also sufficient for us to understand how the flame provides us with heat and light.¹⁵ For if this is the case, the flame will need possess no other quality, and we shall be able to say that it is this motion alone that is called now 'heat' and now 'light', according to the different effects it produces.

As regards heat, it seems to me that our sensation of it can be taken as
10 a kind of pain when it is violent, and sometimes as a kind of tickling, when it is moderate.¹⁶ Since we have already said that there is nothing outside our thought which is similar to the ideas which we conceive of tickling and pain,¹⁷ we can well believe that there is nothing that is similar to that which we conceive of as heat; rather, anything that can move the minute parts of our hands or of any other place in our body can arouse this sensation in us. There are many observations which support this view. For merely by rubbing our hands together we can heat them, and any other body can also be heated without being placed close to a fire, provided only that it is shaken and rubbed in such a way that many of its minute parts are moved and thereby can move the minute parts of our hands.

As regards light, it can also be conceived that this same motion in the flame suffices to make us sense it. But since the main part of my project is to deal with this, I want to try to explain it at length when I resume discussion of this matter.

¹⁴ The relevant contrast here is with Aristotle's theory, whereby flames move upwards because the natural place of fire is upwards. See, for example, *De Caelo* 311^a15ff.

¹⁵ The cases of motion producing combustion and motion producing heat and light are, nevertheless, very different. As is evident from the next paragraph, there is a difference of kind between the motion that produces heat and our sensation of heat, but there is no such difference in the case of combustion.

¹⁶ A mechanistic account of pain and tickling will be provided in the *Treatise on Man*, AT xi. 143–4, p. 119 below.

¹⁷ It is tempting to translate *concevoir* here as 'have', and to speak simply of the idea we have of tickling, rather than the idea we conceive of tickling, but 'have' does not convey the active ingredient in conceiving an idea, which is important in Descartes' account.

Chapter 3

*Hardness and fluidity*¹⁸

I believe that there are innumerable different motions which endure perpetually in the world. After having noted the greatest of these – those which bring about the days, months, and years – I take note that the terrestrial vapours unceasingly rise to and descend from the clouds, that the air is forever agitated by the winds, that the sea is never at rest, that springs and rivers flow ceaselessly, that the strongest buildings eventually fall into decay, that plants and animals are always either growing or decaying: in short, that there is nothing anywhere which is not changing. From this it is evident to me that the flame is not alone in having many minute parts in ceaseless motion, but that every other body has such parts, even though their actions are not as violent and, because of their small size, they cannot be perceived by any of our senses. 11

I do not pause to seek the cause of their motions, for it is enough for me to take it that they began to move as soon as the world began to exist. And that being the case, I reason that their motions cannot possibly ever cease, or even change in any way except in respect of their subject. That is to say, the strength or power found in one body to move itself may pass wholly or partially to another body and thus no longer be present in the first, but it cannot entirely cease to exist in the world.¹⁹ My arguments had satisfied me on this point, but I have not yet had the opportunity to present them to you. In the meantime you might care to imagine, along with most of the learned,²⁰ that there is some prime mover which, rolling 12 around the world at an incomprehensible speed,²¹ is the origin and source of all the other motions found therein.

¹⁸ The heading in the 1664 edition is: *Where the variety, duration and cause of motion are examined, with the explication of the hardness and fluidity of bodies in which these are found.*

¹⁹ For Aristotle, new motions can come into existence, and motion can be dissipated out of existence. Descartes here denies this, albeit by fiat, effectively stating a conservation law. We must be careful about what exactly is conserved, however. It would seem to be not so much the total quantity of motion as the total quantity of the strength [*vertu*] or power [*puissance*] by which a body moves, or, in more convenient terminology, the total quantity of the force of motion. In virtue of conservation of the total quantity of force of motion there will be conservation of the total quantity of motion, but the two must be distinguished, partly because the relations between motion and force of motion in Descartes' natural philosophy are complex, and partly because it is important to realise that conservation of motion is due to conservation of force of motion when one comes to assess the relation between kinematic and dynamic considerations in Descartes. His statement of conservation here involves forces, and so is dynamic rather than kinematic.

²⁰ The term Descartes uses here is 'Doctes', indicating above all scholastic thinkers.

²¹ Gilson gives sources for this doctrine in the Coimbra commentators: see Gilson, *Index*, no. 308.

Now this consideration leads to a way of explaining all the changes that occur in the world, and all the variety that appears on the earth; but I shall confine myself here to speaking of those that bear on my topic.

The first thing I want to call to your attention is the difference between bodies that are hard and those that are fluid. To this end, consider that every body can be divided into extremely small parts. I am not interested in deciding whether the number of these is infinite or not; at least with respect to our knowledge, it is certain that it is indefinite and that we can suppose that there are several million of them in the smallest grain of sand visible to the eye.

And note that if two of these minute parts are touching one another and are not in the process of moving away from each other, then a force, no matter how small, is needed to separate them; for once they are so positioned, they would never be inclined to dispose themselves differently. Note also that twice as much force is needed to separate two of them than is needed for one, and a thousand times as much to separate 13 a thousand of them. Consequently, if one had to separate several million of them at once, as is perhaps necessary in breaking a single hair, it is not surprising that a significant force is required.²²

By contrast, if two or more of these minute parts only touch in passing and while they are in the process of moving one in one direction and one in the other, it is certain that it will require less force to separate them than if they were completely stationary, and indeed none at all if the motion with which they are able to separate themselves is equal to or greater than that with which one wishes to separate them.

Now I detect no difference at all between hard bodies and fluid bodies except that the parts of the one can be separated from the whole much more easily than those of the other. Thus, to make the hardest body imaginable, I think it would be enough for all the parts to touch each other, with no space remaining between any two and none of them in the process of moving. For what glue or cement can one imagine beyond this with which to hold the one to the other?

Moreover, I think that it is enough, to make the most fluid body

²² One should not imagine something like a chain of a hundred links each of which can bear exactly ten pounds here, for if eleven pounds is enough to break any of the links it will not matter how many other links it is attached to: the chain will not support the weight. Rather, one must think of each of the links, not as being attached to one another, but being each attached directly to the weight. In this case the weight is evenly distributed throughout the links, and such links will bear (roughly) a hundred times the weight one will bear.

imaginable, that all its most minute parts be moving away from one another in the most diverse ways and as quickly as possible, even though in that state they are quite able to touch one another on all sides, and to arrange themselves in a space as small as if they were motionless. Finally, I believe that every body approaches these two extremes to a greater or lesser degree, depending on the degree to which its parts are in the process of separating themselves from one another. And this judgement is corroborated by everything I have cast my eye on. 14

Flame, whose parts – as I have already said – are perpetually agitated, is not only fluid, but renders most other bodies fluid. And note that when it melts metals, it acts with a power no different from that by which it burns wood.²³ But because the parts of the metal are all approximately equal [in size], it cannot move one without the other, and consequently it forms completely fluid bodies from them. The parts of wood, by contrast, are unequal in such a way that the flame can separate out the smaller of them and make them fluid – that is, it can cause them to fly away as smoke – without thereby agitating the larger parts.

After flame, there is nothing more fluid than air, and one can see with the naked eye that the parts move separately from one another. For if you take the trouble to watch those minute bodies that are commonly called atoms which appear in rays of sunlight, you will see that, even when there is no wind stirring them up, they flutter about incessantly in a thousand different ways.²⁴ The same kind of thing can also be experienced in all the grosser liquids if differently coloured ones are mixed together in order that their motions might be distinguished more easily. And finally this can be experienced very clearly in acids,²⁵ when they move and separate the parts of some metal. 15

²³ The task that Descartes has set himself here is, with hindsight, an impossible one. His aim is to account for the traditional four elements – earth, air, fire, and water – as the four states of a single substance. Earth, water, and air can be taken as solid, liquid, and gaseous states respectively, and there are clearly prospects for success in treating these as different states of the one substance. But fire cannot be fitted into this schema, and his attempt to draw parallels between the liquefaction of solids and the combustion of solids, although ingenious, is doomed, and never rises above the level of the speculative.

²⁴ The ‘atoms’ that Descartes refers to here are of course dust particles which, in common with many of his contemporaries, he takes to be minute particles of air.

²⁵ Descartes’ term ‘*les eaux fortes*’ has a rather broad variety of meanings. Most literally it is a translation of the Renaissance Latin term for nitric acid, *aqua fortis*, but virtually any liquid which had, or was thought to have, the power of dissolving substances could come under the term, and sixteenth- and seventeenth-century alchemists regularly treated mercury as the basic *eau forte*. Nevertheless, nitric acid is the most likely contender here as it was widely available owing to its use in etching copper plates.

But at this point you may ask, if it is solely the motion of the parts of the flame that cause it to burn and make it fluid, why the motion of the parts of air, which also make it extremely fluid, give it no power at all to burn but, quite the contrary, make it such that our hands can hardly feel it? To this I reply that one must take account not only of the speed of motion, but also the size of the parts. It is the smaller ones that make the more fluid bodies, but it is the larger ones that have more force to burn and, in general, to act on other bodies.

Note, by the way, that here, and always from here onwards, I shall take a single part to be everything that is joined together and which is not in the process of separating, even though the smallest parts could be divided easily into many smaller ones; thus a grain of sand, a stone, a rock, indeed the whole earth itself, can from here on be taken as a single part, in so far as we are considering here only a completely simple and completely equal motion.

16 Now if, among the parts of the air, there are some which are very large in comparison with others, as are the atoms that are seen there, they also move very slowly; and, if there are some that move more quickly, they are also the smallest. But if, among the parts of the flame, there are some that are smaller than those in air, there are also larger ones, or at least there is a larger number of parts of the same size as the largest parts of air, and they move much more quickly. Consequently these alone have the power to burn.

That there are smaller parts may be conjectured from the fact that many bodies that they penetrate have pores so narrow that even air cannot enter them. That there are larger parts, or parts as large but in greater number, is seen clearly from the fact that air alone is not enough to keep the flame burning.²⁶ That they move more quickly is sufficiently evident from the violence of their action. And finally, that it is the largest of these parts that have the power to burn, and not the others, is apparent from the fact that the flame that issues from brandy, or from other very subtle bodies, hardly burns at all, while that which comes from hard and heavy bodies is very hot.²⁷

²⁶ Literally, air alone is not enough to 'nourish' the flame. The connection between air's inability to keep a flame alight and the claim that its largest parts must be larger than, or more numerous than, those of air is obscure. The metaphor of nourishment seems to be the key to what Descartes has in mind here: we can only nourish ourselves by breaking down relatively large things. The ability of something to nourish seems to be associated with its amenability to being broken down into smaller parts.

²⁷ Descartes attempts to spell out the structural differences between various kinds of body in the *Meteorology*: see AT vi. 233-4. This material may date from as early as the time of composition of the present discussion.

Chapter 4

*On the void, and how it comes about that our senses do not perceive certain bodies*²⁸

But we need to examine in greater detail why, although it is as much a body as any other, air cannot be sensed as easily as other bodies; and in doing this we shall free ourselves from an error which has been a prejudice since childhood, when we believed that the only bodies around us were those that we could perceive, and consequently that, if air were one of these then, because we perceive it so faintly, it must at least not be as material and solid as those we sense more clearly. 17

On this topic, the first thing I would like you to note is that all bodies, whether hard or fluid, are made from the same matter, and that it's impossible to conceive of the parts of this matter ever composing a more solid body, or occupying less space, than they do when each of them is touched on all sides by the others surrounding it. From this it seems to me to follow that if there could be a void anywhere it must be in hard bodies rather than fluid ones;²⁹ for it is obviously much easier for the parts of the latter to press and arrange themselves against one another, because they are moving, than it is for those of the former, which are motionless.

When you put powder in a jar, for example, you shake and pound it to make room for more powder; but if you pour liquid into it, it immediately arranges itself in the smallest space into which one can put it.³⁰ And indeed, if you think in this respect of some of the experiments that philosophers commonly use to show that there can be no void in nature, you will readily appreciate that all those spaces that people consider 18

²⁸ The heading in the 1664 edition is: *What judgement we must make about the void, and the reason why our senses are not aware of certain bodies.*

²⁹ The traditional Atomist explanation of differences in density was in terms of the amount of void that existed between the atoms making up a body. The more empty space between atoms, the less the body's density. In undermining the Atomist view, Descartes shifts the focus to fluidity. We naturally think in terms of an inverse proportion between density and fluidity, and the present argument is designed to show that the behaviour of hard bodies is incompatible with the postulation of a void.

³⁰ There are two problems with this counter-example to the traditional Atomist account. First, given that Descartes has made the ease with which something can be penetrated or cut a criterion for its being a fluid, powders should be treated as fluids, not as solids. Secondly, if one does treat powders as a kind of solid, as Atomists presumably do, then one has to distinguish between the behaviour of powders, which can be pounded into a smaller volume, and rigid solids, which cannot be.

empty, and where we perceive only air, are no less full – and of the same matter – as the spaces where we perceive other bodies.

For pray tell me why on the one hand Nature would cause the heaviest bodies to rise and the most solid to break, as we can see it doing in certain machines, rather than to allow their parts to cease to touch one another or to touch other bodies, and yet on the other allow the parts of air, which are easy to bend and arrange in every way, to remain next to each other without being touched on each side, or without there being any body between them which they touch. Could one really believe that, on the one hand, the water in a well has to rise, contrary to its natural inclination, merely in order that the pipe of a pump may be filled, and that, on the other hand, the water in the clouds does not have to fall in order to fill the spaces here below, if there were even the least void between the parts of the bodies they contain?³¹

19 But you could bring up a more considerable difficulty here, namely, that it does not seem that the parts composing liquid bodies can move about incessantly as I have said they do, unless there is some empty space between them, at least in the places they vacate as they move about. I would have trouble replying to this had I not learned from a variety of observations that all motions that occur in the world are in some way circular. That is, when a body leaves its place, it always enters into that of another, and this latter into that of another, and so on to the last body, which at the same instant occupies the first. Thus there is no more of a void between bodies when they are moving than when they are at rest. And note here that for this to happen it is not necessary that all the parts of the bodies that move together be arranged exactly in a ring, as in a true circle,³² or even that they be of equal size and shape, for any such inequalities can easily be compensated for by other inequalities in their speeds.

We do not usually notice these circular motions when bodies are moving in air because we are accustomed to thinking of air as being just empty space. But look at fish swimming in the pool of a fountain: if they do not come too near the surface of the water, they cause no motion at all in it, even though they are passing beneath it at great speed. It is clearly apparent

³¹ In other words, a pump can raise water against its natural inclination (its weight tending to cause it to fall, not rise) because a vacuum would be formed unless the water rose: and this being the case, if there were empty spaces between the parts of matter on the earth, we would have even more reason to expect that they would draw water out of the clouds, since this would be in keeping with the tendency of water to fall, due to its weight.

³² In fact, all that is required is that the motions form a closed curve.

from this that the water they push before them does not push all the water in the pool indiscriminately, but only that which can best serve to perfect the circle of the fishes' motion and to occupy the place they vacate. ²⁰

And this observation is sufficient to show the ease and familiarity of such circular motions to Nature. But I now want to put forward another observation, which shows that no motion ever occurs which is not circular. When the wine in a cask does not flow through an opening at the bottom because the top is shut tight, it is improper to say, as is commonly done, that this takes place because of 'fear of a void'. It is well known that the wine has no mind with which to fear anything, and even if it did, I do not know why it should fear a void, which is wholly chimeral. Instead, what we must say is that the wine cannot leave the cask because outside everything is completely full, and the part of the air whose place the wine would occupy if it were to flow out can find nowhere else in the universe to occupy, unless an opening is made in the top of the cask through which the air can rise in a circle into its place.

Nevertheless, I do not want to say categorically that there is no void in Nature. I fear that my treatise would be too lengthy if I were to undertake to explain the matter at length, and the observations of which I have spoken are not sufficient to secure it, although they are enough to persuade us that those spaces where we sense nothing are filled with the same matter, and contain at least as much of that matter, as those occupied by the bodies that we perceive. ²¹ Thus, when a vessel is full of gold or lead, for example, it contains no more matter than when we think it empty. This may seem strange to those people whose reasoning extends no further than their fingertips, and who think there is nothing in the world other than what they touch. But once you have given a little consideration to what makes us perceive or not perceive a body with our senses, I am sure that you will find that there is nothing incredible in this. For you will recognise clearly that, far from all the things around us being perceivable, on the contrary it is those that are there most of the time that can be perceived the least, and those that are there all of the time can never be perceived at all.

The heat of our heart is very great, but we do not feel it because it is always there. The weight of our body is great, but it does not discomfort us. We do not even feel the weight of our clothes, because we are used to wearing them. The reason for this is clear enough: we cannot perceive a body by our senses unless it is the cause of some change in our sense organs – that is, unless it moves in some way the small parts of matter of ²²

which those organs are composed. The objects that are not always present can do this well enough, provided they have enough force; for if they damage something in the sense organs while acting upon them, that can be repaired afterwards by nature, when they are no longer acting. But as for those objects which continually touch us, even if they had the power to induce a change in our senses and to move some parts of their matter, they would have to have moved them and separated them completely from the others at the beginning of our life, and in this way they would have left there only the parts that completely resist their action, and without which they could not be perceived by our senses in any way. You can see from this that it is no wonder that there are many spaces around us in which we do not perceive any body by our senses, even though they contain bodies no less than the spaces in which we perceive them the most.

But it must not be thought that the gross air that we draw into our lungs while breathing – the air which turns into wind when set in motion, which seems hard when enclosed in a balloon, and which is composed only of exhalations and smoke – is as solid as water or earth. Here we must follow the common opinion of the Philosophers, who all maintain that it is rarer, and we can tell this easily from experience. For when the parts of a drop of water are separated from one another by the agitation of heat, ²³ they can make up much more of this air than could be contained in the space that held the water. From this it follows with certainty that there are many small gaps between the parts of which the air is composed; for there is no other way to conceive a rare body. But because these gaps cannot be empty, as I said above, I conclude from this that there must be other bodies, one or many, mixed with the air, and these bodies fill the tiny gaps left between the parts as tightly as possible. It only now remains for me to consider what these other bodies can be, and after this I hope it will not be difficult to understand what may be the nature of light.

Chapter 5

*On the number of elements and their qualities*³³

The Philosophers maintain that above the clouds there is a kind of air much subtler than ours, which is not composed of terrestrial vapours, as

³³ The heading in the 1664 edition is: *The reduction of the four Elements to three, with an explanation and establishment of them.*

our air is, but constitutes an element in itself. They say too that above this air there is yet another body, more subtle still, which they call the element of fire. And they add that these two elements are mixed with water and earth to make up all the bodies below.³⁴ Thus I shall merely be following their opinion if I say that this subtler air and this element of fire fill the gaps between the parts of the gross air that we breathe, so that these bodies, interlaced with one another, make up a mass as solid as any body can be. 24

But so that you might understand my thought on this subject better, and not think that I am forcing you to believe everything the Philosophers tell us about the elements, I must describe them to you in my own fashion.

I conceive the first, which may be called the element of fire, as the most subtle and penetrating fluid in the world. And following on from what has been said above concerning the nature of fluid bodies, I imagine its parts to be much smaller and to move much more quickly than any of the parts of other bodies. Or rather, so that I will not have to allow any void in nature, I do not attribute parts having any determinate shape or size to this first element; but I am convinced that the impetuosity of their motion is sufficient to cause it to be divided, in every way and in every sense, by collision with other bodies, and that its parts change shape at every moment to accommodate themselves to the shape of the places they enter. Thus there is never a passage so straight nor an angle so tight among the parts of other bodies that the parts of this element do not enter into it without difficulty and do not fill it entirely.

As for the second, which may be called the element of air, I conceive 25 this too to be a very subtle fluid in comparison with the third, but compared with the first we need to attribute some size and shape to each of its parts and to imagine them as more or less round and joined together like grains of sand or dust. Thus they are not able to arrange themselves or press against each other in such a way that there never remain many small gaps around them; and it is much easier for the first element to slide into these than for the parts of the second to change shape expressly in order to fill them. And so I am convinced that nowhere in the world can this second element be so pure that there is not always a little of the first matter with it.

Beyond these two elements, I accept only a third, namely that of earth. I judge its parts to be proportionately larger than and more slowly

³⁴ There is a representative selection of passages from scholastic texts on the elements in Gilson, *Index*, nos. 156–8.

moving than those of the second, as those of the second are in comparison to those of the first. And indeed I think it is enough to conceive of it as one or more large masses, whose parts have very little or no motion that might cause them to change position with respect to one another.

If you find it strange that, in explaining these elements, I do not use the qualities called 'heat', 'cold', 'moistness', and 'dryness', as the Philosophers do,³⁵ I shall say that these qualities appear to me to be themselves in need of explanation. Indeed, unless I am mistaken, not only these four qualities but all others as well, including even the forms of inanimate bodies, can be explained without the need to suppose anything in their matter other than motion, size, shape, and arrangement of its parts. Because of this, I shall have no difficulty in getting you to understand why I acknowledge no elements other than the three I have described. For the difference that must exist between them and those other bodies that the Philosophers call 'mixed' or 'composite' consists in the fact that the forms of these mixed bodies always contain in themselves some qualities which are contrary and counteract one another, or at least do not tend to the preservation of one another. But the forms of the elements should be simple and not have any qualities that do not accord with one another so perfectly that each tends to the preservation of all the others.

Now I cannot find any such forms in the world except the three I have described. For the form that I have attributed to the first element consists in its parts moving with such a great speed and being so tiny that there are no other bodies able to stop them; in addition, they need have no determinate size, shape, or position. The form of the second element consists in its parts having such a middling motion and size that, just as there are many causes in the world which could increase their motion and diminish their size, there are as many that could do the opposite; and so they always remain balanced as it were in the same middling condition. And the form of the third element consists in its parts being so large or so closely joined together that they always have the force to resist the motions of other bodies.³⁶

³⁵ On the traditional view of the elements, as represented for example in Aristotle, the four elements were explained in terms of two pairs of contrary principles: hot versus cold, and wet versus dry. In this schema, earth was cold and dry, water cold and wet, air hot and wet, and fire hot and dry.

³⁶ As we shall see when we come to ch. 7, Descartes has what might be described as a 'contest' notion of collision in which the greater force always 'wins out', rather than a conception in which the forces are mutually modified. Consequently, a body with the greater force will always be able to 'resist' a lesser one.

Examine as much as you please all the forms that can be given to mixed bodies by the various motions, the various shapes and sizes, and the different arrangement of the parts of matter: I am sure that you will find none that does not contain in itself qualities that tend to bring it about that matter changes and, in changing, to reduce to one of the forms of the elements.

Flame, for example, whose form requires that its parts move very quickly and in addition have some size, as we said above, cannot last long without dying out; for either the size of its parts, in giving them the force to act against other bodies, will cause their motion to diminish, or the violence of their agitation, in causing them to break up on smashing into the bodies they encounter, will cause a diminution of their size. Thus it will be possible for them to be reduced gradually to the form of the third element, or to that of the second, and even some of them to that of the first. In this way, one can see the difference between this flame, or every-day fire, and the element of fire I have described. And you must also recognise that the elements of air and earth – that is, the second and third element – are not more like the gross air we breathe or the earth on which we walk, but that generally all the bodies that appear around us are mixed or composite and subject to decay. 28

But we do not think therefore that the elements have no places in the world to which they are particularly destined, and where they can be perpetually conserved in their natural purity.³⁷ On the contrary, each part of matter always tends to one of their forms and, once it has been so reduced, never tends to leave that form. Consequently, even if God had created only mixed bodies at the beginning, all bodies would nonetheless have had the chance to shed their forms and take on those of the elements. Thus we now have every reason to think that all those bodies that are large enough to be counted among the most notable parts of the universe each have the form of one of these elements, and that the only mixed bodies are on the surfaces of these bodies. But there must be mixed bodies, for the elements have quite contrary natures, and two of them could not come 29

³⁷ In other words, nothing Descartes has argued up to now is contrary to the Aristotelian doctrine of natural place, whereby each of the elements has a natural place to which that element will move if it is unconstrained, and where it will naturally come to rest when it has reached that place. It might seem peculiar that Descartes should revert to such a traditional doctrine here, but the strategy may be to show that construing the elements in terms of size and speed, rather than as being qualitatively different, is still compatible with traditional Aristotelian cosmology. In other words, Descartes could contend that, at this point in the argument, he is merely offering a more economical account of the elements.

into contact without acting against each other's surfaces, and thereby bestowing on the matter there the various forms of these mixed bodies.

In this regard, if we consider in general all the bodies of which the universe is composed, we will find among them only three kinds which can be called large and which can count among the principal parts: namely, the Sun and the fixed stars as the first kind, the heavens as the second, and the Earth with the planets and the comets as the third. That is why we have every reason to think that the Sun and the fixed stars have as their form nothing other than the first element, the heavens the second, and the Earth with the planets and comets the third.

I include the planets and the comets together with the Earth because they, like it, also resist light and reflect its rays, and so I recognise no difference between them. And I include the Sun and the fixed stars together, and attribute to them a nature totally contrary to that of the Earth, because the action of their light is enough for me to recognise that
30 their bodies are of a very subtle and very agitated matter.

As for the heavens, inasmuch as they cannot be perceived by our senses, I think I am right in attributing to them a middle nature between that of the luminous bodies whose action we perceive and that of the solid and heavy bodies whose resistance we perceive.³⁸

Finally, we do not perceive mixed bodies anywhere other than on the surface of the Earth.³⁹ And if we consider that the whole space that contains them – namely that which extends from the highest clouds to the deepest mines that human avarice has ever excavated to extract metals – is extremely small in comparison with the Earth and with the immense expanses of the heavens, we will readily be able to imagine to ourselves that these mixed bodies, taken all together, are just a crust produced on top of the Earth by the agitation and mixing of the matter of the heavens surrounding it.

In this way, we have reason to think that it is not only in the air we breathe, but also in all the other bodies right down to the hardest rocks and the heaviest metals, that there are parts of the element of air mixed with those of earth and consequently parts of the element of fire as well, because they are always found in the pores of the element of air.

³⁸ As Descartes has already indicated, the heavens are not empty spaces but are filled with a pure air, as distinct from the 'gross' air with which we are familiar on the Earth.

³⁹ Why Descartes restricts mixed bodies to the Earth is not clear. On the basis of what he has already told us, there is no reason why other planets should not have mixed bodies. It is possible that he associates the presence of mixed bodies with the presence of life, in which case the much-discussed question of 'other worlds' would have been raised, something he may have wanted to avoid.

It should be noted, however, that even though there are parts of these three elements mixed with one another in all bodies, properly speaking only those that can be ascribed to the third element, because of their size or the difficulty they have in moving, compose all the bodies we see around us. For the parts of the other two elements are so subtle that they cannot be perceived by our senses. One may picture all these bodies as sponges in that, even though a sponge has many pores or small holes which are always full of air or water or some similar fluid, we do not think that these fluids enter into its composition. 31

Many other things remain for me to explain here, and for my own part I would be happy to add a number of other arguments to make my opinions more plausible. But so as to make this long discourse less boring for you, I want to wrap up part of it in the guise of a fable, in the course of which I hope the truth will not fail to manifest itself sufficiently clearly, and that this will be no less pleasing to you than if I were to set it forth wholly naked.

Chapter 6

*Description of a new world, and the qualities of the matter of which it is composed*⁴⁰

For a while, then, allow your thought to wander beyond this world to view another, wholly new, world, which I call forth in imaginary spaces before it. The Philosophers tell us that these spaces are infinite, and they should certainly be believed, since it is they themselves who invented them.⁴¹ But in order to keep this infinity from impeding and hampering us, let us not try to go all the way, but rather enter it only far enough to lose sight of all the creatures that God made five or six thousand years ago,⁴² and after stopping there in some definite place, let us suppose that God creates 32

⁴⁰ The heading in the 1664 edition is: *Description of a New World, very easy to know, but nevertheless similar to ours, and even to the chaos which the poets imagined to have preceded it.*

⁴¹ Descartes wrote to Mersenne on 18 December 1629 asking 'whether there is anything definite in religion concerning the extension of created things, that is, whether it is finite or infinite, and whether there are real created bodies in what is called imaginary space, for although I have been afraid to touch on this question, I believe that I shall have to go into it'. We do not have Mersenne's reply, but the question of 'imaginary spaces' was a theologically vexed question because of its connection with the issue of a plurality of worlds. The medieval discussion of the plurality of worlds had focused on a number of different cases, one of which was whether it was possible for there to be a world completely outside this one, that is, outside our cosmos, which existed in an 'imaginary' space.

⁴² That is, from the date of the creation of the world as commonly reckoned, on the basis of biblical chronology, in Descartes' time.

anew so much matter all around us that, in whatever direction our imagination may extend, it no longer perceives any place that is empty.

Even though the sea is not infinite, those who are on a vessel in the middle of it can extend their view seemingly to infinity, and nevertheless there is still water beyond what they see. Thus even though our imagination seems to be able to stretch to infinity, and we do not assume this new matter to be infinite, we can assume nevertheless that it fills spaces much greater than those we have imagined. And in order that there be nothing in this assumption that you find objectionable, let us not allow our imagination to extend as far as it could, but purposely confine it to a determinate space which is no greater, say, than the Earth and the principal stars in the firmament, and let us suppose that the matter which God has created extends indefinitely far beyond in all directions. For it
33 is much more reasonable to – and we are much better able to – prescribe limits to the action of our mind than to the works of God.⁴³

Now since we are taking the liberty of imagining this matter as we fancy, let us attribute to it, if we may, a nature in which there is absolutely nothing that everyone cannot know as perfectly as possible. To this end, let us explicitly assume that it does not have the form of earth, fire, or air, or any other more specific form, like that of wood, stone, or metal; nor does it have the qualities of being hot or cold, dry or moist, light or heavy, or of having any taste, odour, sound, colour, light, or of any other quality in nature of which there might be said to be something which is not known clearly by everyone.

On the other hand, let us not think that this matter is the ‘prime matter’ of the Philosophers, which they have stripped so thoroughly of all its forms and qualities that nothing remains in it which can be clearly understood.⁴⁴ Let us rather conceive of it as a real, perfectly solid body, which uniformly fills the entire length, breadth, and depth of this great space in the midst of which we have brought our mind to rest. Thus, each

⁴³ In other words, Descartes holds that an infinitely extended universe is within God’s power, but he is happy to assume here that his imagined world is simply spatially indefinite. This is a distinction that he will later claim, in conversation with Burman, to have been the first to formulate (AT v. 167).

⁴⁴ On the doctrine of ‘prime matter’, what results when one strips matter of all properties and forms is a propertyless substratum, which Aristotle himself seems to have conceived as a limiting case which could never actually be achieved (in principle), but which later thinkers took to be a genuine substratum underlying forms and qualities. Descartes does not want to conceive of his world in these terms if for no other reason than that he does not want to allow that a world stripped of the forms and qualities he mentions would be propertyless: on the contrary, there is a presumption that in removing these, what we would be left with would be its genuine properties.