The *Treatise on Light* and related material

Treatise on Light and other principal objects of the senses

Chapter 1

On the difference between our sensations[1] *and the things that produce them*[2]

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.

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 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 Philosophers[5] 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 resem- 6
blance 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 in[6]

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 eyes[8] 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-corpuscularian 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* 311ª15ff.

[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 11
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.

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, 14
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.

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 15
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.

[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.