Chapter 7

René Descartes

OPTICS

Discourse One: Light

THE CONDUCT OF OUR LIFE depends entirely on our senses, and since sight is the noblest and most comprehensive of the senses, inventions which serve to increase its power are undoubtedly among the most useful there can be. And it is difficult to find any such inventions which do more to increase the power of sight than those wonderful telescopes which, though in use for only a short time, have already revealed a greater number of new stars and other new objects above the earth than we had seen there before. Carrying our vision much further than our forebears could normally extend their imagination, these telescopes seem to have opened the way for us to attain a knowledge of nature much greater and more perfect than they possessed . . . But inventions of any complexity do not reach their highest degree of perfection right away, and this one is still sufficiently problematical to give me cause to write about it. And since the construction of the things of which I shall speak must depend on the skill of craftsmen, who usually have little formal education, I shall try to make myself intelligible to everyone; and I shall try not to omit anything, or to assume anything that requires knowledge of other sciences. This is why I shall begin by explaining light and light-rays; then, having briefly described the parts of the eye, I shall give a detailed account of how vision comes about; and, after noting all the things which are capable of making vision more perfect, I shall show how they can be aided by the inventions which I shall describe.

Now since my only reason for speaking of light here is to explain how its rays enter into the eye, and how they may be deflected by the various bodies they encounter, I need not attempt to say what is its true nature. It will, I think, suffice if I use two or three comparisons in order to facilitate that conception of light which seems most suitable for explaining all those of its properties that we know

through experience and for then deducing all the other properties that we cannot observe so easily. In this I am imitating the astronomers, whose suppositions are almost all false or uncertain, but who nevertheless draw many very true and certain consequences from them because they are related to various observations they have made.

No doubt you have had the experience of walking at night over rough ground without a light, and finding it necessary to use a stick in order to guide yourself. You may then have been able to notice that by means of this stick you could feel the various objects situated around you, and that you could even tell whether they were trees or stones or sand or water or grass or mud or any other such thing. It is true that this kind of sensation is somewhat confused and obscure in those who do not have long practice with it. But consider it in those born blind, who have made use of it all their lives: with them, you will find, it is so perfect and so exact that one might almost say that they see with their hands, or that their stick is the organ of some sixth sense given to them in place of sight. In order to draw a comparison from this, I would have you consider the light in bodies we call 'luminous' to be nothing other than a certain movement, or very rapid and lively action, which passes to our eyes through the medium of the air and other transparent bodies, just as the movement or resistance of the bodies encountered by a blind man passes to his hand by means of his stick. In the first place this will prevent you from finding it strange that this light can extend its rays instantaneously from the sun to us. For you know that the action by which we move one end of a stick must pass instantaneously to the other end, and that the action of light would have to pass from the heavens to the earth in the same way, even though the distance in this case is much greater than that between the ends of a stick. Nor will you find it strange that by means of this action we can see all sorts of colours. You may perhaps even be prepared to believe that in the bodies we call 'coloured' the colours are nothing other than the various ways in which the bodies receive light and reflect it against our eyes. You have only to consider that the differences a blind man notices between trees, rocks, water and similar things by means of his stick do not seem any less to him than the differences between red, yellow, green and all the other colours seem to us. And yet in all those bodies the differences are nothing other than the various ways of moving the stick or of resisting its movements. Hence you will have reason to conclude that there is no need to suppose that something material passes from objects to our eyes to make us see colours and light, or even that there is something in the objects which resembles the ideas or sensations that we have of them. In just the same way, when a blind man feels bodies, nothing has to issue from the bodies and pass along his stick to his hand; and the resistance or movement of the bodies, which is the sole cause of the sensations he has of them, is nothing like the ideas he forms of them. By this means, your mind will be delivered from all those little images flitting through the air, called 'intentional forms',[1] which so exercise the imagination of the philosophers. You will even find it easy to settle the current philosophical debate concerning the origin of the action which causes visual perception. For, just as our blind man can feel the bodies around him not only through the action of these bodies when they move against his stick, but also through the action of his hand when they do nothing but resist the stick, so we must acknowledge that the objects of sight can be perceived not only by means of

the action in them which is directed towards our eyes, but also by the action in our eyes which is directed towards them. Nevertheless, because the latter action is nothing other than light, we must note that it is found only in the eyes of those creatures which can see in the dark, such as cats, whereas a man normally sees only through the action which comes from the objects. For experience shows us that these objects must be luminous or illuminated in order to be seen, and not that our eyes must be luminous or illuminated in order to see them. But because our blind man's stick differs greatly from the air and the other transparent bodies through the medium of which we see, I must make use of yet another comparison.

Consider a wine-vat at harvest time, full to the brim with half-pressed grapes, in the bottom of which we have made one or two holes through which the unfermented wine can flow. Now observe that, since there is no vacuum in nature (as nearly all philosophers acknowledge), and yet there are many pores in all the bodies we perceive around us (as experience can show quite clearly), it is necessary that these pores be filled with some very subtle and very fluid matter, which extends without interruption from the heavenly bodies to us. Now, if you compare this subtle matter with the wine in the vat, and compare the less fluid or coarser parts of the air and the other transparent bodies with the bunches of grapes which are mixed in with the wine, you will readily understand the following. The parts of wine at one place tend to go down in a straight line through one hole at the very instant it is opened, and at the same time through the other hole, while the parts at other places also tend at the same time to go down through these two holes, without these actions being impeded by each other or by the resistance of the bunches of grapes in the vat. This happens even though the bunches support each other and so do not tend in the least to go down through the holes, as does the wine, and at the same time they can even be moved in many other ways by the bunches which press upon them. In the same way, all the parts of the subtle matter in contact with the side of the sun facing us tend in a straight line towards our eyes at the very instant they are opened, without these parts impeding each other, and even without their being impeded by the coarser parts of the transparent bodies which lie between them. This happens whether these bodies move in other ways – like the air which is almost always agitated by some wind – or are motionless – say, like glass or crystal. And note here that it is necessary to distinguish between the movement and the action or tendency to move. For we may very easily conceive that the parts of wine at one place should tend towards one hole and at the same time towards the other, even though they cannot actually move towards both holes at the same time, and that they should tend exactly in a straight line towards one and towards the other, even though they cannot move exactly in a straight line because of the bunches of grapes which are between them. In the same way, considering that the light of a luminous body must be regarded as being not so much its movement as its action, you must think of the rays of light as nothing other than the lines along which this action tends. Thus there is an infinity of such rays which come from all the points of a luminous body towards all the points of the bodies it illuminates, just as you can imagine an infinity of straight lines along which the actions coming from all the points of the surface of the wine tend towards one hole, and an infinity of others along which the actions

coming from the same points tend also towards the other hole, without either impeding the other.

Moreover, these rays must always be imagined to be exactly straight when they pass through a single transparent body which is uniform throughout. But when they meet certain other bodies, they are liable to be deflected by them, or weakened, in the same way that the movement of a ball or stone thrown into the air is deflected by the bodies it encounters. For it is very easy to believe that the action or tendency to move (which, I have said, should be taken for light) must in this respect obey the same laws as the movement itself. In order that I may give a complete account of this third comparison, consider that a ball passing through the air may encounter bodies that are soft or hard or fluid. If the bodies are soft, they completely stop the ball and check its movement, as when it strikes linen sheets or sand or mud. But if they are hard, they send the ball in another direction without stopping it, and they do so in many different ways. For their surface may be quite even and smooth, or rough and uneven; if even, either flat or curved; if uneven, its unevenness may consist merely in its being composed of many variously curved parts, each quite smooth in itself, or also in its having many different angles or points, or some parts harder than others, or parts which are moving (their movements being varied in a thousand imaginable ways). And it must be noted that the ball, besides moving in the simple and ordinary way which takes it from one place to another, may move in yet a second way, turning on its axis, and that the speed of the latter movement may have many different relations with that of the former. Thus, when many balls coming from the same direction meet a body whose surface is completely smooth and even, they are reflected uniformly and in the same order, so that if this surface is completely flat they keep the same distance between them after having met it as they had beforehand; and if it is curved inward or outward they come towards each other or go away from each other in the same order, more or less, on account of this curvature . . . It is necessary to consider, in the same manner, that there are bodies which break up the light-rays that meet them and take away all their force (namely bodies called 'black,' which have no color other than that of shadows); and there are others which cause the rays to be reflected, some in the same order as they receive them (namely bodies with highly polished surfaces, which can serve as mirrors, both flat and curved), and others in many directions in complete disarray. Among the latter, again, some bodies cause the rays to be reflected without bringing about any other change in their action (namely bodies we call 'white'), and others bring about an additional change similar to that which the movement of a ball undergoes when we graze it (namely bodies which are red, or yellow, or blue or some other such color). For I believe I can determine the nature of each of these colors, and reveal it experimentally; but this goes beyond the limits of my subject. All I need to do here is to point out that the light-rays falling on bodies which are colored and not polished are usually reflected in every direction even if they come from only a single direction . . . Finally, consider that the rays are also deflected, in the same way as the ball just described, when they fall obliquely on the surface of a transparent body and penetrate this body more or less easily than the body from which they come. This mode of deflection is called 'refraction.'[2]

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Discourse Four: The senses in general

Now I must tell you something about the nature of the senses in general, the more easily to explain that of sight in particular. We know for certain that it is the soul which has sensory awareness, and not the body. For when the soul is distracted by an ecstasy or deep contemplation, we see that the whole body remains without sensation, even though it has various objects touching it. And we know that it is not, properly speaking, because of its presence in the parts of the body which function as organs of the external senses that the soul has sensory awareness, but because of its presence in the brain, where it exercises the faculty called the 'common' sense. For we observe injuries and diseases which attack the brain alone and impede all the senses generally, even though the rest of the body continues to be animated. We know, lastly, that it is through the nerves that the impressions formed by objects in the external parts of the body reach the soul in the brain. For we observe various accidents which cause injury only to a nerve, and destroy sensation in all the parts of the body to which this nerve sends its branches, without causing it to diminish elsewhere. . . .[3] We must take care not to assume – as our philosophers commonly do – that in order to have sensory awareness the soul must contemplate certain images[4] transmitted by objects to the brain; or at any rate we must conceive the nature of these images in an entirely different manner from that of the philosophers. For since their conception of the images is confined to the requirement that they should resemble the objects they represent, the philosophers cannot possibly show us how the images can be formed by the objects, or how they can be received by the external sense organs and transmitted by the nerves to the brain. Their sole reason for positing such images was that they saw how easily a picture can stimulate our mind to conceive the objects depicted in it, and so it seemed to them that the mind must be stimulated to conceive the objects that affect our senses in the same way – that is, by little pictures formed in our head. We should, however, recall that our mind can be stimulated by many things other than images – by signs and words, for example, which in no way resemble the things they signify. And if, in order to depart as little as possible from accepted views, we prefer to maintain that the objects which we perceive by our senses really send images of themselves to the inside of our brain, we must at least observe that in no case does an image have to resemble the object it represents in all respects, for otherwise there would be no distinction between the object and its image. It is enough that the image resembles its object in a few respects. Indeed the perfection of an image often depends on its not resembling its object as much as it might. You can see this in the case of engravings: consisting simply of a little ink placed here and there on a piece of paper, they represent to us forests, towns, people, and even battles and storms; and although they make us think of countless different qualities in these objects, it is only in respect of shape that there is any real resemblance. And even this resemblance is very imperfect, since engravings represent to us bodies of varying relief and depth on a surface which is entirely flat. Moreover, in accordance with the rules of perspective they often represent circles by ovals better than by other circles, squares by rhombuses better than by other squares, and similarly for other shapes. Thus it often happens that in order to be more perfect as an image and to represent an object better, an engraving ought not to resemble it. Now we must

think of the images formed in our brain in just the same way, and note that the problem is to know simply how they can enable the soul to have sensory awareness of all the various qualities of the objects to which they correspond – not to know how they can resemble these objects. For instance, when our blind man touches bodies with his stick, they certainly do not transmit anything to him except in so far as they cause his stick to move in different ways according to the different qualities in them, thus likewise setting in motion the nerves in his hand, and then the regions of his brain where these nerves originate. This is what occasions his soul to have sensory awareness of just as many different qualities in these bodies as there are differences in the movements caused by them in his brain.

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Notes

1 A reference to the scholastic doctrine that material objects transmit to the soul 'forms' or 'images' (Fr. *espèces*, Lat. *species*) resembling them.

2 Discourses Two and Three are omitted here.

3 There follows an account of the function of the nerves and animal spirits in producing sensation and movement. Cf. *Treatise on Man*, AT XI 132 ff and *Passions*.

4 See note 1 above.