The Philosophical Writings of *DESCARTES*

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VOLUME I

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natural shape, according to the distance of the objects (for if you squeeze 117
it just a little more or less than you ought, the picture becomes less distinct) . . .[1]

Now, when you have seen this picture in the eye of a dead animal, and (124)
considered its causes, you cannot doubt that a quite similar picture is formed in the eye of a living person, on the internal membrane for which we substituted the white body – indeed, a much better one is formed there since the humours in this eye are full of animal spirits and so are more transparent and more exactly of the shape necessary for this to occur. (And also, perhaps in the eye of an ox the shape of the pupil, which is not round, prevents the picture from being so perfect.) . . .

The images of objects are not only formed in this way at the back of (128)
the eye but also pass beyond into the brain . . .[2]

DISCOURSE SIX: VISION 130

Now, when this picture thus passes to the inside of our head, it still bears some resemblance to the objects from which it proceeds. As I have amply shown already, however, we must not think that it is by means of this resemblance that the picture causes our sensory perception of these objects – as if there were yet other eyes within our brain with which we could perceive it. Instead we must hold that it is the movements composing this picture which, acting directly upon our soul in so far as it is united to our body, are ordained by nature to make it have such sensations. I will explain this in more detail. All the qualities which we perceive in the objects of sight can be reduced to six principal ones: light, colour, position, distance, size and shape. First, regarding light and colour (the only qualities belonging properly to the sense of sight), we must suppose our soul to be of such a nature that what makes it have the sensation of light is the force of the movements taking place in the regions of the brain where the optic nerve-fibres originate, and what
makes it have the sensation of colour is the manner of these movements. 131
Likewise, the movements in the nerves leading to the ears make the soul hear sounds; those in the nerves of the tongue make it taste flavours; and, in general, movements in the nerves anywhere in the body make the soul have a tickling sensation if they are moderate, and a pain when they are too violent. But in all this there need be no resemblance between the ideas which the soul conceives and the movements which cause these ideas. You will readily grant this if you note that people struck in the eye seem to see countless sparks and flashes before them, even though they shut their

1 A diagram is omitted here and the text abridged.

2 Here Descartes repeats the account given in the *Treatise on Man*, pp. 105f above.

eyes or are in a very dark place; hence this sensation can be ascribed only to the force of the blow, which sets the optic nerve-fibres in motion as a bright light would do. The same force might make us hear a sound if it affected the ears, or feel pain if it affected some other part of the body. This is also confirmed by the fact that whenever you force your eyes to look at the sun, or at some other very bright light, they retain its impression for a short time afterwards, so that even with your eyes shut you seem to see various colours which change and pass from one to another as they fade away. This can only result from the fact that the optic nerve-fibres have been set in motion with extraordinary force, and cannot come to rest as soon as they usually can. But the agitation
132 remaining in them when the eyes are shut is not great enough to represent the bright light that caused it, and thus it represents the less vivid colours. That these colours change as they fade away shows that their nature consists simply in the diversity of the movement, exactly as I have already suggested. And finally this is evidenced by the frequent appearance of colours in transparent bodies, for it is certain that nothing can cause this except the various ways in which the light-rays are received there. One example is the appearance of a rainbow in the clouds, and a still clearer example is the likeness of a rainbow seen in a piece of glass cut on many sides.

But we must consider in detail what determines the quantity of the light which is seen, i.e. the quantity of the force with which each of the optic nerve-fibres is moved. For it is not always equal to the light which is in the objects, but varies in proportion to their distance and the size of the pupil, and also in proportion to the area at the back of the eye which may
(133) be occupied by the rays coming from each point of the object . . . We must also consider that we cannot discriminate the parts of the bodies we are looking at except in so far as they differ somehow in colour; and distinct vision of these colours depends not only on the fact that all the rays coming from each point of the object converge in almost as many different points at the back of the eye, and on the fact that no rays reach the same points from elsewhere . . . but also on the great number of optic nerve-fibres in the area which the image occupies at the back of the eye.
134 For example, if an object is composed of ten thousand parts capable of sending rays to a certain area at the back of the eye in ten thousand different ways, and consequently of making ten thousand colours simultaneously visible, these parts nonetheless will enable the soul to discriminate only at most a thousand colours, if we suppose that in this area there are only a thousand fibres of the optic nerve. Thus ten parts of the object, acting together upon each of the fibres, can move it in just one single way made up of all the ways in which they act, so that the area

occupied by each fibre has to be regarded as if it were only a single point. This is why a field decked out in countless different colours often appears from a distance to be all white or all blue; why, in general, all bodies are seen less distinctly from a distance than close at hand; and finally why the greater the area which we can make the image of a single object occupy at the back of the eye, the more distinctly it can be seen. We shall need to take special note of this fact later on.

As regards position, i.e. the orientation of each part of an object relative to our body, we perceive it by means of our eyes exactly as we do by means of our hands. Our knowledge of it does not depend on any image, nor on any action coming from the object, but solely on the position of the tiny parts of the brain where the nerves originate. For this position changes ever so slightly each time there is a change in the position of the limbs in which the nerves are embedded. Thus it
is ordained by nature to enable the soul not only to know the place 135
occupied by each part of the body it animates relative to all the others, but also to shift attention from these places to any of those lying on the straight lines which we can imagine to be drawn from the extremity of each part and extended to infinity. In the same way, when the blind man, of whom we have already spoken so much, turns his hand A towards E [Fig. 8], or again his hand C towards E, the nerves

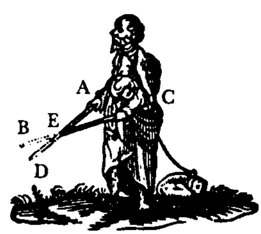

Fig. 8

embedded in that hand cause a certain change in his brain, and through this change his soul can know not only the place A or C but also all the other places located on the straight line AE or CE; in this way his soul can turn its attention to the objects B and D, and determine the places they occupy without in any way knowing or thinking of those which his hands occupy. Similarly, when our eye or head is turned in some direction, our soul is informed of this by the change in the brain which is caused by the nerves embedded in the muscles used for these movements. . . . You must not, therefore, find it strange that objects can be seen in
their true position even though the picture they imprint upon the eye is 136

inverted. This is just like our blind man's being able to feel, at one and the same time, the object B (to his right) by means of his left hand, and the object D (to his left) by means of his right hand. And as the blind man does not judge a body to be double although he touches it with his two
137 hands, so too, when both our eyes are disposed in the manner required to direct our attention to one and the same place, they need only make us see a single object there, even though a picture of it is formed in each of our eyes.

The seeing of distance depends no more than does the seeing of position upon any images emitted from objects. Instead it depends in the first place on the shape of the body of the eye. For as we have said, for us to see things close to our eyes this shape must be slightly different from the shape which enables us to see things farther away; and as we adjust the shape of the eye according to the distance of objects, we change a certain part of our brain in a manner that is ordained by nature to make our soul perceive this distance. Ordinarily this happens without our reflecting upon it – just as, for example, when we clasp some body with our hand, we adjust our hand to its size and shape and thus feel it by means of our hand without needing to think of these movements. In the second place, we know distance by the relation of the eyes to one another. Our blind man holding the two sticks AE and CE (whose length I assume he does not know) and knowing only the distance between his two hands A and C and the size of the angles ACE and CAE, can tell from this knowledge, as if by a natural geometry, where the point E is. And similarly, when our two eyes A and B are turned towards point X, the length of the line AB and the size of the two angles XAB and XBA enable
138 us to know where the point X is. We can do the same thing also with the aid of only one eye, by changing its position.[1] Thus, if we keep it turned towards X and place it first at point A and immediately afterwards at point B, this will be enough to make our imagination contain the magnitude of the line AC together with that of the two angles XAB and XBA, and thus enable us to perceive the distance from point X. And this is done by a mental act which, though only a very simple act of the imagination, involves a kind of reasoning quite similar to that used by surveyors when they measure inaccessible places by means of two different vantage points. We have yet another way of perceiving distance, namely by the distinctness or indistinctness of the shape seen, together with the strength or weakness of the light. Thus, if we gaze fixedly towards X [Fig. 9], the rays coming from objects 10 and 12 do not converge so exactly upon R or T, at the back of our eye, as they would if

1 A diagram is omitted here.

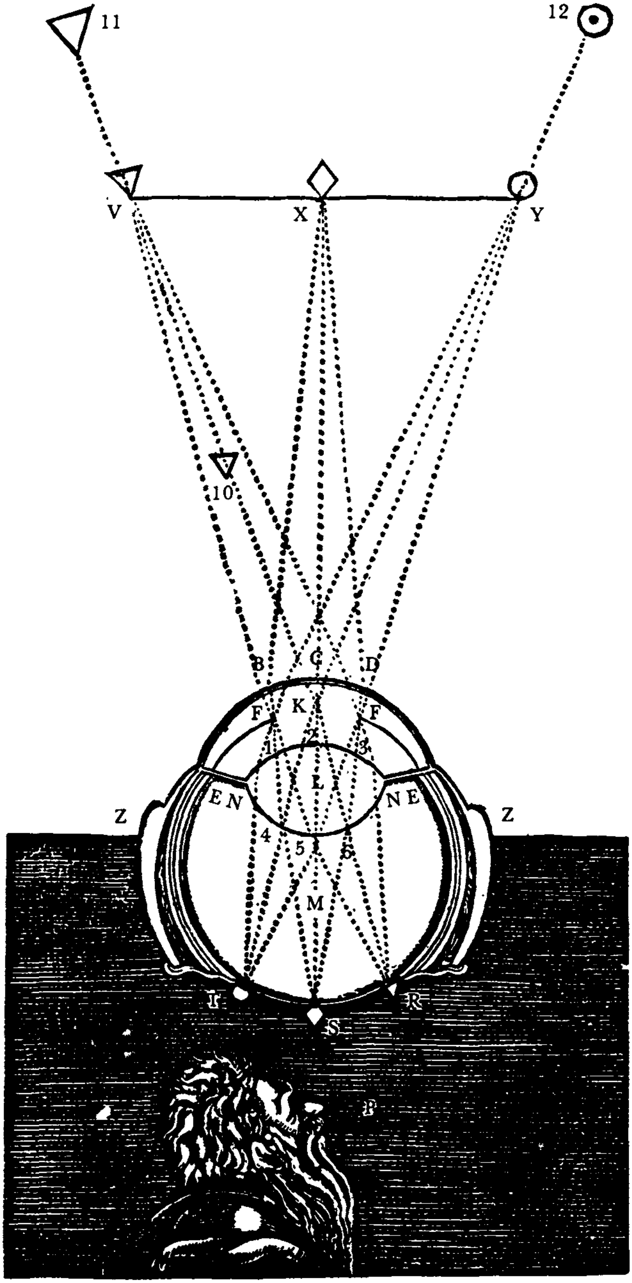

Fig. 9

these objects were at points V and Y. From this we see that they are farther from us, or nearer to us, than X. Then, the light coming from object 10 to our eye is stronger than it would be if that object were near V, and from this we judge it to be nearer; and the light coming from object 12 is weaker than it would be if it were near Y, and so we judge it to be farther away. Finally, we may already have from another source an image of an object's size, or its position, or the distinctness of its shape and its colours, or merely the strength of the light coming from it; and
139 this may enable us to imagine its distance, if not actually to see it. For
140 example, when we observe from afar some body we are used to seeing close at hand, we judge its distance much better than we would if its size were less well known to us. If we are looking at a mountain lit up by sunlight beyond a forest covered in shadow, it is solely the position of the forest that makes us judge it the nearer. And when we look at two ships out at sea, one smaller than the other but proportionately nearer so that they appear equal in size, we can use the difference in their shapes and colours, and in the light they send to us, to judge which is the more distant.

Concerning the manner in which we see the size and shape of objects, I need not say anything in particular since it is wholly included in the way we see the distance and the position of their parts. That is, we judge their size by the knowledge or opinion that we have of their distance, compared with the size of the images they imprint on the back of the eye – and not simply by the size of these images. This is sufficiently obvious from the fact that the images imprinted by objects very close to us are a hundred times bigger than those imprinted by objects ten times farther away, and yet they do not make us see the objects a hundred times larger; instead they make the objects look almost the same size, at least if their distance does not deceive us. It is obvious too that we judge shape by the knowledge or opinion that we have of the position of the various parts of an object, and not by the resemblance of the pictures in our eyes. For
141 these pictures usually contain only ovals and rhombuses when they make us see circles and squares.

But in order that you may have no doubts at all that vision works as I have explained it, I would again have you consider the reasons why it sometimes deceives us. First, it is the soul which sees, and not the eye; and it does not see directly, but only by means of the brain. That is why madmen and those who are asleep often see, or think they see, various objects which are nevertheless not before their eyes: namely, certain vapours disturb their brain and arrange those of its parts normally engaged in vision exactly as they would be if these objects were present. Then, because the impressions which come from outside pass to the

'common' sense by way of the nerves, if the position of these nerves is changed by any unusual cause, this may make us see objects in places other than where they are ... Again, because we normally judge that the (142)
impressions which stimulate our sight come from places towards which we have to look in order to sense them, we may easily be deceived when they happen to come from elsewhere. Thus, those whose eyes are affected by jaundice, or who are looking through yellow glass or shut up in a room where no light enters except through such glass, attribute this colour to all the bodies they look at. And the person inside the dark room which I described earlier attributes to the white body the colours of the objects outside because he directs his sight solely upon that body. And if our eyes see objects through lenses and in mirrors, they judge them to be at points where they are not and to be smaller or larger than they are, or inverted as well as smaller (namely, when they are somewhat distant from the eyes). This occurs because the lenses and mirrors deflect the rays coming from the objects, so that our eyes cannot see the objects distinctly 143
except by making the adjustments necessary for looking towards the points in question.[1] This will readily be known by those who take the trouble to examine the matter. In the same way they will see how far the 144
ancients went wrong in their catoptrics when they tried to determine the location of the images in concave and convex mirrors. It must also be noted that all our methods for recognizing distance are highly unreliable. For the shape of the eye undergoes hardly any perceptible variation when the object is more than four or five feet away, and even when the object is nearer the shape varies so little that no very precise knowledge can be obtained from it. And if one is looking at an object at all far away, there is also hardly any variation in the angles between the line joining the two eyes (or two positions of the same eye) and the lines from the eyes to the object. As a consequence, even our 'common' sense seems incapable of receiving in itself the idea of a distance greater than approximately one or two hundred feet. This can be verified in the case of the moon and the sun. Although they are among the most distant bodies that we can see, and their diameters are to their distances roughly as one to a hundred, they normally appear to us as at most only one or two feet in diameter – although we know very well by reason that they are extremely large and extremely far away. This does not happen because we cannot conceive them as any larger, seeing that we easily conceive towers and mountains which are much larger. It happens, rather, because we cannot conceive them as more than one or two hundred feet away, and consequently their diameters cannot appear to us to be more than one or two feet. The

1 A diagram is omitted here, and the text is slightly condensed.

145 position of these bodies also helps to mislead us. For usually, when they are very high in the sky at midday, they seem smaller than they do when they are rising or setting, and we can notice their distance more easily because there are various objects between them and our eyes. And, by measuring them with their instruments, the astronomers prove clearly that they appear larger at one time than at another not because they are seen to subtend a greater angle, but because they are judged to be farther away. It follows that the axiom of the ancient optics – which says that the apparent size of objects is proportional to the size of the angle of vision – is not always true. We are also deceived because white or luminous bodies, and generally all those which have a great power to stimulate the sense of sight, always appear just a little nearer and larger than they would if they had less such power. The reason why such bodies appear nearer is that the movement with which the pupil contracts to avoid their strong light is so connected with the movement which disposes the whole eye to see near objects distinctly – a movement by which we judge the distance of such objects – that the one hardly ever takes place without the other occurring to some extent as well. (In the same way, we cannot fully close the first two fingers of our hand without the third bending a little too, as if to close with the others.) The reason why these white or
146 luminous bodies appear larger is not only that our estimation of their size depends on that of their distance, but also that they impress larger images on the back of the eye. For it must be noted that the back of the eye is covered by the ends of optic nerve-fibres which, though very small, still have some size. Thus each of them may be affected in one of its parts by one object and in other parts by other objects. But it is capable of being moved in only a single way at any given time; so when the smallest of its parts is affected by some very brilliant object, and the others by different objects that are less brilliant, the whole of it moves in accordance with the most brilliant object, presenting its image but not that of the others. Thus, suppose the ends of these little fibres are 1, 2, 3 [Fig. 10] and the rays which come, for example, from a star to trace an image on the back of the eye are spread over 1, and also slightly beyond over the six nerve-endings marked 2 (which I suppose are reached by no other rays

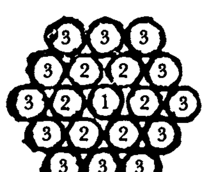

Fig. 10

except very weak ones from regions of the sky next to the star). In this case the image of the star will be spread over the whole area occupied by the six nerve-endings marked 2 and may even spread throughout that occupied by the twelve marked 3 if the disturbance is strong enough to be propagated to them as well. So you can see that the stars, while appearing rather small, nevertheless appear much larger than their extreme distance should cause them to appear. And even if they were not perfectly round,
they could not fail to appear so – just as a square tower seen from afar 147
looks round, and all bodies that trace only very small images in the eye cannot trace there the shapes of their angles. Finally, as regards judgement of distance by size, shape, colour, or light, pictures drawn in perspective show how easy it is to make mistakes. For often the things depicted in such pictures appear to us to be farther off than they are because they are smaller, while their outlines are more blurred, and their colours darker or fainter, than we imagine they ought to be.[1]

1 The contents of the rest of the *Optics*, and of the *Meteorology* and the *Geometry*, are as follows:

Optics

Discourse Seven:	The means of perfecting vision
Discourse Eight:	The shapes that the transparent bodies must have in order to deflect rays through refraction in all the ways which are useful to vision
Discourse Nine:	The description of telescopes
Discourse Ten:	The method of cutting lenses

Meteorology

Discourse 1:	The nature of terrestrial bodies
Discourse 2:	Vapours and exhalations
Discourse 3:	Salt
Discourse 4:	Winds
Discourse 5:	Clouds
Discourse 6:	Snow, rain and hail
Discourse 7:	Storms, lightning and all the other fires that blaze in the air
Discourse 8:	The rainbow
Discourse 9:	The colours of clouds and the circles or coronas that we sometimes see around the heavenly bodies
Discourse 10:	The appearance of many suns

Geometry

Book 1:	Problems that can be solved by constructions using only circles and straight lines
Book 2:	The nature of curved lines
Book 3:	Problems requiring the construction of solids and supersolids