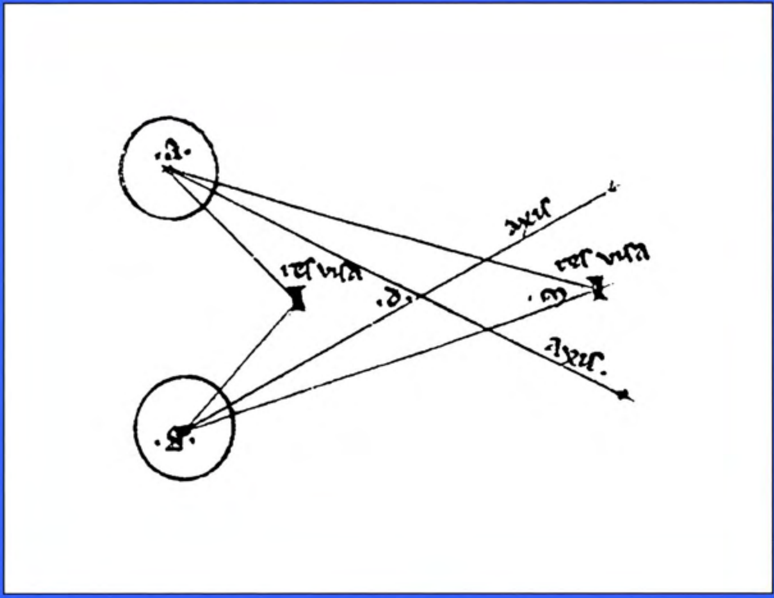
ALHACEN'S THEORY OF VISUAL PERCEPTION

A Critical Edition, with English Translation and Commentary, of the First Three Books of Alhacen's *De Aspectibus*, the Medieval Latin Version of Ibn al-Haytham's *Kitāb al-Manāẓir*

Volume Two
English Translation



A. Mark Smith

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VOLUME ONE
Introduction and Latin Text

VOLUME TWO
English Translation

A. Mark Smith

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VOLUME TWO

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VOLUME II

BOOK ONE OF ALHACEN'S *DE ASPECTIBUS*

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[BOOK ONE]

[CHAPTER 1][1]

[4.1] We find that when our sight fixes upon very strong light-sources it will suffer intense pain and impairment from them, for when an observer looks at the body of the sun, he cannot do so properly because his vision will suffer from its light. By the same token, when he looks at a polished mirror flooded with sunlight, and his eye is placed at the spot to which the light from that mirror is reflected,[2] his vision will also suffer from the reflected light reaching his eye from the mirror, and he cannot open his eye to look at that light.[3]

[4.2] Furthermore, we find that when an observer stares at a pure white body illuminated by sunlight, and keeps staring for awhile, then shifts his focus from it to a dark, dimly lit location, he can scarcely make out the visible objects at that location. Instead, it will seem to him as if there were a screen between himself and them. Then, after awhile his vision will clear up and return to its normal state. So too, when an observer looks at a strong fire and continues to stare at it for a long time, if he then shifts his focus to a dark, dimly lit location, he will experience the same visual effect.

[4.3] We also find that, when an observer looks at a pure white body illuminated by intense daylight, even though there may be no [direct] sunlight, if he continues to look at that body for awhile and then shifts his focus to a dark location, he will see the form of its light, along with its shape, in that dark location. If he then closes his eyes and stares for a time, he will see the form of that light in his eye. In time this effect will wear off, and his vision will return to its normal state. The same thing will happen to his vision when he stares at an object illuminated by sunlight.[4]

[4.4] Likewise, if he looks at a bright white body illuminated by strong firelight and continues to stare at it, then refocuses on a dark location, he will experience the same visual effect. So too, when an observer is in a room with a large window open to the sky and continues to stare out at the sky during daylight, then shifts his focus to a dark spot in the room, he will see the form of the light that he perceived through the window along with the shape of the window in that dark spot. And if he closes his eye, he will also see that form in it.

[4.5] All of these occurrences therefore indicate that light may affect vision in some way.

[4.6] And we also find that when an observer looks at a thickly planted garden illuminated by sunlight and continues to stare at it, then shifts his focus to a dark location, he will see the form of that light tinged by the green of those plants in that dark location. Afterward, under the same circumstances, if he stares at white objects lying in shadow or in a weakly illuminated location, he will see those colors mixed with green. And if he closes his eye and stares, he will see the form of the light as well as the form of green in his eye.[5] In time this effect will clear up and disappear. Likewise, if he looks at an object that is colored azure or red or any other bright hue illuminated by sunlight and continues to stare at it, then shifts his focus to white objects lying in a dimly lit location, he will find their colors mixed with the original hue.

[4.7] These instances therefore indicate that illuminated colors may affect vision.

[CHAPTER 2][6]

[4.8] In addition, we see the stars at night but do not see them in daylight; and the only difference between the two times is that the intervening air between our eyes and the sky is illuminated during the day and dark at night. Hence, while the air is dark, we see the stars; but when the intervening air between our eyes and the stars is illuminated, the stars will be invisible to us.[7]

[4.9] Likewise, suppose that an observer looks during the night toward a location illuminated by the light of a fire and that the firelight shines upon the ground; suppose also that there are tiny objects or objects with subtle[8] features in that location and that they lie in shadow that is not too intense; and suppose that the fire is not interposed between the observer's eyes and those objects and, accordingly, that the observer makes those objects out as well as the subtle features possessed by them. Let him then move from his [original] position until the fire is situated between his eyes and those objects. In that case, neither the objects [themselves], if they are tiny, nor the subtle features possessed by them will be visible to him, and he will scarcely make them out when the fire lies between his eyes and those objects. If, however, the fire is screened from his line-of-sight, he will immediately make out those objects that had been invisible to him; but if the screen between his eyes and the fire is lifted, those objects will again be invisible to him.

[4.10] These situations therefore indicate that intense lights that shine upon the eyes and upon the air lying between the eyes and the visible object prevent the sight from making out certain objects that are dimly illuminated.

[4.11] Furthermore, when an observer looks at a polished body on which there are subtle engravings that are not of a different color but rather of the same color as the body, and when the observer is in a moderately lit place, and this place faces the sun or some walls that are illuminated by intense light, then, when that object faces the sky or the illuminated wall, some light will be reflected from it to the eye, and the observer will find the light that appears on the body's surface, as well as at the spot where the light reflects, to be quite intense and brilliant. Moreover, if the observer looks at that polished body under these circumstances, he will see none of the engravings in it where the intense, brilliant light is. Afterward, if the observer inclines that body away from the [original] location so that the reflection takes place to another spot outside the location of his eyes, and if in this case a moderate light shines upon that body, then the observer will make out the engravings in it that he had not made out when the light was reflected from the body to his eyes.

[4.12] By the same token, when light reflects to the eyes from a smooth page with subtle tracings on it, sight will not discern those tracings, nor will it perceive them distinctly as long as the light is reflected from that page to the eyes. But if the surface of the page is slanted so that its position is changed and the light no longer reflects from it to the eyes, then the visual faculty will make out those tracings and will perceive them distinctly.[9]

[4.13] Likewise, when there is a low fire in a dimly lit place, it will be visible and will be made out by sight, but when it lies in sunlight, the object that is on fire will appear as a solid body that is colored with a very bright hue.

[4.14] And if a bright white body is placed next to that [burning] body, and if that [white] body lies in shadow or is dimly illuminated, the color of the [burning] body will appear on it, as we discussed earlier.[10] Then, if that white body is brought out into sunlight, the color that shines upon it will disappear, but if it is brought back into the shadow, that color will appear shining upon it. And if the white body lies in strong light so that the [color of the other] body no longer appears upon it, but if that [white] body is shaded by a solid body and remains in place while the light that shines upon it is attenuated, the color that shines upon it will [re]appear. And if the shading body is removed so that the light shining upon the white body intensifies, the color shining on it will disappear.

[4.15] Likewise, when we bring a brightly colored, transparent body next to a roaring fire and place a white cloth in the shadow of that body, the color of that transparent body will shine upon that cloth, as we pointed out earlier.[11] Then, if we bring another fire next to that cloth so that its light shines upon that cloth, the color that appeared upon the cloth will disappear, and only the white of the cloth will be seen. But if we remove that second fire, the color will [re]appear upon the cloth.

[4.16] Also, certain marine animals have shells or membranes that will appear incandescent when they are in a dark location without light; but if an observer looks at them in daylight or in firelight, he will perceive them but will see no light or fire in them. By the same token, when the animal that is called a "firefly" flits about at night, it looks like a lamp, but when an observer examines it in daylight or in firelight, the animal will appear without fire.[12]

[4.17] Accordingly, all of the situations that we have detailed indicate that intensely luminous objects sometimes occlude features possessed by various visible objects, whereas feeble illumination sometimes reveals certain features possessed by various visible objects.

[CHAPTER 3]

[4.18] Oftentimes several characteristics of subtle tracings or tiny writing are invisible to sight when they are in dimly lit or dark locations, whereas, when they are brought out into intensely illuminated locations or are placed in sunlight, those features of theirs that were invisible in the dark or in feeble light will appear. Likewise, sight is incapable of making out subtle tracings in dark places or in feeble light; but when they are brought out into strong light, they are made out by sight.

[4.19] It is therefore shown by this example that strong light reveals many features of visible objects and that feeble light occludes many visible features.[13]

[CHAPTER 4]

[4.20] Furthermore, we find that many solid bodies that are tinged with such bright colors as azure, wine-red, or sky-blue appear of a dull color when they are in dark or dimly lit locations.[14] But when they lie in strong light, their colors will appear bright and clear, and the more intense the light shining upon them, the brighter and clearer their color will be. And when any of these bodies is placed in a dark location with very little light, that body will appear dark, sight will not discern its color, and it will appear black. But when it is brought out into intensely illuminated locations, its color will appear and will be discerned by sight.

[4.21] We also find that, when strong light shines upon bodies whose colors are dull, their colors brighten; and we also find that when strong light shines upon solid white bodies, their whiteness and brightness will be sensibly increased.

[4.22] So too we find that, when intensely colored transparent objects, such as robust wines of deep redness that are in transparent vessels, are in dark or dimly lit locations, they will appear black and dark, as if they were not transparent. But when they are in strong light or flooded by sunlight, their colors will brighten, and their transparency will become apparent.

[4.23] Likewise, when transparent colored stones are in dark locations, their colors will appear dull and dark; but when intense light shines upon them, or when they are placed against a light-source so that its light shines through them, their colors will appear bright, and their transparency will be revealed by the passage of light [through them].

[4.24] Furthermore, when colored transparent objects are put against the light and a white object is placed [facing them] on the side opposite the light, then, as we described it above,[15] if the light is intense, the form of that color will appear in the shadow cast upon the facing white object. But if the light shining on the transparent object is feeble, only its shadow, not its color, will appear on the facing white object.

[4.25] In addition, we find that peacock feathers and the cloth called "amilialmon"[16] vary in color according to sight at different times of the day, depending on how the light shines upon them.

[4.26] These phenomena involving color therefore indicate that the way the colors of tinted bodies are perceived by sight depends entirely upon the light that shines upon them.[17]

[CHAPTER 5]

[4.27] And since strong light [shining] from visible objects at times occludes certain features possessed by some visible entities and at times reveals certain features possessed by some visible entities, and since feeble light [shining] from visible objects at times reveals certain features possessed by some visible entities and at times occludes certain features possessed by some visible entities, and since the colors of tinted objects are sometimes altered by variation in the light that shines upon them, and since strong light shining upon the eye sometimes prevents sight from making out certain visible objects, and since in all these instances sight nonetheless perceives nothing about visible objects unless they are illuminated, the form of the visible object that sight perceives depends entirely upon the light possessed by that visible object, as well as upon the light that shines upon the eyes when that visible object is perceived, and upon [the light that illuminates] the aerial medium between the eyes and the visible object.

[4.28] Why, however, strong light prevents sight from perceiving certain visible objects will be shown by us when we discuss the way in which vision is carried out.[18]

[CHAPTER 6][19]

[5.1] The eye is in fact composed of various membranes and bodies, and its origin and wellspring lie at the front of the brain.

[5.2] For two matching hollow[20] nerves emerge from the front [of the brain], each arising from a spot on one of the two sides of the anterior part of the brain. And it is said that each of them has tunics and that they both arise from the two membranes of the brain and reach the middle of the outer surface of the front of the brain. They then intersect and form a single hollow nerve, after which this nerve splits, and they again form two matching and equal hollow nerves. Finally, these two nerves continue until they reach both cavities of the two eyesockets that contain the eyeballs.[21]

[5.3] In the center of both of these eyesockets lie two openings of equal size, each one similarly disposed in relation to the common nerve. The [two] nerves therefore pass through these two openings and come out into the cavity of the two eye sockets where they expand and enlarge, and the endpoint of each of them forms something like the utensil used for pouring wine into jars. And each eye is attached to this endpoint on the nerve, which is like a funnel—i.e., the aforementioned utensil—and it forms a whole with it; and the location of each eye is the same in relation to the common nerve.

[5.4] And each eye as a whole is composed of several tunics.

[5.5] Accordingly, the first of these tunics is a white fat that fills the cavity of the bone, and it forms the majority of the eye and is called the sclera.[22]

[5.6] And inside this [outer tunic of] fat is a round, concave sphere that is generally black, but green[23] or grey in some eyes, and the body of this sphere is thin yet nonetheless solid rather than loosely textured. And its outer surface is attached to the sclera, while its inner surface is concave; and on its concave side there is a sort of roughness. The sclera surrounds all but the anterior part of this sphere, for the sclera does not cover the front of this sphere but encircles it. And this tunic is called the uvea because it is similar to the [skin of] a grape.[24]

[5.7] In the center of the anterior surface of the uvea is a round opening that passes into its hollow, and it lies opposite the end of the hollow of the nerve to which the eye is attached.[25]

[5.8] This opening and the entire front part of the uvea that the sclera encircles are covered over by a tough, white, transparent tunic called the cornea, because it is like white, clear horn.

[5.9] Toward the front of the uvea's cavity lies a small, white, moist sphere that retains moisture, and, instead of a [perfectly] clear transparency it has some consistency. Its transparency, moreover, is like the transparency of ice, and therefore it is called the glacialis; and it takes this name because its transparency is like that of ice.[26] It is attached to the endpoint of the hollow [optic] nerve, and in the anterior part of this sphere there is a slight flattening of the surface, and it is like the flattening of the surface of a lentil. Thus, its anterior surface is a section of the surface of a sphere that is larger than the spherical surface containing its two openings, and its flattened section faces the opening that lies at the front of the uvea, and it is equally situated with respect to it.[27]

[5.10] This humor is divided into two parts of different transparency: one of them toward the front and the other toward the back. The transparency of its rear part is like that of ground glass,[28] and this part is called the vitreous humor. The two parts together are surrounded by an extremely fine membrane called the aranea, because it is like a spider's web in texture.

[5.11] Furthermore, toward the front of the uvea's hollow there is said to be a round opening, and it lies upon the endpoint of the hollow of the nerve. The glacialis is affixed in this opening, and the circumference of this opening (which is formed by the extremity of the nerve) encompasses the midpoint of the sphere of the glacialis; and the uvea is conjoined with the glacialis by the circle forming this opening. And it is said that the uvea arises from the inner tunic of the two tunics forming both hollow [optic] nerves and that the cornea arises from the outer tunic of the two tunics forming this nerve.[29]

[5.12] A serous, white, clear, transparent humor fills the hollow of the uvea, and it is called the albugineous humor because it is like the white of an egg in its fluidity, whiteness, and transparency. And this humor fills the hollow of the uvea, and it is contiguous with the front surface of the glacialis, and it fills the opening in the front of the uvea, and it is contiguous with the concave surface of the cornea.[30]

[5.13] Now the sphere of the glacialis is affixed to the hollow of the [optic] nerve, and it is succeeded within that hollow by the vitreous humor. Thus, the cornea, the albugineous humor, the glacial humor, and the vitreous [humor] will lie one behind the other in that order, and all these tunics [and humors] are transparent. And the opening in the front of the uvea lies directly opposite the opening of the hollow of the [optic] nerve. Hence, between the surface of the cornea and the opening at the front of the hollow of the [optic] nerve there will be many straight-line connections since [all the intervening tunics and humors] are transparent and contiguous.[31]

[5.14] And it is said that visual spirit emanates from the front of the brain and fills the two hollows of the two nerves that are first joined with the brain; and this spirit extends to the common nerve, fills its hollow, and continues to the two secondary hollow nerves. It then fills them and continues to the glacialis to endow it with the power of seeing.[32]

[5.15] Between the circumference of the glacialis that is connected to the uvea and the opening in the hollow of the eye socket from which the nerve issues there is some space, and the nerve fills this space, from the very opening to the circumference of the glacialis as it expands and funnels outward. The farther from the opening it gets, the more it expands until it reaches the circumference of the sphere of the glacialis, and it is affixed to its circumference.

[5.16] The body of the sclera encompasses this expanded portion of the nerve, and it encompasses the uveal sphere, but the uveal sphere lies in front of the midpoint of the sclera toward the [front] surface of the eye. The body of the sclera is joined with the uveal sphere as well as with the endpoint of the expanding nerve and keeps it fixed in place. Hence, when the eye moves, it will move as a whole. And thus the nerve to which the eye is affixed will follow its movement and will flex at the opening in the hollow of the eye socket, because the hollow of the eye socket contains the entire eyeball, and the eyeball moves as a whole within this hollow.[33]

[5.17] The sclera is also connected to the part of the nerve that lies toward the front [of the eye] as well as to the rest of the tunics, so it holds them [all] firmly in place. Thus, the flexing of the nerve with the motion of the eye occurs only at the back of the eye; so it happens at the opening in the hollow of the eye socket. Likewise, when the eye is still and the nerve is flexed, that flexing will occur only at the opening in the hollow of the eye socket. For the parts of the whole eye do not shift with respect to each other either when it is in motion or when it is still. Thus, the flexing of the nerve to which the eye is attached only happens at the opening in the hollow of the eye socket, whether the eye is moving or is still.

[5.18] The outer surface of the cornea is spherical and is therefore continuous with the surface of the entire eye and with the whole eyeball.[34] The eye as a whole forms a sphere larger than the uveal sphere, which is one of its parts. However, the outer surface of the cornea is continuous with the surface of the entire eye, which is larger than the surface of the uveal sphere. Its radius is therefore larger than the radius of the uvea.

[5.19] The inner surface of the cornea that is positioned over the opening in the uvea is a concave spherical surface parallel to its outer surface, for this section of the eye is of equal thickness. The center of this concave surface is therefore the same as the center of the outer, convex surface, and this concave surface intersects the surface of the uveal sphere at the circumference of its opening. Therefore its center lies deeper in the eye than the center of the uvea, for this follows inexorably from the properties of [intersecting] spheres.

[5.20] In addition, since the uveal sphere is not concentric with the sclera but lies in front toward the outer surface of the eye, and since the outer surface of the eye forms part of a sphere that is larger than the uvea, the center of the outer surface [of the eye] will lie deeper in the eye than the center of the uvea.

[5.21] Moreover, when it is extended, the straight line that connects the two centerpoints—i.e., the center of the cornea's [outer or inner] surface and the center of the uvea—passes through the center of the opening at the front of the uvea as well as through the midpoints of the two parallel corneal surfaces. For the concave surface of the cornea and the convex surface of the uvea are intersecting spherical surfaces. Now the line that joins their centers passes through the center of the circle of intersection, and it will be perpendicular to its surface, for a line dropped to the center of [such a] circle and perpendicular to its surface passes through the centers of the two [intersecting] spheres.[35]

[5.22] The concave surface of the cornea is contiguous with the surface of the albugineous humor at the front of the uveal opening, and it covers it. Thus, the surface of the albugineous humor is also a spherical surface whose center coincides with the center of the surface that covers it. So the outer surface of the cornea, as well as its inner surface, and the surface of the albugineous humor contiguous with the concave surface of the cornea are parallel spherical surfaces. Moreover, their centers form a common point that is deeper inside [the eye] than the uvea's center.

[5.23] When the line passing through the center of the uvea, the center of the cornea, and the center of the opening at the front of the uvea is extended rectilinearly, it will pass through the middle of the hollow of the nerve to which the eye is attached, for the opening at the front of the uvea lies opposite the opening within the body of the uveal sphere that forms the extremity of the hollow of the nerve [where its expanded end attaches to the uveal sphere].

[5.24] The anterior surface of the glacialis is also a spherical surface, and it intersects the uveal sphere; so its center lies deeper [in the eye] than the center of the uvea. And the straight line connecting these two centerpoints passes through the center of the circle of intersection, so it is also perpendicular to it. But the circle of intersection between the surface at the front of the glacialis and the surface of the uveal sphere forms either the circle defining the boundary between glacialis and uvea or a circle parallel to that one. For the surface at the front of the glacialis is opposite the opening at the front of the uvea, and it is uniformly positioned with respect to it. Thus, the boundary of this surface—which is the circle of intersection between the two surfaces of the glacialis—is either the circle of attachment itself or a circle parallel to that circle.[36]

[5.25] Accordingly, if the circle of intersection between the two surfaces of the glacialis is the circle of attachment itself, then this circle forms the circle of intersection between the anterior surface of the glacialis and the [inner] surface of the uvea. But if the circle of intersection between the two surfaces of the glacialis is parallel to the circle of attachment connecting the sphere of the glacialis and the uvea (which is certainly the case if the attachment occurs at the rear portion of the glacialis), then, if it is imagined to enlarge beyond its present spherical limits, the anterior surface of the glacialis will intersect the uveal sphere to form a circle parallel to that circle—i.e., the circle of intersection between the two surfaces of the glacialis—on account of the uniform placement of this circle with respect to the circumference of the uveal sphere. And this circle is parallel to the circle of attachment. Hence, the circle of intersection between the front surface of the glacialis and the uveal sphere will be either the circle of attachment itself or a circle parallel to it. Accordingly, if this circle is the circle of attachment itself, then the straight line passing through the center of the anterior [surface] of the glacialis and the center of the uvea will pass through the center of this circle and will be perpendicular to it, because this circle will be the circle of intersection between two spherical surfaces. But if this circle is parallel to the circle of attachment and is parallel to the circle of intersection between the two surfaces of the glacialis, then it lies on the same spherical surface as the circle of intersection between the two surfaces of the glacialis—i.e., the anterior surface of the glacialis—and it is parallel to it. Consequently, the line that passes through the center of the uveal sphere and the center of the surface at the front of the glacialis passes through the center of the circle of attachment in all situations. And it will be perpendicular to that circle whether the circle of attachment is the [actual] circle of intersection between the front surface of the glacialis and the uveal sphere or whether it is parallel to that circle.[37]

[5.26] Also, the anterior surface of the glacialis and the surface of the rest of the glacialis are two intersecting spherical surfaces. Thus, the center of the front surface lies deeper [within the eye] than the center of the rear surface;[38] and the straight line connecting these two centers passes through the center of the circle of intersection, and it will be perpendicular to it. And it has already been shown that this line passes through the circle of attachment and is perpendicular to it, for this circle [of intersection] is either the circle of attachment itself or is parallel to it. Thus, the line passing through the center of the uvea, as well as through the center of the anterior [surface] of the glacialis and the center of the circle of attachment (this line being perpendicular to this circle) passes through the center of the remaining portion of the glacialis.

[5.27] And since this line passes through the center of the remaining portion of the glacialis as well as through the center of the circle of attachment, and since it stands at right angles to the surface of the circle of attachment, then it extends through the middle of the hollow of the nerve to which the eye is attached, because the circle of attachment coincides with the extremity of the hollow of the nerve.

[5.28] And it has already been shown that the line passing through the center of the uvea, the center of the cornea, and the center of the opening which is at the outer or front [surface] of the uvea extends through the middle of the hollow of the nerve.[39] The line, therefore, that passes through the two centers of the surface[s] of the glacialis, as well as through the center of the uvea, is the very line that passes through the center of the cornea, the center of the uvea, and the center of the opening at the front of the uvea. So this line passes through the center of the cornea, the center of the uvea, the two centers of the surface[s] of the glacialis, the center of the opening at the front of the uvea, and the center of the circle of attachment. It also passes through the two centers of all the tunics facing the opening in the uvea,[40] and it is perpendicular to the surfaces of all the tunics facing the uvea's opening. It is perpendicular as well to the surface of the uvea's opening and to the circle of attachment, and it extends through the middle of the hollow of the nerve to which the eye is attached.

[5.29] And since it has been shown that both the center of the cornea and the center of the anterior surface of the glacialis lie upon this line and that both lie deeper [in the eye] than the center of the uvea, it is perfectly appropriate for the center of the anterior surface of the glacialis to be the same as the center of the cornea, so that the centers of all the surfaces facing the opening in the uvea form a single, common point. Hence, all the lines projected from that centerpoint to the surface of the eye will be perpendicular to all the surfaces facing the [uveal] opening.[41] Accordingly, we will later show in our discussion of how vision takes place that the center of the corneal surface and the center of the anterior surface of the glacialis form a single, common center. Thus, the surfaces of the tunics of the eye that face the opening in the uvea form spherical surfaces that share a single, common centerpoint.[42]

[5.30] In addition, because this centerpoint forms the center of the outer surface of the eye that is continuous with the surface enclosing the whole eye (and the entire eye is round save for the bit that the sphere of fat forming the sclera lacks at the front of the eye, and this shortfall makes no difference in the eye's motion since it is not in contact with the cavity in the eye socket), this centerpoint will be the centerpoint for the entire eye. Hence, it lies inside the eye as a whole. The centerpoint of the surfaces of the tunics of the eye facing the uveal opening therefore lies inside the eye as a whole.

[5.31] When the eyeball moves, then, the point within the eye that forms the center of the surfaces of the tunics of the eye will not shift [in relation to the eye socket], nor will it shift in relation to those surfaces. On the contrary, it stays fixed, for when the eye moves it moves only as a whole, and the parts of that whole do not move in relation to one another when it moves. But this centerpoint lies within [the eye as a whole], so it does not move with the motion of that whole. Likewise, the tunics of the eye do not move with the motion of the eye as a whole—i.e., with the motion of the eye itself—so this centerpoint does not move in relation to the surfaces of the tunics, whether [the eye is] in motion or at rest.

[5.32] And it has already been shown that the flexing of the nerve when the eye moves or when it is immobile occurs only at the opening in the cavity of the eye socket, because it only takes place at the very back of the eye.[43] It follows that the flexing of the nerve when the eye is moving or at rest only takes place behind the eye's centerpoint.

[5.33] Nor do the parts of the eye move with respect to each other whether [the eye is] in motion or at rest. Thus, the centerpoints of the eye's tunics do not move with respect to the eye as a whole, whether the eye is in motion or at rest. Accordingly, the straight line passing through the centerpoint does not move with respect to the eye as a whole or to its parts, no matter whether [the eye is] in motion or at rest. And since this line moves with respect neither to the eye as a whole nor to its parts, then this line does not move with respect to the surface of the circle of attachment or its circumference. But this circle forms the extremity of the hollow of the [optic] nerve. Thus, its surface and the surface of the nerve's hollow have the same orientation; and the inclination of the funnel-shaped portion of the nerve to the surface of this circle is constant, because the glacialis maintains a constant orientation with respect to this nerve.

[5.34] Since the parts of the eye do not move with respect to one another, the surface of the [optic] nerve's hollow, from the circumference of the circle of attachment to the place where the funnel-shaped part of the nerve begins to flare outward, moves with respect neither to the eye as a whole nor to the circle of attachment.

[5.35] Furthermore, it has already been shown that the line passing through the centers [of the ocular components] does not move with respect to the circle of attachment and that this line extends through the middle of the [optic] nerve's hollow.[44] But if this line does not move with respect to the circle of attachment, and if the surface of the nerve's hollow from the circumference of the circle of attachment to the place [in the eye socket] where it flexes does not move with respect to the circle of attachment, then this line does not move with respect to the hollow of the nerve up to the point where it flexes. Thus, the line that passes through the center of the tunics of the eye passes through the center of the circle of attachment, and it will stand at right angles to it, and it extends through the middle of the hollow of the funnel-shaped portion of the nerve up to the point where the nerve flexes. It will always maintain a constant position with respect to the surface of the nerve's hollow within the eye, as well as [with respect] to all the parts of the eye and all the surfaces of the tunics of the eye, and it does not change that position whether the eye is moving or at rest.

[5.36] These, therefore, are the dispositions of the tunics of the eye, the dispositions of their centerpoints, and the disposition of the straight line passing through their centerpoints.

[5.37] Moreover, both eyes are similar in all respects, with regard to their tunics, as well as to the shape of their tunics and the situation of each of the tunics with respect to the eye as a whole. And given this fact, the location of each of the previously discussed centerpoints with respect to the whole of one eye as well as to its parts corresponds to that of the centerpoints of the other eye as a whole as well as to its parts. And since the location of the centerpoints in either eye corresponds to the location of the centerpoints in its mate, the line passing through the centerpoints of one eye will be similarly situated in respect to the eye as a whole, its parts, and its tunics as the line passing through the centerpoints of the other eye in respect to that eye as a whole, its parts, and its tunics. Thus, the two lines passing through the centerpoints of the tunics of both eyes are similarly situated in all respects.

[5.38] Each of the scleras is affixed with these components [into the eye-sockets], for two small muscles grow out of them, one toward the side of the tear ducts, the other toward the back edge. And lids and eyelashes cover both eyes.

[5.39] What we have thus shown is how the eye is composed, its [overall] structure, and the structure of its [component] tunics. And everything we have said about the tunics of the eye and their structure has already been shown by anatomists in books on anatomy,[45] and this is the way the eye is formed.

[CHAPTER 7]

[6.1] It has already been shown above that light emanates in every [possible] direction from any luminous body, however it is illuminated.[46] Thus, when the eye faces any visible object that shines with some sort of illumination, light from that visible object will shine on the eye's surface. And it was shown that it is a property of light to affect sight, whereas it is in the nature of sight to be affected by light. It is therefore fitting that sight sense the luminosity of a visible object only through the light that shines from it upon the eye.

[6.2] It was also shown earlier that the form of the color of any tinted body that shines with any sort of illumination is always mingled with the light shining in every direction from that body, and light and the form of color will always correspond with one another.[47] Therefore, since the form of the color of the visible object will always coexist with the light shining from the visible object to the eye, and since light and color will reach the surface of the eye together, and since sight senses the color that is in the visible object by means of the light shining upon it from the visible object, it is quite fitting that sight sense the color of the visible object only from the form of [that] color reaching the eye along with the light [shining from the object].

[6.3] Also, the form of color is always mingled with the form of light and is not separable from it. So sight senses light only when it is mingled with color.[48] It is thus quite fitting that sight sense the color and light that are in the visible object only through a form that is composed of both the light and color shining upon it from the surface of the visible object.

[6.4] In addition, the tunics of the eye that are centered on the front of the eye are contiguous and transparent, and the first of these, i.e., the cornea, is in contact with the air that initially transmits the form. But it is among the properties of light to pass through any transparent body, and it is likewise a property of the form of color that it mingles with light in order to pass through a[ny] transparent body. Therefore, it extends through the transparent air in the same way as light. And it is in the nature of transparent bodies to receive the forms of light and colors and to transmit them in facing directions.[49] Hence, the form that comes from the visible object to the surface of the eye will pass through the transparency of the tunics of the eye from the opening that is at the front of the uvea. It will therefore reach the glacial humor and will also pass through it on account of its transparency. It is thus quite fitting for the tunics of the eye to be transparent for the sole purpose of letting the forms of light and colors that reach the eye pass through.

[6.5] At this juncture, then, let us summarize all of these points.

[6.6] And we will say that sight senses the light and colors that are in the surface of the visible object and that they pass through the transparency of the tunics of the eye. This is by now the accepted opinion of natural philosophers about how vision occurs.[50]

[6.7] We will now say that this alone does not suffice to describe the way vision occurs, for, without some additional qualification, this explanation does not stand, for the form of light and color of any colored and illuminated body extends in all directions through the transparent air that is contiguous with it. However, the eye faces several visible objects of different colors at the same time, and between each of them and the eye there are direct lines through the continuum of air that links them. And since the forms of light and color that are in a visible object facing the eye will reach its surface, the forms of the light and color belonging to any of the visible objects facing the eye at the same time reach the surface of the eye at the same time. And since the forms extend from the visible object to any facing point and reach the eye only when it faces [that object], the form that comes from the visible object to the eye reaches the entire surface of the eye. And since this is the case, when the eye faces any surface of a visible object, if the form of its color and light reaches the eye's surface, and if at that time the observer sees other visible objects of a different color that face the eye, then the form of the light and color of any of those visible objects will reach the eye's surface. And the form of all of those visible objects will reach the entire surface of the eye. On the whole, then, several different lights and several different colors will reach the entire surface of the eye, and each of them fills the surface of the eye. So a form composed of various colors and lights reaches the surface of the eye.

[6.8] If sight were then to sense that composite form, it would sense a color different from the color of any one of the objects, and it would not distinguish [any of the component] visible objects through it. Yet, if it were to sense one of those visible objects and were not to sense the rest, it would discern one visible object but not the others. But it discerns all of those visible objects at the same time, and it discerns them [all] distinctly.

[6.9] On the other hand, if it were unable to sense [any] one of those forms, it would sense none of the visible objects facing it. But it senses them all.

[6.10] Furthermore, in the same visible object there will be different colors and designs according to some arrangement, and from any spot on that object light and color emanate along every straight line that extends [from it] through the continuous air. Therefore, since the parts of a single visible object have different colors, from any one of those spots the form of color and light will reach the entire surface of the eye; and thus the colors of those parts will mingle on the eye's surface, whence sight will either perceive them mingled together or will perceive none of them. Yet if it perceives them mingled together, neither the parts themselves nor their colors will be discerned or perceived according to their proper arrangement. And if it fails to perceive any of their forms, it fails to perceive any of their parts; and if it fails to grasp any of their parts, it will fail to perceive the visible object [as a whole]. But sight does perceive any illuminated visible object facing it, and it perceives the parts of it that are of different colors distinctly and according to their proper arrangement.

[6.11] This being the case, it follows either that vision will take place in some other way or that this account will only be part of the story. Therefore, we ought to consider whether this account can be suited to the circumstances under which the colors of visible objects are distinguished, and the parts of those objects are perceived by sight according to their proper arrangement, so they will correspond to reality.

[6.12] Accordingly, we will say that when the eye faces any visible object, the form of both the color and the light in that object will come from any point on its surface to the entire surface of the eye. Moreover, from every point on every visible object facing the eye under these circumstances the forms of the color and light in it will come to the entire surface of the eye. Hence, if the eye were to sense throughout its entire surface the forms of the color and light that come from any given point on the visible object's surface, it would sense throughout its entire surface the form of every point on the surface of the visible object as well as the form of every point on the surfaces of all the visible objects facing it in that situation. So the parts of any one visible object would not be perceived according to their proper arrangement, nor would they be properly discerned by it.[51]

[6.13] But if the eye sensed at only one point on its surface the form reaching its entire surface from one point on the surface of the visible object, and if it did not sense the form of that point throughout its entire surface, the parts of the visible object would be perceived by it according to their proper arrangement, and all the facing visible objects would be properly discerned. The reason is that when it perceives the color of a single point at only one point on its surface, it will perceive the color of one part of the visible object at one part of its surface, and it will perceive the color of another part [of the object] at another part of its surface. And it will perceive each part of visible objects at a spot on its surface different from the spot where it will perceive another visible object; so [different] visible objects will be perceived by it in proper arrangement and distinctly, as will the parts of each of them.[52]

[6.14] So let us now consider whether this is possible and corresponds to reality. And we should say at the outset that vision takes place only through the glacialis, whether vision occurs by means of forms coming from the visible object to the eye or by some other means. Moreover, vision does not occur through one of the other tunics in front of it, for those tunics in front are only there to serve the glacialis. For if an injury happens to the glacial humor while the other tunics remain sound, vision will be extinguished; but if the remaining tunics suffer injury while retaining their transparency, and if the glacialis remains healthy, sight will not be disrupted. Likewise, if there is an obstruction in the opening of the uvea so that the capacity of its humor to transmit light is destroyed, sight will be extinguished, even when the cornea is healthy; but if the obstruction is removed, sight will be restored. So too, if a crass, nontransparent spot develops within the albugineous humor, and if it lies directly in front of the glacial humor between it and the opening of the uvea, vision will be extinguished; but when that dense spot is removed or turned aside from the straight line between the glacialis and the opening in the uvea, sight will be restored. And medical science attests to all these points.[53]

[6.15] Therefore, the destruction of [visual] sensation that ensues from degeneration of the glacialis while the tunics in front of it remain healthy is an indication that [visual] sensation occurs by means of this humor alone, not by means of the rest of the tunics in front of it. Furthermore, the destruction of [visual] sensation that ensues from the disruption of the transparency between the glacialis and the eye's surface by a crass, nontransparent body indicates that the transparency of these tunics exists only to link the transparency of the eye's tunics with the transparency of the air so as to form a continuum of transparent media between the glacialis and the visible object. Also, the destruction of [visual] sensation when the straight lines between the glacialis and the eye's surface are interrupted indicates that the glacialis will sense only along the straight lines between it and the surface of the eye.

[6.16] We shall therefore say that, if the visual sensation of the color and light that are in a visible object arises from the form coming to the surface of the eye from visible objects, and if this sensation occurs by means of the glacialis alone, then sight will not sense that form at the surface of the eye itself but only after it passes through the eye's surface and reaches the glacialis. And the form that reaches from the visible object to the eye's surface passes through the transparency of the eye's tunics, for it is among the properties of transparency that the forms of light and colors pass through it and continue rectilinearly. We have already made this point in regard to air; and if all transparent objects were to be tested, it would be found that light will extend through them only in straight lines.[54] And in our discussion of the refraction [of light] we shall show how this point is to be experimentally confirmed.[55] Therefore, if visual sensation of the light and color in a visible object is due to a form coming from that visible object to the eye, [that] sensation will arise [only] when that form itself reaches the glacialis. And it has already been shown that it is not possible for sight to perceive a visible object as it really exists unless it perceives the form of one point on the object at one point only on its own surface.[56] So it is not possible for the glacialis to perceive a visible object as it really exists unless, from the form reaching it from the object, it perceives the color of one point on that visible object at one particular point on the surface of the eye. Now a form comes from any given point on the surface of the visible object, and it passes through the entire surface of the eye into its interior. If, however, the glacialis perceives only the form that reaches it at a single point on the surface of the eye from a single point on the visible object, this form having reached the entire surface of the eye and having passed through the tunics to the glacialis, and if it senses the color of that point alone that passes from the surface of the eye to [that] single point on its surface, and if it does not perceive that [same] point on the visible object from the rest of the form reaching its surface from the rest of the eye's surface, then vision will be achieved, the parts of the visible object will be perceived according to their proper arrangement, and the visible objects will be properly discerned by sight.[57]

[6.17] Moreover, vision will be achieved in this way alone. And such cannot be the case unless [each] one of the points on the surface of the eye through which the form of any one point on the surface of the visible object passes is distinct from the remaining points on the surface of the eye, and unless the line along which the form is radiated to that point on the surface of the eye is distinct from the remaining lines along which the form is radiated. Accordingly, the glacialis can perceive the form arriving along that line through the point on the surface of the eye that lies upon that line but cannot perceive it along any other.

[6.18] And when lights are examined[58] and the way they pass into and continue through transparent bodies is experimentally determined, it is found that light continues through a transparent body along straight lines, as long as the body is of consistent transparency. But when it strikes a body whose transparency is different from the transparency of the body through which it previously extended, it will not continue upon the straight lines along which it had extended before unless those lines are perpendicular to the surface of the second transparent body. If, however, those lines are oblique rather than perpendicular to the surface of the second body, the light will be bent at the surface of the second body rather than continue straight.[59] And when it is bent, it will extend through the second body along those straight lines to which it has been inclined; and the lines along which the light has been bent in the second body will also be oblique rather than perpendicular to the surface of the second body. And if some of the lines along which the light reaches the first body are perpendicular to the surface of the second body and some inclined, the light that is orthogonally incident will extend straight through the second body. The light arriving along oblique lines, for its part, will be diverted along oblique lines at the surface of the second body, and it will extend rectilinearly through that body along those oblique lines into which it has been diverted. And we shall explain this in our discussion of bending, and we shall show how one can confirm this phenomenon experimentally, and it will [thus] be empirically ascertained.[60]

[6.19] And since this is the case, when the form of the light and color that reach the surface of the eye from any given point on the visible object arrives at the surface of the eye, only the light and color that are incident at right angles upon the surface of the eye will pass straight through the transparency of the tunics of the eye. The form incident along any other line will be refracted[61] and will not pass straight through, because the transparency of the tunics of the eyes is not the same as the transparency of the air contiguous with the surface of the eye; and those forms that are refracted will also be refracted along oblique lines rather than continuing along lines perpendicular to the [refracting surfaces] at the points of refraction. And there is only one straight line that extends from any single point on the surface of the visible object to a given point on the surface of the eye so as to be orthogonal to the surface of the eye, whereas there is an infinite number of lines extending to the surface of the eye that are inclined to it. And the form that arrives straight along the perpendicular passes straight through the tunics of the eye along the perpendicular, whereas all the forms incident to that [same] point along oblique lines are refracted at that point, and they pass through the tunics of the eye along oblique lines as well. None of them passes through along the same lines that they followed in arriving, nor [do they pass] straight through along the perpendicular erected at that point [of refraction].[62]

[6.20] Moreover, at any given time, the forms of all the points on the surfaces of all illuminated visible objects facing the surface of the eye arrive simultaneously at any point on it, for there is a straight line between that point and any point facing it. Also, the forms from any one of the points on the surfaces of illuminated visible objects radiate along every straight line that can be extended from that point, but of all the points facing the eye whose forms are incident upon a given point on the surface of the eye [at any given time], there is only one at that time that arrives along the perpendicular erected to that point on the surface of the eye. The forms of all the remaining points reach that point on the surface of the eye along oblique lines. Furthermore, through any point on the surface of the eye the forms of all the points on the surfaces of all the visible objects facing the eye pass simultaneously. But the form of only one point passes straight through the transparency of the tunics of the eye, and that point is the one that lies at the endpoint of the perpendicular extending from the given point on the surface of the eye. The forms of all the remaining points are refracted at that point on the surface of the eye, and they pass through the transparency of the tunics of the eye along lines that are oblique with respect to the eye's surface.

[6.21] Also, from any given point on the surface of the glacialis there extends only one line that is perpendicular to the surface of the eye. But there are an infinite number of lines extending from that point that will be oblique to the surface of the eye. Thus, besides the perpendicular itself, an infinite number of lines extends from the point on the surface of the glacialis where the perpendicular to the surface of the eye originates, and this perpendicular passes through the opening in the uvea; the rest of the lines also pass through the opening in the uvea and reach the surface of the eye.

[6.22] Furthermore, if we suppose these lines to be refracted according to the way determined by the difference in transparency between the transparency of the corneal body and the transparency of the air, then the endpoints of all the lines that extend from any given point on the surface of the glacialis and pass through the opening of the uvea to reach the surface of the eye along oblique paths reach different locations and different points among the set of [all] points on the surfaces of visible objects that face the eye at any given time. And none of these lines intersects the point at the end of the perpendicular. So the forms of the points that lie on the surfaces of the visible objects at the extremities of all these lines are propagated rectilinearly along these lines, and they reach the surface of the eye where they are refracted to the same point on the surface of the glacialis, except for the form of the point lying at the extremity of the perpendicular, for it extends straight along the perpendicular and passes [straight through] to that point on the glacialis. Thus, if at any one of its points the glacialis senses all the forms reaching that point along all the lines of radiation,[63] at every point it will sense forms that are mixed together from many different forms and many [different] colors [extending] from the visible objects that face the eye at that time. Hence, on the basis of this [mixed form] it will discern none of the [individual] points on the surfaces of those visible objects, nor will the forms of those points that reach that point be perceived according to their proper arrangement. Yet if the glacialis were to sense at one of its points only the form that reaches it along one particular radial line, the [individual] points on the surfaces of the visible objects would be properly discerned by it.

[6.23] But none of the points whose forms reach the glacialis along refracted lines is more exceptional than any of the other points whose forms are refracted, nor is any refracted path more exceptional than any other; and the forms that are refracted at any given point on the glacialis at any given time are innumerable. On the other hand, the point whose form reaches any one point on the glacialis along the perpendicular is unique; no other form accompanies it straight along the perpendicular, for all the forms that are refracted are refracted along oblique lines alone. Moreover, since the center of the eye's surface coincides with the center of the glacialis' surface, any line that is perpendicular to the surface of the eye is perpendicular to the surface of the glacialis. Hence, the form that arrives along the perpendicular is distinguished from all the other forms in two respects, the first of which is that it extends from the surface of the visible object to the point on the glacialis along a straight line, whereas the remaining forms reach [that point] along refracted lines. The second is that the perpendicular dropped to the surface of the eye is the very same perpendicular that is dropped to the surface of the glacialis, whereas the rest of the lines along which the remaining forms that are refracted reach [the eye] are oblique to the surface of the glacialis, because they are oblique to the surface of the eye.

[6.24] Furthermore, the effect of light arriving along perpendiculars is stronger than the effect of light arriving along oblique lines. Therefore, it is quite fitting that at any given point the glacialis senses only the form reaching it straight along the perpendicular and does not sense any form that strikes it at that point along refracted lines.[64]

[6.25] In addition, since the center of the eye's surface and the center of the surface of the glacialis coincide, all of the perpendiculars erected to the surface of the glacialis as well as to the surface of the eye intersect at that common center, and they will form diameters for the tunics of the eye. And every perpendicular will strike the surface of the cornea at one point and will strike the surface of the glacialis at one point, but at that point on the cornea only one perpendicular can be dropped, and at that point on the glacialis no perpendicular other than that one can be dropped. So the form that extends from any given point on the surface of the visible object along the perpendicular dropped from it to the surface of the eye strikes the surface of the eye at one point, but none of the other forms arriving [from that point on the visible object] along nonperpendicular lines strikes [the surface of the eye at] that particular point. Furthermore, it has already been shown that from any point on any colored body that is somehow illuminated light and color emanate along every straight line that can be extended from that point.[65]

[6.26] Therefore, one can imagine a straight line [extended] between any point facing a given surface and any point on that surface, and between that point and that whole surface a cone can be imagined with its vertex at that point and its base formed by that surface. And that cone contains all the straight lines that are imagined to lie between that [vertex-]point and all the points on that surface.[66]

[6.27] Accordingly, since the form of light and color radiates from any point on the surface of a colored and illuminated body along every straight line that can be extended from that point to any point facing that illuminated and colored body, the form of the light and color on that body's surface is radiated from any point on the surface of that body to that facing point along a straight line extending between that same body and that point. The form of the light and color of any colored body that is somehow illuminated thus extends from its surface to any point facing that surface along a line contained by the cone that is formed between that point and that surface. And the form will be arranged within that cone according to the lines that intersect at that point, which forms the cone's vertex, and that arrangement will be the same as the arrangement of the spots of color on the surface of that body.

[6.28] So when the eye faces any visible object, a cone can be conceived of as formed between the point that represents the center of the eye and the surface of that visible object, the vertex of that cone being the center of the eye and its base being the surface of that visible object. And if the intervening air between that visible object and the eye is continuous, if there is no opaque body interposed between that visible object and the eye, and if that visible object is somehow illuminated, the form of the light and color on the surface of that visible object will reach the eye along a line contained by that cone. And the form of every point on the surface of that visible object will radiate along the straight line connecting that point and the vertex of the cone, which lies at the center of the eye.

[6.29] Furthermore, since the center of the eye['s surface] is the same as the center of the surface of the glacialis, all of these lines will be perpendicular to the outside surface of the eye as well as to the surface of the glacialis and all the surfaces of the eye that are parallel [to them]. And the cone that coincides with all these perpendicular lines will encompass all these perpendiculars and the air through which the form [in its entirety] extends along perpendicular lines from the whole surface of that visible object facing the eye. Also, the surface of the glacialis will intersect that cone, so the form of the light and color on the surface of that visible object reaches the section of the glacialis that is demarcated by the cone. At any point on this section of the surface of the glacialis the form of a corresponding point on the surface of the visible object will arrive along the perpendicular dropped from that point on the surface of the visible object to the surfaces of the tunics of the eye as well as to the surface of the glacialis.[67] And this form passes straight through the transparency of the tunics of the eye along that perpendicular, but no other form passes straight through in tandem with that form along that perpendicular line. That form, moreover, will reach this spot on the glacialis according to the arrangement determined by the lines along which it arrives there, those lines being perpendicular to the glacialis and intersecting at the center of the eye in an arrangement corresponding to that of the parts of the surface of the visible object.[68] Furthermore, under these circumstances several forms reach any point on this section of the glacialis from several points on the visible surfaces at the same time. Thus, several forms arising from several different colors reach this section of the glacialis that has been demarcated by the cone.

[6.30] If, therefore, the glacialis senses the form reaching it at one, distinct point along only one of the lines within that cone, and if at that [same] spot on its surface it senses no other form than the form reaching it along that line, then it will sense the form of that object as it actually exists, and it will sense it according to its arrangement [on the visible surface]. Moreover, under those circumstances, it will be able to sense the forms of visible objects other than that visible object on the basis of the cones that demarcate other sections upon its surface, and it will be able to sense the form of each of those visible objects as they actually exist as well as to sense their relative locations as they actually exist.

[6.31] But if the glacialis senses forms arriving at it along refracted lines, the forms it will sense at the same section on its surface that was cut by the cone will be mixed from the forms of parts of the given visible object as well as from the forms of many different visible objects, and those forms will represent mixtures of many different colors. Moreover, at some spot on its surface other than that one it will sense a form that is mixed from the forms of many different visible objects, and so it will not sense the form reaching it along the line within the cone as it actually exists, nor will it sense any of the forms reaching it along the perpendiculars as they actually exist, nor will it sense any of the forms reaching it along refracted lines [as they actually exist]. Hence, it will not sense the form of any individual visible object as it actually exists, nor will visible objects facing it at any given time be [individually] discerned by it.

[6.32] But sight will [in fact] perceive separate visible objects, and it will perceive the parts of an individual visible object according to their actual arrangement on the surface of the visible object, and it will perceive several visible objects together at the same time. And since vision is due to forms reaching the eye from visible objects, the glacialis will sense none of the forms of visible objects that reach it along refracted lines.

[6.33] Furthermore, none of the forms reaching the surface of the glacialis from visible objects will be arranged on the surface of the glacialis according to reality, and none of the forms reaching the surface of the glacialis from the parts of the individual object will be arranged on the surface of the glacialis according to reality except for the forms reaching it directly along the perpendiculars dropped to the surface of the eye. The forms, moreover, that are refracted at the surface of the eye reach the surface of the glacialis in reverse order. And in addition to that, the form of one point is spread out upon an area of the surface of the glacialis rather than arriving at a point, and this follows from the fact that when the form of a right-hand point with respect to the eye reaches a point on the surface of the eye, assuming that the line along which that form extends is oblique to the eye's surface, it will refract to the left of the normal dropped from the center of the eye to that point on its surface. And the form that is refracted in this way at the extremity of the normal [at the point of refraction] reaches a point to the left of the point on the surface of the glacialis where that perpendicular intersects it. So too, the form of a left-hand point with respect to the eye that extends to that same point [of refraction] on the surface of the eye and that is oblique to this surface will be refracted to a point on the right of the normal as well as on the right of the point on the surface of the glacialis that lies on that normal. For after refraction, refracted forms do not incline along the normal dropped to the point of refraction, nor do those forms coincide with the normal, nor do they pass through it or continue by it, for such is the property of refracted forms.[69]

[6.34] Likewise, [when] the forms of two points on the same side of the viewer extend to one point on the surface of the eye and are bent in the same direction at that surface, [they] arrive at the surface of the glacialis in reverse order, for the two lines along which the two forms of the points extend intersect at the point on the surface of the eye where the two forms meet, and they meet the normal at the point to which it is dropped on the surface of the eye. Thus, if these two lines are oblique to the surface of the eye and lie on the same side of the normal dropped from the center of the eye to that point [of refraction], the forms of the two points are refracted to the side opposite that one. Also, because the two lines along which the two forms arrive at that single point on the surface of the eye intersect at that point, it follows that, as they continue along their respective straight lines after intersection, their position with respect to their source in the visible object, as well as to the normal, appears reversed. And of those two lines, the one that lay [farther] to the right before arriving at the surface of the eye ends up [farther] to the left after passing through the surface of the eye, whereas the one [farther] to the left [ends up farther] to the right.[70]

[6.35] The same will hold for the [relative] position of the two lines along which the two forms are refracted at one point on the surface of the eye, for the two forms that are refracted at one point both approach the normal, and, after intersecting [the normal], the form that arrived along the line farther from the normal continues along a line that is also farther from the normal, but less so than before. Meantime, after intersecting [the normal], the form that arrived along the line nearer to the normal still continues along a line that is nearer the normal, but more so than before, and the same holds for all forms that are refracted at a single point.[71]

[6.36] And if this phenomenon is experimentally scrutinized with great care, the result will be found to agree with what we have claimed. And we shall show how to carry out this experimental confirmation properly in our section on refraction,[72] and at that time everything to do with refraction will be revealed. But in that section we shall not avail ourselves of the discussion of matters that we have demonstrated in this book concerning such phenomena.

[6.37] Therefore, when the forms of two points on one side of a visible object arrive obliquely at a single point on the surface of the eye, they will intersect [and continue] along two lines whose [relative] position with respect to the visible object from the perspective of the viewer will be opposite to the [relative] position of the two lines along which the two forms originally reached the surface of the eye. Accordingly, the position of the two points on the surface of the glacialis to which the two forms reach will be opposite the position of the two points [on the surface of the visible object] from which the two forms originate. All forms that are refracted at one point on the surface of the eye thus arrive in reverse order on the surface of the glacialis.[73]

[6.38] Furthermore, the form of any point facing the eye reaches the entire surface of the eye; hence it will be refracted at the entire surface of the eye. And the form that is refracted at the entire surface of the eye is refracted to an area on the surface of the glacialis that has some dimension, not to a point, for if refracted forms were to meet at one point after refraction, they would either intersect or pass through the normals at whose endpoint they have been refracted, or the form would pass out of the plane within which it has been refracted.[74] But, after being refracted, no refracted form meets the normal at whose endpoint it was refracted, nor does it pass through it, nor does it pass out of the plane within which it was refracted. And all of these points become clear with experimentation. Therefore, [when] the form of a single point on a visible object reaches the surface of the glacialis through refraction, [it] will not reach it at a single point but, rather, at an area on the surface of the glacialis that has some dimension. Moreover, the relative positions of the forms of different points on the surface of the visible object that reach the surface of the glacialis through refraction will not be the same as their actual positions on the surfaces of [those] visible objects, but reversed. Thus, none of the refracted forms of visible objects reaching the surface of the glacialis represents the surfaces of the visible objects as they actually are. But it has already been shown that forms arriving along perpendiculars are arranged on the surface of the glacialis according to reality, because they extend orthogonally from the surfaces of visible objects to the surface of the glacialis. Except for the forms extending along perpendicular lines, then, none of the forms of visible objects that reach the surface of the glacialis is arranged on the surface of the glacialis according to its actual arrangement on the surfaces of visible objects.

[6.39] Hence, if visible objects are sensed by means of forms reaching the eye from the surfaces of visible objects, sight will perceive none of the forms of visible objects that reach it along lines other than those whose endpoints meet at the center of the eye, for sight perceives none of the forms of visible objects unless they are arranged [in sight] according to their actual arrangement on the surfaces of visible objects.

[6.40] Moreover, if the center of the eye[ball]'s surface is not [the same as] the center of the surface of the glacialis, then the straight lines originating at the center of the surface of the eye that extend through the opening in the uvea and reach visible objects will be oblique rather than perpendicular to the surface of the glacialis; and their [relative] positions on the surface of the glacialis will not be constant, except for one line alone, and that is the one that passes through both centers. Therefore, the glacialis can only sense the forms reaching its surface from the surfaces of visible objects along those lines alone—i.e., the lines that are perpendicular to the surface of the eye, which is the surface of the cornea. For only the forms that lie upon these perpendiculars are arranged on the surface of the glacialis according to their arrangement on the surfaces of visible objects.

[6.41] If, then, the glacialis perceives visible objects by means of forms reaching it and perceives only that form reaching it along these lines, and if these lines are not perpendicular to its surface, then it will perceive forms along lines that are oblique to its surface and whose [relative] locations are variable with respect to its surface. So it perceives forms along oblique lines that have different [relative] positions, and it will perceive all refracted forms along lines that have different [relative] positions with respect to its surface. But if it were to perceive all refracted forms along lines that have different [relative] positions, none of the visible objects would be [individually] discerned by it, according to what has been demonstrated above.[75] And if it is not possible for the glacialis to perceive refracted forms of visible objects along lines that have different [relative] positions, it is not possible for it to perceive the forms of visible objects along lines that are perpendicular to the surface of the eye unless those lines are perpendicular to its surface and unless their [relative] position on its surface is constant. But these lines will only be perpendicular to the surface of the glacialis if the center of its surface is the same point as the center of the surface of the eye. Thus, if the visual sensation of visible objects is due to forms reaching the eye from the colors and light of [those] visible objects, then the center of the eye's surface and the center of the surface of the glacialis must be a single, common point, and sight can perceive none of the forms of visible objects unless it does so exclusively along the straight lines whose endpoints meet at this centerpoint.

[6.42] Now it is not impossible for the two centers to coincide, for it has already been shown that the two centers lie behind the center of the uvea upon a single straight line that passes through all the centers [of the tunics of the eye].[76] And since it is not impossible for the two centers to be the same and for the straight lines passing through the centers to be perpendicular to the two surfaces—i.e., the surface of the glacialis and the surface of the eye—then it is also not impossible for the visual perception of visible objects to be due to the forms of light and color coming to it from the surfaces of [those] visible objects, if the perception of those forms takes place along perpendicular lines alone. And this is so because it is in the nature of sight to receive forms that reach it from visible objects, and also because, in addition to this qualification, it is in the nature of sight only to accept those forms that reach it along specific lines, not along all lines; and these specific lines are the straight lines alone whose endpoints meet at the center of the eye, and these lines converge at the center because they are diameters (of the eye, that is) and are perpendicular to the surface of the sensing organ. And so [visual] sensation will be due to the forms that come from visible objects, and the perpendicular lines [along which they are sensed] will be, as it were, the instrument of sight by means of which visible objects will be [individually] discerned by sight and the parts of every visible object will be [properly] arranged [for visual perception].

[6.43] Moreover, the fact that sight functions according to particular lines has counterparts in [other] natural phenomena. For light originates at luminous bodies and extends along straight lines only rather than following curved or crooked lines; and heavy bodies fall naturally along straight lines, not along crooked, curved, or winding lines. Moreover, such bodies will follow not every straight line lying between them and the surface of the earth, but only those select straight lines that are perpendicular to the surface of the earth and to the earth's diameter.[77] Also, celestial bodies move along circular lines rather than along straight lines or lines of other kinds. And when we examine natural motions, we will find that each of them takes place according to specific lines. So it is not impossible for sight to be constituted in such a way as to suffer the effects of light and color along a specific set of straight lines that alone intersect at its center and are perpendicular to its surface. Furthermore, it is granted by mathematicians that sight perceives visible objects along only those straight lines whose endpoints meet at the center of the eye, and there is no disagreement among them about this point.[78] These lines are called "radial lines" by them.

[6.44] Since this is possible, and since forms of light and color reach the eye and pass through the transparency of the tunics of the eye, and since vision is achieved upon the reception of these forms only when the eye receives them along perpendicular lines, sight perceives the light and colors of the surfaces of visible objects only through forms reaching it from the surfaces of visible objects. Moreover, it perceives these forms only along those particular straight lines whose endpoints meet at the center of the eye.

[6.45] Let us now summarize what can be concluded from everything we have said.

[6.46] And let us say that vision senses the light and color on the surface of a visible object through the form of both the light and color that extend from the surface of the visible object through the transparent medium that lies between the eye and the visible object, and sight perceives the forms of visible objects only along the straight lines that are extended between the visible object and the center of the eye. And along with this it has been shown that this is possible rather than impossible.[79]

[6.47] But we will expound on the issue by saying that vision can only occur in this way. For when sight senses a visible object after having not sensed it, something that was not affecting it before now affects it, but nothing will happen later that was not in effect earlier except through some cause. And we find that when the eye faces a visible object, it will sense it; but when it is removed from that facing position, it will not sense it, whereas when it is brought back to the facing position, the sensation returns. Likewise, we find that when the eye senses a visible object and then [the viewer] closes his eyelids, the sensation ceases; but when he opens his eyelids while the visible object faces him, the sensation returns. Now a cause is such that, when it ceases to operate, what it causes ceases to exist; and when it is brought back to bear, what it causes comes back into existence. Therefore, what causes the visible object to have an effect on sight is the fact that the visible object faces the eye. Hence, sight does not sense a visible object unless the visible object creates an effect on it as it faces the eye.[80]

[6.48] In addition, sight does not perceive a visible object unless the intervening medium is transparent. Now the visual perception of a visible object through the air that lies between eye and object is not due to the moisture in the air but, rather, to its transparency, for if some [transparent] stone or any other transparent body is interposed between the eye and the visible object, sight will still perceive the visible object. And the [clarity of] perception will depend upon the transparency of the intervening body, so that the more transparent the intervening body the clearer the visual sensation of the visible object. Likewise, when clear, transparent water intervenes between the eye and the visible object, sight will perceive a visible object through the water; but if that water is tinged with some strong dye so that its transparency is destroyed, then, even though the water's moisture persists, sight will not perceive that visible object in the water.[81]

[6.49] It will therefore be clear from these circumstances that sight is achieved only because of the transparency of the intervening medium, not because of its moisture. Hence, the effect that the visible object creates in sight when it faces what arouses sensation in it is realized only through the transparency of the medium between the eye and the visible object. The light and color of a visible object are therefore perceived by sight only by means of the effect of that light and color in the eye, and this effect is not created in the eye by color and light unless the medium between the eye and the visible object is transparent.

[6.50] In terms of its essential relationship to light and color, transparency differs from opacity only insofar as the form of light and color passes through a transparent object, whereas it does not pass through one that is not transparent, and insofar as a transparent body receives the form of light and color and transmits it in [all] directions facing the light and color; a body that is not transparent, on the other hand, does not possess this quality. And since sight senses the light and color in a visible object by means solely of an effect created by them in the eye; and since that effect is created in the eye only when the medium between the eye and the visible object is transparent; and since a transparent body is distinguished from one that is not transparent solely by the fact that, in regard to its essential relationship to light and color, it is suited to the reception of forms and colors as well as to their transmission in facing directions; and since it has been shown that, when the eye faces a visible object, the form of the light and color in the visible object are transmitted into the eye and reach the surface of the sensing organ, sight senses the light and color of a visible object by means solely of a form extending through the transparent medium between the visible object and the eye, that form creating in the eye the effect of the visible object that faces it across the transparent medium.

[6.51] Now we might claim that the transparent medium receives something from the eye and transmits it to the visible object, so that sensation comes about from the extension of this thing between the eye and the visible object. This is the opinion of the proponents of [visual] rays.[82]

[6.52] Accordingly, let it be supposed that such is the case and that [visual] rays issue from the eye and pass through the transparent medium to reach the visible object, and [suppose] that [visual] sensation occurs by means of these [visual] rays. But if [visual] sensation occurs in this way, I ask whether something is transmitted back to the eyes through those [visual] rays or not. On the one hand, if [visual] sensation occurs by means of [visual] rays, but they transmit nothing back to the eye, then sight will perceive nothing. On the other hand, sight does sense the visible object, and if it senses the visible object but does so only by means of [visual] rays, then those [visual] rays that sense the visible object [must] transmit something back to the eye by means of which sight senses the visible object. Yet if the [visual] rays transmit something back to the eyes [and it is] by means of this [that] visual sensation of that visible object will occur, then sight will sense the light and color in the visible object by means solely of something coming from the light and color in the visible object to the eye, and the [visual] rays [must] transmit it. Under all conditions, then, sight will only occur by means of some visible property reaching [the eye] from the visible object, whether or not [visual] rays issue from the eye.

[6.53] Now it has already been shown that vision is achieved only through the transparency of the medium intervening between the eye and the visible object, and it is not achieved when the medium between them is not transparent.[83] It is obvious, moreover, that a transparent body is distinguished from one that is not transparent in no way other than the aforementioned one. This being the case, as we have said, and since it has been shown that the form of the light and color in a visible object reaches the eye when it faces the eye, then what comes to the eye from the visible object to provide the means by which it perceives the light and color in the visible object, no matter the circumstance, is this very form [and this form] alone, whether [visual] rays issue [from the eye] or not.

[6.54] And it has already been shown that forms of light and color are continually generated in air and in all [other] transparent bodies, and these forms continually extend through the air, as well as through [other] transparent bodies, in various directions, whether the eye is present or not.[84] Hence, the extramission of [visual] rays is superfluous and useless.[85] Accordingly, the eye senses the light and color of the visible object only by the form coming from the light and color in the visible object.

[6.55] Furthermore, it has already been shown that the form of every point on a visible object facing the eye reaches the eye along several different lines and that sight can apprehend the form of the visible object according to its actual arrangement on the surface of the visible object only when the forms are received along straight lines that are perpendicular to the surface of the eye as well as to the surface of the sensing organ; [it has been shown] as well that [these] straight lines will not be perpendicular to [both of] these surfaces unless the centers of these surfaces form a single point and that this is possible. And since all this is true as claimed, the center of the surface of the glacialis and the center of the surface of the eye must lie at a single point. Sight therefore can perceive only those forms of visible objects [that reach the eye] along the straight lines whose endpoints meet at this center. And this is what, earlier in our discussion of the shape of the eye, we promised to show in this chapter, and this has now been demonstrated: i. e., that the center of the glacialis and the center of the surface of the eye form the same common point.[86]

[6.56] Now that this has been demonstrated, it remains for us to consider the opinion of the proponents of [visual] rays and to show what is false and what is true about that opinion. Accordingly, we should say that if vision results from something passing from the eye to the visible object, then that thing is either corporeal or not. If it is corporeal, then when we look at the sky and see the stars in it, at that moment physical substance must stream from our eyes to fill the space between the heavens and the earth without the eye's being diminished in any way; but this is illogical.[87] Therefore, vision cannot be due to the extramission of some physical substance by the eye to the visible object. But if what is emitted from the eye is not corporeal, it will not feel the visible object, for sensation can only occur in bodies. Thus, nothing issues from the eye to the visible object to sense that object.

[6.57] And it is obvious that vision occurs through the eye. This being the case, if sight perceives a visible object only when something issues from the eye to the visible object but what issues [from the eye] does not sense the visible object, then what issues from the eye to the visible object transmits nothing back to the eye to serve as the means through which it can perceive the visible object. Also, the idea that something issues from the eye is based not on empirical evidence but on supposition, and nothing should be supposed unless dictated by logic. Yet the proponents of [visual] rays posit them because they have found that sight perceives a visible object when eye and object are spatially separated; but it is a cardinal precept among men that sensation cannot occur without [physical] contact, so the proponents of visual rays have concluded that vision only occurs through something issuing from the eye to the visible object and thereby sensing the visible object where it is or taking something from the visible object and transmitting it back to the eye, at which time the eye will sense it.[88]

[6.58] But since a sensitive body cannot issue from the eye to the visible object, and since only a body can sense a visible object, the only option left is to suppose that what issues from the eye to the visible object takes something from the visible object and transmits it to the eye. And since it has been shown that air and [other] transparent bodies receive the form of a visible object and transmit it to the eye as well as to every [other] body facing the visible object, what is assumed to transmit something from the visible object to the eye is nothing but the air or [other] transparent media intervening between the eye and the visible object. And since air and [other] transparent bodies transmit something from the visible object to the eye, they transmit it at any given moment and under all conditions when the eye faces the visible object [and they do so] without needing anything to issue from the eye. Thus, the reason that has led the proponents of [visual] rays to claim the existence of [such] rays is superfluous, because what has led them to claim that [visual] rays exist is their opinion that vision cannot be achieved except by something that extends from the eye to the visible object so as to transmit something back to the eye from the visible object. But since air and [other] transparent media fulfill this task without needing anything to issue from the eye, and, in addition, since they [already] extend between the eye and the visible object, then, since there is no need to suppose that something else transmits anything from the visible object to the eye, the opinion [of the proponents of visual rays] is pointless. Hence, the claim that [visual] rays exist is nullified.

[6.59] Moreover, all the mathematicians who claim the existence of [such] rays use nothing but imaginary lines in their demonstrations, and they call them "radial lines." But we have already shown that sight perceives visible objects along such lines alone. The opinion of those who suppose that radial lines are imaginary is thus true, whereas the opinion of those who suppose that anything issues from the eye is false.[89] And we have now demonstrated that what actually obtains does not confirm [the existence of] visual rays, nor has reason led [us to accept] them.

[6.60] On the basis of everything we have said, then, it has now been demonstrated that the eye senses the light and color on the surface of a visible object by means solely of a form that extends from the surface of the visible object to the eye through a transparent medium intervening between the eye and the visible object, and [it has been demonstrated] that sight perceives only those forms [reaching the eye] along the straight lines that are conceived to extend between the visible object and the center of the eye, those lines alone being perpendicular to all the surfaces of the tunics of the eye. And this is what we wanted to demonstrate.

[6.61] This is therefore how vision takes place generally, because, in terms of naked sensation, sight perceives only the light and color that are in the visible object. The remaining characteristics of visible objects that sight perceives, e.g., shape, size, and the like, are perceived by sight not through naked sensation but through reason and defining features.[90] And we shall show this later in the second book after we finish discussing the various visible properties that sight perceives. But what we have shown—namely, how vision takes place—conforms to the opinion of those who have verified it on mathematical grounds as well as [those who have verified it] on physical grounds. It has been shown therefore that both parties have something true to say and that both opinions are correct and compatible, but neither is wholly satisfactory without the other [to complement it], nor can vision be properly accounted for without drawing upon what both have to say.

[6.62] Hence, [visual] sensation is due solely to the form and to the effect of the form on the eye as well as to the passion aroused in the eye by the form, and the eye is constituted in such a way as to be affected by this form according to a specific orientation, i.e., the orientation of perpendicular lines upon its surface. Moreover, it is in the nature of the eye to be so constituted only because individual visible objects would not be distinguished [by it], nor would the parts of any of them be properly arranged on the eye unless the sensation [aroused in it] occurred exclusively along those lines. Therefore, radial lines are imaginary lines, and they define the specific direction according to which the eye is affected by the form.

[6.63] And it has already been shown that when the eye faces a visible object, a cone will be formed between the visible object and the center of the eye, its vertex being the center of the eye and its base the surface of the visible object.[91] And between any point on the surface of the visible object and the center of the eye there will be an imaginary straight line that is perpendicular to the surfaces of the tunics of the eye, and the cone will thus contain all such lines. And the [anterior] surface of the glacialis will cut this cone, for the center of the eye, which forms the vertex of the cone, lies behind the [anterior] surface of the glacialis; and if the air that intervenes between the eye and the visible object is continuous, the form will extend from the visible object along this cone through the air enclosed by it, as well as through the transparent tunics of the eye, to the area on the surface of the glacialis that is demarcated by that cone. And the cone will contain all the radial links between the eye and the visible object by means of which the eye perceives the form of that visible object, and that form will be arranged within this cone as it actually exists upon the surface of the visible object as well as upon the area on the surface of the glacialis [that is demarcated by the cone].[92]

[6.64] Furthermore, it has already been shown that [visual] sensation occurs only through the glacialis.[93] Hence, the visual sensation of the light and color on the surface of a visible object occurs only at the area on the glacialis that is demarcated by the cone formed between that visible object and the center of the eye. And it has been said earlier that there is some measure of transparency and some measure of opacity in this humor and, accordingly, that it is like ice in appearance.[94] Therefore, insofar as there is some transparency in it, it receives forms, and they pass through it by virtue of the transparency that is in it; but insofar as there is some opacity in it, it impedes the forms passing through it by virtue of the [modicum of] opacity it possesses. And the forms are [thereby] impressed on its surface and within its body.[95] Likewise, when it shines upon a transparent body possessing some measure of opacity, light will pass through it on account of its transparency, but the light is impressed on its surface according to its opacity.

[6.65] Also, the glacialis is constituted to receive these forms and to sense them. The forms thus pass through it according to its capacity to receive them sensibly.

[6.66] And when the form reaches the surface of the glacialis, it will create an effect in it, and the glacialis will suffer that effect, because it is a property of light to affect the eye, and it is a property of the eye to be affected by light. And this effect that light creates in the glacialis passes through the body of the glacialis along straight, radial lines exclusively, for the glacialis is constituted to receive the forms of light along radial lines. And as the light passes through the body of the glacialis, color passes along with it, for color is mingled with light. For its part, the glacialis accepts this effect and its passage, and from this effect and the passion [aroused by it] the glacialis will sense the forms of the visible objects that are [incident] upon its surface. And those forms pass through its whole body, and from the arrangement of the parts of the form on its surface, as well as within its whole body, it will sense the arrangement of the parts of the [visible body] affecting it.[96]

[6.67] And the effect that light has upon the glacialis is in the form of pain. Now some pains can indeed be suffered without the [affected] organ's being distressed by them, and such pains are not perceptible to sense, so the sufferer does not recognize them as pain. An indication of this fact is that light arouses pain insofar as strong light, such as sunlight, when a viewer stares at the sun itself, or sunlight, when it is reflected to the eye from polished bodies, distresses the eye and clearly hurts it, for such [strong] light arouses obvious pain in the eye. But the effect of all light upon the eye is of the same kind, varying only in intensity. And since these effects are all of the same kind, and since the effect of stronger light is in the form of [manifest] pain, then every effect of light is in the form of pain, varying only in intensity. And because of the lightness of the effects of weak and moderate light upon the eye, the [visual] sense fails to recognize them as pain. Hence, the sensation aroused in the glacialis by the effect of light is of the same kind as sensible pain.[97]

[6.68] After occurring at the glacialis, this sensation spreads through the hollow [optic] nerve and arrives at the front of the brain where sensation culminates and where the final sensor is located, this latter being the sensitive faculty at the front of the brain, and this faculty will perceive all sensibles. The eye, for its part, is nothing more than an instrument for this faculty, for the eye receives the forms of visible objects and transmits them to the final sensor, but the final sensor perceives those forms and perceives the visible properties possessed by them. And the form [impressed] on the surface of the glacialis extends through the body of the glacialis, then through the subtle flux [of visual spirit] in the hollow of the [optic] nerve until it reaches the common nerve. When the form reaches the common nerve, the visual process is complete, and from the form that arrives at the common nerve the final sensor will perceive the forms of visible objects.[98]

[6.69] However, the viewer will perceive visible objects with two eyes; thus, since the form of a visible object must reach both eyes, two forms will reach the visual faculty from a single visible object. Nevertheless, the viewer will perceive the visible object as single, and the reason is that, when the two forms reaching the two eyes from one visible object reach the common nerve, the two forms meet and are superimposed upon one another to make a single form. And it is from this form, which is united from the two [original] forms, that the final sensor will perceive the form of that visible object.[99]

[6.70] That the two forms reaching both eyes from a single visible object are united and made into a single form before the final sensor perceives it and that the final sensor perceives the form only after the two [original] forms are united is indicated by the fact that, when a viewer moves one of his eyes while the other remains immobile, and when the motion of the eye that is moved is in an upward direction, he will see a facing visible object doubled. If, however, he elevates the one eye while covering the other, he will only see [the object] as single.

[6.71] Thus, if the [final] sensor were to perceive [an object as] single [just] because it is single, then it ought to perceive it as single all the time; and if two forms were always to come to it from one visible object, then it would invariably perceive the single object doubled. But since the final sensor will only perceive the visible object through a form reaching it, the fact that it will sometimes perceive a single object as double and sometimes as single indicates that, when it perceives the object doubled, two forms reach it, whereas when it perceives the single visible object as single, a single form reaches it. In both cases, since two forms reach the two eyes from a single visible object, and since what is transmitted to the final sensor is sometimes two forms and sometimes a single form, and since the form that is transmitted to the final sensor is transmitted only by the eye, then, when it perceives a single object singly, what is transmitted to the final sensor from that object is a single form [arising] from the two forms reaching the two eyes from the single visible object.

[6.72] Since this is the case, then the two aforementioned forms extend from the two eyes and meet before the final sensor perceives them, and it is after their juncture that the final sensor will perceive the form united from them. But when the final sensor perceives the two forms that reach the two eyes from a single object as double, those two forms extend from the two eyes but do not meet [in perfect superposition], so they reach the final sensor as two forms.

[6.73] Moreover, the fact that a single visible object is sometimes perceived as single and sometimes as double indicates that vision is not due to the eye alone, for it it were, then at the moment of its perception the two eyes would perceive the two forms reaching them from a single object as one and the same form. And if that were the case, then they would always perceive one form from those two.

[6.74] And the fact that a single visible object is sometimes perceived as single and sometimes as double, while in either case two forms are [impressed] in the two eyes, indicates that, besides the two eyes, there is some sensitive agent according to which the two forms extending from a single object that is perceived singly are perceived as one and according to which the two forms are perceived as two when the object is perceived as double, which indicates that [visual] sensation is fully achieved only by that sensitive agent, not by the eyes alone.

[6.75] In addition, [visual] sensation extends from the [sensing] organs to the final sensor only through the nerves that link those organs and the brain. Therefore, the two forms pass from the eye through the nerve that extends between the eye and the brain until it reaches the final sensor. These two forms thus pass from the two eyes and meet where the two nerves join.

[6.76] And clear evidence that the forms of visible objects extend through the hollow of the nerve to reach the final sensor and that vision is achieved [only] after [their] arrival there is that, when there is some obstruction in this nerve, vision is destroyed, but when the obstruction is removed, vision is restored. And medical science testifies to this fact.[100]

[6.77] Now the reason that the two forms sometimes join and sometimes do not is that, when the two eyes are in their natural position, they will be similarly oriented with respect to the single visible object, and thus the form of the single object will reach two places [on the surfaces of the two eyes] that are similarly oriented. However, when one eye is displaced, the orientation of the eyes will differ with respect to that visible object, and thus the two forms of that object will reach [two places on the surfaces of the two eyes] with different orientations.[101] But it has already been mentioned in [the section on] the structure of the eye that the common nerve is similarly oriented with respect to the two eyes,[102] and so two spots at corresponding locations on the two eyes will be similarly oriented with respect to the same location in the common nerve, and the two hollows of the nerve are joined to form a single place where the two forms of the visible object are united.

[6.80] We might claim that the forms arriving at the eye do not reach the common nerve, but that the sensible effect [of those forms] will instead extend from the eye to the common nerve, just as the sense of pain and the sense of touch [extend through the nerves], and that at this time the final sensor perceives that sensible effect.

[6.81] And we shall respond that this sensation arising in the eye does indeed reach the common nerve; still, the sensation arising in the eye is not a sensation of pain alone; it is a sensation of the effect of a kind of pain along with a sensation of light and color as well as of the arrangement of the parts of the visible object. However, the sensation of different colors and of the arrangement of the parts of a visible object is not of the nature of pain. And we shall show later how the visual sensation of all these qualities occurs.[103] Therefore, the sensation that reaches the common nerve includes the sensation of light and color and of the arrangement [of parts], and it is by means of some form that the final sensor perceives light and color.

[6.83] We are now left to address the following issue: When the forms of light and color extend through air as well as through [other] transparent bodies to reach the eye, since air and [other] transparent bodies accept all colors, and since the forms of any light that are present at the same time extend through the same air at the same time and pass through the transparency of the tunics of the eye when they reach a single eye, then these colors and light ought to mingle in the air and in the [other] transparent bodies and arrive at the eye completely mixed, and so the colors of visible objects will not be [individually] discerned by sight. And if this is the case, then visual sensation cannot be due to these forms.

[6.84] Let us reply, accordingly, that air and [other] transparent bodies are neither transformed nor altered by colors in a permanent way; rather, it is in the nature of color and light that their forms extend along straight lines, and it is in the nature of a transparent body that it not prevent the forms of light and color from passing through its transparency. And it accepts these forms only to transmit them, not to be transformed upon accepting them. Furthermore, it has been shown that the forms of light and color extend through air only along straight lines.[104] Therefore, the forms of the light and color in bodies that occupy the same air at the same time extend along straight lines, but [some of] those lines along which the different forms extend will be parallel, some will intersect, and others will have various [other] orientations; but each of these lines is distinguished by the body from which the form radiates along that line. Thus, each of the forms extending from different bodies through the same air extends along its own line and passes through to facing forms.

[6.85] Moreover, evidence that light and colors do not mingle in air or in [other] transparent bodies is [found in] the fact that, when several candles are at various distinct locations in the same area, and when they all face a window that opens into a dark recess, and when there is a white wall or [other white] opaque body in the dark recess facing that window, the [individual] lights of those candles appear individually upon that body or wall according to the number of those candles; and each of those [spots of light] appears directly opposite one [particular] candle along a straight line passing through the window. Moreover, if one candle is shielded, only the light opposite that candle will be extinguished, but if the shielding body is lifted, the light will return.

[6.86] And this can be tried anytime.

[6.87] In addition, if the lights were to mingle with the air, then they would mix in the air contained by the window; they ought, then, to pass through mixed so as not to be [individually] discerned afterward. But we do not find this to be the case. Therefore, the lights do not mix in air; instead, each of them extends along straight lines; and those lines are parallel, or they intersect, or they have various [other] orientations. And the form of each light-source radiates along all the [straight] lines that can be extended from it through the air, and in accord with this [the resulting forms of light] do not mingle in the air, nor is the air tinted by them; rather, they merely pass through its transparency, and the air does not thereby become transformed.

[6.89] And what we have said about light and color, as well as about the air, should be understood [to apply] to all transparent bodies, including the transparent tunics of the eye.[105]

[6.90] However, the sensitive organ [of the eye], i.e., the glacialis, does not receive the form of light and color in the same way as air and other insensitive transparent bodies, but in a different way from that, for this organ is constituted for the [sensitive] reception of that form. Therefore, it receives the form both as a sensitive body and as a transparent body. And it has already been shown that the effect aroused in it by this form is a kind of pain. Thus, the way it receives this form is different from the way insensitive transparent bodies receive them. Nevertheless, although it receives this form as a sensitive body and is thereby altered or transformed, this organ is not tinted by the color of this form,[106] nor do the forms of color and light persist in it after it ceases to face them or they cease to face it.

[6.91] But this point can be countered with the following argument: It has already been maintained [not only] that intense and bright colors upon which strong light shines create an effect in the eye, but [also that] the changes they cause in the eye persist after they are removed, and the forms of the color persist in the eye for some time; moreover, whatever the eye perceives afterward will be mingled with those colors.[107] This is clear and indubitable. And since this is so, then the eye must be tinted by color and light, so it follows that [all] transparent bodies are tinted by colors and light.

[6.92] In response we shall say that this very phenomenon indicates that the eye is not tinted by color and light and that the alterations caused by color and light do not persist in it, for these alterations that we have mentioned only happen because of an excess in the intensity of light and color. And it is clear that these alterations persist in the eye only for a short time and disappear afterward, whereas weak alterations do not persist at all. The eye, therefore, is not tinted by these alterations in a permanent way, nor do they persist in it after they are removed. Accordingly, it will be evident that [moderate] light and colors affect the eye, but that after they are removed the alterations they cause do not persist even for a short time. Hence, the glacialis is altered by light and colors only [at the time] it senses [them], but then the effect disappears after they are removed. It is therefore requisite that it be altered by color and light, but not in a permanent way.

[6.93] Moreover, the eye is constituted to suffer the effect of colors and light and to feel them, but the resulting alteration does not thereby persist in it. On the other hand, air, [other] transparent bodies, and the transparent tunics of the eye in front of the glacialis are not constituted to suffer the effect of light and color and feel them, nor are they constituted to do anything but transmit light and colors.[108]

[6.94] It has therefore now been shown that the eye is not tinted by colors and the forms of light in a permanent way. It has also been shown that the forms of light and color do not mingle in air or in [other] transparent bodies but that the eye perceives many of them at the same time through the [same] air; and each of the eyes perceives them according to the cone that is formed between the visible object and the center of the sight.

[6.95] But why is it that not all the forms of all the colors appear on all those bodies [upon which they shine], but that some appear and some do not, depending on whether the color is intense, or the light that illuminates the color is intense, or the illumination of the body upon which the form appears is faint? The eye is responsible for this, because these forms [that do not appear] are not [just] shining upon bodies that face them but upon bodies that are illuminated by some colored light. For the form of any body's light and color continually shines upon all facing bodies when they do not lie too far away. As far as light is concerned, in fact, this is obvious, for, when any body that is somehow illuminated is tried (as long as the illumination is not very weak), and when the trial is carried out as we have described—i.e., when a white body is placed opposite it within a dark recess, and when there is a narrow opening between the illuminated object and that dark recess—[it is obvious] that the light will then appear upon that body.[109] On the other hand, colors will appear only under the proper conditions, for it has been shown by induction that the forms of colors are always weaker than the colors themselves, and the farther the forms are from their source, the weaker they will be.[110]

[6.96] It has also been shown by induction that, when intense colors are situated in dark places and the light that shines upon them is very weak, those colors will appear dark and will not be [properly] discerned by sight. But when they are situated in well-lit places and the light shining upon them is strong, the colors will appear and will be [properly] discerned by sight.[111]

[6.97] Furthermore, it has been shown by induction that, when intense light shines upon the forms of colors appearing on bodies facing them, those colors will disappear from sight, and they will only appear when the light is not intense or [its source] is far away.[112]

[6.98] It has also been shown that, when intense light shines on the eye, it will prevent it from seeing many visible objects that face it at that time but are not visible by themselves.[113]

[6.99] It has been shown as well that the eye does not perceive colors except by means of a form reaching it from that color and that it will be perceived along the appropriate [radial] lines.[114] Therefore, when a viewer looks at an opaque object upon which the form of the color has shone, he will perceive that form by means only of a secondary form reaching him from that form [shining on the object]. But this secondary form is weaker than the primary form [shining] on that body, whereas that primary form is weaker than the color itself [in the source-object]. Now sight does not perceive the opaque body upon which the form appears unless some light appears in it, whether it be the light that accompanies the form of the color shining on it or that light along with some other light. Thus, the secondary form that reaches the eye from the primary form comes to the eye along with the form of the light in that opaque body. But the color of that opaque body upon which the form lies will also be perceived by sight in that situation. Hence, the form of its color arrives at the eye along with the secondary form reaching it from the form of the color that shines upon it, but the form of the color of this body that reaches the eye in this situation is a primary form. The eye, moreover, perceives what it perceives only along specific [radial] lines, and the specific [radial] line between it and the opaque body along which it perceives the form of the color of that opaque body is the same as the [radial] line along which it perceives the secondary form coming [to it] from the form of color shining upon that body, for that form [too] lies on the surface of that body. Therefore, the eye perceives this form along the [radial] lines that lie between it and that body, and it perceives the color of that body along the [radial] lines that lie between it and that body. Likewise, the eye perceives the light in that body along these same [radial] lines. Hence, three forms of that color reaching the eye are perceived by the eye along the same [radial] line.[115]

[6.100] And since this is so, they are perceived mingled together, and the secondary forms that reach the eye from the form of color that shines upon the body facing it will always be perceived by the eye mingled with the form of the color of that body, as well as with the form of its light. The eye thus perceives a form derived from the two colors [and] that [form] is different from the form of either of them. If, then, the opaque body upon which the form [shines] is of a bright color, the form it conveys to the eye will be bright, and it is a primary form, and it is mingled with the secondary form that reaches the eye from the form of the color shining upon that body. But this form is weak, so it is not apparent to sight, because, when a bright color is mingled with a faint color, the bright color overwhelms the faint one. And the same things are invariably found [to obtain] in the case of colors and dyes when they are mixed together. However, the form of the color is invisible when the light that shines on it is intense only because the secondary form reaches the eye along with the form of intense light as well as with the whiteness of the body.

[6.101] Now it has already been shown that when intense light shines on the eye, it prevents the eye from perceiving weak forms.[116] Therefore, when intense light reaches the eye along with the whiteness of the body upon which it shines, it will prevent the eye from perceiving the weak secondary form that reaches it along with that light. On the other hand, if the body upon which the form of the color shines is white, but if the light that shines upon it is weak and the form of the color that shines upon it is also weak, then, even though it is weak, the form of the light in that body, along with the body's whiteness, will overwhelm the form of the color, which is very weak. So when it reaches the eye, that form will not be [properly] discerned by the eye. If, however, the body upon which the light shines is white and the color whose form shines upon it is black or dark, that form will be outshone only by the whiteness of that body; so it will appear as shadow, and the eye will perceive that body as not very white, just as it will perceive a white body in shadow, so its form will not be [properly] discerned by it.

[6.102] All of this will obtain when the light that illuminates the colored body is intense and the whiteness of the form that shines from it upon the facing body is dull. If, however, the light in the colored body is weak, then the form that shines from it upon the facing body will be dark, and it will appear to the eye just like the colors it perceives in dark, poorly lit locations or the colors of transparent bodies upon which weak light shines. Hence, when the light that shines upon colored bodies is feeble and when the forms of their colors shine on facing bodies, they will only appear as shadows as far as visual sensation is concerned. And if such a body facing the color lies in a dark location, none of the color will appear on it on account of its darkness and the darkness of the form shining on it. But if the body facing this color lies in an illuminated location and there is light other than the light of its form shining on it, and if this body is illuminated, then its color will appear superimposed upon that form; and the color of that body will appear to the eye but not the form, because it acts just like a shadow, and its shadowing effect will not be [properly] discerned by the eye. However, if that body upon which the form shines is white and, moreover, is illuminated by some light other than the form's light, then, on account of its darkness, the form will merely dim the body's whiteness and luminosity in much the same way as shadows are cast on white objects.

[6.103] And forms of this sort will only be perceived by the eye on bodies facing colors.

[6.104] Therefore the eye does not perceive the form of a color on a body facing that color except when the secondary form reaching it from the form of its color is more intense and more overwhelming than the primary form coming along with it from the light and color that are in the body upon which the form shines. But this situation is quite rare, and for that reason such a form is rarely seen; moreover, among those [that are seen] only the form of intense, brilliant colors appears when the light that shines upon those colors is intense, and when those forms shine upon facing, white bodies, and when the light shining upon those bodies is weak in relation to those forms. Whatever is not of this sort does not appear.

[6.105] Likewise, the failure of feeble light to appear upon a body facing it is due to the fact that, when the body facing the feeble light is lit by another [more intense] light-source, the two lights will mingle, and therefore the feeble light will not be [properly] discerned by the eye. But when the body facing the feeble light is dark, the form of the feeble light will not appear upon it because the form of the light is weaker than the light itself, and the secondary form reaching the eye from that form, by whose mediation the eye must perceive the form [shining] upon the body facing the light, is weaker than that form. Therefore, if the light is feeble and the facing body is dark, the form that shines upon the facing body will be very weak, and the secondary form that reaches from it to the eye will be weak to the point of vanishing. And the eye does not perceive light that is weak to the point of vanishing.

[6.106] Hence, the forms of all illuminated colors and the forms of every light shine upon facing bodies, but several of them do not appear to the eye for the reasons we have enumerated. But some of them do appear when they conform to the conditions we have discussed. Therefore, the reason why the eye does not perceive the forms of all the colors in colored bodies [shining] on all bodies facing them but perceives some and thereby perceives all the colors in the colored bodies has now been demonstrated. And the reason is that it perceives the colors in colored bodies from the actual form reaching it from them, that form being stronger than the secondary form reaching it from the forms of the colors that are on the bodies facing them. And it also perceives the [primary] form of the colors separately, not mingled with others, whereas it perceives the secondary form that reaches it from the forms of their colors mingled with others.

[6.107] And this is what we promised to show at the end of the third chapter,[117] and it has now been shown that sight only perceives the colors of visible objects mingled with the forms of light that are in them and mingled with all the forms shining upon them from the colors of facing bodies. Moreover, if there is some opacity in the transparent medium intervening between them and the eye, its color will also mix with those colors, and the eye does not perceive that color separately. Nonetheless, the forms that shine on colored bodies are, on the whole, very weak, and the secondary forms coming from them to the eye are weak to the point of vanishing. On account of this, the colors of the bodies themselves will generally overwhelm the forms [of color] shining upon them. Likewise, if there is a modicum of opacity in the transparent medium intervening between the eye and the visible object, its color will not be distinguished by the eye from the color of the visible object that comes with it when the color of the visible object that accompanies it is stronger than its color.

[6.108] But the reason intense light prevents the eye from perceiving certain visible objects is that the forms that reach the eye along one [radial] line are only perceived as mixed by the eye. And if some of the mixed forms dazzle while others are faintly radiant, the bright form will overwhelm the weak form, and the weak form will thus not be perceived by the eye. But when the forms that are mingled are of nearly the same strength, they will be perceived by the eye, but each of them will be perceived according to how the other forms that mingle with it will be mixed up with it, for mixed forms are perceived as mixed, not separately, by the eye.

[6.109] Hence, the stars are not perceived by the eye during daylight because the light that pervades the air [at that time] is more intense than starlight. When a viewer looks up into the sky during daylight, then, the air between him and the heavens will be illuminated by sunlight and will be perfectly contiguous with the [surface of the] eye, and the stars will lie behind that light.[118] Thus, the form of a star and the form of the light in the air intervening between the eye and that star will reach the eye along one [and the same radial] line, so they will be perceived as mixed. But the form of daylight in the air is considerably stronger than the form of the starlight, so that the light in the air will overwhelm the starlight, and thus the form of the star will not be [properly] discerned.

[6.110] The same holds for a faint light that is in the midst of intense light—e.g., a faint fire in sunlight, or a firefly in daylight, or the like. When such visible objects are in sunlight or in daylight, their forms will come to the eye mixed with the form of the intense light shining upon them. And since the eye will perceive the form of such visible objects mixed with the form of the intense light, the form of the intense light will overwhelm the form of the faint light.

[6.111] Moreover, a faint light or a weak form of a visible object is frequently unseen when intense light shines on the eye, even though the two forms do not reach the eye along the same [radial] line. This will be the case when the two forms radiate along neighboring [radial] lines and reach the eye at two neighboring spots [on its surface]. And this becomes clear at night in firelight, for, when the eye perceives the firelight and the firelight is near the eye so that its light is intense, and when there is some visible object facing the eye in that situation, and it is illuminated by faint, accidental light, and when that visible object is farther from the eye than the fire and lies along a line-of-sight near the fire's line-of-sight, then the eye will not perceive that visible object properly. If, however, the viewer shields the fire from his sight or moves his line-of-sight with respect to the fire so that the line-of-sight along which he perceives that visible object lies far from the fire's line-of-sight, then he will perceive that visible object more clearly [than before].[119]

[6.112] The reason for this is that the visible object possessing the faint accidental light has a dark form, and when the eye perceives that form without perceiving intense light along with it, it will sense the faint light, given that there is some darkness between the eye [and the object] or an absence of intense light on the side of it where the form of the weak light reaches. But when the eye perceives the form of faint light while it perceives the form of intense light along with it, then it perceives the intense light at a spot on the eye that is next to the spot at which it perceived the dark form. The eye will [therefore] not perceive the faint light in the dark form for two reasons: first, because when intense light reaches the eye, the entire eye is illuminated, and when the entire eye is illuminated, faint light will not appear in it, particularly when the [intensity of the] faint light is minimal in comparison to [that of the] intense light;[120] and second, [because] the faint light abuts on the intense light at the two neighboring spots on the eye. But the faint light is almost dark in comparison with the intense light, so when the [intense] light lies next to the weak, dark form while the form of the intense light floods the eye, then the eye will not perceive the form that is faintly illuminated, and all it will perceive of a dark form is its darkness; and so the form will not be [properly] discerned by the eye, nor will the eye perceive it properly.

[6.113] Moreover, the overshadowing of the forms of faint light because of the nearness of intense light has its counterpart in colors, for when spots of some relatively dark color are painted on a white body, the spots will appear black because of the intensity of the [body's] whiteness. But if identical spots are painted on a pitch-black body, they will appear almost white, and their darkness will go unseen. But when a color is painted on bodies that are neither intensely white nor pitch-black, the color will be seen as it really is.

[6.114] By the same token, when a grass-green color is painted on a yellow body, it will appear dark, but when it is painted on a black body, it will appear the color of wild marjoram, and the same holds for all colors that lie midway between two extremes.[121]

[6.115] Thus, when neighboring visible objects differ sharply in the intensity or faintness of their color, the faint color will be unseen by the eye, because the qualities of light and color will be perceived only with respect to others around them. And intense light will prevent the eye from perceiving faintly illuminated visible objects only because of the mingling of the form of the weak light with its form, as well as because of the predominance of the forms of intense light over the forms of faint light and the inability of the sense to perceive anything whose intensity is minimal in comparison to that of something else.

[6.116] Accordingly, we have now accounted for all the subjects that bear on this chapter.

[CHAPTER 8]

[7.1] The tunics that we discussed in our account of the structure of the eye serve as instruments through which vision is achieved.

[7.2] Now the first tunic, which is called the cornea, is a transparent but tough membrane, and it extends over the opening in the anterior of the uvea. Its primary function is to cover the opening in the uvea so as to keep the albugineous humor, which lies in front of the uvea, in place. It is transparent so that the forms of light and color can pass through it into the interior of the eye, for they only pass through transparent bodies. Its toughness, moreover, is meant to keep it from deteriorating easily, for it is exposed to air and can easily be damaged by smoke, dust, and the like.

[7.3] The albugineous humor, for its part, is transparent, and it is quite fluid. It is transparent in order to let forms pass into it and extend through it to the glacial humor. It is moist, however, in order to keep the glacial humor continually moist so that it can maintain its proper condition, for the membrane that covers the glacialis is extremely thin, and the least dryness could damage it.

[7.4] Now the black tunic, i.e., the uvea, that contains the albugineous humor, is black, tough, thick, and spherical, and in its front there is a round opening, as we pointed out earlier.[122] It is black in order to darken the albugineous and glacial humors so that the forms of faint light can appear in them, for faint light definitely appears in dark locations but is invisible in brightly illuminated locations. Moreover, it is somewhat tough in order to hold the albugineous humor in place so that none of it leaks out. It is thick in order to be opaque, for if it were thin, it would be translucent; but since it is thick, its inner side will be dark.[123] It is spherical because the sphere is the most efficient of shapes and is least susceptible to injury, whereas figures that have corners are easily altered at [those] corners. There is an opening at the front of this tunic so that forms can pass through it into the interior of the eye, and this opening is circular because the circle is the simplest and most capacious figure of all figures having the same circumference.[124]

[7.5] The glacial humor has many characteristics that help bring [visual] sensation about. For it is moist and subtle, and it possesses some transparency as well as some opacity. Covering it is a very thin membrane, and its surface takes shape as a composite of two different spherical surfaces, the anterior of which is more gradually curved than the posterior.[125] It is moist so that it can more easily suffer the effect of light, and it is subtle because such bodies are exquisitely sensitive. It is, moreover, somewhat transparent so that it can receive the forms of light and color and so that light and color can pass through it, but it is somewhat opaque so that the forms of light and color can persist in it for awhile in order to let the form of the light and color impressed in it be seen by the sensitive faculty.[126] If it were perfectly transparent, though, the forms would pass through it, but it would not feel the effect of the forms, which is of the nature of pain, and so it would not perceive those forms.

[7.6] The membrane that covers this humor is there to constrain it so that it does not flow, for unless something constrained them, the humors would flow and would not maintain a constant shape. But this membrane is exceedingly rare so that it will not block out the incoming forms. It is spherical for the same reason we mentioned earlier, and its anterior surface is formed from a great sphere so as to be parallel to the anterior surface of the eye in order that the centers of both [surfaces] form a single point.

[7.7] The hollow nerve to which the whole eye is attached is hollow so that the visual spirit can flow through it from the brain to reach the glacialis and thereby endow it in turn with sensitive power, and so that the forms can also pass through the subtle substance flowing through its hollow until they reach the final sensor at the front of the brain.

[7.8] And the wellsprings of the two nerves to which the two eyes are attached lie on both sides of the anterior part of the brain so that the location of the two eyes will correspond with the location of their two wellsprings. Their wellspring was not in the middle of the anterior part of the brain because this location is more appropriately designated for the sense [of smell].[127]

[7.9] Indeed, there are two eyes because of the beneficence of the Creator[128] [who chose to double the eyes] so that, if one of them were to be injured, the other would remain [functional], and also so that the face would look more comely [than it would with only one eye].

[7.10] The reason, moreover, that the two [optic] nerves join has already been given in [the section on] how vision occurs.[129]

[7.11] The surfaces of the tunics of the eye are spherical and parallel, and their centers coincide at one point so that [any line] perpendicular to the first of them is perpendicular to all. And they are spherical so that [all their] perpendiculars may issue from the single point that forms their center and then diverge as they part from the center in order that the cone projected from that center can contain all the perpendiculars extending from any visible object [to that centerpoint] and can demarcate a small spot on the surface of the eye as well as on the sensitive organ, that spot, no matter its smallness, being able to encompass the entire form reaching from the visible object to the eye. If, however, the surfaces of the tunics of the eye were flat, the form of the visible object would not reach the eye along perpendiculars unless the eye were the same size as the object. But there is no other figure than the sphere in which the perpendiculars come together and meet at a single point and upon whose surface those perpendiculars fall in perfect order.

[7.12] According to this disposition many cones can extend at the same time to many visible objects from the center of the eye, and each of them will demarcate a small section on the surface of the sensitive organ that encompasses the [whole] form of that visible object. And all the tunics have a single center for the reason we have given before, that reason being so that the perpendiculars issuing from the visible object to one of those tunics will be perpendicular to all of them and so that forms may pass through all of them along a single [radial] line.

[7.13] Now the reason sight perceives visible objects only along such perpendiculars is that it is only according to such perpendiculars that the parts of the visible object are properly arranged on the surface of the sensitive organ. And it was already shown earlier that the form of a visible object cannot be properly arranged on the surface of the sensitive organ unless the form is received along these [radial] lines alone.[130] Accordingly, this is an intrinsic characteristic of the eye, so it is naturally constituted not to receive any form except along these [radial] lines. And the fact that the eye is endowed with this property is one of the things manifesting the incredible perspicacity of the Creator and the providence of nature in designing the instruments of sight and the arrangement according which [visual] sensation is achieved and visible objects are discerned.

[7.14] The sclera encloses all of these tunics; and there is some moisture in it, yet it also has some firmness, and is somewhat tough. It encloses all of these tunics in order to keep them together and to preserve them, and it is somewhat moist so that the locations of the tunics can thereby be prepared and so that those tunics cannot be quickly dried out. It is somewhat firm and tough so that it can keep the tunics in place and have them maintain their [spherical] shape so that they will not be readily subject to change. It is white so that the face will be comely on that account.[131]

[7.15] The entire eyeball is round because roundness represents the best, most capacious, and most easily moved of shapes. The eye, however, needs to move, and to move quickly, so that by moving it can face many visible objects at the same time and so that, by moving, the viewer's central [line-of-sight] can face all parts of a visible object in order to perceive it with a true and consistent perception, for sensation through the middle of the sensitive organ is most clear (we will demonstrate this later in a suitable place).[132] The eye moves quickly so that in very short order it can see all the parts of a visible object as well as [all] the visible objects facing it.

[7.16] The eyelids are designed to preserve the eye during sleep and to keep the eye still when it is fatigued by light, for intense light harms the eyes, and if the eyes are continually open to it, they will be debilitated. This is obvious when the eyes stare at an intense light for a long time. Likewise, when there is smoke or dust in it, air harms the eye. Thus, the eyelids shield the eye from light when the eyes need it, and it protects them from the air and wipes away many harmful residues from them. Then, when the eyes are tired, the eyelids are closed over them so that they can finish resting, and the eyelids move quickly so that they can close over the eyes as soon as anything harmful approaches the eyes.

[7.17] The eyelashes are there, however, to mitigate some of the light when it will hurt the eye because of its intensity, and for this reason the viewer squints his eye and narrows it so that he can see from a narrow field of vision when intense light would hurt it.

[7.18] These things we have discussed cover the functions of the instruments of vision, from which the great perspicacity of the Creator is manifest. Let his name therefore be blessed, along with the goodness of nature in its providential order.

[CHAPTER 9]

[8.1] It has been demonstrated earlier[133] that the eye perceives none of the visible objects that occupy the same air with it (provided that it does not perceive them by means of broken rays) unless the following conditions are met, namely: (1) that there be some space between eye and object, (2) that the object face the eye—i.e., that a straight line can be imagined extended between any point on the surface of the visible object perceived by the eye and some point on the surface of the eye, (3) that the object possess some illumination, (4) that it have some [perceptible] size with respect to the eye's sense-capacity, (5) that the aereal medium be continuous and transparent and that there not be any opaque body in it [between eye and object], and (6) that the visible object block sight—i.e., that there be no transparency in it, or if there is, that it be more opaque than the air intervening between it and the eye; but this can only happen with color or the like. Furthermore, sight will not perceive a visible object unless these six conditions are met as a whole; if the visible object fails to meet any one of these conditions, it will not be perceived by sight.

[8.2] Each one of these conditions is necessary to sight for some specific reason.

[8.3] Accordingly, the reason that the eye perceives a visible object only when there is some separation between eye and object but does not perceive it when it is placed directly upon it eye is twofold. First, the eye does not perceive a visible object unless there is some light in it. But if that object is placed directly upon the eye and has no intrinsic luminosity, there will be no light on its surface where it touches the eye, for, by its position, the body of the eye will be prevented from seeing it.[134] On the other hand, an object that is intrinsically luminous cannot be placed upon the surface of the eye because intrinsically luminous bodies include the stars and fire, which cannot be placed upon the eye.[135] The second reason is that vision will only occur on the side facing the opening in the uvea at the center of the eye's surface, but when a visible object is placed on the eye, the area of the object that touches the eye will only be the size of the area it touches on the eye. But if the eye perceives the visible object through direct contact, it will perceive only that part directly touching the opening but will not perceive the rest of the visible object. And if the visible object is passed over the surface of the eye until the eye touches the entire surface of the visible object at the center of its own surface, it will perceive the object one part at a time, and when it perceives the second part it will not perceive the first part, so it will be unable to perceive the whole object at once. Further, if that is the case, the form of the [entire] visible object will not be delineated in it [but will appear] much as [would be the case] if some visible object were placed on an opaque body, and there were an aperture smaller than the visible object in that opaque body, and the visible object were placed at the opening; [for] in that case only the part of the object placed at the aperture would be perceived. Then, if the visible object were moved over the aperture until it was perceived bit-by-bit by the eye, its whole form would not be delineated in the eye.

[8.4] Hence, if vision were [to take place] through physical contact, the eye would not perceive the entire visible object nor [would it perceive] its shape and arrangement unless the visible object were the same size as the central spot on the eye through which vision would occur; and, in addition, it could not perceive several visible objects at the same time. But when there is some space between the eye and the visible object, the eye can at once perceive the entire visible object at a small spot [on its surface], even if the visible object is large; and it can perceive several visible objects at the same time. Furthermore, when the visible object is separated from the eye, it will be possible for light to shine on the surface of that object facing the eye.[136] For these two reasons, then, sight does not perceive visible objects unless there is some space between them and the eye.

[8.5] That sight perceives a visible object occupying the same air as the eye while facing it only if a straight line can be [imagined extended] between any point on the object and some point on the area of the eye's surface where vision occurs is due to the following. It has already been shown that vision will not occur except through forms reaching the eye from the visible object and that forms are perceived only along straight lines.[137] As a result, the eye does not perceive an object unless there is a straight line between it and the object. And if opaque bodies are interposed to cut all the [straight] lines between them, objects will disappear from sight, whereas if an opaque body interrupts [only] some of those straight lines, a certain part of the visible object at the endpoints of the [straight] lines interrupted by the opaque object will disappear from sight.

[8.6] Sight does not perceive a visible object unless it is illuminated for two reasons: either because the forms of the color in the visible objects do not radiate through the air except when light accompanies the color, or because the form of the color does radiate through the air, even though no light accompanies it, but does not make a perceptible effect upon the eye except by means of [accompanying] light. Now it is clear that the form of light is stronger than the form of color, that light has a more noticeable effect than color, and that, because it is weak, the form of color cannot affect sight the way that light does. But the form of color in an illuminated body is invariably mingled with the form of light, and, when it reaches the eye, it affects sight by virtue of its intensity as well as by virtue of the disposition of the eye to suffer its effect. But since light is mingled with the form of color and is not discerned separately from it, the eye only senses the form of light mingled with the form of color. Therefore, the eye senses the color of the visible object only on the basis of that color mingled with the form of the light reaching it from the visible object, and consequently, as far as sight is concerned, the colors of many visible objects vary according to variations in the light shining upon them.[138] Therefore, since the form of color does not affect sight unless it is mingled with light, and since color does not generate a form unless it is illuminated, sight perceives no visible object unless it possesses some illumination.

[8.7] Why sight does not perceive a visible object unless it has some [appreciable] size is explained in the following way. It has been shown that the form of a visible object reaches the eye by means only of cones whose vertex lies at the center of the eye and whose base is formed by the surface of the visible object and that such a cone demarcates a small area on the surface of the sensitive organ where the form of the visible object will be arranged.[139] If the visible object is extremely small, the cone formed between it and the center of the eye will be extremely small. Accordingly, the area demarcated upon the sensitive organ will be so small as to be virtually a point. But the sensitive [organ] does not sense a form unless the area on its surface to which the form comes has a perceptible size in proportion to the whole [of the surface]. Moreover, sensitive powers are finite, so when the area of the sensitive organ to which the form comes does not have a perceptible size in proportion to the whole sensitive organ, it will not feel the effect made there because of its smallness, the result being that it does not perceive the form.[140] Therefore, a visible object can be perceived by sight if the cone that is formed between the object and the center of the eye will demarcate an area on the surface of the glacialis that has a perceptible size in proportion to the whole surface of the glacialis. But the resulting sensation will depend entirely upon the extent of [the eye's] sensitive power, which does not go on to infinity, and that power varies with the capacity of the [given] eye. But if the cone that is formed between the visible object and the center of the eye demarcates an area on the surface of the glacialis that has an imperceptible size in proportion to the entire surface of the glacialis, sight cannot perceive that object. It is for this reason that sight will not perceive an extremely small object.

[8.8] That the eye does not perceive a visible object unless the medium intervening between that object and the eye is transparent is because vision only occurs by means of a form reaching from the visible object to the eye. But forms only extend through transparent bodies, so vision is achieved when the visible object occupies the same air as the eye (provided that the perception does not take place through broken rays) only if the air between the visible object and the eye is continuous and an opaque body does not interrupt the straight lines extending between them, for a form extends through air of uniform transparency only along straight lines. For this reason the eye perceives a visible object that occupies the same air with it and faces it only when the air between eye and object is of uniform transparency.

[8.9] There are two reasons why sight does not perceive a visible object unless it is [completely] opaque or possesses some opacity. One reason is that whatever is opaque is colored, and [it is] from color [that] the form by means of which sight perceives the color of a visible object comes to the eye. Whatever is absolutely transparent, however, lacks color, so it is not perceived by the eye. The second reason is that sight does not perceive a visible object unless it is illuminated and a secondary form of the light in it reaches the eye along with the form of its color. But there will be no secondary form of light shining on any object unless it is fixed in the object upon which it shines. Therefore, if the light is fixed in that body, a secondary form will radiate from it; but when light shines upon an exquisitely transparent body, it will not be fixed in it but will pass through its transparency. When a transparent body faces the eye, then, and when light shines upon it from the direction of the eye, it will pass through it and not be fixed on its surface.[141] Accordingly, there will be no light on the surface of that body facing the eye and sending its form to the eye. On the other hand, if that light-source whose light shines upon that transparent body faces the eye, its light will pass through the transparent body and will reach the eye, but it will carry with it no color from the transparent body to the eye, for a transparent body that is absolutely transparent has no color. From that direction, then, sight will perceive the light-source from which the light shines upon the transparent body from behind it, but it will not perceive the transparent body [itself] insofar as sight does not perceive any visible object that is absolutely transparent. Furthermore, if the transparency of the body is the same as the transparency of air, that body will be disposed just like the air, so it will not be perceived by sight, just as air and transparent bodies whose transparency is no less absolute than the transparency of air will not be perceived by sight, for there is no form extending from them to the eye that can affect sight. And the same will hold if some transparent body other than air intervenes between the eye and the visible object and the transparency of the visible object is no less attenuated than the transparency of the intervening body.

[8.10] And if a visible object is opaque, it will be colored, and when light shines upon it, it will be fixed upon its surface, and a form of its color, as well as of the light shining upon it, will extend through the air and through transparent bodies. And when this form reaches the eye, it will affect it, and from that effect the eye will sense the visible object. Moreover, when the visible object is transparent, but less so than the air, it will possess [some] color according to its opacity, and when light shines upon it, that light will be fixed in it somehow according to the opacity it possesses but will pass through it according to its transparency. There will thus be a form extending from it through the air according to the color and light on its surface, and when that form reaches the eye, it will affect the eye, and the eye will sense that visible object. For this reason sight perceives no visible object unless it is [completely] opaque or unless there is some opacity in it.[142]

[8.11] The reasons why sight perceives nothing unless the aforementioned conditions are met as a whole have now been set forth, and what we have explained is what we intended to explain in this book.

NOTES TO BOOK ONE

[1]As was pointed out in "Introduction," p. xxiii above, the opening of chapter 1 in the Latin version of this treatise is actually the opening of chapter 4 in the Arabic version, the first three chapters in all likelihood never having been rendered into Latin.

[2]Note that in the Latin text to this point two forms of "light"—*lux* (lines 1 and 4) and *lumen* (line 7, as well as line 9) —are used. Roughly speaking, *lux* should be understood as the essential, inherent light in a self-luminous body, whereas *lumen* can be understood as the illuminative effect of *lux* on other bodies as well, by extension, as of its physical manifestation in transparent media. As Bacon puts it, "we say that the *lumen* of the sun in the air is the species [i.e., formal replica] of the solar *lux* in the body of the sun" (*De multiplication specierum* I, 1, trans. Lindberg, *Roger Bacon's Philosophy*, pp. 2-5). As Bacon points out subsequently (p. 5), this differentiation reflects the distinction drawn by Avicenna in his commentary on the *De anima*; for a Latin edition of this work, see *Liber de anima seu sextus de naturalibus I-II-III*, ed Simone Van Riet (Louvain: E. Peeters, 1972), pp. 169-171. According to Sabra, *Optics*, 2, pp. 21-23, the two Arabic terms at issue are *daw* (= *lux*) and *nur* (= *lumen*), both of which Ibn al-Haytham uses, but not consistently nor to draw precisely the same distinction that Avicenna does.

[3]This example shows that light causes a sensation (or "passion") of pain in the eye; this pain is the root cause of, and thus necessary for, visual sensation; and it is usually at such a low level that we do not recognize it as such; see 6.67, p. 376 above.

[4]This example shows that an inordinately intense light-effect can create a briefly lasting impression in the eye in the form of an afterimage, which overrides subsequent visual effects and thus interferes with normal vision. Alhacen also establishes that bright color can create this effect, a point upon which he will elaborate in short order.

[5]According to Alhacen, light and color are ontologically distinct, but color requires illumination to affect the eye visually. Hence, like pure light, illuminated color, if too intense, can create a briefly lasting impression in the eye in the form of an afterimage. Note that, for Alhacen, the afterimage is the same color as the original color-stimulus rather than its complement, as we now understand it.

[6]This chapter-break, along with the next three, was imposed arbitrarily by the Latin translator; see "Introduction," pp. xxiii-xxiv above, for a discussion.

[7]Note that the illumination of the atmosphere is caused by the retention of sunlight by the matter of the air, which has some opacity in it. Thus, the air, while acting as a transmitter of light, is also capturing light and thereby acting as a screen; see I, 3, 44, in Sabra, *Optics*, vol. 1, p. 29.

[8]The Latin term *subtilis* can be rendered into English in various ways: e.g.,

"tiny," "fine," "delicate," even "exquisite." I have chosen here and, with few exceptions, throughout the rest of the text to render it by its direct derivative, "subtle," in order to allow it the broadest range of meanings. Accordingly, features may well be subtle by virtue of their minuteness, but they may also be subtle by virtue of their delicacy or understated nature.

[9]Here Alhacen implies that two different sorts of illuminative effect are at play. On the one hand, the paper retains some of the incoming light by virtue of its whiteness; on the other hand, it reflects some of that incoming light by virtue of its polish, which is a function of its smoothness. Thus, according to Alhacen's definition in book 4 of the *De aspectibus*, "politum est lene multum in superficie, et lenitas est ut sint partes superficiei continue sine pororum multitudine . . . et finis lenitatis est privatio pororum et privatio divisionis partium," *De aspectibus*, IV, 3, *Opticae thesaurus*, p. 104; see also II, 3.193, p. 502 below.

[10]I, 3.113-114, in Sabra, *Optics*, vol. I, p. 44.

[11]I, 3.124, in Sabra, *Optics*, vol. I, p. 46.

[12]This example crops up again in 6.110, p. 385 above, as well as in III, 6.12, p. 598 below, where the firefly is referred to as "a certain flying creature called 'aluerach' in Arabic"—a fairly clear indication that the task of translation had changed hands--and for the worse—between book I and book III; see "Manuscripts and Editing," pp. clxviii-clxix above.

[13]The ulterior point in this section and its complement in 4.17, p. 346 above, is that, as far as visibility is concerned, light is subject to threshold conditions. Hence, either an excess or a deficiency in luminosity can cause vision to malfunction. Alhacen goes on to say, however, that the amount of light necessary for proper visibility is proportionate to a variety of other factors, including the size of the object and its distance from the viewer. As we shall see, Alhacen has much more to say on this score in the third book, where he discusses the threshold conditions of visibility at length.

[14]By "bright" color, Alhacen seems to mean "strong" color—that is, a color that is deep rather than dazzling; see note 37, p. 537 below for further discussion of this point.

[15]See 4.15, pp. 345-346 above.

[16]According to Sabra, *Optics*, vol. 2, p. 45, the Arabic term for this cloth is *abu qalamun*, among whose meanings is included "chameleon." In II, 3.218, p. 506 below, the same Arabic term is rendered "alburalmon" in the Latin text. The variation in color that the peacock feathers and the cloth manifest is, of course, due to the variable refraction, reflection, and interference of light which creates the effect of a spectrum, the same effect that can also be seen in the feathers at the neck of a pigeon. The assumption here is that these colors are somehow actually in the objects but are only revealed under certain light-conditions; see note below.

[17]In order to demonstrate that color is a real, inherent property of physical objects, Alhacen devotes considerable attention in I, 3.132-137 to refuting the idea that color is some sort of mediate effect created by light in the eye; see Sabra, *Optics*, vol. 1, pp. 48-49. In other words, color is essentially objective, not subjective. In taking this realist position, Alhacen is following both Aristotle and Ptolemy; see, e.g., Ptolemy, *Optics*, II, 14-16, in Smith, *Ptolemy's Theory*, pp. 75-76 As Sabra ob-

serves in *Optics*, vol. 2, p. 39, one of the objects of Alhacen's argument is the atomists, who supposed color to be a psychological state created by the physical interaction of atoms. Another could well be Plato, whose account in *Timaeus* 67d-e reduces color to an effect of the physical interaction of outgoing visual flux and incoming particles emitted by various visible sources; see Smith, *Ptolemy and the Foundations*, pp. 28-29. The fact that colors have an absolute, objective existence, however, does not mean that they are always perceived as they truly are; a variety of factors, such as intensity of illumination, surrounding color-context, and the physical state of the optic system can cause colors to vary in both hue and clarity.

[18]Alhacen's explanation of how the visual process occurs occupies the whole of chapter 6; within this context, Alhacen's account of why inordinately bright light or color impedes proper vision is to be found in 6.108-115, pp. 385-387 above.

[19]This is chapter 5 in the Arabic original of the text, so the succeeding chapters of the Latin text will deviate accordingly in numerical designation from their Arabic counterparts.

[20]The modifier *obticus*, conjoined with *nervus*, is found in that form in all the manuscripts. While it could easily be taken as an orthographic variant of *opticus*—in which case it would seem natural to render it as "optic"—context makes it clear that its proper English rendering is "hollow." Indeed, Roger Bacon makes this point clear in referring to the "nervi optici, id est concavi" in *Perspectiva* I.2.1, ed. and trans. Lindberg, *Roger Bacon and the Origins*, p. 22, line 36.

[21]Alhacen's description of the optic system is essentially Galenic and, as is indicated by his continual use of *dicitur* ("it is said"), seems to be based on authority rather than on first-hand observation. The two cerebral membranes out of which the two tunics of the nerves supposedly arise are the *dura mater*, which forms the tougher, outer membrane, and the *pia mater*, which forms the softer, inner membrane of the brain. The crossing of the nerves, which forms the optic chiasma, is henceforth designated in the text as the "common nerve" (*nervus communis*). For a discussion of Galen's account of ocular anatomy and Ḥunayn Ibn Isḥāq's later adaptation of it, see "Introduction," pp. xxxvii-xxxix and xlvii-xlix above. Figure 1.1, taken from ms *P3* (f 4v), illustrates the complex of optic nerves springing from the brain at left, passing through the optic chiasma, and emerging through the eyesockets.

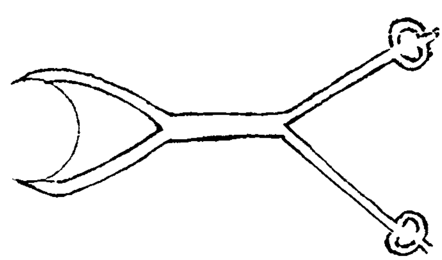

figure 1.1

[22]The Latin term rendered here as "sclera" is *consolidativa*, so called because its primary function is to hold the eye together (*consolidare*) and maintain its essential structure. This tunic is also called *conjunctiva* (see, e.g., Bacon, *Perspectiva* I.2.2), and is, in fact, designated as such by Sabra in *Optics*, I, 5.5. That term, however, is misleading, since in modern usage it refers only to the mucous membranes enclosing the eye in front. Alhacen's "consolidativa" corresponds to Galen's "scleral tunic" (*chiton skleros*);" see "Introduction," p. xxxviii above.

[23]According to Sabra's translation, the Latin text has substituted "green" (*viridis*)

for "blue" in the Arabic version; see I, 5.6 in Sabra, *Optics*, vol. 1, p. 56.

[24]Alhacen's "uvea" corresponds to Galen's "choroid tunic" (= *chiton choroeides*); see "Introduction," p. xxxvii above.

[25]This opening is, of course, the pupil, and the part of the uvea that shows through the cornea is the iris. As will become clear later on, the assumption (incorrect) that the pupil lies directly in line with the opening in the nerve at the back of the eye is mandated by Alhacen's theory of visual imaging.

[26]The reason that Alhacen denies perfect transparency to the *glacialis* is that, if it did not have something to block or impede the passage of light or illuminated color, it could not be affected by them. Thus, it has a modicum of consistency (*spissitudo*) or opacity (*densitas, soliditas*) that enables it to take on the impression of light and color physically for a very brief time (see 6.64, p. 375 above). For a more detailed account of Alhacen's understanding of transparency and its optical properties, see note 59, p. 404 below.

[27]Being "equally situated" with respect to the pupil means that all the rectilinear lines drawn from the circumference of the pupil tangent to the sphere of the *glacialis* will be equal in length. Thus, as will be established later, the straight line perpendicular to the plane of the pupil and passing through its centerpoint will also pass through the centerpoint of the sphere of the *glacialis*. As Alhacen implies in 5.26, p. 352 above, the *glacialis* is spherical only in the ideal sense; in reality it is composed of two intersecting spheres, the anterior one being of a larger radius and thus of a more gradual curvature than the posterior one. It is this relative moderation of curvature that constitutes the "flattening" (*compressio*) to which Alhacen adverts here. Note, by the way, that the sphere Alhacen designates as *glacialis* in this case includes both the lens and the vitreous body behind it and, therefore, both the "crystalline" (*krystalloiedes*) and "vitreous" (*hyaloeides*) humors of Galen's anatomical description; see "Introduction," p. xxxvii above.

[28]As Sabra points out in *Optics*, vol. 2, p. 51, note 10.2, Galen, and Ḥunayn Ibn Isḥāq following him, liken the vitreous humor to melted, rather than ground or crushed, glass. What Alhacen meant by likening this humor to ground glass (*vitrum quasi frustatum*) is unclear at best. The important point is that, by so characterizing this humor, Alhacen has established that the *glacialis* is divided front and back into two portions that are distinguished by their particular transparencies. The front portion of the *glacialis* that is filled with glacial humor constitutes the crystalline lens. Rather than render the Latin term *glacialis* as "crystalline lens," however, I have chosen to leave the term untranslated in order to reflect the fact that, in adverting to the *glacialis*, Alhacen has the entire sphere in mind, even though the effectively sensitive part of it consists of its anterior portion.

[29]Presumably, the "opening" (*foramen*) in the uvea referred to here is simply the insertion-point for the sphere of the *glacialis*, it being at this point that the *glacialis* is attached around its equator to the uvea. Note the distinction of tunics by their origin in the two cerebral membranes: *pia mater* for the uvea and *dura mater* for the outer casing of the eye (i.e., the sclera) of which the cornea forms the frontmost part; see 5.18, p. 350 above.

[30]According to Alhacen's account, then, there are three tunics (or four if the *aranea* is included) and three humors in the eye. The tunics, in order from outer-

most to innermost, are the *consolidativa* or sclera, the cornea, the uvea, and the *aranea*. The humors, in order from front to back, are albugineous (i.e., aqueous), glacial, and vitreous. Note that Alhacen omits the retina, although perhaps the *aranea* is somehow meant to substitute for it.

[31]Figure 1.2, taken from ms *P3* (f 6r), offers a schematic representation of the eye according to Alhacen's description. The small circle at the top is the pupil (*foramen uvee* = "opening in the uvea"); enclosing it is the *spera cornea* = "corneal

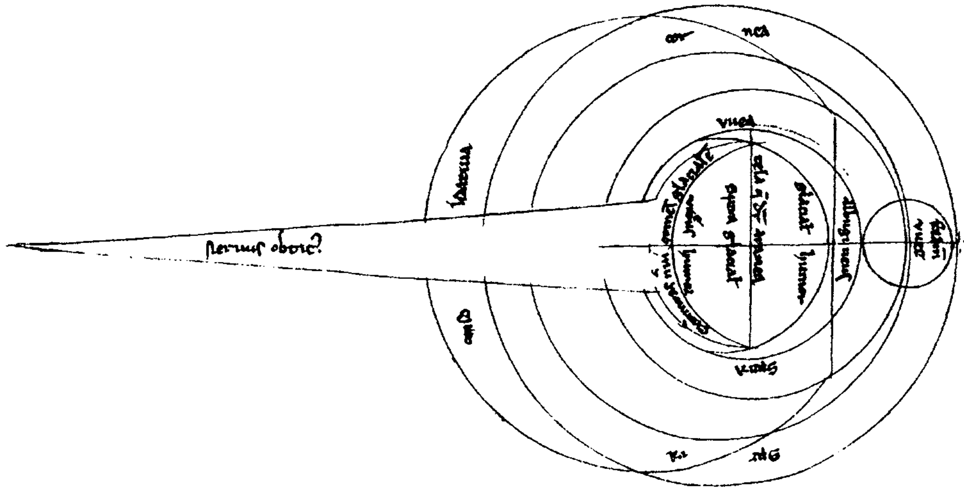

figure 1.2

sphere," which is intersected by the *consolidativa* = sclera. Inside the corneal sphere is the *spera uvea* = "uveal sphere," which encloses, in order from top to bottom, the *albugineus* = "albugineous humor," the *glacialis humor*, and the *vitreus humor* = "vitreous humor"—these latter two humors filling the *spera glacialis* = "glacial sphere," and separated by the *tela que dicitur aranea* = "the net called 'spider's web,'" so called because of its exquisite fineness. The funnel-shaped insertion at the back of the glacial sphere is the *nervus obticus* = "hollow [optic] nerve," and where it joins the sphere of the *glacialis* at the rear the text reads *exterioris nervi continens glacialem* = "the outer side of the nerve that encloses the *glacialis*."

Figure 1.3 on the following page illustrates the same thing in a somewhat less abstract way. In this representation. the eyeball is contained within the outer sphere of the *consolidativa* or sclera which is centered on **C**, its anterior portion constituting the cornea. Inside the sclera is the smaller uveal sphere, whose center is **C1**. The opening at its front, just behind the cornea, forms the pupil. Contained within the uveal sphere is the sphere of the *glacialis*, whose "flattened" anterior surface, **AB**, is concentric with the sclera. The entire surface of the *glacialis* is covered by the exquisitely thin membrane of the *aranea*. The space between the inside of the cornea and the anterior surface of the *glacialis* is filled with albugineous humor. The *glacialis* itself is filled with glacial humor toward the front and vitreous humor toward the rear. At this point of the description, Alhacen does not discuss the interface between the two humors, although the rendering of the eye in figure 1.2 on the previous page shows it as flat and separated by an offshoot of the *aranea*; cf 5.10, p. 349 above. This entire system is attached to the hollow optic nerve, which flares out to form the uveal tunic on the inside of the eye and the scleral tunic on its outside. The inner sheath of the nerve thus forms the uveal tunic, which ultimately arises from the *pia mater* of the brain, and the outer sheath of the nerve forms the scleral tunic, which ultimately arises from the *dura mater* of the brain. The axis of the eye, which passes through both **C** and **C1**, passes through the very middle of the nerve's hollow.

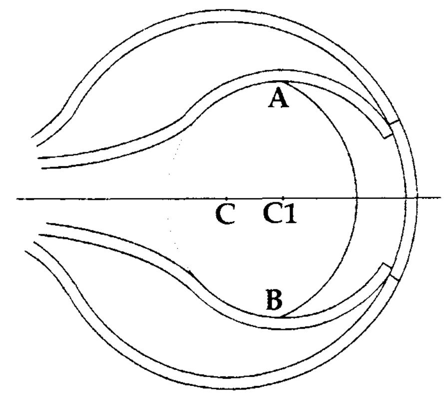

figure 1.3

[32]Alhacen's visual spirit is a localized form of the animal spirit produced in the ventricles of the brain and responsible for all sensitive and intellectual functions. In that capacity, it clearly parallels Galen's *pneuma psychikon*. For a further discussion of the anatomical and physiological model to which Alhacen subscribes in his theory of vision, see "Introduction," pp. lvii-lx above.

[33]It is thus by maintaining the constituent tunics of the eye rigidly in place (i.e., by "consolidating" them) that the *consolidativa* lives up to its name. Accordingly, the only motion proper to the eye is rotational motion up-or-down or side-to-side in place.

[34]Although Alhacen makes it clear here that the cornea forms a perfect continuation of the sclera, the representations of the eye in various manuscript-sources tend to show the sclera and cornea as distinct, intersecting spheres. Such representational ambiguities reflect various differences among such later theorists as Roger Bacon, John Pecham, and Witelo about the structure of the eye, those differences deriving from the various sources upon which they relied. Not surprisingly, as a very close follower of Alhacen, Witelo is in essential agreement with him about the eye's structure and components; see *Perspectiva* III, prop. 4, in Unguru, ed. and trans., *Witelonis* Perspectivae *liber secundus et liber tertius*, pp. 294-298 (Latin), 105-111 (English). Pecham, too, is in essential agreement with Alhacen, although he mentions a slightly different arrangement, championed by Bacon, that includes the retina, which is a continuation of the *aranea* in the back of the eye; see *Perspectiva communis* I, props. 31-32, in Lindberg, ed. and trans. *Roger Bacon and the Origins*, pp. 112-117. Bacon shows the most signal departure from Alhacen in terms of his detailed account of the tunics, which he subdivides into the following: the innermost tunic, which consists of the retina at the back and the uvea in front; the middle tunic, which consists of the secundina at the back and the cornea in front; and the third tunic, which consists of the sclera (*sclyros*) at the back and the *consolidativa* or *conjunctiva* in front; see *Perspectiva* I.2.2, in Lindberg, ed. and trans., *Roger Bacon and the Origins*, pp. 27-31. Bacon goes on in *Perspectiva* I.3.3 to make the puzzling claim (which he attributes to Alhacen) that the *consolidativa* is not spherical but bulges

outward at the front; see Lindberg, *Roger Bacon and the Origins*, pp. 40-43.

[35]This follows as a corollary from Euclid, *Elements*, III, 11 and 12.

[36]In other words, according to the conditions specified in 5.11, p. 349 above, since the *glacialis* is attached at its equator to the expanded optic nerve, and thus the uvea, then, if the intersection of the "flattened" anterior portion and the more acutely curved posterior portion of the glacialis occurs at the equator of the *glacialis*, as defined by the sphere containing the posterior portion, the *glacialis* will be attached where those two portions intersect. Otherwise, the circle of intersection for those two portions will be posterior or anterior to the circle of attachment and parallel to it, as is illustrated in figure 1.4, in which **AB** represents the plane in which the circle of attachment lies, that plane passing through the equator of the *glacialis*.

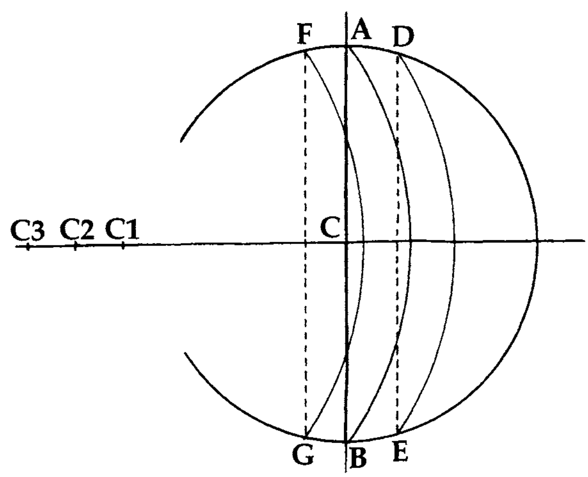

figure 1.4

C represents the center of the *glacialis*, **CC3** the axis of the eye, and **C1**, **C2**, and **C3** possible centers of curvature for the anterior surface of the *glacialis*. Those centerpoints therefore lie farther within the eye than centerpoint **C** of the eye itself, and no matter which of those centerpoints is taken, the resulting surface—whether **DE**, **AB**, or **FG**—will intersect the sphere of the *glacialis* in a plane parallel to, or coincident with, the plane of attachment.

[37]Alhacen seems to be responding in this lengthy discussion to two anatomical schools having differing views on precisely where the *glacialis* attaches to the uvea. Accordingly, Alhacen is at pains to establish that, no matter where that circle is, the axial line passing through it from the center of the pupil to the center of the optic nerve at the back of the eye will always be perpendicular to it. This point will be crucial to his account of the visual selection of coherent images in II, 2.19-25, pp. 423-428 below.

[38]As is clear from figure 1.4, since the center of the anterior surface of the *glacialis* coincides with the center of the eyeball, and since the center of the uveal sphere containing the posterior part of the *glacialis* (and thus the primary defining sphere

for the *glacialis*) is anterior to the eyeball's center, then the center of the anterior surface of the *glacialis* necessarily lies deeper in the eye than does the center of the posterior surface of the *glacialis*.

[39]5.21, p. 351 above.

[40]These consist of the centerpoint of the scleral/corneal sphere; the centerpoint of the uveal sphere; and the centerpoint of the sphere containing the anterior surface of the *glacialis*, which turns out to coincide with the centerpoint of the scleral/corneal sphere; see 5.29, p. 353 above.

[41]Projected through the circular pupil, these lines, taken *in toto*, form a cone whose vertex lies at the centerpoint of the eye and whose axis passes straight through all of the established centerpoints to the very center of the hollow of the optic nerve at the back of the eye.

[42]Alhacen's demonstration that the eye as a whole and the anterior surface of the *glacialis* share a common centerpoint is to be found in 6.23-29, pp. 362-364 above. Under the conditions specified to this point, then, the anterior portion of the *glacialis*, which constitutes the so-called crystalline lens, must lie toward the front of the eye as a whole, as indeed must the entire glacial sphere. It is worth noting, however, that Ḥunayn Ibn Isḥāq located the *glacialis* dead center in the eye and that, following him, a long succession of Latin "medical" authorities, including the likes of Leonardo da Vinci and Andreas Vesalius, continued this tradition; see Eastwood, *Elements of Vision*, pp. 5-7; see also A. Mark Smith, "Ptolemy, Alhazen, and Kepler and the Problem of Optical Images," *Arabic Sciences and Philosophy* 8 (1998): 8-44, esp. 30-32.

[43]5.17, p. 350 above.

[44]5.23, p. 351 above.

[45]See "Introduction," pp. lii and lxxxi above, for some identification of these anatomical authorities, which certainly include Galen and Hunayn ibn Ishaq.

[46]I, 3.1-3.110, in Sabra, *Optics*, vol. 1, pp. 13-43.

[47]I, 3.113-131, in Sabra, *Optics*, vol. 1, pp. 44-48.

[48]Although up to this point Alhacen has treated light as if it were not only absolutely distinct from color, but also *per se* visible, he makes it clear here that this distinction in more analytic than real, light being inextricably linked with color as the cause of its visibility. Hence, although Alhacen, unlike Aristotle, Ptolemy, and Galen, seems to accord light independent physical existence at a theoretical level, he reduces it to a catalyzing agent at a practical level insofar as its primary function is to render color effectively visible; see "Introduction," pp. liv-lv above.

[49]That is, in the same general direction as, but not necessarily in a direct line with, the original line of incidence. Thus, although transparent and reflective bodies are similar in that they break (*reflectere*) incident light-rays, in not breaking them completely, transparent bodies allow them to pass through and thus not to reverse their original direction.

[50]Among such "natural philosophers" we can of course include Galen, Ḥunayn Ibn Isḥāq, and Avicenna.

[51]Alhacen has thus set up the problem: since each point on any object facing the eye radiates its form to every point on the eye's surface, and since every point on any such object radiates its form to each point on the eye, then the resulting

impression should be confused to absolute indistinction. Why, then, do we see things distinctly? It is this question that Alhacen addresses in the analysis that follows, from 6.13 to 6.45.

[52]Here Alhacen lays out his basic approach in resolving the above problem: i.e., it is necessary to reduce the *effective* light- and color-impressions on the eye's surface to the point where a perfect point-by-point representation of the visual field is projected onto the eye's surface.

[53]Cataract surgery, particularly in the form of couching (i.e., pushing the crystallized obstruction aside, out of the line of vision) was practiced not only in the Arabic Middle Ages, but also antiquity; see Thomas Shastid, "History of Ophthalmology," in Casey A. Wood, ed., *The American Encyclopedia of Ophthalmology*, vol. XI (Chicago: Cleveland Press, 1917), pp. 8524-8904, esp. pp. 8580-8722. It should be noted, however, that most of these "cataracts" actually involved obstructions in the aqueous or albugineous humor rather than in the crystalline lens itself (Shastid, "History," pp. 8580-8584). The supposition that the *glacialis*, or crystalline lens, is the true organ of visual sensation, all the remaining tunics designed to serve it, harks back to Galen, whose influence was carried into the Arabic tradition by various theorists, of which the most significant was Ḥunayn Ibn Isḥāq; see "Introduction," pp. xlvii-xlix above.

[54]Alhacen's discussion of the rectilinear propagation of light through air is found in I, 3.1-8 *et passim*: Sabra, *Optics*, vol. 1, pp. 13-15. Note Alhacen's effort to establish the universality of this fundamental property of transparency (i.e., that it allows rectilinear propagation of light and color) for any and all transparent objects. That he felt the need to establish this point seems to indicate a keen awareness on his part that transparency might somehow be object-specific—i.e., that light might radiate through glass, for instance, along a different kind of trajectory than it would through water or diamond. Thus, whereas we today take for granted that light, whether it be moonlight, starlight, or sunlight, has absolutely constant attributes, Alhacen feels compelled to establish this point; see, e.g., I, 3.9-19, in Sabra, *Optics*, vol. 1, pp. 15-20).

[55]This experimental verification that light passes rectilinearly through refractive media is to be found at the very beginning of the seventh book of the *De aspectibus* (see Risner, *Opticae thesaurus*, pp. 231-235). Note that the word for "refraction" in this instance is *obliquatio*; indeed, *obliquare* in its various derivative forms is by far the most common term for "refract" in the Latin version of this treatise.

[56]6.12, p. 358 above.

[57]Figure 1.5 on the following page is provided in ms *P3* (f 12v) to illustrate the point that one, and only one, set of rays must be selected at the eye's surface if the visual faculty is to get a distinct view of the visual field. Points **A** and **B** on the right hand arc represent points of light (**A** being labeled *punctus lucis*), the larger circular segment to the left represents the surface of the eye (*superficies visus*), and the smaller circle inside it and concentric with it represents the *glacialis*. The legend below the figure reads: *Id est, licet ab A puncto lucis veniat lux ad totam superficiem oculi, tamen glacialis non comprehendit eum a tota superficie oculi sed a puncto in quo cadit perpendicularis super glacialem; similiter intelligendum est de B puncto lucis alio* ("That is, even though the light [emanating] from luminous point **A** reaches the eye's en-

tire [exposed] surface, still, the *glacialis* does not perceive it according to the entire surface of the eye but according to the point where the [light-ray] is perpendicular to the *glacialis*; and the same holds for the other luminous point **B**").

[58]Note the use of the plural form (*luces*) for light. In using that form, Alhacen is presumably underlining the fact that all light, whatever its source, acts in a uniform manner; cf. note 54, p. 403 above.

[59]In this case, transparencies are assumed by Alhacen to differ according to their refractive power—or, as we would have it today, their optical density. Overall, according to Alhacen's account, transparency varies in terms of thickness or consistency (*spissitudo*), density (*densitas*), or compactness (*soliditas*). Thus, there is a spectrum of transparencies ranging upward from perfect (a theoretical but not practical maximum) to perfectly imperfect (i.e., completely opaque or reflective). Accordingly, *spissitudo*, *densitas*, and *soliditas* confer a measure of opacity upon transparent media that allows them to trap some of the light and color radiating through them (see note 26, p. 398 above). Such is the case with misty air or somewhat turbid water, which are thereby rendered more opaque and, as a result, more visible. The problem, of course, is how to relate refractivity—as a function of *spissitudo*, *densitas*, or *soliditas*—to relative opacity—as a function of the same variables: after all, somewhat turbid water has essentially the same refractivity as clear water, even though the two vary considerably in terms of their ability to transmit light.

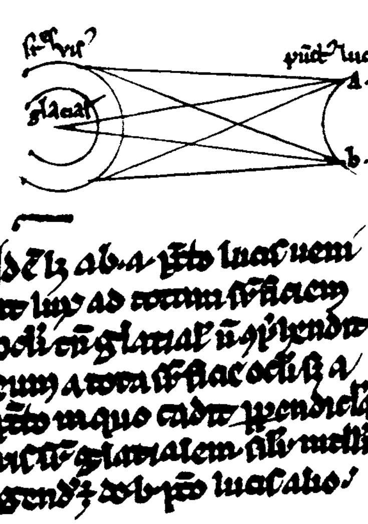

figure 1.5

[60]This experimental verification is to be found in the seventh book, directly after the experimental verification that light passes rectilinearly through refractive media (see Risner, *Opticae thesaurus*, pp. 325-240).

[61]Note that the Latin term *reflectere* is used interchangeably to denote "reflect" or "refract" throughout the first three books of the *De aspectibus*; nowhere is *refringere* or any of its forms, such as *refractus*, used in the Latin manuscript tradition, except by Risner, who imports it into his 1572 edition of the *De aspectibus* to clarify the distinction between reflection and refraction.

[62]The point Alhacen is making here is that, after refraction, it is impossible for any ray to follow a path perpendicular to the surface of refraction. Alhacen returns to this point somewhat more explicitly toward the end of 6.33, pp. 365-366 above.

[63]The Latin term *verticatio*, which I have translated as "line," carries a strong implication of directionality and, on that basis, might as easily be translated as "vector;" see notes 1 and 101 to book 2, pp. 531 and 545 below.

[64]Here Alhacen endows the radiated light-form with the dynamic qualities of physical projectiles striking resistant surfaces. As we have already seen in the "Introduction," pp. xxix-xxxi above, Ptolemy provides the obvious precedent for this

dynamic model in his likening of visual radiation to projection and his use of this analogy to account for variations of visual acuity within the visual cone as well as according to distance. As Alhacen explains it, then, the more directly the rays/ projectiles strike resistant surfaces, such as that at the front of the *glacialis*, the more powerful their impingement upon them; see 6.43, p. 369 above, for an even more overt analogy between the dynamics of light-radiation and the dynamics of physical projection in the form of free-fall. On the basis of this dynamic model, Alhacen isolates those rays that are *effectively* sensed by the *glacialis*—i.e., those that strike it most forcefully—from all the rest. Those that strike it most forcefully, of course, are the ones that strike it orthogonally. The capacity to sense these impinging forms, and to do so selectively, is due to the charge of visual spirit continually suffusing the *glacialis* from the brain; see 5.14, pp. 349-350 above.

[65]I, 3.141-143: Sabra, *Optics*, vol. 1, p. 50. The qualifier "somehow" used with "illuminated" is presumably meant to distinguish bodies that are self-luminous from those that are illuminated from some external source.

[66]Mathematically equivalent to the visual cone of Euclidean-Ptolemaic optics, the cone of radiation described here is the one adverted to obliquely in 5.29, p. 353 above.

[67]The result, therefore, is a mosaic of light- and color-forms that are in perfect point-to-point correspondence with the generating object-surface. Notice, however, that the resulting mosaic conforms to the shape of the anterior surface of the *glacialis*, not that of the generating object-surface.

[68]Figure 1.6 shows that, if the forms passing through the cornea to the anterior surface of the *glacialis* are perpendicular, then the rays **DC**, **AC**, and **BC** along which they continue unrefracted through the glacialis will intersect at center **C** of the eye to form a cone. Those rays that strike the same points on the cornea (or the anterior

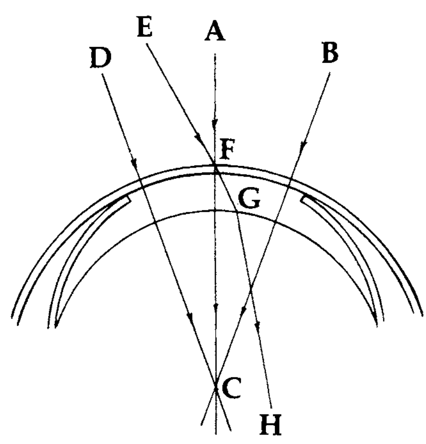

figure 1.6

surface of the *glacialis*) at an angle, on the other hand, will not make an effective impression and will also be refracted so as not to reach the center of the eye. Thus, ray **EF** strikes the cornea obliquely and is refracted toward the normal. Passing thence through the aqueous humor, it strikes the anterior surface of the *glacialis* obliquely along **FG**. At point **G** it will again be refracted toward the normal to pass into the *glacialis* along **GH** so as to miss centerpoint **C**.

[69]Figures 1.7a and 1.7b are provided in ms *P3* (f 17r) to illustrate the two points in this paragraph: i.e., that if rays are refracted at the cornea, the image projected on the surface of the *glacialis* will be inverted, and that refracted rays will never reach or pass beyond the normal. The first figure is explained by the accompany-

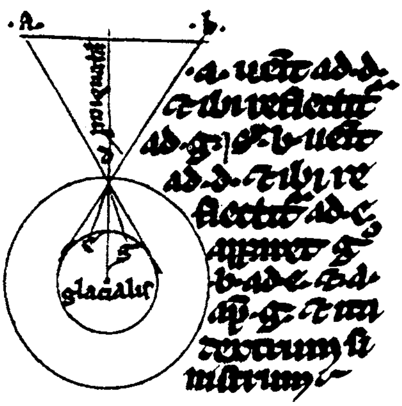

figure 1.7a

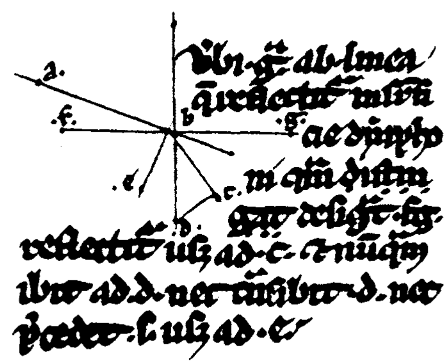

figure 1.7b

ing legend: *A venit ad D et ibi reflectitur ad G; similiter B venit ad D et ibi reflectitur ad E; apparet ergo B ad E et A apud G, et ita dextrum sinistrum* ("**A** reaches **D** and at this point is refracted to **G**; likewise **B** reaches **D** and at this point is refracted to **E**; hence **B** appears at **E** and **A** at **G**; so the right-hand [point **B** appears to the] left-hand [side of the *glacialis*, and vice versa]"). The second figure is explained thus by its accompanying legend: *Verbi gratia, AB linea que reflectitur in superficie dyaphoni quam ~~distingat~~ designat FG reflectitur usque ad C et nunquam ibit ad D nec transibit D nec precedet, scilicet, usque ad E* ("For instance, line **AB**, which is refracted at the transparent surface that **FG** designates is refracted to **C** and will never continue to **D** or pass through **D** or proceed on to **E**").

[70]In other words, as figure 1.8 illustrates, when the rays from object-points **A** and **B** in the left-hand sector of the visual field reach point **C** on the eye's surface and refract toward normal **DC**, then ray **AC** will refract toward the normal to point **E** on the surface of the *glacialis*, whereas ray **BC** will refract toward the normal to point **F** on the surface of the *glacialis*. In that case, not only will the two points

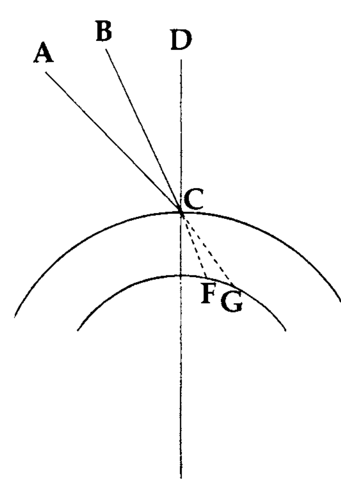

figure 1.8

be seen on the right-hand side of the *glacialis* (i.e., the side opposite to where they lie in the visual field), but, being seen at **F**, the more leftward of the two points **A** and **B** (i.e., **A**) will appear farther to the right (i.e., at **E**) on the surface of the *glacialis*.

[71]The point here seems to be that, no matter how closely the incident rays or the resultant refracted rays approach the normal, the refracted ray will never coincide with the normal, nor will they cross one another to interchange their relative locations. Accordingly, no matter how close the neighboring spots on the surface of the visible object, and no matter how close to perpendicular the rays along which they reach the surface of the cornea, after refraction they will invariably be projected in reverse order on the *glacialis*.

[72]That is, in book 7.

[73]Alhacen is appealing to common experience, which tells us that such an image-reversal cannot occur because, if it did, we would see things reversed and inverted. Alhacen makes the same appeal to common experience in order to justify his account of how the visual image abstracted at the surface of the *glacialis* continues in proper, upright order into the hollow of the optic nerve; see II, 2.6-7, p. 419 below.

[74]Here Alhacen has recourse to a point he has yet to demonstrate: namely, that in refraction the incident and refracted rays, as well as the normal to the point of refraction, all lie in the same plane. In fact, he defers this demonstration to the third chapter of book 7 (see Risner, *Opticae thesaurus*, pp. 242-243).

[75]Alhacen seems to be forwarding two arguments in 6.40 and 6.41: (1) if the *glacialis* and the cornea did not share the same center, then rays passing orthogonally through the cornea would reach the *glacialis* in distorted order, so the resulting image would be distorted, and (2) if one set of oblique lines could be sensed by the *glacialis*, then it should be sensitive to all oblique lines, in which case every point on the *glacialis* would sense all the forms reaching it, the resulting visual impression being reduced to absolute indistinction, as claimed in 6.17-21, pp. 360-362 above.

[76]In 5.21 *et passim*, p. 351 above.

[77]This analogy between light-radiation and free-fall has crucial implications for the dynamic analysis of light. Accordingly, light-radiation can be thought of in terms of upward projection, its power decreasing continually the farther out from its point-source it gets, just as a body thrown upward loses momentum the farther from the center of "gravity" (i.e., the earth's center), it gets. Cf. Ptolemy's account as described in the "Introduction," p. xxx above.

[78]These mathematicians certainly include Euclid and Ptolemy, as well, perhaps, as al-Kindī and Aḥmad ibn ʿĪsā, all of whom subscribed to some form of the visual-ray theory. They also include Galen, who gives a detailed description of the visual cone in the *De usu partium*; see the discussion in the "Introduction," pp. xli-xliii above. Alhacen has much to say about the "mathematicians" in I, 1.3-5 (Sabra, *Optics*, vol. 1, pp. 4-5), but, as Sabra warns us in his commentary (*Optics*, vol 2, pp. 8-10), in referring to various "mathematicians," Alhacen may have in mind not particular historical figures but particular theoretical positions.

[79]Note the systematic (and laudable) caution Alhacen displays in acknowledging that to this point he has only shown that the theory of image-formation on the *glacialis* so painstakingly described to this point is not necessarily true, simply

not untrue. The demonstration that it is, in fact, necessarily true begins in the next paragraph.

[80]Alhacen's purpose in this section is to establish that visible objects are the ultimate source of vision and that when such objects do not face us, or when we block them from view, they disappear from sight. In the process, however, he has provided an inductive demonstration of something that might at first blush seem intuitively obvious: that the objects we see lie physically outside the eye, beyond the eyelids. Implied therein is a pretty clear distinction between objective (physical) reality and its subjective (perceptual) counterpart. For a more explicit elaboration on Alhacen's part of this point, see II, 3.73, p. 450 above.

[81]Against whom, if anyone in particular, Alhacen is arguing here is unclear. In *De sensu et sensato* 2, 438a5-24, Aristotle raises something resembling the issue when he takes Democritus to task for claiming that the eye owes its peculiar nature to its being composed of water; see also Theophrastus, *On the Senses*, 49, in George M. Stratton, trans., *Theophrastus and the Greek Physiological Psychology Before Aristotle* (London: Allen and Unwin, 1917), p. 109. "True," Aristotle agrees with Democritus, "the visual organ proper is composed of water, yet vision appertains to it not because it is water but because it is transparent—a property common alike to water and to air, . . . whence the necessity of the interior of the eye being transparent, i.e. capable of admitting light" (trans. J. I. Beare, in Jonathan Barnes, ed., *The Complete Works of Aristotle: The Revised Oxford Translation* [Princeton: Princeton University Press, 1984], p. 696). Thus, Aristotle concludes in *De sensu* 3.439a20- 24, "what we call transparent is not something peculiar to air, or water, or any other of the bodies usually called transparent, but is a common nature and power, capable of no separate existence of its own, but residing in these" (trans. J. I. Beare, in Barnes, *Complete Works*, p. 697); see also *De anima* 2, 7.418b4-9. Alhacen's argument against the idea that water is the principle of transparency may, therefore, have been prompted by the implications of Aristotle's account. Note, incidentally, that the transparencies cited by Alhacen in this passage (i.e., of clear versus dyed water) differ in terms of translucency rather than of refractivity; see note 59, p. 404 above.

[82]That is, those within the Euclidean-Ptolemaic visual-ray tradition.

[83]6.49, pp. 370-371 above.

[84]I, 3.141, in Sabra, *Optics*, vol. 1, p. 50.

[85]Here, of course, we see that "Ockham's Razor" was already well honed and in full use long before Ockham's day. Despite the logical force of Alhacen's refutation, Roger Bacon argues that, in order to bring the visual act to completion, the eye must send out "species" to external objects. In short, eye and object must provide complementary radiation. Citing a range of authorities, from Ptolemy to al-Kindī to justify his position, Bacon goes on to claim that Alhacen was merely arguing against the extramission of a *material* agent from the eye, whereas the radiation he has in mind is formal; see *Perspectiva* I.7.2-4, in Lindberg, ed. and trans., *Roger Bacon and the Origins*, pp. 101-107. For a complete discussion of Bacon's conception of "species" and its radiation/multiplication in the *De multiplicatione specierum*, see Lindberg, *Roger Bacon's Philosophy*, pp. liii-lxxi.

[86]6.23-29, pp. 362-364 above.

[87]Here Alhacen is hoisting Euclid by his own petard, since Euclid claims in the

very first postulate of his *Optics*, that the visual rays proceed (or diverge) indefinitely outward. In *Catoptrica* 1, Hero of Alexandria (fl. mid-first century) cites the fact that we see the distant stars as soon as we open our eyes as a demonstration not only that our visual flux fills the intervening space, but that, in order to do so, it must move with unbelievable swiftness.

[88]In defense of the visual-ray theory, its proponents point out that we "see" objects in space, physically removed from us, and are able to apprehend their actual spatial disposition through a sense of visual touch. We are thus able to determine more-or-less intuitively how and where objects exist in physical space. Without some sort of physical contact, analogous to that which occurs when we extend our arms out to distant objects, we would be unable to reach such a determination. As we shall see later on in the second book, Alhacen offers a counter-explanation based on perceptual inference and estimation that itself is ultimately based on repeated experience and what we learn from it; see note 80, p. 408 above.

[89]There is no doubt that Ptolemy subscribes to the first opinion, i.e., that the visual ray is an imaginary construct. Galen, al-Kindī, and Aḥmad ibn 'Īsā seem to follow him in this opinion. Euclid, on the other hand, is unequivocal in his acceptance of the physical reality of individual visual rays. All four theorists seem to support the second opinion (i.e., that something issues from the eye) in one form or another.

[90]Like Aristotle and Ptolemy, Alhacen believes that sight has a proper object or special sensible that distinguishes it from the four other senses. In Alhacen's case that proper sensible consists of color, along with its complement in light. Thus, when it exercises its peculiar capacity to sense that object, without any ulterior interpretation, sight is acting in its "naked" form (or *solo sensu* ["by brute sensation"] as the Latin text phrases it later in book 2). The resulting sensation is extremely low-level—i.e., perception that what is being sensed is color or light—and does not even include the perception that the given color is of such-and-such a kind. This latter sort of perception (i.e., of specific type or kind), which is inferential and interpretive, requires a higher level of processing, as does the perception of such nonvisible characteristics (that is, characteristics that cannot be grasped *solo sensu*) as shape, size, and so forth. As Alhacen will establish later on, as well, many of our general perceptions (e.g., of "horse") depend on inferential short cuts, conclusions drawn on the basis of "signs" or key defining features (four legs, long neck, long face, particular gait) that are recognized through experience.

[91]6.28, p. 364 above.

[92]The point made in note 67, p. 405 above, is worth reiterating here: the pointillist image projected on the anterior surface of the *glacialis* is not a perfect replica of the object-surface because the *glacialis* is spherical in shape; therefore, there will be some distortion because of the disparity in surfaces.

[93]6.4, p. 356 above.

[94]5.9, p. 349 above.

[95]The Latin term that I have rendered by the verb "to impress" in this passage is *figere*, which means "to fix" in a variety of senses, perhaps the most apposite of which in this case is "to implant" or "to affix by piercing." One of its corollary meanings is thus "to impress." Furthermore, the use of this particular verb, "to

impress," is in keeping with the analogy Aristotle offers in *De anima* II, 12 between sensation and the stamping of a seal in wax (see also III, 12, 434b29-435a10); see III, 2.82 and 84, pp. 587-588 below.

[96]*Sensu spoliato*, then, the *glacialis* fulfills its proper function by selectively sensing the point-forms of impinging light and color, which form a light- and color-mosaic at its surface, and by transmitting that mosaic, as a sort of visual image, in proper order and arrangement into and through the eye to the optic nerve.

[97]Alhacen is following in a long tradition, one that includes Ptolemy in particular, that reduces sight to a form of touch. Thus, just as in touch, so in sight, the basic stimuli range in intensity from a feather touch, which barely registers at all, to an extremely sharp blow, which registers as extreme pain. As Sabra points out (*Optics*, vol. 2, p. 56), Alhacen could have learned through Theophrastus of Anaxagoras' belief that all perception entails pain. Whether he was actually made aware of Anaxagoras' theory in this way and, if so, was brought his own view by it, is open to question. A more probable source is Ptolemy, who supposes that vision is due to a passion aroused in the visual flux by illuminated color and, furthermore, that if the stimulus is too strong, the passion "hurts and offends" (*nocet et ledit*) the eye; see *Optics* II, 23 in Smith, *Ptolemy's Theory*, p. 79.

[98]Here the "visual process" is taken in its "pure" sense, without any perceptual interpretation. Thus, seeing in the proper sense is a matter solely of creating and transmitting the visual image referred to in note 96 above that visual image forming the basis for perceptual adjudication by the final sensor. Alhacen's final sensor has a clear counterpart in Ptolemy's *virtus regitiva* (Governing Faculty), which is responsible for all higher-level perceptual functions; see Smith, *Ptolemy's Theory*, pp. 28-29. It has another (perhaps common) counterpart in the Aristotelian faculty of "common sensibility," which is located by later Arabic commentators at the very forefront of the first cerebral ventricle; see "Introduction," pp. xlv-xlvi above, for a discussion of this issue.

[99]Alhacen thus follows Ptolemy in explaining image-fusion in physical rather than psychological terms; see Smith, *Ptolemy's Theory*, pp. 29-31. The assumption that image-fusion takes place at the optic chiasma is explicitly articulated by Galen, although Ptolemy seems to follow it implicitly in his account of binocular vision; see "Introduction," pp. xxxiii-xxxiv above.

[100]This claim about the destruction of sight by blockage in the optic nerve is quite common and, moreover, makes sense, but surely the supporting claim that removal of such blockage restores sight reflects theoretical imperatives rather than actual surgical experience.

[101]The underlying explanation of diplopia as described here is essentially the same as Ptolemy's: i.e., the two "visual" cones imagined between the center of the eye and the object do not share the same base, so they do not the same visual field. Nor, for that matter, do they demarcate corresponding areas on the surface of the cornea or *glacialis*. Both cones will thus provide different images for the ultimate delectation of the final sensor or Governing Faculty.

[102]5.3, p. 348 above.

[103]In chapter 2 of the second book, pp. 417-429 below.

[104]I, 3.1-8 *et passim*: Sabra, *Optics*, vol. 1, pp. 13-15.

[105]Alhacen's argument may be summarized as follows: Insofar as they are transparent, transparent media allow light and color to pass perfectly freely through them. Thus posing no resistance to such passage, they provide no way for light and color to become "fixed" in them (on this notion of "fixing" see note 95, pp. 409-410 above and note 126, p. 413 below). Accordingly, the forms of light and color can cross paths within transparent media without ever interfering or even interacting with one another. Note Alhacen's emphasis here on the fact that transparency is an essential and general quality whose nature is absolutely independent of the object in which it inheres; see note 54, p. 403 above.

[106]Alhacen means that the eye does not take on color in the way that, say, white cloth would take on dye; it is, of course, tinged by color accidentally, in the way that a shaded white wall facing a brightly colored object is, as described, for instance, in 4.14, p. 345 above.

[107]4.1-4.6, pp. 343-344 above.

[108]The persistence of afterimages seems therefore to be due not to the retention of the causal agent—i.e., bright light or color—but, rather, to the lingering sense-effect that continues to excite the visual spirit suffusing the optic complex. Accordingly, as a merely transparent body, the *glacialis* does not retain the incoming light, no matter how intense, but as a sensitive body it may retain the effect of that light if it is intense enough.

[109]The previously described trial Alhacen seems to have in mind involves a fully enclosed chamber with one opening through which light is allowed to stream inward and illuminate the opposite wall or various objects placed inside. This set-up is adverted to at various reprises throughout the third chapter of the Arabic version.

[110]I, 3.121: Sabra, *Optics*, vol. 1, p. 45. Note the general statement that, "the farther the forms [of light and color] are from their source, the weaker they will be." The most obvious way to translate this statement mathematically is according to a simple inverse relation between light-intensity and distance (i.e., $I = 1/d$), and, indeed, this seems to have been the general understanding of the relationship between light-intensity and distance until the time of Kepler; see Smith, *Descartes's Theory*, pp. 32-40, esp. p. 36, n. 13.

[111]4.20, p. 346 above.

[112]4.14, p. 345 above. What Alhacen has in mind here are the forms of bright colors (e.g., sunlit vegetation) that shine on nearby white bodies and tinge them, provided that those white bodies are not themselves brightly illuminated.

[113]4.9, p. 344 above.

[114]6.39, pp. 367-368 above.

[115]By "primary form" Alhacen means a form that is radiated directly from a given color- or light-source. Secondary forms therefore derive from primary forms that have been "fixed" at the surface of some opaque body upon which they radiate (e.g., sunlight on a white wall). Accordingly, the three forms at issue in this passage are (1) the primary form of the inherent color of the opaque body being looked at, (2) the primary form of that body's inherent light, and (3) the secondary form of the illuminated color shining upon that body from an external source and radiating to the eye in tandem with those two primary forms.

[116]4.9, p. 344 above.

[117]I, 3.144: Sabra, *Optics*, vol. 1, pp. 50-51. This reference to the third chapter in the Arabic original (and missing in the Latin version) provides one of very few clues to the fact that the Latin text—or the Arabic exemplar upon which is was based—was deficient; see "Introduction," p. xxiii above.

[118]See note 7, p. 395 above.

[119]This example harks back to 4.9, p. 344 above.

[120]This explanation would seem to belie Alhacen's carefully crafted theory of visual selectivity; after all, if the *glacialis* is constituted to feel only those forms that impinge on it orthogonally, then why should the flood of intense light matter, since all but one of the component rays of that flood will necessarily be refracted at the surface of the eye and will thus strike the *glacialis* obliquely?

[121]As Sabra points out in his commentary on this passage, in *Optics*, vol. 2, pp. 57-59, many of the color-terms Alhacen uses are difficult to interpret for a variety of reasons, not the least of which is their being keyed to unfamiliar substances (e.g., the "red" associated with the head of a particular bird). Such difficulties of interpretation seem to have carried over into the Latin. Accordingly, while the phrase "grass-green color" (*color viridis segetalis*) seems to be a proper rendering of its Arabic counterpart, "black body" (*corpus nigrum*) in Latin is "dark-blue body" in Arabic (the list of Arabic-Latin color-equivalents Sabra provides on p. 59 is misleading because the order of comparisons [i.e., grass-green on yellow looks dark; grass-green on black looks light] is reversed in the Latin version). The basic point, of course, is that a given color will change its apparent hue when it is seen against the background of other colors, depending on their brightness or darkness, so that color-perception depends not just upon the quantity and quality of illumination but also upon ambient color. This latter point is crucial to Aristotle's account of the yellow band in the rainbow, its appearance being due to the "whitening" of the stratum of the red band that is juxtaposed against the green of its brighter neighboring band; and Aristotle goes on to claim that in woven and embroidered cloth apparent hue depends heavily upon color-juxtaposition; see *Meteorology* III, 3, 375a6-26.

[122]5.6-7, p. 348 above.

[123]By this account, then, the primary function of the uvea is to darken the interior of the eye so that light (and color) of virtually any intensity can remain visible within the area between the pupil and the hollow of the optic nerve at the back of the *glacialis*. Accordingly, the eye is somewhat like a camera, although, as will become clear later, it has no focusing function whatever.

[124]Both here and at the beginning of this passage, the perfectly round shape of the constituent element (be it the pupil or the uvea) is dictated by a sort of metaphysical necessity: it must be shaped for the best, and the best—in terms of design efficiency—is circular or spherical because those are the simplest and most capacious planar and three-dimensional shapes possible. According to Alhacen, then, the sphericity of the eye is not just functionally, but mathematically, determined; cf. Hunayn ibn Ishaq's account as described in "Introduction," pp. xlviii-xlix above.

[125]The thin membrane mentioned above is the *aranea* or "cob-web," which, according to this description, encloses both the glacial and vitreous humors; see 5.10,

p. 349 above. Overall, the *glacialis* (both humors included) comprises a sphere from whose anterior surface a portion is cut off by a surface-segment that is part of a sphere of gentler curvature; see 5.9, 5.24 and 5.26, pp. 349 and 351-352 above. Hence, the primary form of the *glacialis* is spherical, even though its sphericity is rendered imperfect by the flattening of the anterior surface.

[126]On the implications of *figere*, rendered here by "to impress," see note 95, p. 409-410 above. Alhacen's claim here that the glacial humor's opacity allows it to retain light and color for a short time seems to contradict his explicit denial of such retention in 6.90-94, pp. 380-381 above.

[127]The Latin text does not specify smell as the sense appropriate to this location, but the Arabic version does. Moreover, it is a commonplace within the Galenic tradition that the olfactory system originates at this middle spot in the forefront of the brain; see, e.g., *De usu partium*, VII, I. 469, in May, p. 405.

[128]The Latin term I have rendered as "Creator" is *operator*, a term that carries with it the connotation of "craftsman" or "one who physically manipulates." Assuming, then, that Alhacen is referring to God here (cf. 7.18, p. 390 above), he is emphasizing His capacities as designer and implementer, much in the mold of the Demiurge described in Plato's *Timaeus*. The accompanying notion that the optic system is perfectly suited by design to fulfill its basic functions is, of course, a Galenic commonplace that is echoed by such key Arabic followers as Hunayn ibn Ishaq; see, e.g., Eastwood, *Elements of Vision*.

[129]6.69-72, pp. 376-377 above.

[130]6.27, pp. 363-364 above.

[131]Note the aesthetic judgments Alhacen makes here and in I, 7.9, claiming that the doubling of the eyes and the whiteness of the sclera reflect the intention of the "Creator" (*operator*) to make the optical system as aesthetically pleasing as it is functional. While such a claim may seem to reflect mere bias on Alhacen's part, it is in fact consistent with (and thus justifiable according to) the experientially based account of perceptual judgment he offers later in the second book.

[132]The "suitable place" is II, 2.24-30, pp. 427-429 below. Note how Alhacen's discussion of the spherical shape of the eye and the circular shape of the pupil (see 7.4, pp. 387-388 above) is informed both theoretically (metaphysically) and pragmatically (physically). On the one hand, the sphere and circle are the most perfect of figures on rational grounds: they are perfectly simple, and they are perfectly efficient in spatial compass. Yet the sphericity of the eye is also dictated by its need to move as freely and quickly as possible in order to scan the visual field for the clear and swift visual perception. Ptolemy argues for the sphericity of the universe and the circularity of celestial motion along much the same line: "The motion of the heavenly bodies is the most unhampered and free of all motions, and freest motion belongs among plane figures to the circle and among solid shapes to the sphere; similarly, since of different shapes having an equal boundary those with more angles are greater [in area or volume], the circle is greater than [all other] surfaces, and the sphere greater than [all other] solids," *Almagest* I.3, trans. G. J. Toomer, *Ptolemy's Almagest* (New York: Springer), pp. 39-40.

[133]I, 2.1-12, in Sabra, *Optics*, vol 1, pp. 6-9.

[134]The Latin text is obviously confused here; evidently, the point to be made is

that the body of the eye blocks light from reaching the surface of the object that is in contact with it so that the object cannot be rendered visible by extrinsic light.

[135]It is not clear from this passage whether Alhacen means to equate stars and fire according to a shared nature—i.e., being hot—which of course is why fire, put in direct contact with the eye, will burn it and thus destroy rather than induce vision. On the other hand, he may simply mean that the stars, being absolutely unreachable, cannot possibly be put into physical contact with the eye or anything else in the sublunar realm.

[136]This passage makes evident the intent of the garbled account at the beginning of 8.3.

[137]6.39, pp. 367-368 above.

[138]See also 6.96 and 6.113-114, pp. 381 and 386 above.

[139]6.63, p. 375 above.

[140]Alhacen's argument here seems circular: the reason that objects of a certain size fall below the threshold of visual perceptibility is that their forms make an imperceptibly small impression on the *glacialis*. The gist of the argument seems clear enough, though. As we will see later on in the third book, where Alhacen discusses the threshold conditions of sight at some length, perceptibility also depends on the intensity of the impression made on the *glacialis*. Hence, a light-source of moderate size can be too feeble, or too distant, to make itself felt by the *glacialis*.

[141]Here I have chosen to translate the Latin term *figere* as "to fix" rather than "to impress," as in 7.5, p. 388 above. The point Alhacen is making here is that, when exposed to light, opaque objects actually take on that light by resisting it and thus preventing it from passing through their substance. Since a perfectly transparent body poses absolutely no resistance to this passage, such a body cannot take on any light whatever and therefore cannot radiate the secondary form of that light by means of which the body can be seen.

[142]In this passage Alhacen seems to be saying that color is the principle of opacity—or vice versa. If so, then perhaps he is attempting, on that basis, to make sense of Aristotle's rather cryptic claim that color is "the limit of the transparent in determinately bounded body" (*De sensu* 3, 439b12, trans. J. I. Beare, in Barnes, *Complete Works*, p. 698).

BOOK TWO OF ALHACEN'S *DE ASPECTIBUS*

Topical Synopsis

[2.1-2.5] Review of previous discussion of image-selection by the *glacialis*. **[2.6]** Rays passing into the eye from the *glacialis* cannot intersect at centerpoint of eye because the image would be inverted. **[2.7-2.10]** How such intersection is forestalled by refraction of the rays at the interface between glacial and vitreous humors. **[2.11-2.18]** For the visual image to reach the common sensor in proper order, it must be transmitted both physically and sensitively through the optic complex. **[2.19-2.23]** The visual axis must be perpendicular to the interface between glacial and vitreous humor if the image is to reach the common sensor in proper arrangement. **[2.24-2.30]** Visual clarity is greatest along the visual axis and diminishes with increasing angular distance from it.

[3.1-3.25] Visual perception involves more than brute sensation; it also requires intellectual judgments that are based on differentiation and recognition. **[3.26-3.36]** Such judgments are essentially syllogistic, but they usually occur so fast that we are unaware of the inferential process. **[3.37-3.41]** From infancy humans are innately disposed to reason and to perceive syllogistically, and they generally do so easily and unconsciously. **[3.42]** Repeated perceptions lead to virtually instant recognition of visible objects through memorization. **[3.43-3.44]** List of the twenty-two visible intentions. **[3.45-3.48]** Perception of these intentions is ultimately based on brute sensation of illuminated color that is transmitted to the final sensor for subsequent judgment and differentiation. **[3.49-3.66]** How light and color are sensed and perceived. **[3.66-3.93]** How the fact of remoteness is perceived and how distance is perceived and reckoned. **[3.94-3.120]** How spatial disposition is perceived.

[THE SECOND BOOK]

[CHAPTER 1]

[1.1] It has been shown how vision takes place, and it does so [by means of a] sensation in the eye [produced] by a form of the light and color in a visible object arranged as they actually exist in the surface of the visible object. However, sight perceives many characteristics of visible objects besides light and color.

[1.2] It has also been shown in the first book that vision will occur only along radial lines, but radial lines vary in their dispositions, and likewise the dispositions of the forms reaching along them to the eyes vary.[1]

[1.3] Moreover, the visual perception of a visible object does not occur the same way every time, nor does it occur the same way for all visible objects. Instead, the way sight perceives visible objects varies, and the visual perception of the same visible object varies [even] when it is in the same situation and lies the same distance [from the eye].

[1.4] And in this book we shall show the various dispositions of the radial lines, and we shall specify their characteristics along with all the visible properties that are perceived by sight. And we shall show how sight perceives each of them as well as how visual perception varies for each of them.

[CHAPTER 2]

[2.1] It has already been shown in the first book that the radial lines along which the eye perceives visible objects are straight lines whose endpoints meet at the center of the eye.[2] And it has been shown in [the section on] the structure of the eye that the sensitive organ, which is the *glacialis*, is attached at the end of the hollow of the nerve to which the entire eye is attached, and [it has been shown] that, when this nerve flexes, it only flexes behind the center of the eye in the back of the whole eye, at the opening in the eye socket.[3]

[2.2] It has also been shown that the straight line passing through all the centers of the tunics of the eye extends through the middle of the nerve's hollow, reaches straight to the middle of where the nerve's hollow flexes, and passes through the center of the opening in the anterior of the uvea.[4] It has been shown, moreover, that the position of this line does not change with respect to the eye as a whole, nor with respect to the surfaces of the tunics, nor with respect to the component parts of the eye.[5] Therefore, the straight line passing through all the centers of the tunics of the eye invariably passes straight through to the hollow of the nerve to which the eye is attached where that nerve flexes, [and it does so] under all conditions, whether the eye is in motion or at rest. And since this line passes through the center of the eye as well as through the center of the opening in the front of the uvea, it extends through the middle of the cone whose vertex lies at the center of the eye, and the circumference of the opening in the front of the uvea circumscribes that cone; hence, let us call this line the "axis" of the cone.

[2.3] Furthermore, it has been demonstrated in that same first book that the cone formed between the visible object and the center of the eye demarcates an area on the surface of the *glacialis* that encompasses the entire form of the visible object at the base of that cone.[6] And the form will be arranged on that area of the surface of the *glacialis* by the radial lines extending between the visible object and the eye according to the [actual] arrangement of parts on the surface of the visible object. Thus, when the eye perceives some visible object and that object's form reaches the area on the surface of the *glacialis* demarcated by the aforesaid cone, every point on the aforesaid form lies on the radial line that extends between that point [on the surface of the *glacialis*] and a point facing it on the surface of the visible object, and [it is] along this line that the form comes directly to that point on the surface of the *glacialis*. Therefore, if the form of the visible object lies at the middle of the surface of the *glacialis*, the aforesaid axis will be one of the lines along which the forms of the points on the surface of the visible object extend, and the point on the surface of the visible object where the endpoint of this axis touches will be the point whose form comes [to the eye] along the axis.

[2.4] It has been shown in the first book, as well, that the forms perceived by the eye extend through the body of the *glacialis* and into the hollow of the nerve to which the eye is attached, and they reach the common nerve which is centered at the front of the brain—and this is where the forms of visible objects will be perceived by the final sensor—and [it has been shown] that vision is not fully realized until the form reaches the common nerve and that [such] forms will extend from the surface of the *glacialis* into the body of the *glacialis* along straight radial lines only, for the *glacialis* only receives these forms along radial lines.[7]

[2.5] And the final sensor perceives the locations of the [constituent] parts of the visible object only according to their locations on the surface of the visible object itself. And since the relative locations of the parts of the form, i.e., of the form reaching to the surface of the *glacialis*, are [the same as] the relative locations of the parts of the surface of the visible object, and since these forms are propagated as has been described, and since all these things obtain, vision will not be fully achieved until after the form on the surface of the *glacialis* reaches the common nerve, and its parts are situated as they actually are on the surface of the *glacialis* without any confusion.

[2.6] But the form reaches from the surface of the *glacialis* to the common nerve only by continuing through the hollow of the nerve to which the eye is attached. Thus, if the form does not extend through the hollow of this nerve with the same arrangement it has on the *glacialis*, it will not arrive at the common nerve in proper order. But the form cannot extend from the surface of the *glacialis* to the hollow of the nerve along straight lines and still preserve the proper arrangement of its parts, for all of those lines meet at the center of the eye. In that case, when they are extended along straight lines past that centerpoint their relative positions will be reversed, so the rightward [radial lines] will fall to the left, and vice versa, and the higher ones [will be] lower and the lower ones higher. Therefore, if the form extends along straight radial lines, it will contract at the center of the eye to form a virtual point; and since the center of the eye [in terms of its visual components] lies at the center of the entire ocular globe and in front of where the hollow of the nerve flexes, if the form is extended from the center as a single point along a single line, it will arrive at the place where the hollow of the nerve flexes as a single point. Accordingly, the whole form will not reach the place where the hollow of the nerve flexes, because it will arrive only as a single point, i.e., the one at the extremity of the axis of the [visual] cone.[8] But if it extends along straight radial lines to pass through the center [of the eye], it will be reversed according to the reversal of the lines along which it arrived after intersection. Hence, the form cannot reach from the surface of the *glacialis* to the hollow of the nerve so as to have its parts arranged as they actually are [in the object]. The form can therefore only reach from the surface of the *glacialis* to the hollow of the nerve along refracted lines that intersect the [original] radial lines.[9]

[2.7] Since this is the case, then, vision will not be fully achieved until after the form that arrives at the surface of the *glacialis* is refracted so as to extend along lines intersecting the [original] radial lines. So this refraction must occur before the form reaches the center [of sight], for if it is refracted after passing through that centerpoint, it will be reversed.

[2.8] And it has already been shown that this form passes through the body of the *glacialis* along straight radial lines, and since the form can reach the hollow of the nerve only after it has been refracted along lines intersecting the [original] radial lines, the form is refracted only after it passes through the body of the *glacialis*. And it has already been claimed in [the section on] the structure of the eye that the body of the *glacialis* varies in transparency and that its posterior portion, which is called the vitreous [body], differs in transparency from its front portion.[10] Moreover, in the *glacialis* there is no body, other than the vitreous [body], that is different in form[11] from the form of the anterior portion. But it is among the properties of the forms of light and color to be refracted when they meet with another body that differs in transparency from the first body [through which they were first radiating]. Thus, the forms are refracted only when they reach the vitreous humor, and this body differs in transparency from the body at the front of the *glacialis* only so that the forms can be refracted in it.[12]

[2.9] Furthermore, the surface of this body must lie in front of the center [of eye] so that the forms can be refracted at it before they pass through that centerpoint.[13] And this surface must be uniform in shape, for if it were not uniform in shape, the form would appear distorted after refraction. But a surface of uniform shape is either plane or spherical.[14] Now this surface cannot be formed from a sphere whose center is the center of the eye, for it it were, the [incoming] radial lines would always be perpendicular to it, so the form would extend along those straight lines and would not be refracted. Nor can [this surface] be formed from a small sphere, for if it were formed from a small sphere, then when the form is refracted at it and continues on, it will be distorted. Hence, this surface is plane, or it is spherical [and formed] from a sphere that is the right size not to have its curvature affect the arrangement of the form.[15]

[2.10] Hence, the surface of the glacial humor that forms the common section between that [vitreous] body and the anterior body of the *glacialis* is a surface of uniform shape that lies in front of the center of the eye. And all the forms reaching the surface of the *glacialis* extend through the body of the *glacialis* along straight, radial lines until they arrive at this surface, but when they arrive at this surface, they are refracted at it along uniformly arranged lines that intersect the [original] radial lines. Therefore, radial lines conduce to the proper arrangement of the forms of visible objects only at the *glacialis*, for it is at this organ that [visual] sensation will begin. And it has also been shown in the first book that, given the size of the visible object and the smallness of the sensitive organ, it is impossible for the form of a visible object to be properly arranged on the surface of the eye except along such lines.[16] Hence, these lines exist solely to be the instrument of sight through which visible objects are finally perceived as they exist in reality. However, in reaching the final sensor [in proper order], the forms do not need to continue along such straight lines.[17]

[2.11] Now the reception of forms by the sensitive organ is not like the reception of such forms by transparent bodies. For the sensitive organ receives these forms while sensing them, and they pass through it according to its transparency, but the sensitive power it possesses receives these forms in a sensitive way. Transparent bodies, however, receive these forms only for the purpose of transmitting them, but they do not sense them. And since a sensitive body does not receive these forms in the same way as nonsensitive transparent bodies do, the forms need not continue through the sensitive body along the same [radial] lines that transparent bodies require. Therefore, the eye is constituted to receive forms along radial lines only insofar as it is a property of forms to extend through transparent bodies along all straight lines. But if these forms reach the sensing organ in proper order and are perceived by the sensing organ in proper order, there will be no need for such [radial] lines afterward.

[2.12] Accordingly, only the front portion of the *glacialis* is constituted for the reception of forms along radial lines; the posterior portion, which is called the vitreous [body], along with the receptive capacity that is in this body, is constituted with its sensation of these forms only to maintain their arrangement. And since this is so, the way the vitreous [humor] receives the forms is not the way that the anterior portion of the *glacialis* receives them, and the receptive capacity of the vitreous [humor] is not the [same as] the receptive capacity in the anterior portion [of the *glacialis*].

[2.13] Moreover, since the way the vitreous [humor] receives forms is not the way the anterior portion of the *glacialis* receives them, the refraction that the forms undergo at the surface of the vitreous [humor] can only be due to the difference in the receptive sensitivity of these two bodies. Thus, the refraction of forms at the vitreous [humor] has two determinants, one being the difference in transparency between the two bodies, the other being the difference in receptive sensitivity between these two bodies.

[2.14] Now if the transparency of the two bodies were uniform, the form would extend through the vitreous body along straight, radial lines on account of the uniformity of transparency, but it would be refracted on account of the difference in sensitivity. Under these circumstances, then, the form would be distorted after refraction, or else there would be two forms [created] on account of this [disparity in the] nature [of the two media]. But since the difference in transparency prompts refraction, i.e., bending, and since the difference in sensitivity prompts [such] bending, the form will remain single after refraction, and it is for this reason that the transparency of the vitreous humor and the transparency of the glacial humor are different. Therefore, the forms reach the vitreous humor arranged as they actually are on the surface of the visible object, and this body receives them and senses them. Then they are refracted according to the difference in transparency and the difference in sensitivity possessed by this body, and so the form arrives according to its proper arrangement.[18] The resulting sensation, as well as the resulting form, will then extend through this body until the sensation and form reach the final sensor. But the passage of the sensation and the passage of the form through the body of the vitreous and through the sensitive body that fills the hollow of the optic nerve to the final sensor will be like the passage of the sensation of touch or the sensation of pain to the final sensor.

[2.15] However, the sense of touch and the sense of pain extend from the [sensing] organ only through the fibers of the nerves and through the spirit pervading those fibers. And when the forms of visible objects reach the body of the vitreous humor, the sensation will extend from that organ through the sensitive body pervading the hollow of the nerve and linking the eye to the front of the brain. In tandem with sensation, moreover, the forms extend [through this nervous channel] in their proper arrangement, for the sensitive body naturally conserves the arrangement of such forms. And this arrangement is conserved in the sensitive body, because the arrangement of the parts of the sensitive body that receive the parts of the form, as well as the arrangement of the receptive power in the parts of the receiving body, is uniform throughout the vitreous humor and the whole of the subtle matter pervading the hollow of the nerve. Since this is the case, when the form reaches a given point on the surface of the vitreous [humor], it will run along a continuous line, and it will not change its [relative] position in the hollow of the nerve through which the sensitive body extends. And all the lines along which all the points in the form run will be uniformly arranged with respect to one another, and all these lines will bend at the bend of the nerve, and at the point of bending all will be arranged as they were before bending, and afterward as well, because of the sensitive quality of this body. Accordingly, the form will reach the common nerve properly arranged, and it is not possible for the forms of visible objects to extend to the final sensor in any way other than this, for it is not possible for forms to reach the common nerve properly arranged unless their passage occurs in this way.[19]

[2.16] And since forms extend according to this arrangement, the form reaching any point on the surface of the *glacialis* must always extend along the same line to the same point at the common nerve where the form [as a whole] reaches. But the form reaching any given point on the surface of the *glacialis* also invariably reaches the same point on the surface of the vitreous [humor]. From this it follows that from any two points that are correspondingly situated on [each of] the two eyes two forms extend to the same point in the common nerve.[20]

[2.17] It also follows that the sensitive body pervading the hollow of the nerve should be somewhat transparent so the forms of light and color can appear in it, and it follows, as well, that its transparency should be like the transparency of the vitreous humor so that the forms are not refracted when they reach the posterior surface of the vitreous humor at the hollow of the nerve, for when the transparency of two bodies is identical, the forms will not refract. And it is not possible for the forms to be refracted at this surface, because this surface is spherical and is formed from a sphere. However, if the forms were to refract at this surface, they would not get very far from it before they were distorted.[21] So there can be no refraction of forms at this surface.

[2.18] If the transparency of the sensitive body pervading the hollow of the nerve is no different from the transparency of the vitreous humor, there will be no variation [in transparency] to cause a variation in the form. And although the form extends in tandem with sensation, the transparency of the sensitive body that pervades the hollow of the nerve is no different from the transparency of the vitreous body. However, the transparency of this body is intended only to let forms extend through it along the lines that transparency requires. So it is transparent only so that it can receive the forms of light and color and so that those forms can appear in it, for a body does not receive light and color, nor do the forms of light and color pass through it, unless it is [completely] transparent or there is some transparency in it. And light and color do not appear in a transparent body unless there is some opacity to go along with its transparency, and for this reason the *glacialis* is neither exquisitely transparent nor inordinately opaque. Hence, the sensitive body that pervades the hollow of the nerve is transparent, but along with that there is some opacity in it. So the form passes through this body on account of the transparency it possesses, and forms are revealed to the sensitive power in it on account of the opacity it possesses. And the final sensor perceives the forms of light and color only from the forms reaching through this body when they arrive at the common nerve, and it perceives light from the illumination of this body and color from its coloring.[22] This, then, is how forms will reach the final sensor and how the final sensor will perceive them.

[2.19] Having shown that forms are refracted at the surface of the vitreous [humor], we should add that the axis of the cone of radiation cannot be obliquely incident upon this surface, nor can any other line be perpendicular to that surface.[23] For if the [visual] axis were to intersect this surface obliquely, then, when forms arrived at this surface, they would vary in arrangement and would change their orientations. But forms can reach the surface of the vitreous humor properly arranged only when the axis of the cone is perpendicular to this surface. For when the eye faces some visible object and the visual axis reaches the surface of that visible object, the form of that visible object will reach the surface of the *glacialis* arranged according to the actual arrangement of the parts on the surface of the visible object, and the form of the point on the surface of the visible object at the extremity of the [visual] axis will reach the point on the surface of the *glacialis* intersected by that axis. Furthermore, the forms of all the points on the surface of the visible object that are equidistant from the point at the extremity of the [visual] axis will extend to points of the forms on the surface of the *glacialis* that are equidistant from the point where the [visual] axis intersects it, for all of the points reaching the surface of the *glacialis* lie on radial lines extending from the center of the eye to the surface of the eye, and the visual axis is perpendicular to the surface of the *glacialis*. Therefore, all the planes containing the [visual] axis and intersecting the surface of the *glacialis* will be perpendicular to its surface.

[2.20] And it has already been shown that the surface of the vitreous humor is either plane or spherical and that its center is not the center of the eye. Therefore, if the visual axis intersects that surface obliquely rather than orthogonally, only one of the planes containing the [visual] axis will be perpendicular to that surface, so all the remaining planes containing the [visual] axis will be oblique to it, for such is a property of lines that are oblique to plane and spherical surfaces. Let us then imagine a plane containing the [visual] axis and perpendicular to the surface of the vitreous humor [and let it be] extended beyond the [visual] axis. It will therefore intersect the surface of the vitreous [humor] and the surface of the *glacialis* and will describe two different common sections in them. Then let us imagine two points on the common section of this plane and the surface of the *glacialis*, and let them be equidistant from the point where the [visual] axis intersects the *glacialis*. Let us also imagine two lines extending from the center of the *glacialis* to these two points. Therefore, the two lines will lie along with the [visual] axis in the same plane that is perpendicular to the surface of the vitreous humor, for, along with the centerpoint, the two points form three points on this surface. Moreover, the two angles formed by these two lines with the [visual] axis will be equal, and these two lines will intersect the common section on the surface of the vitreous [humor] at two points. Likewise, the [visual] axis will intersect this common section at the point midway between these two points. Therefore, if the surface of the vitreous [humor] is plane, the common section will be a straight line.[24] But if the [visual] axis is oblique to the surface of the vitreous [humor], and the plane forming the common section is perpendicular to this surface, then the [visual] axis will be oblique to the common section [of the two planes], i.e. to this line. So the sides of the two angles will be unequal, because, if the [visual] axis were perpendicular to this common section, it would be perpendicular to the surface. But since the two aforementioned angles are unequal while the two angles at the center of the *glacialis*, which is the endpoint of the [visual] axis, are equal, then the two segments of the line forming the common section will be unequal. Thus, the two points at the end [of those segments] will lie at different distances from the point on the [visual] axis that intersects this line.[25] But it is to these two points that the forms of the two points that are equidistant from the [visual] axis on the surface of the *glacialis* reach, for they lie at the endpoints of the two radial lines passing through these two points. Now the point lying on the [visual] axis at the surface of the vitreous [humor] is the one to which the form of the point on the [visual] axis at the surface of the *glacialis* extends. Granted that the [visual] axis is oblique to the surface of the vitreous [humor], granted that the surface of the vitreous [humor] is plane, granted that the two points of the form that reaches the surface of the *glacialis* are equidistant from the point reached by the [visual] axis, and granted that these two points lie on a plane that is perpendicular to the surface of the vitreous [humor], then, when they extend onward to the surface of the vitreous [humor], they will lie at unequal distances from the point reaching along the [visual] axis.[26]

[2.21] If the axis is oblique to the surface of the vitreous [humor] and the surface of the vitreous [humor] is plane, the common section of any plane containing the [visual] axis and intersecting the surface of the vitreous [humor] will form two unequal angles with the [visual] axis, except for a single plane, and that is the plane that intersects the surface of the vitreous [humor] orthogonally, for the common section formed by it will subtend two right angles with the [visual] axis. But the [visual] axis will be oblique to the common sections of every other [intersecting] plane. And if the two aforesaid angles are unequal while the two angles opposite the two portions of the common section—i.e., the angles at the center of the surface of the *glacialis*—are equal, then the two portions of the common section on the surface of the [vitreous] humor will be unequal, and the two endpoints of this common section will lie at different distances from the point on the [visual] axis. However, the two portions of the common section on the surface of the *glacialis* will be equal, and the two endpoints of this common section will be equidistant from the point where the [visual] axis intersects the surface of the *glacialis*. This being the case, when the form passes from the surface of the *glacialis* to the surface of the vitreous [humor], its arrangement will not be the same as it is on the surface of the *glacialis* or as it is on the surface of the visible object.

[2.22] The same will also hold when the vitreous surface is spherical and the [visual] axis strikes it obliquely, for when the points on the surface of the *glacialis* that lie equidistant from the [visual] axis reach the surface of the vitreous [humor], their distance from the axial point will be unequal. For when the [visual] axis is not perpendicular to the surface of the vitreous [humor], and when the surface of the vitreous [humor] is spherical, this axis will not pass through the center of [the sphere that defines the surface of] the vitreous [humor], but it will pass through the center of [the sphere that defines] the surface of the *glacialis*. Therefore, the lines that extend from the center of the *glacialis* to points that are equidistant from the point of [intersection of] the [visual] axis on the surface of the *glacialis* subtend equal angles with the axis at the center of the *glacialis*. And if this is so, but the center of the *glacialis* is not the center of the vitreous [humor], then these lines will demarcate unequal arcs on the surface of the vitreous humor.[27] And only two lines lying in the same plane as the [visual] axis and subtending right angles with it mark off equal arcs on the surface of the vitreous [humor], and those are lines that lie on a plane that intersects the surface of the vitreous [humor] orthogonally. Thus, if the [visual] axis is oblique to the surface of the vitreous [humor], the forms that reach the surface of the vitreous [humor] will be improperly arranged, whether that surface is plane or spherical.

[2.23] But if the axis is perpendicular to the surface of the vitreous [humor], it will be perpendicular to all the common sections [on it], and any two lines that extend from the center of the *glacialis*, which is a point on the [visual] axis, will subtend right angles with the [visual] axis and will mark off two equal segments on the common section on the surface of the vitreous [humor]. Moreover, the two endpoints of the two equal segments will be equidistant from the point of [intersection of] the [visual] axis on the surface of the vitreous [humor], whether the surface of the vitreous [humor] is plane or spherical. Under all circumstances, then, the form reaches the surface of the vitreous with its parts arranged as they are on the surface of the eye only when the [visual] axis is perpendicular to the surface of the vitreous [humor]. Moreover, the [final] sensor only senses the form as it actually is when that form reaches it, and the [final] sensor perceives the arrangement of the parts of the visible object as it really exists on the surface of the visible object. It is therefore not possible for the forms to reach the surface of the vitreous [humor] without having their parts arranged as they really are [on the surface of the visible object]. It is not possible, then, for the visual axis to be oblique to the surface of the vitreous [humor]; so it will be perpendicular. Thus, all the remaining radial lines will be oblique to this surface, whether it is plane or spherical, because they intersect the [visual] axis at the center of the *glacialis*. However, none of these lines, except the [visual] axis, passes through the center of the surface of the vitreous [humor], assuming it is spherical, because it is perpendicular to this surface, but the center of the surface of the *glacialis* is not the [same as the] center of the surface of the vitreous humor. And since it has been shown that forms reaching the surface of the *glacialis* only reach the hollow of the nerve after having been refracted along oblique lines, and since their refraction happens only at the surface of the vitreous [humor], and since the [visual] axis is perpendicular to this surface while all the remaining radial lines are oblique to this surface, then, when the forms reach the surface of the vitreous [humor], all of the points on them except for the axial point will be diverted, for this point extends straight along the [visual] axis until it reaches the bend in the hollow of the nerve. Therefore, no form other than [that of] the point on the [visual] axis that reaches the surface of the *glacialis* extends to the hollow of the nerve along a straight line; all the rest of the [forms of the] points reach the hollow of the nerve along oblique lines.

[2.24] Thus, when the eye perceives a visible object that faces the middle of the eye, and since the [visual] axis lies inside the cone of radiation that encompasses that visible object, the form of that visible object will reach the surface of the *glacialis* along straight radial lines. From this surface forms then extend along straight, radial lines as well, until they reach the surface of the vitreous [humor]. Then, from this surface the [form of the] axial point will reach straight along the axial line until it reaches the place where the hollow of the nerve bends. Meantime, all the remaining points are refracted along lines that intersect the [original] radial lines, and they maintain the same arrangement until they reach the place where the hollow of the nerve bends. Thus, the form will arrive at this place arranged according to its order on the surface of the *glacialis* as well as its order on the surface of the visible object [itself]. However, the disposition of refracted forms is not like the disposition of forms that pass straight on, for refraction will necessarily change them is some way.[28] Therefore, it follows from this circumstance that the point extending straight along the [visual] axis to the place where the hollow of the nerve bends is more clearly perceived than all the [other] points of [such] forms.[29]

[2.25] Also, the refraction of points reaching the surface of refraction nearer the axial point is less, and [that of those reaching it] farther [from that point] is greater, for refraction depends entirely upon the angles that are formed by the [radial] lines along which the forms arrive and the normals to the surface of refraction. And refraction of lines forming smaller angles with the normals will occur at smaller angles, whereas refraction of lines forming greater angles with the normals will occur at greater angles. But radial lines that are nearer the [visual] axis are less oblique to the surface of refraction, so they form smaller angles with the normals to the surface of refraction. Those, on the other hand, that are farther from the [visual] axis are more oblique to the surface of refraction, so they form greater angles with the normals. And forms that suffer less refraction are clearer [to sight], whereas forms that suffer greater refraction are less so.[30] Thus, the point on the [visual] axis [whose form] reaches the place where the hollow of the nerve bends is more clear[ly seen] than all the rest of the points, and whatever point is nearer it is more clear[ly seen] than one lying farther from it.

[2.26] Now these forms are the ones that extend to the common nerve, and it is from these that the final sensor perceives the form of the visible object. And since this form arrives at the place where the hollow of the nerve bends with varying dispositions—i.e., in such a way that its axial point is clearer than all the remaining points and that whatever point lies nearer it is clearer than one farther from it—the form that reaches the common nerve [and] on the basis of which the sensitive faculty perceives the form of the visible object will vary in disposition. So the point on it that corresponds to the axial point on the surface of the visible object is clearer than all the other points of the form, and the nearer to it any point lies, the clearer it is.

[2.27] And when the dispositions of visible objects are examined, and when the way sight perceives [several] visible objects at the same time is determined along with how it perceives the parts of a single visible object, the results will be found to agree with what we have shown. For when a viewer faces several visible objects at the same time, and when his eye remains steady, and he does not shift it, he will find that the visible object directly along his central line-of-sight is clearer than those to the side of it, and [he will find] that what lies nearer his central line-of-sight will be clearer. By the same token, when the viewer looks at a large visible object, and his line-of-sight is aimed directly at the midpoint of that visible object and remains steady, he will perceive the middle of that visible object more clearly than he will the outer edges of that object. This will become eminently clear when several visible objects are adjacent to one another, and the viewer faces one of the objects that is in the midst of the rest, for in that case, if his focus remains steady, he will perceive that middle object with clarity; and along with that he will also perceive those that surround it, but not clearly. This is especially obvious when those visible objects occupy considerable space, for then there will be a significant difference between the perception of the middle object and the perception of the outer ones.

[2.28] Subsequently, if he shifts his viewpoint under these conditions so that he looks directly at an object other than the visible object he faced before, he will perceive this second object more clearly. The first one, however, he will perceive more dimly. And if he faces the one at the end and focuses on it, he will perceive it more clearly than he did under the original condition because of its distance from his line-of-sight [at that time], and at the same time he will perceive the middle object more dimly, even though it is nearer to him. Moreover, there will be a significant difference [in clarity] between his perception of the middle object when he focuses on the object at the end and his perception of the middle object when he focuses on it.

[2.30] From this experiment it will therefore be clear that vision [taking place] through the center of the eye, along the [visual] axis as defined by us, is clearer than vision at the edge of the eye, along lines surrounding the [visual] axis. It has therefore been shown that vision [taking place] along the axis of the visual cone will be clearer than vision [taking place] along all [the other] radial lines and, moreover, that vision [taking place] along a line nearer the [visual] axis is clearer than [vision taking place] along a line that is farther [from the visual axis].

[CHAPTER 3]

[3.1] The sense of sight, in fact, perceives none of the visible properties unless they are embodied.[31] Moreover, many inherent properties, as well as many accidental properties combine together in a body, and sight perceives many of the inherent and accidental properties possessed by bodies.[32] Color is one of those properties that occur in bodies, and light as well, and the sense of sight perceives both of these in bodies. It also perceives other properties besides these two, e.g., shape, spatial disposition, size, motion, and other properties that we shall specify later.[33] It also perceives similarities and differences among colors, as well as similarities and differences among lights. So too, it perceives similarities among shapes, and spatial dispositions, and motions.

[3.2] Furthermore, these properties are not all perceived in the same way, nor is it through brute sensation that every one of them is perceived.[34] For, when the eye perceives two individuals at the same time, and when they are similar in structure, it will perceive [that they are] individuals, and it will perceive that they are similar. But the similarity of the two forms of the two individuals is neither the [two] forms themselves nor either one of them.

[3.3] But since sight perceives the individuals by means of forms coming to the eye from the two individuals, it therefore perceives the similarity of the two individuals on the basis of the similarity of the two forms reaching from the form [of each of those individuals][35] to the eye. But the similarity of the two forms is neither the forms themselves nor a third form pertaining to similarity.

[3.4] But yet the similarity of the two forms consists in their agreement in some respect. Therefore, the similarity of the two forms will only be perceived through a comparison of one to the other and from a perception of what it is in virtue of which they are similar. And since sight perceives similarity, but there is no third form in it by which it perceives similarity, sight cannot perceive the similarity of the two forms unless it compares one to the other.

[3.5] Likewise, sight perceives the difference between two different forms by a comparison of one to the other.[36]

[3.7] And since that is the case, the visual sense does not perceive similarity and difference among forms through brute sensation but through a comparison of forms among each other.

[3.8] In addition, when sight perceives two colors of the same kind, but one of them is more vivid[37] than the other, e.g., myrtle-green and pistachio-green, it will perceive that they are green, but it will also perceive that one of them is of a more vivid green. So it will differentiate between two greens, and it will perceive their similarity in greenness as well as their difference in vividness or dullness.

[3.9] Nonetheless, differentiation between two greens is not the actual sensation of green, for the sensation of green arises from the [general] "greening" of sight as well as from the [specific] "greening" of sight by both greens, so it will perceive that they are of the same kind.[38] Therefore, the perception by sight that one green is more vivid than the other and [yet] that the two are of the same genus represents a differentiation of the coloring that occurs in sight, not the actual sensation of color.

[3.10] The same also holds when two colors are similar in vividness and are of the same kind, for sight perceives the two colors, and it perceives that they are of the same kind and that they are similar in vividness.

[3.11] And the same holds for the effect of light on sight, for sight perceives the light and differentiates between strong and weak light.

[3.12] Thus, the perception by sight of similarity and difference among colors, of similarity and difference in light, and of similarity in the outlines, shapes, and spatial dispositions of the forms of visible objects, as well as of differences among them, arises only from comparing them to one another, not from brute sensation.

[3.13] In addition, the sense of sight perceives the transparency of [completely] transparent bodies as well as the transparency of bodies that are not absolutely transparent, but it does not perceive such transparency through any other procedure than comparison. For transparent stones of slight transparency are not perceived by sight to be transparent until after they are placed against the light; then the light will be perceived behind them, and it will [thereby] be perceived that they are transparent. Likewise, the transparency of no transparent body will be perceived by sight until after a body or light that lies behind it is perceived, and along with that it will be perceived through differentiation that what appears from behind is different from the transparent body [through which it appears].

[3.14] However, the perception that what lies behind the transparent body is different from that [transparent] body is not [arrived at] by brute sensation; rather, it is a perception [arrived at] by judgment.[39] And since transparency will only be perceived [indirectly], by implication, it will be perceived only through differentiation[40] and judgment.

[3.15] Writing, as well, will be deciphered only by [the reader's] discerning the forms of the letters, along with their combinations, and by comparing them to similar ones already known to the writer.[41] And by the same token, when the way many visible characteristics are perceived is examined, it will be found that they are not perceived through brute sensation, but through judgment and differentiation.

[3.16] And since this is the case, not everything that is perceived by sight is perceived through brute sensation; instead, many visible characteristics will be perceived through judgment and differentiation in conjunction with the sensation of the form that is seen.

[3.17] However, sight does not possess the power to differentiate; the faculty of discrimination[42] differentiates these properties. Nonetheless, the differentiation of these visible characteristics that is carried out by the faculty of discrimination cannot take place without the mediation of sight.

[3.18] Sight also perceives many things by means of recognition, so it recognizes that a human is a human, that a horse is a horse, and that Socrates is Socrates when it has seen the same thing before. And it recognizes familiar animals, trees, shrubs, and stones when it has seen them or their like before. Moreover, it recognizes all familiar characteristics[43] that are in visible objects.

[3.19] Sight perceives what kind of thing[44] a visible object is through recognition exclusively. But recognition is not perception by brute sensation, for sight does not recognize everything it has seen before. And when sight perceives some particular individual and is later removed from it for a long time, then sees that individual again but does not remember it, it does not recognize that individual, for it does not recognize what it knew before unless it remembers. Therefore, if recognition were perception by brute sensation, it would follow that, when sight saw some individual that it had seen before, it would immediately recognize it on seeing it again under all conditions, but such is not the case.

[3.20] And since recognition occurs only through remembering, recognition is not perception by brute sensation. Perception through recognition does, however, entail perceiving by some means of judgment, for recognition is the perception of similarity between two forms—i.e., of the form sight perceives at the moment of recognition and the form of that visible object, or its like, that it has perceived one or more times before. Accordingly, there will be no recognition without remembering, for if the original form is not present in memory, sight will not perceive the similarity of the two forms, and so it will not recognize the visible object.[45]

[3.21] Recognition, moreover, entails recognition of the form of some individual object or of the form of its kind. Therefore, the recognition of an individual arises from the assimilation of the form of an individual at the time sight perceives that individual to another form that it has perceived before. Recognition of kind arises from an assimilation of the form of a visible object to other forms resembling it among individuals of its kind that it has perceived earlier.

[3.22] But perception of similarity entails judgment, for it only occurs by means of comparing one form to another. Therefore, recognition is merely a form of judgment; yet this form of judgment is distinct from other [forms of] judging, because, rather than involving an evaluation of all the characteristics of a form, recognition will occur through defining features.[46] Thus, when sight perceives a certain characteristic in a form and remembers an earlier form [with that characteristic], it will immediately recognize the form. But this is not the case with everything that is perceived through judgment, for various things that are perceived through judgment are perceived only after a scrutiny of all the characteristics they possess.

[3.23] For instance, at the very moment a writer sees the combination "ABCD," he will immediately grasp that it is "ABCD". Therefore, from his perception that "A" comes first and that "D" comes last, he will grasp that it is "ABCD". Likewise, if he sees "DOMINUS" written, he will immediately grasp it through recognition and habit. And the same holds for all words familiar to him; when the writer sees them, he will immediately grasp them without having to differentiate one from the other. But such is not the case when the writer sees an unfamiliar written word that he has not seen before, for the writer will not recognize this word until after he has differentiated its letters, and [only] afterwards will he recognize the word. Thus, when any form, or its like, that has not been seen before is perceived by sight, sight will not perceive what that form represents until after it has differentiated all or several of the characteristics of that form.

[3.24] On the other hand, a familiar form will be perceived immediately by sight through a perception of certain of the characteristics possessed by that form. Therefore, whatever is perceived through recognition will be perceived by means of a defining feature, but not everything that is perceived through judgment will be perceived by means of a defining feature. Still, several characteristics of visible objects are perceived only through recognition, and the perception of what kind of thing a given visible object is, or what kind of thing a given object perceived by another sense is, will occur only through recognition. And the faculty of recognition is allied with the faculty of sensation, so the perception of sensible characteristics is fully achieved only through recognition.

[3.25] However, recognition does not occur through brute sensation. Therefore, of [all] the characteristics that are perceived by visual sensation, some are perceived through brute sensation, some through recognition, and some through judgment and differentiation.

[3.26] Also, several of the visible characteristics that are perceived through judgment and differentiation are perceived in an extraordinarily short time, and it is not apparent that their perception involves judgment and differentiation because of the speed of the inferential process through which these characteristics are perceived. For shape, size, transparency, and similar characteristics that are possessed by visible objects are generally perceived by means of an extremely quick perception. But there is no perception at that time that their perception involves judgment. Since the perception of these characteristics does involve judgment, however, it is only because of the obviousness of their interrelationships and the faculty of discrimination's familiarity with such characteristics [that the process of judgment goes unnoticed by the perceiver]. Accordingly, as soon as this form reaches [the eye], sight perceives all the characteristics it possesses, and so they will be differentiated by it at the moment of perception.

[3.27] And the same applies to logical argument and all forms of reasoning when the premises are evident and general; the faculty of discrimination does not require much time to reach the conclusions entailed by them but, instead, will understand the conclusion immediately after grasping the premises.

[3.28] The reason is that the faculty of discrimination does not proceed by juxtaposing and ordering premises in the way that an argument based on terms does, for its conclusions will not be based on words or on the arrangement of premises.[47] The procedure followed by the faculty of discrimination is not like this, because the faculty of discrimination grasps the conclusion without needing words and without needing an arrangement of premises or an arrangement of words.

[3.29] For the arrangement of words in an argument is only one way in which the faculty of discrimination reaches a conclusion, but to reach a perceptual conclusion the faculty of discrimination does not need [this particular] mode of reasoning or [this particular] arrangement of [premises leading to] a perceptual conclusion.

[3.30] Therefore, the visible properties that are perceived through judgment are generally perceived very quickly, and for the most part it does not seem as if their perception is arrived at through judgment. Even in the case of visible properties that are perceived through judgment and differentiation, since they are frequently perceived through judgment, and since the faculty of discrimination [already] knows these characteristics if it sees them later, it will perceive them through recognition without having to differentiate all the properties in objects seen later, and it will do so through defining features alone. Moreover, it will reach its conclusion by means of recognition without having to go through the steps of argumentation, as happens, for example, with the writer who sees an unfamiliar word for the first time.

[3.31] And the same holds for all deductions that are made through judgment when their premises are evident and their conclusions true; for when the soul[48] realizes that the conclusion is true and reaches that conclusion frequently afterward, the conclusion will be transformed into an evident premise. Thus, when the soul sees the premise, it will immediately reach the conclusion without having to go through the steps of argumentation.

[3.32] Moreover, several deductions whose truth the faculty of discrimination knows only through judgment are deemed to be first principles and are thought to be grasped naturally through pure understanding alone, not by means of judgment. For example, it is assumed that [the proposition] "the whole is greater than the part" will be judged naturally by the understanding to be true and that the perception of its truth does not involve judgment. But the fact that the whole is greater than the part will only be understood through judgment, for there is no way for the differentiating [faculty] to grasp that the whole is greater than its part without first knowing the meaning of "whole" and "part" and the meaning of "greater." For if it does not know the meaning of "parts," it will not know the meaning of "whole." But the meaning of "whole" is simply "totality," whereas to be a "part" means simply to be "something," and "greatness" is a relation [of something] to something else, so to be "greater" than something else means to be more than equal to it. So the test of whether every whole is greater than its part is whether the former is somehow equal to the latter yet exceeds it by some amount. From the conjunction of the meaning of "greater" with the meaning of "whole" in [terms of] additional amount, it becomes apparent that the whole is greater than the part. And since the conclusion that the whole is greater than the part is reached only in this way, its realization occurs by judgment alone, not by natural understanding. So what occurs by nature in the understanding is merely the perception of the conjunction of the meaning of "whole" and the meaning of "greater" in [terms of] additional amount.[49]

[3.33] Now the arrangement of this syllogism is as follows: (1) Every whole exceeds the part. (2) Everything that exceeds something else is greater than it. (3) Therefore, every whole is greater than its part. But the speed with which the faculty of discrimination reaches the conclusion is due only to the fact that the major premise is evident.[50] Nonetheless, the realization by the faculty of discrimination that the whole is greater than its part occurs through judgment, and since the major premise is obvious to it, it will realize the conclusion as soon as the specific minor premise occurs to it, and that specific premise involves the meaning of "whole" as exceeding the part. And since the truth of the conclusion of this syllogism is absolutely certain in the soul and exists in memory, when the proposition occurs to it, the understanding accepts it without having to go through the steps of argumentation, so it realizes it by means of recognition alone.

[3.34] Everything of this kind is called a "first principle" by mankind. And it is supposed that such will be grasped by pure understanding so that there is no need of anything but pure understanding to realize its truth.[51] And the reason for this is that such propositions are grasped immediately.

[3.35] Therefore, syllogisms whose premises are universal and obvious are grasped in an imperceptible amount of time. Then, if the syllogism is frequently reiterated, the intellect will grasp it in such a way that the truth of its conclusion will be assimilated or certified in the soul, at which time the conclusion will become an evident premise.[52] In this way the faculty of discrimination will grasp numerous deductions that are reached by means of judgment in an imperceptible amount of time without having to go through the steps of argumentation.

[3.36] Furthermore, how visible characteristics will be perceived by judgment and recognition is often not apparent, for their perception will occur very quickly, and the perception of how they are perceived will occur only through a second deductive process that follows the initial deductive process through which the visual perception was realized. However, the faculty of discrimination does not use this second deductive process at the time it perceives a given visible characteristic, nor does it discern how it perceives that characteristic, nor can it because of the speed with which it perceives characteristics by means of recognition and by deduction whose premises are evident and indubitable to the soul. For this reason it does not notice how it grasps the truth of various true propositions that are perceived by means of recognition, and their truth is affirmed on the basis of a judgment made when they are realized. For when these propositions occur to the faculty of discrimination, it immediately judges that they are true by means of recognition, but at the point of recognition it does not investigate how that truth was verified before, nor does it investigate how it perceives that the propositions are true when they occur to it.

[3.37] Furthermore, the second deductive process through which the faculty of discrimination perceives how it perceives what it perceives is not a process that occurs terribly quickly; instead, it requires deliberation. For perceptions differ; some occur naturally to the understanding,[53] some occur through recognition, and some occur through deliberation and discernment. Therefore, the perception of how the perception occurs and that it is of such-and-such a kind is reached only through a deductive procedure and a differentiation that is not swift. Accordingly, at the instant of perception, how the visible properties perceived through judgment are [themselves] perceived is usually not evident.

[3.38] Moreover, man is inherently apt to differentiate and deduce without difficulty or effort, and he does not perceive that he is deducing unless he deduces with difficulty. For when he does not exert effort and thought, he does not perceive that he is engaged in deduction. Therefore, customary deductions whose premises are evident and that do not demand effort are natural to man, and because of this he does not perceive that, when he is grasping such conclusions, he is grasping them through deduction. Evidence that man is inherently apt to deduce and that he engages in deduction without perceiving that he is deducing is found in children at an early stage in their growth. For a child grasps many things that a grown man discerns, and he uses many procedures for differentiation. For instance, when two things of the same kind, such as two fruits, are shown to a child, and when one is more attractive than the other, he will accept the more attractive one and reject the other. But the choice of the more attractive object is based exclusively upon a comparison of one to the other. So the child's perception that the attractive one is attractive and that the ugly one is ugly—and, likewise, his choosing the more attractive over the less attractive one—indicates that he chooses it only after comparing one to the other, perceiving the form of each of them, and perceiving by deduction the attractiveness of the more over the less attractive one. But the choice of the more attractive is based entirely upon a major premise that asserts that what is more attractive is better, and what is better is more worthy of being chosen. The child therefore uses this premise, but he does not perceive that he is using it.

[3.39] And since this is the case, the child deduces and differentiates.

But there is no doubt that the child does not know what a deduction is and does not perceive whether he is deducing or not when he does. Moreover, if one were to try to teach him what deduction is, he would not understand. Yet, since the child does deduce yet has no idea what a deduction is, it follows that the human soul is inherently apt to engage in deduction without difficulty or effort, yet when a man perceives that something is of such-and-such a kind, he does not perceive that he achieves this perception through deduction. It is only obvious conclusions whose premises are exceedingly obvious that are drawn through judgment, though; when conclusions whose premises are not particularly obvious and which entail difficulty are drawn by a man, he may well perceive that he makes them through judgment when they really are a matter of differentiation.

[3.40] From everything we have said, then, it has been shown that some characteristics that are perceived by sight are perceived through brute sensation, others through recognition, and others yet through differentiation, deduction, judgment, and syllogism; and [it has also been shown] that the manner in which particular characteristics are perceived by sight is usually not evident because of the speed with which it perceives through recognition, and because of the speed with which it grasps visible properties through deduction, and also because the faculty of discrimination is inherently apt to deduce without effort or difficulty, doing so instead naturally and customarily.

[3.41] Furthermore, that faculty does not need to go through the deductive steps to perceive any of the particular characteristics that are frequently seen.

[3.42] Moreover, characteristics that are frequently seen and are perceived through judgment and differentiation exist in the soul in such a way that mankind does not perceive that they are ensconced there;[54] nor does their being ensconced there have a perceptible beginning, for it is from childhood that man perceives visible objects, and it is from childhood that some differentiation occurs in him, especially the differentiation through which sensible distinctions are perceived. Thus, he perceives sensible characteristics by judgment and differentiation and gains a knowledge of sensible characteristics, and these sensible characteristics are continually presented to him until they are ensconced in his soul in such a way that he does not even perceive their being ensconced. Hence, when a particular characteristic that is [already] ensconced in his soul is presented to him, he will perceive it through recognition the moment it is presented. But in the process he does not perceive how he perceives it, or how he recognizes it, or how the knowledge of that characteristic has come to be ensconced in his soul. Accordingly, all of the particular characteristics that are perceived through judgment and differentiation and that are frequently re-presented [to him] have already been grasped by man at an earlier time and have become ensconced in the soul so that a universal form of some particular property is created and ensconced in the soul.[55] As a result, such properties are perceived without [the soul's] having to go through the deductive steps it went through initially, and without having to undergo the process of judging through which the veracity of that characteristic is grasped,[56] and without perceiving how the perception of that property arises when it arises, and without perceiving how recognition occurs at the moment of perception. So there is no lingering need to retrace the steps of deduction except in the case of particular characteristics possessed by particular individuals, such as the shape of a particular thing (i.e., in an individuated object), or the spatial disposition of an individual visible object, or the size of an individual visible object, or a comparison of the color of one individual visible object with the color of another visible object, and the like. In these ways the perception of all particular properties of visible objects will take place.

[3.43] And now that all of these points have been explained, we shall begin to explain how each of the particular visible properties is perceived by sight and the kinds of deductive processes the faculty of discrimination employs in grasping the properties perceived by the sense of sight.

[3.44] The particular properties that are perceived by sight are numerous, but they are generally reduced to twenty-two, namely: *light, color, distance,*[57] *spatial disposition,*[58] *corporeity,*[59] *shape, size, continuity, discontinuity* or *separation, number, motion, rest, roughness, smoothness, transparency;* likewise: *opacity, shadow, darkness, beauty, ugliness, similarity,* and *difference* among all particular characteristics as well as among all the forms composed of particular characteristics. These, then, are all of the things that are perceived by the sense of sight. If there is any visible characteristic besides these, it will be subsumed under one of them: e.g., arrangement, which will be subsumed under spatial disposition; writing and drawing, which are subsumed under shape and arrangement; straightness, curvature, concavity, and convexity, which are subsumed under shape; multitude and dearth, which are subsumed under number; equality and excess, which are subsumed under similarity and difference; joy, laughter, and sadness, which are included in the shape of the face (and are therefore subsumed under shape); weeping, which is included in the shape of the face along with the streaming of tears (so it is subsumed under shape and motion); moistness and dryness, which are subsumed under motion and rest, for moistness is perceived by the sense of sight only from the fluidity of the moist body and from the motion of one of its parts with respect to another, whereas dryness is perceived by sight only through the rigidity of the parts of the dry body as well as through the lack of motion in fluidity. And likewise, every particular property perceived by sight is subsumed under the headings that we described earlier, and all of the visible properties are as we have claimed above.[60]

[3.45] This being the case, moreover, the differentiation and deduction carried out by the faculty of discrimination, as well as the recognition of forms and their defining features, will occur only through the faculty of discrimination's differentiation of the forms reaching into the hollow of the common nerve when the final sensor perceives them and through recognition of the defining features of those forms.

[3.46] Furthermore, the sensitive body reaching from the surface of the sensitive organ to the hollow of the common nerve—i.e., the visual spirit—is sensitive throughout, for the sensitive power extends through the whole of this body. Therefore, when the form reaches from the surface of the sensitive organ to the hollow of the common nerve, every part of the sensitive body will sense the form. And when the form arrives at the hollow of the common nerve, it will be perceived by the final sensor, and at that time differentiation and deduction will take place. Thus, the sensitive power senses the form of the visible object throughout the entire sensitive body that extends from the surface of the sensitive organ to the hollow of the common nerve, and the faculty of discrimination discerns the properties that the form possesses at the moment the final sensor perceives the form. This, then, is the way in which the forms of visible objects will be perceived by the sensitive power, as well as by the final sensor and the faculty of discrimination.[61] On this basis, moreover, it will be shown that the sensitive power senses the place on the sensitive organ where the form reaches, for it only senses the form according to the place where the form arrives.

[3.47] It has also been shown in the preceding chapter that a form extends from any given point on the surface of the *glacialis* along a single, continuous line, following whatever bends or curves are in it, until it reaches a single point at the place where the form enters the hollow of the common nerve.[62] And since that is the case, the form arriving at an area on the surface of the *glacialis* extends from there to another area in the hollow of the common nerve. Moreover, the form of each of the different visible objects that are perceived together at the same time extends to a specific place in the hollow of the common nerve, and the forms of all of those visible objects reach the hollow of the common nerve, and the relative arrangement of those forms in the hollow of the common nerve will be the same as the relative arrangement of the visible objects themselves.[63] Thus, when the eye faces some visible object, the form of the light and color on that visible object reaches the surface of the eye and the surface of the *glacialis*, and it extends along the determinate paths that we described [earlier], preserving its proper arrangement, shape, and structure until it reaches the hollow of the common nerve. And it will be perceived by the sensitive power when it arrives at the body of the *glacialis* to pass through the whole of the sensitive body. Then, when it reaches the hollow of the common nerve, it is perceived by the final sensor, and the faculty of discrimination differentiates all the [visible] properties it possesses. But the form of color and the form of light reach the hollow of the nerve only because the sensitive body that pervades the hollow of the nerve is colored by the form of light and color and is illuminated by the form of light. So the form reaches the hollow of the common nerve, and the portion of the sensitive body that is in the hollow of the common nerve where the form of the visible object extends will be colored by the color of that visible object and illuminated by the light that is in that visible object. And if the visible object possesses one color, that portion of the sensitive body will be of one color, whereas if the parts of the visible object are of different colors, the parts of that portion of the sensitive body in the hollow of the common nerve will be of different colors. The final sensor, moreover, perceives the color of the visible object from the coloring that it encounters in that portion [of the sensitive body], and it perceives the light of the visible object from the illumination it encounters in that [same] portion. Meanwhile, the faculty of discrimination perceives various particular properties that are in the visible object by discerning the properties that are in that form at that spot—i.e., from the arrangement of the parts of the form, from the configuration of what surrounds that form, from the configuration of that form's parts, from the different colors, spatial dispositions, and arrangements of the parts of that form, and from their similarity and difference.[64]

[3.48] Furthermore, the light reaching from the colored visible object to the eye does not arrive on its own without color, nor does the form of the color reaching from the colored visible object to the eye arrive on its own without light, so the form of the light and color in the visible object arrives only as a mixture, and the final sensor perceives such forms only as mixtures. Notwithstanding this fact, the [final] sensor perceives the illuminated visible object and perceives that the light appearing in the visible object is distinct from the color, and this perception constitutes differentiation. [The capacity of] differentiation, however, belongs to the faculty of discrimination alone, not to the sensitive faculty. Yet when it is perceived by the discriminative faculty, this property becomes ensconced in the soul, so there is no need for repeating the deductive steps when every [such form] reaches it [afterward]; instead it remains ensconced in the soul. The faculty of discrimination's perception that the light in the object is distinct from the color in it, as well as its perception that the accidental light in the colored visible object is distinct from the color in it, is due to the fact that the light shining on any given visible object can vary, sometimes increasing and sometimes decreasing. Yet, despite these variations, its color remains the same; even though the brightness of the color may vary according to the variation in light, the color does not vary in kind. Moreover, accidental light may shine on a visible object through an aperture, but when that aperture is blocked, that visible object will be darkened. Hence, from the faculty of discrimination's perception of the variation in light shining on visible objects, and from its perception of the visible object's being illuminated at times and lacking light at others, it perceives that the colors possessed by visible objects are distinct from the light that shines on them. Therefore, the form of the colored visible object that the sensitive faculty perceives is a form mixed from the form of the light and color that are in the visible object, and the faculty of discrimination perceives that the color that is in it is distinct from the light that is in it. But this perception takes place according to recognition at the moment the form reaches the [final] sensor, for already ensconced in the soul is the notion that the light in every form that is a mixture of light and color is distinct from the color in that form.[65]

[Perception of Light and Color]

[3.49] Among the properties belonging to the form, the first one that the faculty of discrimination perceives is the kind of color [it possesses]. But what kind of color [the form possesses] will be perceived by the faculty of discrimination only through recognition, if the color of the visible object is among those colors familiar to it, so the faculty of discrimination's perception of what kind of color [the form possesses], which occurs through recognition, arises exclusively from a comparison of the form of its color to forms that it has perceived before, that is, from forms resembling [the form of] that color.[66] For, when it perceives a red color and perceives that it is red, sight will not perceive that it is red unless it recognizes it, and this recognition is due only to an assimilation[67] of it to things it has perceived before. If, however, sight had never perceived a red color until this time, it would not know that the red it perceives is red. Thus, when the color is one of the familiar colors, it will be known to sight through recognition, but if it is among colors that are unfamiliar to it, such that sight has never perceived such a color before, it will not be perceived by sight so as to be recognized by it; rather sight will assimilate it to colors that are near it, ones that it has already apprehended. Thus, brute sensation provides the basis for perceiving a color; then, when [that color] is transmitted to the eye over and over again, it will be perceived through recognition, specifically, of what kind of color it is.

[3.50] What kind of light [is being seen] will also be perceived by sight through recognition alone, for sight recognizes sunlight and differentiates it from moonlight and firelight, and thus it recognizes moonlight and firelight. Therefore, the perception by sight of what kind of light each of these is occurs only through recognition.

[3.52] Everything perceived by the sense of sight after light and color will therefore not be perceived through brute sensation but will be perceived through differentiation and deduction along with sensation. For everything that is perceived through differentiation and deduction will be perceived only by distinguishing the properties possessed by the sensible form, and likewise, everything that is perceived through recognition is perceived solely through a perception of the defining features conveyed by the sensible form. But the properties perceived through differentiation, deduction, and recognition are only perceived with the sensation of the form. The light in an intrinsically luminous body, however, is perceived by sight on its own, as it actually exists, on the basis of the sensation itself; and the light and color in a colored body illuminated by accidental light are perceived by sight mixed together, and [they are thus perceived] through brute sensation. Therefore, essential light is perceived by the sensitive faculty from the illumination of the sensitive body, and color is perceived by the sensitive faculty from an alteration and a coloring that occurs in the sensitive body. And along with this sort of perception of light by the sensitive body on the basis of accidental light mixed with that color, the sensitive faculty thus perceives the colored light of the body when the form of color reaches it, but it only perceives its light when the form of essential light reaches it.[68] So these are the only two visible properties that are perceived by sight through brute sensation.

[3.53] We shall say, further, that the perception of color, insofar as it is color, precedes the perception of what kind of color it is: that is, sight perceives color and senses that it is color before it senses what kind of color it is. For as soon as the form reaches the eye, the eye is colored, and when the eye is colored, it senses that it is colored, and thus it senses the color [itself]. Then, by differentiating the color and comparing it to colors already known to sight, it perceives what kind of color it is. Therefore, the perception of color, insofar as it is color, will occur before the perception of what kind of color it is, and the perception of what kind of color it is will occur through recognition. Evidence that sight perceives color, insofar as it is color, before it perceives what kind of color it is [can be found] in the fact that, when visible objects whose colors are strong—e.g., deep green, brown, and the like—are in a location that is not too dark, those colors are only perceived by sight in that location as color [in the generic sense].[69] Still, it senses that they are colors, but it does not discern what kind of colors they are at the beginning of perception. When the location is not too dark, however, and when sight scrutinizes [the colors] closely, it will perceive what kind of colors they are, or [it will do so] if the light increases and intensifies in that location. From this experiment it will therefore be clear that sight perceives color, insofar as it is color, before it perceives what kind of color it is.

[3.54] What sight perceives about color at the very moment it reaches the eye is its coloring-effect, and coloring is a sort of darkening or shading when the color is subtle. And if the visible object is of various colors, sight will first perceive the gradations in darkness of the various parts of the form of that visible object, or [it will perceive them] as various gradations of shadow. So the first thing that sight perceives from the form of color is a change in the sensitive organ and a coloring in it that consists of darkness or something resembling darkness. Then the sensitive faculty will differentiate that coloring. And if the visible object is illuminated, that color will be differentiated by sight, and what kind of color it is will be perceived when it belongs to the set of colors that sight has frequently perceived. Moreover, if it is one of the colors that sight has almost constantly perceived, [what kind of color it is] will be perceived in minimal time, so that there is no perceptible time between the instant when the color is recognized and the instant when it was first perceived as mere color. However, if it belongs to the set of colors that are not clear and that have only been perceived rarely by sight, or if the color lies in a dark, dimly lit place, what kind of color it is will be perceived by sight only after a perceptible interval of time. Furthermore, if the visible object is dark, so that there is only a little illumination in it, as is the case with what is perceived at night or in places that are extremely dark, only its darkness will be discerned by the sensitive faculty. From the perception of colors in dark places, therefore, it is clear that the perception of color, insofar as it is color, precedes the perception of what kind of color it is.

[3.55] A further indication that sight perceives color, insofar as it is color, before it perceives what kind of color it is can be found in the fact that, when sight perceives an unfamiliar color that it has never seen before, it will perceive that it is a color, yet it will nonetheless have no idea of what kind of color it is. But when it scrutinizes that color closely, sight will assimilate it to the nearest color resembling it.

[3.56] From these experiments, then, it is eminently clear that the perception of color, insofar as it is color, will precede the perception of what kind of color it is. And it has also been shown on the basis of these experiments that the perception of what kind of color it is will be based only on differentiation. Hence, what sight perceives through brute sensation is only [the fact of] color, insofar as it is color, as well as [the fact of] light, insofar as it is light, but other than this brute sensation perceives nothing without differentiation, deduction, and recognition.

[3.57] We should also point out that the perception of what kind of color it is invariably takes time, for the perception of what kind of color it is occurs only through differentiation and assimilation. But differentiation can only occur over time; therefore, the perception of what kind of color it is invariably takes time. There is clear evidence, moreover, that the perception of what kind of color it is invariably takes time in what is seen to happen in the motion of a top,[70] for if lines of various colors are painted on the outer surface of that top so as to extend from its center, on the side of its axle, to its outer edge, then, when the top is spun vigorously while one looks at it, he will perceive all of its colors as a single color different from all the colors on it, that color appearing to be composed of all the colors of those lines. So he will not perceive the lines or the differences among the colors.[71] Moreover, while this is going on, he will perceive the top to be still when its spin is extremely swift, for none of its points remains fixed in the same spot for any perceptible time, but instead every point spins through the entire circumference along which it revolves in minimal time. Accordingly, the form of the point radiates to the eye to [delineate] the circumference of a circle on [the surface of] the eye, so, in the minimal time [of the top's rotation] sight only perceives the color of that point according to the entire circumference of the circle as it is configured in the eye. Hence, in [this] minimal time, sight perceives the color of that point according to its entire path of revolution. And the same holds for all of the points on the surface of the top; sight perceives the color of each of them according to the entire circumference of the circle along which that point moves in minimal time, and every point lying the same distance from the center moves along the same circular circumference as the top spins. On this account, then, it happens that the color of every point among those that are equidistant from the center will appear on the circumference of the same circle during the minimal time that one revolution takes, so the colors of all the points on the entire circumference of that circle will appear mixed. Accordingly, the color of the surface of the top is perceived as a single color mixed from all of the colors that are on its surface.

[3.58] Thus, if sight were to perceive what kind of color it is in an instant, and if it needed no time to arrive at the perception of what kind of color it is, then at any given instant of the top's rotation it would perceive individually what kind of color all of the colors on the top are while it was moving. For if it needs no time to perceive what kinds of colors they are, then, in a portion of the time of revolution and at any instant during the time of revolution as the top spins, sight will perceive those colors in the same way that it will perceive what kinds of colors they are when they are motionless, for all the colors of familiar visible objects remain the same in kind whether they are in motion or at rest. At any instant, therefore, that the visible object moves, its color does not change. But since sight does not perceive what kinds of colors are on the surface of the top when the top spins vigorously, and since it does perceive what kind of colors they are when the top is immobile or spins slowly, then, that being the case, sight does not perceive what hue a given color is unless it remains fixed in the same spot for a perceptible amount of time, or unless it takes a perceptible amount of time to move a distance that is not so untoward as to distort the spatial relationship between that [spot of] color and the eye.[72]

[3.59] It will therefore be obvious from this case that the perception of what kind of color it is will invariably take time, and it will be obvious from this case that the perception of what kinds of things all visible objects are will invariably take time. For, since sight requires time to perceive what kind of color it is that it perceives through brute sensation, it requires all the more time to perceive the visible properties that are grasped through differentiation and deduction.[73] Therefore, the perception of what kinds of things visible objects are, as well as perception through recognition and perception through differentiation and deduction, will invariably take time, but more often than not it will take minimal time.

[3.60] We shall also point out that color, insofar as it is color, and light, insofar as it is light, will invariably take time to be perceived, i.e., that the instant when color will be perceived as color, insofar as it is color, and when light will be perceived as light, insofar as it is light, is different from the instant when the air transmitting the form makes initial contact with the surface of the eye. For color, insofar as it is color, and light, insofar as it is light, are only perceived by the sensitive faculty after the form arrives in the sensitive body, and they are not perceived by the final sensor until after the form reaches the hollow of the common nerve. But the way the form reaches the hollow of the common nerve is just the same as the way light extends from apertures through which it passes to bodies facing those apertures,[74] and light invariably takes time to pass from an aperture to a body facing the aperture, even though the time-interval is imperceptible. For there is only one of two ways in which light can extend from an aperture to a body facing the aperture: either the light will reach a portion of the air abutting on the aperture before it reaches a subsequent portion, after which it will pass to that portion, then on to another until it reaches the body that faces the aperture; or else the light will reach through the whole of the air between the aperture and the body facing the aperture, and it will reach that same body facing the aperture, all at the same instant. If the air receives the light in successive intervals, then light can only reach the body facing the aperture by moving, but motion will only occur in time. On the other hand, if the air as a whole receives the light all at once, the light's reaching the air after it was not there will happen only in time, even though it may be imperceptible. For when the aperture through which the light enters is blocked, and then the obstruction is removed, the instant when the obstruction is removed from the first portion of the aperture and when the air in the aperture on the side of the light is exposed is different from the instant when the light reaches the air contiguous with that portion inside the aperture and continuous with that air at all times. For light does not reach any portion of the air inside the aperture when it is blocked from light until after some portion of the aperture is exposed to the light, but no portion of the aperture is exposed in less than an instant. An instant is indivisible, though. Hence, no light reaches the inside of the aperture at the instant when that portion of the aperture is exposed, for the portion of the aperture that is exposed in an instant is not exposed in successive intervals, nor is that portion of the aperture that is exposed in a single instant a quantifiable portion. For only a point, which lacks dimension, or a line, which lacks breadth, is exposed in an instant, because it is only by being uncovered in successive intervals—and therefore by being moved—that an obstruction possessing length and breadth will be removed. Motion, however, will only occur in time, and the portion of the aperture that is exposed in a single instant lacks breadth.

[3.61] Thus, it consists of a point or a line, but neither a point, which lacks dimension, nor a line, which lacks breadth, constitutes a [quantifiable] portion of air. Therefore, a point, which lacks dimension, or a line, which lacks breadth, constitutes the point of the aperture that is exposed in an instant, and it represents nothing but the limit of some portion of the air inside the aperture, not an [actual] portion of the air. So a point, which lacks dimension, does not receive light, nor does a line, which lacks breadth, for only a body receives light. And since this is the case, none of the light reaches the air inside the aperture at the very instant the initial portion of the aperture is opened. Thus, the instant, or point in time, at which the light reaches the air inside the aperture, or a portion of that air, is different from the instant at which the initial portion of the aperture is opened. And between each of these two instants there is [an interval of] time. Therefore, light passes from the air outside the aperture to the air inside the aperture only over time, but this time is absolutely imperceptible because of the speed with which air receives the forms of light.[75]

[3.62] Likewise, when the eye faces a visible object after having not faced it, and when the air transmitting the form of the visible object makes contact with the surface of the eye after not having touched it, the form will pass from the air transmitting the form to the interior of the hollow of the common nerve only over time.[76] But the sense lacks a means of perceiving this time because it is so short and because the sense lacks adequate precision, being too weak to perceive whatever is exceptionally small. Thus, with respect to the sense, this time-interval amounts to an instant.

[3.63] In addition, the sensitive organ does not sense the forms reaching it until it undergoes their effect. Therefore, it does not sense color, insofar as it is color, or light, insofar as it is light, until after it has undergone the effect of the form of light and color. But the effect of the form of color and the form of light on the sensitive organ constitutes something of an alteration, and alteration only occurs over time. Therefore, sight does not perceive color, insofar as it is color, or light, insofar as it is light, except over time. Moreover, during the time that the form reaches from the surface of the sensitive organ to the hollow of the common nerve, the sensitive power that pervades the entire sensitive body will perceive the color, insofar as it is color, and the light, insofar as it is light, and when the form reaches the hollow of the common nerve, the final sensor will perceive the color, insofar as it is color, and the light, insofar as it is light. Hence, the perception of color, insofar as it is color, and light, insofar as it is light, occurs at a time following the time when the form reaches from the surface of the sensitive organ to the hollow of the common nerve.[77]

[3.64] Furthermore, the first instant at which the form reaches the surface of the eye is different from the first instant at which the air transmitting the form makes contact with the first point on the surface of the eye when the eye faces a visible object after having not faced it or after the eyelids are opened after having been closed. For when this happens, the first point on the surface of the eye touched by the air transmitting the form of that visible object forms a single point or a line, which lacks breadth; then [it continues] bit-by-bit until the air transmitting the form touches the [whole] area on the surface of the eye where the form reaches. But when a point, which lacks dimension, or a line, which lacks breadth, makes contact on the surface of the eye with a point, which lacks dimension, or a line, which lacks breadth, on the surface of the air transmitting the form, none of the form of light and color reaches the surface of the eye, because the smallest portion of the surface to which light or the form of color can reach will be nothing but a surface [itself]. Therefore, at the instant the first point of the air transmitting the form makes contact with a point on the surface of the eye, none of the form reaches the surface of the eye. Therefore, when the eye faces the visible object or the eyelids are opened after having been closed, the first instant at which the form reaches the surface of the eye is different from the first instant at which the air transmitting the form makes contact with the surface of the eye.

[3.65] Since this is the case, the form of light or color does not reach any portion of the sensitive organ or of the surface of the eye except over time. Therefore, the sensitive faculty does not perceive color, insofar as it is color, or light, insofar as it is light, except over time; that is, the instant at which the sensation of color, insofar as it is color, and light, insofar as it is light, occurs is different from the first instant at which the air transmitting the form makes contact with the surface of the eye.

[3.66] From everything we have said, then, it is evident how sight perceives light, insofar as it is light, how it perceives color, insofar as it is color, how it perceives what kind of color or light it is, and how it perceives the quality of light.[78]

{Perception of Distance}

[3.67] Now the distance of a visible object from the eye will not be perceived by sight through brute sensation, nor is the perception of the distance of the visible object a perception of the object's location, nor is the perception of the visible object in its location due solely to the perception of its distance, nor is the perception of the visible object's location due solely to a perception of its distance. For the location of the visible object depends upon three things, namely, distance, direction, and the magnitude of the distance.

[3.68] Hence, the magnitude of the distance is different from the fact of distance, insofar as it is distance, because distance [*per se*] means an absence of contact between two bodies, and an absence of contact means that there is some space between those two bodies. The magnitude of the distance, on the other hand, is the extent of that space. The fact of distance, insofar as it is distance, is thus a matter of spatial disposition; so it is not the magnitude of the distance. Accordingly, perception of the fact of distance [*per se*], which is an absence of contact, is different from perception of the extent of the spatial separation, which is the measure of the distance.[79]

[3.69] Now the perception of the magnitude of a distance follows from the perception of magnitude, whereas the perception of the visible object's distance and the perception of its direction both follow from a perception of the spatial disposition of its location. Furthermore, the way in which either of these is perceived is different from the way in which the other is perceived, for the absence of contact is different from direction. Thus, the perception of a visible object's location is not [the same as] the perception of a visible object's distance.

[3.70] The perception of a visible object in its place consists in the perception of five things: namely, perception of the light that is in it, perception of its color, perception of its distance, perception of its direction, and perception of the magnitude of its distance. None of these, moreover, is perceived by itself, nor is any one of them perceived after another; instead, all of them are perceived together, because they are perceived through recognition rather than through a process of deduction.

[3.71] On the basis of the perception of a visible object in its place, the proponents of [visual] rays have supposed that vision will take place through rays that are emitted from the eye and extend out to the visible object, so that vision will occur at the endpoint of the ray. And they have argued against the natural philosophers[80] by asking [the following question]: If vision occurs by means of a form reaching from the visible object to the eye, and if that form arrives inside the eye, then how is the visible object perceived in its place outside the eye when its form is now extended into the eye? But these theorists have failed to realize that vision is not achieved through brute sensation alone, but that vision is only fully realized through differentiation or previous knowledge, so, if there were no previous knowledge or differentiation, vision would not be realized in the eye, nor would sight perceive what the visible object is when it is seen. For what a visible object is is perceived not through brute sensation but through differentiation, recognition, or a process of deduction that occurs when seeing takes place. Therefore, if vision were a matter of brute sensation alone, and if all the properties of visible objects that are perceived [by sight] were perceived through brute sensation alone, the visible object would not be perceived in its place until after something extended out to it to make contact with it and feel it. However, since vision is not achieved through brute sensation, but through differentiation, deduction, and recognition, there is no need for the sensitive agent to reach out to the visible object in order to perceive it in its place.[81]

[3.72] So let us return to our discussion of how visual perception occurs, and let us say that the distance of a visible object is perceived, as such, only through differentiation. In addition, the [resulting] notion is one of those notions that becomes ensconced in the soul over time in such a way that the fact that it is ensconced there is not perceived by the soul because of the extraordinary frequency with which it recurs to the faculty of discrimination; thus, there is no need for that faculty to repeat the process of perceptual deduction when it perceives each visible object. Nor at the moment of perceiving each visible object does the faculty of discrimination analyze how the notion of a visible object's distance has come to be ensconced in it, for it does not discern how it perceives each visible object when it perceives it. But it perceives distance only in conjunction with other properties possessed by the visible object, and, when it perceives the visible object, it perceives that property by means of previous knowledge.

[3.73] How the faculty of discrimination perceives distance through differentiation is as follows. When the eye faces a visible object after having not faced it, it perceives the visible object, but when it is removed from its facing position, the perception will disappear. Likewise, when the eyelids are opened after having been closed, and when the eye faces some visible object, it will perceive that visible object, but when the eyelids are closed, the perception will disappear. Now it is intuitively obvious that what affects the eye in a given situation but disappears when it is removed is not fixed in the eye, nor is what creates the effect in the eye. It is also intuitively obvious that what appears when the eyelids are opened and disappears when they are closed is not fixed in the eye, nor does the thing creating this effect lie within the eye. Now when the faculty of discrimination perceives that the effect occurring in the eye, which provides the basis for its perception of the visible object, is not something fixed within the eye, nor is the thing creating that effect within the eye, then it immediately perceives that what occurs in the eye comes from outside, so the thing creating the effect lies outside the eye. Moreover, since vision ceases as soon as the eyelids are closed or as soon as the eye is removed from a facing position yet returns as soon as the eyelids are opened or the eye is restored to a facing position, the faculty of discrimination perceives that what is seen in the eye is not placed directly upon the eye. And when the faculty of discrimination perceives that what is seen neither lies within the eye nor is placed directly upon the eye, it immediately perceives that there is distance between that thing and the eye. For it is intuitively obvious, or at least nearly so, to the faculty of discrimination, that, if something is not actually in a body or placed directly upon it, there must be distance between them, and this is how the distance of a visible object, insofar as it is distance, is perceived.

[3.74] However, in perceiving the distance of a visible object, the faculty of discrimination does not need to go through the analytic procedure we detailed, for we have done this only for the sake of illustration. Rather, the faculty of discrimination reaches its perceptual conclusion as soon as sight occurs without relying on such an analytic procedure. Therefore, from the perception of the visible object when the eye faces it or when the eyelids are opened, and from its disappearance when the facing position is changed or when the eyelids are closed, the faculty of discrimination perceives that the visible object lies outside the eye rather than being placed directly upon it. And this is how the faculty of discrimination perceives that there is distance between the eye and the visible object. Then, given the frequent recurrence of this notion, i.e., that all visible objects lie outside the eye and that there is distance between every visible object and the eye, it becomes ensconced in the soul in such a way that the soul does not perceive that it has become ensconced there or how it has become ensconced there. Thus, to perceive the distance of a visible object from the eye requires some differentiation, namely, for the faculty of discrimination to perceive that vision is due to something that operates from outside the eye. And, in addition, when this notion becomes ensconced in the soul, the faculty of discrimination will realize that every visible object that is perceived by sight lies outside the eye and that there is some distance between that object and the eye.[82]

[3.75] As we claimed above, moreover, distance is only perceived in conjunction with other properties. But how distance will be perceived in conjunction with spatial disposition and how the visible object will be perceived in its place will be explained in our discussion of how spatial disposition is perceived.[83]

[3.76] The perception of the magnitude of a distance from the eye varies, for some distances are perceived by the sense of sight, and their magnitudes are accurately determined, but others are perceived without having their magnitudes accurately determined.[84] That a visible object is distant from the eye is perceived for every visible object, and it is grasped with certainty for every visible object. However, the magnitude of the distance is not accurately determined by sight for every visible object, for between some visible objects and the eye there are objects arranged in successive, continuous order, whereas between other visible objects and the eye there are no objects arranged in successive, continuous order, so their distances are not spanned by a continuous, ordered range of bodies. Thus, when sight perceives a continuous, ordered range of bodies, i.e., of visible objects, that spans a given distance, it will perceive the sizes of those bodies. And when it perceives the sizes of those bodies, it will perceive the sizes of the spaces that lie between their extremities. Now the space that lies between the two extremities of a visible body that spans the distance between the eye and a visible object, one of those extremities lying on the side of the visible object, the other on the side of the viewer, represents the distance of the visible object from the eye, for it corresponds to the space between the eye and the visible object.[85] Thus, when sight perceives the measure of this space, it will perceive the measure of the visible object's distance. Therefore, sight perceives the magnitude of the distances of visible objects whose distance is spanned by a continuous, ordered range of bodies by perceiving the measures of the bodies ranged in order along those distances.

[3.77] Now the distance of some of these visible objects is moderate, whereas the distance of others is inordinate.[86] Therefore, the distance of visible objects that lie at a moderate distance is perceived by sight according to a correct and definite perception, because, when visible objects lie at a moderate distance, and there is a continuous, ordered range of bodies between them and the eye, these objects are perceived by sight correctly. And if sight perceives these visible objects correctly, it will correctly perceive the bodies ranged in order between itself and them. Moreover, if sight perceives these bodies correctly, it will perceive the spaces between their extremities correctly. Finally, if it perceives those spaces correctly, it will perceive correctly and with precision the measures of the distances of the visible bodies ranged along those spaces. Therefore, when the distance of visible objects from the eye is spanned by a continuous, ordered range of bodies, and when that distance is moderate, sight perceives the measure of their distances correctly and precisely—which is to say with as much precision as sense can achieve in perception.[87]

[3.78] On the other hand, when visible objects lie at inordinate distances and those distances are spanned by a continuous, ordered range of bodies, even though the bodies along that range are perceived by sight, the measures of the distances of the visible objects will not be perceived correctly and precisely by sight, because visible objects whose distance is untoward are not correctly perceived by sight.[88] And when there are bodies arranged in continuous, successive order between the eye and those visible objects, not all of those [intervening] visible bodies will be correctly perceived by sight because of the excessive distance between their extremities and because they lie beyond the threshold at which sight perceives visible objects with accuracy. And if sight will not perceive those bodies correctly, it will not perceive the spaces between their extremities correctly. Therefore, it will not correctly perceive the distances between itself and the visible objects that lie at the extremities of those bodies. When the distances of visible objects are untoward, then, and when there are bodies in continuous, successive order between them and the eye, the magnitudes of their distances are not correctly perceived by sight.

[3.79] Furthermore, the distances of visible objects whose distance is not spanned by a continuous, ordered range of bodies are certainly not perceived correctly by sight; accordingly, when it perceives clouds over a plain or in places without mountains, sight will conclude that they lie far away [at a distance] comparable to [that of] celestial objects.[89] If, moreover, the clouds lie among mountains but are continuous, the peaks of the mountains may be hidden by the clouds, whereas if the clouds are separated, the peaks of the mountains may appear above them, and sight may perceive portions of the clouds lying against the shoulder of those mountains, and this may happen in the case of mountains that are not very high. From this [sort of] experience, then, it seems that the distance of the clouds is not inordinate, and the majority of them lie closer to the ground than mountain peaks, so the conclusion that they lie exceedingly far away is erroneous. Hence, it will be evident that sight does not [correctly] perceive the measure of the distance of clouds when they lie above a plain, but the measure of the distance of clouds will be [correctly] perceived by sight when they lie among mountains, and the peaks of those mountains appear above them.

[3.80] This phenomenon is also encountered in various visible objects that are situated at ground-level; that is, the measure of their distances, when they are not spanned by a continuous, ordered range of bodies, will not be [correctly] perceived by sight. From such examples, then, it is evident that sight does not perceive the magnitude of the distance of a visible object unless its distance is spanned by a continuous, ordered range of bodies, and unless sight perceives those bodies and determines their measures accurately. For instance, let anyone who wants to conduct the experiment set up a room that he will not enter before the time of the experiment. And let there be a narrow aperture in any of the walls of that room, and let there be a space behind this aperture that has not been seen before that time. Then, within that space let two walls be set up, one nearer the aperture than the other, and let there be some determinate distance between those two walls. Then, let the nearer wall block a portion of the farther wall, but let some portion of that farther wall show. Let the aperture be high enough above the ground that, when the viewer looks through it, he cannot see the ground behind the wall with the aperture in it.[90] When the experimenter enters this place and looks through the aperture, he will definitely see the two walls together, but he will not perceive the distance between them. Indeed, if the first wall lies an inordinate distance from the aperture, he will perceive the two walls as contiguous, and he will perhaps conclude that they are continuous, forming a single wall, when their color is the same.[91] If, however, the first wall lies a moderate distance from the aperture, and if it is perceived that there are two walls, it will be judged that the two are near to, or contiguous with, one another; so the distance between them will not be accurately determined. Furthermore, when it perceives the first wall, given that its distance is moderate, sight [will judge its distance] as if it were near, and it will not determine its distance accurately. So the distance between two bodies of this sort will not be accurately determined by the sense of sight when the experimenter has not seen that location or those two walls before.[92] And sight might perceive those two walls as contiguous, even when it has already determined the distance between them.

[3.81] Since sight does not perceive the distance between two bodies of this sort, it will not perceive the magnitude of the distance of the farther body, even though it perceives its form. And if it does not perceive the magnitude of the distance of this body, even though it perceives the body [itself], then sight will not perceive a continuous range of bodies spanning that distance, so, on the basis of its perception of the form of the visible object, sight will not perceive the magnitude of the distance of that visible object properly. Now sight perceives the magnitude of the distance of a visible object only through deduction. And sight deduces any measure only by comparing that measure to another measure already known to sight or to some measure perceived at the same time; but without an ordered range of bodies spanning the distance of a visible object, sight has no means of measuring the distance of the visible object or of subjecting it to comparison in order to perceive its measure correctly. Moreover, if sight measures the distance by anything other than those bodies, the measure will be arbitrary rather than accurate. Therefore, the magnitude of the distance of a visible object is not perceived by the sense of sight unless its distance is spanned by a continuous, ordered range of bodies, and sight perceives those bodies as well as their measures.

[3.82] The experiment that we have described provides the same results for a variety of visible objects, such as two trees standing in the relationship described for the walls, or a stick placed crosswise to the aperture in the same position as we described for the first wall.

[3.85] Furthermore, the distances of visible objects that stand apart from one other are perceived by sight through a perception of the separation between the visible objects.[93] Moreover, the magnitude of the distances between visible objects is handled by sight in the same way as the [magnitude of the] distances of visible objects from the eye. For, when there is a continuous, ordered range of bodies between two separate visible objects, and when sight perceives those bodies and their measures, it will [correctly] perceive the magnitude of the distance between those two visible objects; if [there is] not [such a range of bodies], however, sight will not correctly perceive the magnitude of the distance between them. Likewise, if there is a continuous, ordered range of bodies between the two visible objects, but if those bodies lie at such a remote distance that sight cannot determine their measures accurately, the measure [of the distance] between those two objects will not be determined accurately.

[3.86] Therefore the distances of visible objects from the eye are perceived only through a perception carried out by the faculty of discrimination, for what occurs in the eye at the time of sight occurs only through something outside [the eye]. Moreover, the magnitude of the distance of visible objects is not correctly perceived by the sense of sight unless the distances of the visible objects are spanned by a continuous, ordered range of bodies, provided that [any such] distance is moderate and, in addition to this, that sight also perceives those bodies ranged in continuous order and accurately determines their measures according to their succession. The measures of distances that do not meet these requirements are not accurately determined by sight. Moreover, of visible objects whose distances are not accurately determined by sight, some lie at distances that are spanned by a range of continuous, ordered bodies, so that, although sight perceives those bodies, their extremities lie an inordinate distance away. Others lie at distances that are spanned by a continuous, ordered range of bodies, but sight does not [correctly] perceive those bodies, whether their distances are inordinate or moderate. Others still lie at distances that are not spanned by a continuous, ordered range of bodies, and these include visible objects that are so high above the earth that they lie an inordinate distance away and have no other [comparable] distance near them or a wall spanning their distance.[94] All visible objects fall under these categories.

[3.87] When sight perceives visible objects the magnitudes of whose distances are not accurately determined by sight, the faculty of discrimination immediately apprehends the measures of their distance according to estimation rather than true reckoning. And it compares their distance to the distance of similar visible objects that have been perceived before by sight, and it depends upon the form of the visible object in making its judgment, and it compares the form of the visible object to the form of similar visible objects that sight has perceived before, the magnitude of their distances having already been accurately determined by the faculty of discrimination. And thus it compares the distance of a visible object the magnitude of whose distance it cannot accurately determine with the distance of similar visible objects that have been perceived by sight before, the measure of their distances having already been accurately determined by the faculty of discrimination. Thus, if the faculty of discrimination cannot accurately determine the lineaments of the form of the visible object, it will compare the magnitude of its entire form to the magnitudes of forms of visible objects that are equal in size, the magnitudes of their distances having already been accurately determined, and it will assimilate the distance of a visible object whose distance it cannot accurately determine to the distance of visible objects that are the same size whose distances have already been accurately determined.[95]

[3.88] And this is the best that the faculty of discrimination can do in perceiving the measures of the distances of visible objects. Thus, in perceiving the distance of an object of this sort, it may reach an accurate determination by following such a deductive process, or it may err. But in those instances in which it does reach an accurate determination, it cannot be sure whether it has reached an accurate determination or not. Moreover, this deductive process will be carried out extremely quickly because the faculty of discrimination is accustomed to perceiving the distance of visible objects through deduction or accurate determination.

[3.89] Furthermore, the faculty of discrimination may estimate the measure of the distance of a visible object if it is spanned by an ordered range of bodies and is moderate, [and it will do so] because the faculty of discrimination is accustomed to estimating or deducing the distances of visible objects and because of the speed with which it arrives at its estimate. And if the distance of the visible object is moderate, there will not be much discrepancy between the estimate of the distances and the true distance.

[3.90] Therefore, when sight perceives any visible object, the faculty of discrimination will immediately perceive its distance, as well as the measure of its distance, to the best of its ability—i.e., through accurate determination or through estimation—and its distance will immediately have an imagined measure in the soul. Thus, given a visible object perceived by sight and having its form imagined in the soul, when its distance is spanned by a continuous, ordered range of objects, that distance being moderate, and when sight perceives those bodies ranged in continuous order over its distance, and when the faculty of discrimination has already apprehended these bodies and accurately determined their measures, then the measure of the distance [of that visible object] is accurately determined.

[3.91] On the other hand, if the distance is not spanned by a continuous, ordered range of bodies, or if it is spanned by a continuous, ordered range of bodies that are perceived by sight but whose distances are so inordinate that sight cannot accurately determine the sizes of those bodies, or if the eye faces a continuous, ordered range of bodies but sight does not [correctly] perceive those bodies or does not accurately determine their sizes, or if the eye could perceive those bodies but does not notice them and therefore does not determine their sizes, whether those bodies lie at an inordinate or at a moderate distance, then the measure of that distance imagined in the soul will not be accurately determined or verified.

[3.92] Now the distances between disjoined visible objects are perceived only through the perception of the separation that exists between them, and some of the magnitudes of the distances between disjoined visible objects are correctly perceived, whereas others are perceived through estimation. Thus, the measure of the distance between two visible objects that have a continuous, ordered range of bodies between them is accurately determined as long as sight perceives those bodies and determines their sizes. On the other hand, if two visible objects do not have a continuous, ordered range of bodies between them, or if they have a continuous, ordered range of bodies between them but sight does not accurately determine the sizes of those bodies or will not perceive those bodies, then the measure of the distance between the two visible objects is not accurately determined. It is therefore in these ways that the sense of sight will perceive the distances of visible objects.

[3.93] Furthermore, when bodies span the distances of familiar objects lying at familiar distances, which sight is used to perceiving, those bodies are perceived by sight and their sizes are accurately determined because they recur to sight so often that sight perceives the measures of their distances through recognition. For, when it perceives any familiar visible object that lies at a familiar distance, sight will recognize it and will recognize its distance, so it will estimate the magnitude of its distance. Therefore, when it estimates the magnitude of the distance of such bodies, the estimate of their distance will be almost exact, so there will not be much discrepancy between the estimated and actual distance. The magnitudes of the distances of familiar objects that lie at familiar distances are therefore perceived by sight through recognition and through an estimate of their sizes. The majority of the distances of visible objects, moreover, are perceived in this manner.

[Perception of Spatial Disposition]

[3.94] Now spatial disposition, which sight perceives among visible objects, can be subdivided into three kinds, the first of which involves the spatial disposition of the entire visible object vis-à-vis the eye or the spatial disposition of any of the visible object's parts vis-à-vis the eye. This kind of spatial disposition is [called] "opposition."[96] The second kind involves the spatial disposition of the surface of a facing visible object vis-à-vis the eye; this includes the spatial disposition of the surfaces of a visible object facing the eye when it has several surfaces and many of those surfaces are exposed to view; it also includes the spatial disposition of the boundaries of the surfaces of the visible objects vis-à-vis the eye, as well as the spatial disposition vis-à-vis the eye of the lines or the spaces between any two points or between any two visible objects that are perceived at the same time by sight.[97] The third kind involves the spatial disposition of the parts of the visible object in relation each another; it also involves the spatial disposition of the boundaries of the surface of the visible object in relation to each other, as well as the spatial disposition of the parts of the boundaries of the surface of the visible object with respect to each other. This kind of spatial disposition is [called] "arrangement." Likewise, the spatial disposition of various visible objects in relation to one another is a subtype of this. Therefore, all spatial dispositions perceived by sight can be subdivided into these three kinds.

[3.95] The spatial disposition of one thing with respect to another is a function of the distance of one of the things from the other and the spatial orientation of the one with respect to the other. Therefore, the opposition of a visible object vis-à-vis the eye depends on the distance of the visible object from the eye and the direction of the visible object vis-à-vis the eye. Now it has already been shown that the perceptual notion of a visible object's distance is ensconced in the soul.[98] The true location of the visible object, however, is perceived from the spatial disposition of the visible object vis-à-vis the eye, for the eye only perceives a visible object from a facing position. Furthermore, the locations perceived by sense are perceived by differentiation, so both sense and [the faculty of] discrimination distinguish among locations, even when there are no visible objects filling them. But [the faculty of] discrimination makes the distinction between a location right in front of the eye and a location near it, and the faculty of discrimination perceives all locations through imagination. Therefore, when the eye faces some location and perceives a visible object [in it], if the eye then shifts its focus from that location to face another location, the original visible object will disappear from view. But when the eye returns its focus to face that [original] location, the original visible object will come back into view.

[3.96] Now if sight perceives the visible object facing it in the location where the visible object is, and if the faculty of discrimination perceives the location facing the eye when that visible object is perceived, and if, when the eye shifts its focus so that it no longer faces that place, the object disappears from view, then the faculty of discrimination will perceive that the visible object only exists in the direction that the eye faces when that visible object is seen.

[3.97] It has also been shown that sight receives forms properly along radial lines and that it is affected by forms only along such lines.[99] It has also been shown that the form extends through the body of the eye along straight, radial lines.[100] Therefore, when the form of the visible object reaches the eye, the sensitive faculty will immediately sense the form, and it will sense the area on the eye where the form reaches, and it will sense the direction [of the radial line][101] along which the form will extend through the body of the sensitive organ. Therefore, when sight perceives the location of the form on the eye and also perceives the direction [of the radial line] along which the form has extended [to the eye], the faculty of discrimination will immediately perceive the location to which, from which, and along which that [radial] line has extended. But the location along which and from which that [radial] line extends is where the visible object is situated. Therefore, it is on the basis of the perception of the area on the eye where the form reaches, along with the perception of the direction [of the radial line] along which the form has extended and according to which sight is affected by the form, that the faculty of discrimination perceives the actual direction from which the form of the visible object has reached [the eye]. This is how the locations of visible objects are differentiated, for visible objects that are separated from one another are discerned by sight [as separated] only through a differentiation of the distinct places on the surface of the sensitive organ where the forms of the individual visible objects reach.[102]

[3.98] Perceiving the location of a visible object in this manner has a parallel in hearing, for the sensitive faculty perceives sound through the sense of hearing, and it also perceives the place from which the sound comes, so it differentiates between a sound coming from the right and a sound coming from the left, as well as [one coming] from in front and [one coming] from behind. Indeed, it differentiates the locations of sounds even more subtly than this, so it distinguishes the location of a sound reaching it from straight ahead more easily than it does the location of a sound reaching it from a location off to the side. But the places from which sounds originate are distinguished by the sensitive faculty by means exclusively of the direction from which the sounds come to the hearing. Thus, the sense of hearing perceives sounds, and it also perceives the direction from which the sounds come, and it is from perceiving the direction from which the sounds reach the hearing, that [direction] being according to the straight lines along which the sound strikes the hearing, that the faculty of discrimination perceives the location from which the sound comes. Consequently, just as the locations of sounds are perceived by the sense of hearing and subsequently by the faculty of discrimination through hearing, so are the locations of visible objects perceived by the faculty of discrimination through visual sensation.

[3.99] Furthermore, among those things demonstrating that the sensitive faculty perceives the direction [of the radial line] along which sight is affected by the form of a visible object, what is perceived in mirrors according to reflection provides support, for the visible object that sight perceives through reflection can only be perceived by sight directly opposite, as if [the object were actually] facing it. And its form reaches the eye along the straight lines that constitute radial lines extended directly outward from the eye. Thus, since sight senses the form along radial lines, it will judge the visible object to lie at the endpoints of those lines, for it will perceive no familiar object that it regularly perceives except at the endpoints of the lines that are imagined [to extend] between the center of the eye and the visible object, and these are radial lines. Hence, from the fact that sight perceives the visible object, after reflection, as if it faced the eye directly along the straight [radial] lines according to which the reflected forms reach the eye [from the mirror], it will be apparent that the sensitive faculty senses the direction [of the radial line] along which the form arrives and along which sight is affected by the form. And when the sensitive faculty senses the direction from which it is affected by the form, the faculty of discrimination perceives the location from which that line extends, so it will perceive the location of the visible object. Thus, the location of a visible object is perceived *grosso modo* by the sensitive faculty from a perception of its spatial disposition at the moment it is seen, so it will be perceived *grosso modo* by the faculty of discrimination from a perception of the spatial disposition of the visible object at the moment it is seen, but it is correctly perceived and accurately determined on the basis of a perception of the direction from which sight is affected by the form of the visible object. However, the notion of the distance of the visible object has already become ensconced in the soul. Thus, as soon as the [form of] the visible object reaches the eye, the faculty of discrimination perceives the location of the visible object along with the ensconced notion of its distance. But the combination of distance and location yields opposition. Therefore, when the faculty of discrimination perceives the location and distance of the visible object together, it will perceive its opposition. Perception of opposition thus arises from a perception of the visible object's location together with a perception of the visible object's distance, and perception of location will be according to the manner we described. Therefore, when the form of the visible object reaches the eye, the sensitive faculty will sense the location on the sensitive organ where the form arrives, and the faculty of discrimination perceives the location of the visible object from the direction [of the radial line] along which the form extends. Moreover, the notion of distance is already established for it. So it perceives location and distance together at the time the form is perceived by the sensitive faculty. Therefore, as soon as the sensitive faculty perceives the form, the faculty of discrimination will perceive the [visible object's] opposition. So the perception of opposition will occur in the way just described.

[3.100] Now it has already been shown how sight perceives the form of a visible object by brute sensation. Accordingly, when the form of the visible object reaches the eye, the sensitive faculty will perceive the color of the visible object, and its light, and the location on the eye that has been colored and illuminated by that form. Meanwhile, the faculty of discrimination will perceive both its location and its distance when its light and color are perceived by the sensitive faculty. Hence, light and color, as well as location and distance, are perceived at the same time, i.e., in minimal time. But location and distance yield opposition, and light and color yield the form of the visible object, so it is on the basis of the perception of the form along with the perception of opposition that the visible object is perceived to be in opposition to the eye. Thus, the perception that the visible object faces the eye results solely from the fact that the form and [the fact of] opposition are perceived together. Then, given the frequent recurrence of this perception, the form is transformed into a sign[103] for the sense and for the faculty of discrimination. Thus, when the form reaches the eye, it is perceived by the sensitive faculty, and the faculty of discrimination perceives its opposition, and from this the sensitive faculty forms the perception of the visible object in its [true] location. In this way, therefore, the perception of the visible object in its [true] location will ensue, and the same holds for any of the parts of the visible object.

[3.101] When, therefore, the distance of the visible object is moderate and is accurately determined in magnitude, the location where the visible object is perceived by sight will be the true location.[104] And [even] if the distance of the visible object is not accurately determined in magnitude, the perception of the visible object's being in opposition will be accurately determined, because opposition, as such, consists of place and distance, in the generic sense. But the location where the visible object is perceived by sight is estimated, not precisely determined, because a determinate location is perceived on the basis, solely, of an accurate determination of the magnitude of the distance.

[3.102] Now the spatial disposition of the surfaces of visible objects vis-à-vis the eye is subdivided into two: directly facing and obliquely facing. A surface [is said] to face the eye directly when it is perceived by sight straight ahead and when the visual axis touches some point on it so as to form equal [i.e., right] angles with it. A surface [is said] to face the eye obliquely when it is perceived by sight at a slant and when the visual axis touches every point on it at an inclination so as to form unequal angles with it, striking that surface everywhere at different inclinations.

[3.103] Now the boundaries of the surfaces of visible objects, as well as the lines in objects and the gaps between visible objects and between the parts of visible objects fall into two categories: first, lines and gaps[105] intersecting the radial lines, and second, lines and gaps parallel to the radial lines they correspond to. As far as spatial disposition is concerned, lines and gaps that intersect the radial lines are subdivided into oblique and directly facing according to the twofold division of spatial dispositions and surfaces. A directly facing line is one to which the visual axis will fall orthogonally at some point, whereas an oblique line is one to which the visual axis, will [invariably] fall obliquely rather than orthogonally, no matter where it is dropped.

[3.104] Now sight perceives the fact that surfaces and lines are oblique, or that they are directly facing, by perceiving difference or equality among the distances of the extremities of the surfaces or lines [from the center of sight[106]]. For when it perceives the surface of a visible object and perceives the distances of its edges, if it senses the equality of the distances of the edges of the surface from the center of sight, or if it senses the equality of the distances [from the center of sight] of two locations lying equidistant from the spot on the surface where the viewer is directing his focus, sight will perceive that the surface is directly facing, and the faculty of discrimination will judge it to be directly facing. On the other hand, when it perceives the surface of the visible object, but perceives that the distances of its extremities [from the center of sight] are different and does not find two locations on that surface that are the same distance [from the center of sight] and equidistant from the spot on the surface to which the viewer directs his focus, sight will perceive that the surface is oblique with respect to itself, and the faculty of discrimination will judge it to be oblique.[107]

[3.105] And the same holds for the spatial dispositions of lines and gaps that are directly facing or oblique; when it perceives that the distances of the two endpoints of the line or gap [from the center of sight] are equal, or when it perceives that two points on the line or surface that are equidistant from the point to which the viewer directs his focus (a point, that is, on the line or gap) are also equidistant from the center of sight, sight perceives that the line or gap is directly facing. On the other hand, sight perceives the line or gap as oblique when it senses that the distances of the two endpoints of the line or gap from the center of sight are different, or when it senses that the distances [from the center of sight] of the two points equidistant from the point to which the viewer is directing his focus are different. And this equality or difference is often perceived by the sensitive faculty by means of estimation and signs. It is therefore in this way that oblique and directly facing [dispositions] will be perceived by sight.

[3.106] Moreover, if the entire surface or entire line faces the eye directly, then no part of it will face the eye directly on its own. Or, rather, no part of it faces the eye directly on its own except for the part directly opposite the [visual] axis. Therefore, when the visual axis scans a surface or line that faces [the eye] directly, the axis will fall obliquely to any part, other than the original point to which the visual axis fell orthogonally. Hence, aside from the aforementioned part, any part on a surface or line that faces [the eye] directly will be oblique, when taken by itself. Yet when the surface or line is taken as a whole, it will be directly facing as a whole.

Furthermore, when the point on the surface or line to which the [visual] axis will be perpendicular is the midpoint of that surface or line, the surface or line will be [in a] perfectly facing [disposition] vis-à-vis the eye. On the other hand, if that point is not the midpoint, then the surface or line will be [in a] directly facing [disposition], but not a perfectly facing one; and the closer the point on the surface or line to which the [visual] axis falls orthogonally is to the midpoint of the surface or line, the closer that surface or line will be to a perfectly facing disposition.

[3.107] Now the spatial dispositions of lines and gaps that are parallel to the radial lines are perceived by sight on the basis of the perception of opposition. For when sight perceives the endpoints of the lines or gaps that are right next to or near visible objects that face it with their own near extremities right next to the eye, it will perceive their spatial disposition, and it will perceive their extension in the line of opposition.[108]

[3.108] It is therefore in these ways that the perception of the spatial dispositions of surfaces, lines, and gaps with respect to the eye will occur to sight.

[3.109] Now some surfaces, lines, and gaps that intersect radial lines are extremely oblique with respect to those radial lines, some are slightly oblique, and some are perpendicular to the radial lines, these latter surfaces, lines, and gaps facing the eye directly. Moreover, for surfaces, lines, and gaps that are extremely oblique with respect to the radial lines, the farther extremity of any of them lies away from the eye, i.e., at the [farther] extremities of the radial lines. The nearer extremity, for its part, lies toward the eye, i.e., near the center of sight. So when sight perceives any line or any gap, it will immediately perceive the two places occupied by the endpoints of that line or that gap. Similarly, when sight perceives any surface, it will perceive where the edges of that surface are by perceiving the extension of that surface according to length and breadth. Thus, when it perceives a surface that is not only oblique, but extremely oblique to the radial lines, sight will perceive where the farther edge is when it perceives the surface, and it will perceive that it lies at the [farther] extremities of the radial lines; it will also perceive where the nearer edge is, and it will perceive that it lies near the center of sight; and the same holds for a line or gap that is extremely oblique. Furthermore, when sight perceives that one of the two extremities of the surface, line, or gap lies away from the eye, and when it also perceives that the other extremity lies toward the eye, it will immediately perceive the remoteness of one of the extremities of that surface, line, or gap and the nearness of the other. Moreover, when it perceives the remoteness of one of the two extremities of the line, gap, or surface and the nearness of the other, it will immediately perceive the oblique disposition of that surface, line, or gap. Therefore, in the case of surfaces, lines, and gaps that are exceedingly oblique with respect to the radial lines, sight perceives their obliquity by perceiving where their two extremities are.

[3.110] Neither the slant of slightly inclined surfaces, lines, or gaps, nor the directly facing [disposition] of surfaces, lines, or gaps that face the eye directly is correctly perceived or accurately determined by sight unless they lie at a moderate distance spanned by an ordered range of bodies that are perceived by sight. From the measures of these bodies it perceives the measures of the distances of the extremities of those surfaces, lines, and gaps, and it [thereby] perceives the equality or inequality of the distances of the two extremities of the surface, line, or gap. For none of the places occupied by the extremities of surfaces, lines, or gaps that face [the eye] directly or that are slightly inclined [to it] lie toward the center of sight [in any discernible way]; instead, their opposite extremities occupy places that are [perceived according to] right and left, or up and down. Therefore, since sight does not perceive the measures of the [appropriate] distances for objects disposed toward the eye in this manner, it will not perceive the difference or inequality, or the equality of the distances of their opposite extremities. And since it does not perceive this, it will perceive neither their obliquity nor their directly facing [disposition]. Thus, if the surfaces, lines, or gaps lie exceedingly far away, and if their obliquity is slight, sight will not be able to perceive their obliquity, nor will it be able to differentiate between oblique and directly facing [dispositions], for the magnitudes of the distances of surfaces, lines, and gaps that lie exceedingly far away are estimated rather than accurately determined by sight. Furthermore, when they lie extremely far away, and when their obliquity is slight, the difference between the distances of their opposite extremities will be [so] tiny [as to] dwindle to nothing compared to the [overall] distances of the extremities [from the eye]. And since sight cannot accurately determine the magnitude of the distances of their extremities, it will not perceive the difference in the distances of their surfaces, lines, or gaps [from the center of sight]. And since it cannot perceive the difference in the distances of the extremities of the surface, line, or gap, it will judge those distances to be the same, and it will not perceive the obliquity of that surface, line, or gap. And since it cannot perceive the obliquity of that surface, line, or gap, it will judge it to face [the eye] directly. So the obliquity of surfaces, lines, or gaps that lie extremely far away will not be perceived by sight when it is slight. Therefore, sight perceives all surfaces, lines, or gaps that lie extremely far away and that are barely inclined as if they were directly facing, so it neither determines their spatial disposition accurately nor differentiates between oblique and directly facing [dispositions] but, rather, perceives oblique and directly facing [dispositions] in the same way.

[3.111] Likewise, when the distance of surfaces, lines, or gaps is moderate but is not spanned by a range of ordered bodies, or if sight does not perceive the bodies spanning their distances or does not determine the magnitudes of their distances accurately, then the spatial disposition of those surfaces, lines, or gaps is not accurately determined by sight. So sight does not discern whether they are oblique or directly facing but determines their spatial disposition through estimation, and sight may well judge something of this sort to be directly facing when, in fact, it is oblique. On the other hand, if the surfaces, lines, or gaps lie at a moderate distance that is spanned by an ordered range of bodies, and if sight perceives those bodies and their magnitudes, it will perceive the magnitudes of the distances of the extremities of those surfaces, lines, or gaps [from the center of sight]. It will also perceive the equality of the distances of their opposite extremities [from the center of sight], if those extremities are equidistant [from the center of sight], or their inequality, if they are not equidistant [from the center of sight]. And when it perceives the equality of the distances of the extremities of the surface, line, or gap [from the center of sight], or when it perceives their inequality, it will perceive the directly facing [disposition] or the obliquity of that surface, line, or gap with accuracy.

[3.112] In the same vein, the obliquity of lines, surfaces, or gaps that are exceedingly oblique are perceived by sight only when their distance is moderate in comparison to their size. For sight does not perceive where the extremities of the surface, line, or gap are unless it perceives how that surface, line, or gap extends. But sight does not perceive how the surface, line, or gap extends unless it lies at a moderate distance in comparison to the size of that surface, line, or gap. Thus, the slant of a surface, line, or gap that cuts the radial lines at an extreme angle will be perceived by sight according to a perception of where its extremities are. And if the slant is slight, or if the [surface, line, or gap] faces [the eye] directly, it will be perceived by sight as oblique or directly facing on the basis of the perception of the magnitudes of the distances of its opposite extremities [from the center of sight]. But sight does not accurately determine the spatial disposition of extremely oblique surfaces, lines, or gaps unless it accurately determines how they are extended, and it does not accurately determine the spatial disposition of surfaces, lines, or gaps that are slightly oblique or directly facing unless it accurately determines the magnitudes of the distances of their extremities and perceives the inequality or equality of the distances of their opposite extremities [from the center of sight]. But sight rarely determines the spatial disposition of visible objects with accuracy. The majority of spatial dispositions that sight perceives among visible objects are perceived by sight only through estimation. Hence, estimation provides the only basis for visual perception of the spatial dispositions of visible objects. Accordingly, when a viewer wishes to determine accurately the spatial disposition of some surface, or of one of the lines on visible objects, or of one of the gaps on the surfaces of visible objects, he will inspect the form of that visible object and examine how its surface, or the line [on its surface], or the gap [on its surface] extends. Hence, if the form of that visible object on which that surface, line, or gap lies is accurately determined, and if the slant of that surface, line, or gap is extreme, sight will perceive its obliquity correctly by perceiving how it extends and by perceiving where its two opposite extremities are. Moreover, if the form of that visible object is clear[ly perceived], if its obliquity is not extreme, and if its distance is spanned by an ordered range of bodies, sight will see the bodies spanning the distances of its extremities and will scrutinize their magnitudes, and then, on the basis of the perception of the magnitudes of the distances of its extremities [from the center of sight], it will perceive the distance of that surface, line, or gap, as well as the degree of its obliquity or the fact that it faces [the eye] directly.

[3.113] If, however, the form of the visible object is not clear[ly perceived], or if it is clear[ly perceived] and its obliquity is not extreme, but its distance is not spanned by an ordered range of bodies, sight will not accurately perceive the spatial disposition of a surface, line, or gap of this kind. In addition, when sight does not perceive a form clearly and does not find its distance spanned by an ordered range of bodies, it will immediately perceive that the spatial disposition of that surface, line, or space is not accurately determined.

[3.114] It is therefore in these ways that sight perceives the spatial disposition of the surfaces of visible objects, or the spatial disposition of lines or gaps in the surfaces of visible objects, assuming that they all intersect the radial lines.

[3.115] When the gap between two disjoined visible objects is extremely far away—i.e., when each of the visible objects at the extremities of the gap lies an inordinate distance [from the center of sight]—that gap will then be perceived by sight as directly facing, even if it is oblique, because it does not perceive the difference in distance [from the center of sight] of [the visible objects forming] its extremities. Yet if one of the two visible objects forming the two extremities of the gap is nearer than the other, and if sight perceives the fact that it is nearer, it perceives the gap between them as oblique insofar as it perceives the nearness of the nearer of the two visible objects and the remoteness of the farther of the two. On the other hand, if one of the two visible objects is nearer, but sight does not perceive its nearness, then it will not sense the obliquity of the gap between them. Thus, the spatial disposition of surfaces, lines, and gaps that intersect the radial lines is not accurately determined by sight unless they lie at a moderate distance and, in addition, unless sight accurately determines the inequality or equality of the distances of their extremities [from the center of sight]. If sight does not accurately determine the equality or inequality of the distance of their extremities [from the center of sight], though, it will be unable to determine their spatial disposition accurately.

[3.116] Furthermore, the majority of the spatial dispositions of visible objects that are perceived by sight are perceived only through estimation. Therefore, if they lie at a moderate distance, there will not be much discrepancy between the spatial disposition perceived by sight through estimation and the true spatial disposition, whereas if they lie extremely far away, sight will not differentiate between oblique and directly facing [disposition]. For, if sight does not perceive the inequality of the distances of the two extremities of the visible object [from the center of sight], it will perceive them to be equal, and so it will judge the visible object itself to be directly facing.

[3.117] It is therefore in these ways that the sense of sight will perceive the spatial dispositions of surfaces, lines, and gaps.

[3.118] The spatial disposition of the parts of the visible object with respect to one another, the spatial disposition of the edges of the surface or surfaces of the visible object with respect to one another, and the spatial disposition of separate visible objects with respect to one another (all of these cases falling under the head of arrangement) are perceived by sight through the perception of the locations on the eye to which the forms of the parts extend and through the perception by the faculty of discrimination of the arrangement of the parts of the form that extend to the eye. For the form of each of the parts of the surface of the visible object reaches a particular spot on the area of the surface of the sensitive organ to which the form of the whole object extends. And if the surface of the visible object is of various colors, and if there are differences among the parts of the visible object according to which those parts are differentiated from one another, the form reaching the eye will consist of different colors, and its parts will be differentiated according to the way the parts of the visible object's surface are differentiated. So the sensitive faculty senses the form while sensing each of the parts of the form by means of a sensation of the colors of those parts, as well as of the light in them, and it senses the locations of the forms of the parts in the eye by sensing the colors and light of those parts, and the faculty of discrimination perceives the arrangement of those locations by perceiving the difference among the colors of the parts of the form and by perceiving the distinctions among the parts. And so it perceives right and left, as well as above or below, by comparing those parts to one another, and it also perceives contiguity and separation.

[3.119] Now, along the line-of-sight—i.e., according to outward or inward projection [vis-à-vis the center of sight]—the relative spatial dispositions of the parts of a visible object are perceived by sight through perception of the magnitude of the distances of the parts from the center of sight and through perception of the difference among the distances of the parts [from the center of sight] according to relative extent. Indeed, when the visible object lies at a moderate distance, the relative spatial dispositions of its parts along the line-of-sight are perceived by sight, but only if it perceives the magnitude of the visible object's [overall] distance [from the center of sight] while perceiving the magnitudes of the distances of its parts [from the center of sight] and while perceiving the inequality or equality among the distances of the parts from the center of sight. However, if sight does not accurately determine the magnitudes of its distance and the magnitude of the distances of its parts [from the center of sight], it will not perceive the arrangement of its parts along the line-of-sight. On the other hand, if the visible object is one of those that are routinely perceived by sight, it will perceive the arrangement of its parts, as well as the shape of its surface, according to outward or inward projection, but [it will do so] through recognition rather than through vision per se. If the visible object is among unfamiliar objects that sight does not recognize, though, it will perceive its surface as flat when it cannot accurately determine the magnitudes of the distances of its parts [from the center of sight]. And this perception arises when sight looks at any convex or concave body that lies extremely far away, for in that case sight will not perceive its concavity or convexity but will perceive the object as flat.[109]

[3.120] As far as differences in location, discontinuity, and continuity are concerned, the relative spatial disposition of the parts of a visible object's surface are not perceived by sight except through a perception of the parts of the form that reach the eye, as well as through a perception of the various colors and differences that distinguish the parts from one another and a perception of the arrangement of the parts of the form by the faculty of discrimination. Neither the relative spatial dispositions nor the relative distances from the eye of the parts of the visible object's surface are perceived by sight along the line-of-sight except through a perception of the magnitude of the distance of the parts and through a perception of the inequality or equality of the magnitudes of their distances. Therefore, the arrangement of the parts along the line-of-sight is [properly] perceived by sight when the magnitudes of their distances [from the center of sight] are accurately determined. On the other hand, the arrangement of the parts is not [properly] perceived when the magnitudes of the distances of its parts are not accurately determined by sight. Furthermore, the arrangement of the individual parts of a visible object is perceived by sight through a perception of the locations on the eye where the forms of those parts extend, as well as through a perception of [their] distinct interpositions on the eye by the faculty of discrimination; and the same holds for individual visible objects. The boundaries of the surface or surfaces of the visible object are perceived by the eye, along with their arrangement, through a perception of the spot on its surface where the color and light of that surface reach the eye and through a perception of the boundaries of that part and the arrangement of the circumference of that part by the faculty of discrimination. In these ways, then, sight perceives the spatial dispositions of the parts of visible objects, the relative spatial dispositions of the surfaces of visible objects, the spatial dispositions of the boundaries of their surfaces, the relative spatial dispositions of the individual parts of visible objects, and the relative spatial dispositions of individual visible objects.

[Perception of Corporeity]

[3.121] Now corporeity, which consists in the extension of a body in three dimensions, is perceived by sight in some bodies and not in others. Still, according to human judgment, it is an absolute given that only a body can be perceived by sense, and so, when someone perceives a visible object, he will immediately realize that it is a body, even though he may not perceive its extension according to three dimensions. But sight perceives the extension of all bodies according to length and breadth on the basis of the perception of the surfaces of bodies that face it. Therefore, when it perceives the surface of a body, thereby realizing that this visible object is a body, it will immediately perceive the extension of that body according to length and breadth. So only the third dimension is left. Now some bodies are enveloped by plane surfaces that intersect each other to form corners, some are enveloped by concave or convex surfaces, some are enveloped by surfaces of various shapes that intersect one another to form corners, and some are enveloped by one [continuous] curved surface. Therefore, if one of the intersecting surfaces that envelop a body is plane, and if that surface faces the eye directly, and if the remaining surfaces that intersect this plane surface that faces the eye directly are perpendicular to that surface or are oblique to it so as to converge on one another behind it, then, when sight perceives that body, only the surface that faces the eye directly will be seen by it. Of such bodies, then, sight perceives only the length and breadth, so it does not sense the corporeity of such bodies. On the other hand, if one of the intersecting surfaces that envelopes the body faces the eye but not directly, and if the intersection of this surface with another surface on that body is perceived by sight so that it can perceive both surfaces at once, then the corporeity of that body will be perceived by sight. For it will perceive the slope of the surface of the body in terms of its depth, whereby it will perceive the extension of the body according to depth. But it will also perceive the extension of that sloping surface in length and breadth, and so it will perceive the corporeity of such a body.

[3.122] And the same holds if one of the surfaces of the body faces the eye directly, and one or more of the surfaces intersect that surface obliquely so as to diverge outward behind the surface that faces the eye, for in such a body sight will perceive both the surface that faces the eye directly and the surface that intersects it obliquely. And it will also perceive the intersection of these surfaces, and thus, as we said, it will perceive the corporeity of that body. And I say that, in general, whenever sight can perceive two surfaces intersecting one another in a given body, it will perceive its corporeity.

[3.123] In the case of bodies with a convex surface that is perceived by sight, whether those bodies consist of one or more surfaces, sight will be able to perceive their corporeity through a perception of their actual [shape], for when a convex surface faces the eye directly, the distances of its parts from the eye will be unequal, and its midpoint will lie nearer the eye than its outer edge.[110] So when sight perceives its convexity, it will perceive that its midpoint is nearer to it than its extremities. And when it senses that the object's midpoint lies nearer to it, whereas the object's outer edge lies farther away, it will immediately sense that the surface curves away from it toward the back, and so it will sense the extension of the body in depth with respect to the surface directly facing it. But it will also perceive the extension of that body according to length and breadth through the perception of the extension of the convex surface according to length and breadth. And the same holds if, in addition to the surface that faces the eye directly, the other surfaces of the body are convex, and if sight perceives their convexity, for sight will also perceive their extension according to three dimensions.

[3.124] In the case of a body containing a concave surface that is perceived by sight, if sight senses another surface on that body and senses the intersection of that surface with the concave one, it will then sense the slope of the [other surface] of that body, and when it senses the slope of that surface, it will immediately sense the body's corporeity. On the other hand, if its concave surface is perceived by sight, but none of the remaining surfaces is exposed to view, sight will not perceive the corporeity of such a body, nor will sight perceive anything about such bodies beyond their extension in two physical dimensions.[111] Moreover, sight will sense the corporeity of such bodies only through previous knowledge, not through a sensation of the three dimensions of the body. But a concave surface also extends in depth according to the propinquity of its outer edge and the remoteness of its midpoint with respect to the eye, but, as far as perception of depth is concerned, only the extension of the [side's] hollow is perceived, not the extension of the body [itself] that contains that concave surface.

[3.125] Thus, the perception of corporeity by sight depends exclusively on a perception of the way the surfaces of bodies slope [toward one another]. But the slopes of the surfaces of bodies according to which sight is alerted to the fact that bodies are bodies are perceived by sight only in the case of bodies that lie at a moderate distance. In the case of bodies that lie extremely far away, however, when their distance is not accurately determined by sight, sight does not perceive the slopes of the surfaces. And thus it does not perceive its corporeity by the sense of sight, for in such bodies sight does not perceive the relative spatial disposition of the parts of their surfaces, so it only perceives them as flat. It does not, therefore, perceive the slopes of the surfaces, and so it does not perceive the body's corporeity. Thus, sight does not perceive the corporeity of a body that lies extremely far away and whose distance is not accurately determined by it.

[3.126] But sight perceives the corporeity of bodies by perceiving the slopes of the surfaces of [those] bodies, and the slopes of the surfaces of [those] bodies are only perceived by sight in the case of visible objects that lie at a moderate distance when the relative spatial disposition of the parts of their surfaces are perceived by sight. And, except for these visible objects, sight does not perceive the corporeity of bodies, or else it perceives their corporeity through previous knowledge alone.[112]

[Perception of Shape]

[3.127] The shape of a visible object is subdivided into two kinds, the first being the shape of the circumference of the surface of the visible object or the [shape of the] circumference of some part of the visible object.[113] The second kind is the shape of the body of the visible object, or the shape of the body of some part of the visible body—which is to say the form of the surface of the visible object whose corporeity is perceived by the sense of sight or the form of a part of the surface of the visible object whose corporeity is perceived [by the sense of sight].[114] Everything that sight perceives in the way of the shapes of visible objects falls under these heads.

[3.128] The shape of the circumference of a visible object's surface is perceived by the sensitive faculty through the perception of the circumference of the form that reaches the hollow of the common nerve and through the perception of the circumference of the area on the surface of the sensitive organ where the form of the visible object reaches, for the circumference of the surface of the visible object is delineated in both of these places. Therefore, whichever of these places the sensitive faculty examines, it will be able to perceive the shape of the circumference of the visible object [delineated] in it. Likewise, the shape of the circumference of any part of the surface of the visible object is perceived by the sensitive faculty through its sensation of the arrangement of the parts of the boundaries of the form of the part. And if the sensitive faculty wants to accurately determine the shape of the circumference of the surface of the visible object or the shape of the circumference of some part of the visible object, it will move the visual axis over the circumference of the visible object. Through [such] a scanning-process, then, it will accurately determine the spatial disposition of the parts of the boundaries of the form of the surface or the part of the surface that lies on the surface of the sensitive organ as well as in the hollow of the common nerve, so it will perceive the shape of the circumference of the surface on the basis of its accurate determination of the spatial dispositions of the boundaries of the form. It is in this way, then, that the shape of the circumference of the visible object, or the shape of the circumference of some part of the surface of the visible object, will be perceived by the sense of sight.

[3.129] Now the form of the surface of a visible object is not perceived by sight except through the perception of the spatial dispositions of the parts of the visible object's surface and through the dissimilarity or similarity of the spatial dispositions of the parts of the surface of the visible object.[115] And the form of the surface is accurately determined through the perception of the inequality or equality of the distances of the parts of the surface of the visible object [with respect to the eye] or [through the perception] of the inequality or equality of the heights of the parts of the surface. For the convexity of the surface is only perceived by sight through the perception of the nearness of the central parts on the surface and the remoteness of the parts at the extremity, or else through the inequality of the heights of its parts when the upper surface of the body is convex. By the same token, the convexity of the outer edge of the surface is only perceived by sight through the perception of the nearness of the midpoint and the remoteness of the outer edge when its convexity faces the eye, or through the inequality of the heights of its parts when its bulge points down or up, or else through the inequality of its right-hand or left-hand parts when its bulge points toward the right or left.

[3.130] When a concave surface faces the eye, however, its concavity is perceived by sight through the perception of the remoteness of the central parts and the proximity of the outer edges. And the same holds for the concavity of the outer edges of the surface when it faces the eye. But sight does not perceive the concavity of the surface when the concavity faces upward or downward, or toward the side, unless the concave surface is cut in such a way that the curvature of its edge facing the eye is apparent.

[3.131] A surface is perceived by sight as flat through the perception of the equality of the distance of its parts and its uniform arrangement throughout, and the same holds for the straightness of the edge of a surface when that edge faces the eye. However, when a surface faces the eye and several edges enclose that surface, the straightness, bend, or curvature of [any] edge of the surface will be perceived by sight through the arrangement of its parts among one another.

[3.132] The convexity, concavity, or flatness of the surface of a visible object facing the eye is perceived by sight through the perception of the difference in, or the equality of, the distances, or heights, or breadths of the parts of the surface [from the center of sight], as well as through the [perception of] how much the distances, or heights, or breadths of the parts exceed one another. Likewise, the convexity, concavity, or flatness of any part of the visible object is perceived by sight through a perception that the distances, or heights, or breadths of the parts of that part vary in magnitude or are equal among one another. It is for this reason that sight will not perceive concavity or convexity except in visible objects that lie at a moderate distance. Sight, moreover, perceives the nearness of certain parts of the surface and the remoteness of others by means of bodies that lie between it and the surface or by means of bodies spanning the distances of the parts, when the nearness or remoteness of those bodies are accurately determined by sight. And if some parts of the surface protrude, and others are indented, then sight perceives their protrusion and indentation through the slopes of the surfaces of the parts, and the intersections of the parts, and their curvatures at the points of indentation, and [it also perceives them] through the relative spatial disposition of the surfaces of the parts. This will be the case when sight has not perceived that surface, or anything like it, before. If, however, that visible object is familiar, sight will perceive its form as well as the form of its surface through previous acquaintance.[116] The form of a visible object that is enveloped by surfaces that intersect one another and that have various spatial dispositions is perceived by sight from the perception of the intersection of its surfaces, and from the perception of the spatial disposition of each of its surfaces, and from the perception of the shape of each of its surfaces.

[3.133] Hence, the forms of the shapes of visible objects whose corporeity is perceived by sight are perceived through the perception of the forms of their surfaces and through the perception of the relative spatial dispositions of their surfaces. Moreover, the forms of visible surfaces whose parts have various spatial dispositions are perceived by sight through the perception of the convexity, concavity, or flatness of the parts of their visible surfaces, or from the height or depth of the parts of the surface. This, therefore, is how the forms and shapes[117] of visible surfaces will be perceived. Moreover, when the sensitive faculty wants to accurately determine the form of a visible object's surface, or the form of any part of the visible object, it will shift its focus straight ahead and will make the visual axis scan all the parts of that object until it will sense the distances of its parts, the spatial dispositions of each of its parts vis-à-vis the eye, and the spatial disposition of all of the parts with respect to one another. And when the sensitive faculty perceives the distances and spatial dispositions of the parts of the surface, and when it perceives the height and depth of those parts, it will perceive the form of that surface of the visible object, and it will accurately determine its shape. But sight frequently errs in its perception of the forms of the surfaces of visible objects and the forms of the shapes of visible objects, but it does not perceive its error. For a slight convexity, or a slight concavity, or a slight protrusion or indentation is poorly perceived by sight along the line-of-sight, even when its distance is moderate, unless it lies very near the eye.

[3.134] Hence, sight perceives the forms of visible objects when the sizes of the parts of their surfaces are perceived by sight and when the inequality or equality of the distances of their parts [from the center of sight] are perceived by sight, whereas sight accurately determines the forms of visible objects when the magnitudes of the distances of their parts [from the center of sight] and the amounts by which the distances of the parts [from the center of sight] differ among each other are accurately determined by sight. Likewise, the shapes of the circumferences of the surfaces of visible objects and the shapes of the circumferences of the parts of the surfaces of visible objects are not accurately determined by sight unless they lie at a moderate distance, and unless sight accurately determines the arrangement of their extremities and the relative spatial dispositions of their parts, and unless it accurately determines their angles of juncture. If neither the spatial disposition of their extremities nor their angles of juncture, assuming they have such, are accurately determined by sight, sight will not accurately determine their shapes. Therefore, all the shapes of visible objects are perceived by sight in the ways that we have described.

[Perception of Size]

[3.135] The magnitude or size of a visible object is perceived by sight, but the way it is perceived is a matter of debate as far as the perception of magnitude is concerned. Several of those [authorities who have tried to explain this] believe that a visible object's size is perceived by sight only through the size of the angle formed at the center of sight, that angle also containing the surface of the visual cone whose base encompasses the visible object, [and they further believe] that sight correlates the sizes of visible objects to the sizes of the angles formed by the rays that comprehend the visible objects at the center of sight. So the perception of magnitude depends solely upon those angles.[118] Certain other [authorities] believe that the perception of size is not achieved through a correlation of the angles alone, but also through an evaluation of the distance and spatial disposition of the visible object along with a correlation of the angles.[119]

[3.136] Actually, it is not possible for the perception of the sizes of visible objects by sight to depend solely upon a correlation of angles subtended by visible objects at the center of sight, for, as far as sight is concerned, the same visible object may not differ in size, even though it lies at distances that vary to a moderate extent.[120] For when a visible object is near the eye so that sight perceives its size, and then it is moved some distance away from the eye, its size will not diminish much as far as sight is concerned, provided that the second distance is moderate. Moreover, as far as sight is concerned, the size of no familiar visible object will ever change as its distances change, assuming that those distances are moderate.

[3.137] Likewise, when bodies of equal size lie at different distances, and the farther distance is moderate, they will be perceived as equal in size by sight. Nevertheless, the angles subtended by the same visible object at various moderate distances differ by some amount. For when a visible object lies one cubit from the eye and is then moved farther away from the eye until it lies two cubits from it, there will be a significant difference in the two angles subtended by that object at the center of sight. Still, sight does not perceive the object lying two cubits away as any smaller than the object lying one cubit away. By the same token, if it is moved three or four cubits away from the eye, it will not appear smaller, even though the angles formed at the center of sight will differ by a considerable amount.[121]

[3.138] So too, if a square is drawn on the surface of some body, and if that body is raised until the surface on which the square is drawn is almost parallel to the line-of-sight so that the eye can still make out the square, sight will perceive the square as having equal sides, although the angles subtended by the sides of the square at the center of sight will be unequal when the center of sight lies near the surface on which the square is drawn. Nevertheless, sight will perceive the sides of the square as equal.

[3.139] Likewise, when diameters are drawn in a circle at various angles to one another, and the surface on which the circle is drawn is raised until it is nearly parallel to the line-of-sight, the angles subtended by the circle's diameters at the center of sight will vary significantly according to the orientation of the diameters. Nevertheless, sight invariably perceives the diameters of the circle to be equal, as long as they lie at a moderate distance.[122]

[3.140] If the perception of [the size of] visible objects depended solely on a correlation of the angles subtended by visible objects at the center of sight, then, the sides of the square would not be perceived as equal, nor would the diameters of the circle be perceived as equal, nor would the circle be perceived as circular, nor would any single visible object be perceived to be of the same size at various distances. Therefore, on the basis of such experiments, it is clear that the perception of the sizes of visible objects does not depend solely on a correlation of angles.

[3.141] Now that this has been shown, let us determine precisely how magnitude is perceived. It has already been shown that the perception of various sensible properties depends entirely upon deduction and differentiation.[123] Magnitude is one of those properties that is perceived through judgment and deduction, and the basis upon which the faculty of discrimination determines the size of the visible object is the size of the area on the eye upon which the form of the visible object is projected. And the area upon which the form of the visible object is projected is determined and measured by the angle at the center of sight that contains the visual cone, which encompasses [both] the visible object and the area on the eye upon which the form of the visible object is projected. Therefore, the area on the eye upon which the form of the visible object is projected and the angle containing the visual cone that encompasses that area are factors that the sensitive faculty and faculty of discrimination cannot do without in perceiving the magnitude of the visible object.

[3.142] Still and yet, neither an evaluation of the angle by itself, nor an evaluation of the area on the eye subtending that angle, suffices on its own for the faculty of discrimination to perceive size, for, when a single visible object lying near the eye is perceived by sight, the sensitive faculty will perceive the location on the eye upon which the visible object's form is projected, and it will perceive the size of that location. Then, if that visible object is drawn farther away from the eye, it will still be perceived by sight, and the sensitive faculty will perceive the location on the eye upon which the form is projected the second time, and it will perceive the size of that location. And it is clear that the location of the eye upon which the form is projected in the first place and the location of the eye upon which the form is projected afterward differ in size, for the [size of the] location of the form on the eye will depend upon the sizes of the angles encompassing the visible object at the center of sight. The farther away the visible object gets, the narrower the [visual] cone encompassing it will get, and [the narrower that cone gets, the narrower] its angle [will get], and [the narrower that angle gets, the narrower] the location on the eye upon which the form is projected [will get]. So when the sensitive faculty perceives the location upon which the form of the visible object is projected, and when it perceives the size of that location, it will perceive the decrease in size of that location according to the distance of the visible object from the eye.

[3.143] This situation occurs over and over again for sight; that is, visible objects continually recede from the eye, or the eye recedes from them, or they continually approach the eye, or the eye approaches them, and sight perceives them, and it perceives the decrease in the size of the locations of their forms on the eye with the increase in distance, and it also perceives the increase in the size of the locations of their forms on the eye with the decrease in distance. On the basis, therefore, of such repeated experience, it becomes ensconced in the soul that, as far as the faculty of discrimination is concerned, the farther the visible object recedes from the eye, the smaller the location of its form on the eye becomes, and [the smaller that location becomes, the smaller] the angle at the center of sight encompassing the visible object [becomes]. When this happens, it is established in the faculty of discrimination that [the size of] the area upon which the visible object's form is projected, as well as the angle at the center of sight encompassing the visible object, depends entirely on the distance of the visible object from the eye. And when this fact is ensconced in the soul, then, if the faculty of discrimination determines the size of a visible object, it will not evaluate the angle alone but will evaluate the angle and the distance together, for it has been established for it that the angle will depend entirely upon the distance. Thus, the sizes of visible objects will be perceived only through differentiation and correlation. But the correlation through which the size of the visible object is perceived involves a correlation of the base of the visual cone, which is the surface of the visible object, to the angle of the cone as well as to the magnitude of the length of the cone, which is the distance of the visible object from the eye. Furthermore, the evaluation [carried out] by the faculty of discrimination invariably includes [an evaluation of] the area on the surface of the sensitive organ upon which the form of the visible object is projected along with an evaluation of the distance of the visible object from the surface of the eye, for the size of the area upon which the form is projected will invariably depend on the size of the angle encompassing that area at the center of sight. For the most part, moreover, the difference between the distance of the visible object from the surface of the eye and its distance from the center of sight has no effect [on the perception of] distance.

[3.144] It has also been shown that the sensitive faculty perceives the lines extending between the center of sight and the visible object, these lines representing radial lines, and it perceives the arrangement of these lines, as well as the arrangement of visible objects and the arrangement of the parts of any visible object.[124] When the sensitive faculty perceives this [set of arrangements], the faculty of discrimination perceives that the farther these [radial] lines extend from the center of sight, the larger the intervals between their extremities will get. But this fact is already ensconced in the soul, and along with it there is also ensconced in the soul the fact that, the farther the radial lines get from the center of sight, the larger the visible object at their extremities will be. Thus, when sight perceives a visible object and perceives its boundaries, it will perceive the [radial] lines along which it perceives the boundaries of that visible object. But the [radial] lines along which it perceives the boundaries of the visible object form the angle at the center of sight that encompasses that visible object, and they are also the [radial] lines encompassing the location on the eye upon which the form of the visible object is projected. Thus, when sight perceives those [radial] lines, the faculty of discrimination will imagine the extension of those [radial] lines from the center of sight to the boundaries of the visible object. And when, on that basis, it perceives the magnitude of the visible object's distance, it will imagine the magnitude of the length of those lines, as well as the extent of the interval between their endpoints, but the intervals between the endpoints of these lines form cross-sections of the visible object. So when the faculty of discrimination imagines the size of the angle, the magnitude of the lengths of the radial lines, and the extent of the intervals between their endpoints, it will perceive the actual size of the visible object.

[3.145] Now the [radial] lines that extend between the center of sight and the boundaries of any visible object perceived by sight are perceived by the sensitive faculty and the faculty of discrimination, and the sensitive faculty and the faculty of discrimination perceive the size of the area on the eye upon which the form of that visible object is projected. And when the faculty of discrimination perceives the radial lines, it will perceive their relative spatial disposition, and it will perceive their convergence or divergence, and it will perceive how they extend. To complete the perception of the visible object's size, then, nothing remains but [to determine] the magnitude of the visible object's distance.

[3.146] It has already been shown in [the discussion of] how the distance of a visible object is perceived that the distance of any visible object is perceived by sight either precisely or by estimation.[125] So when the faculty of discrimination perceives the spatial disposition of the radial lines encompassing the boundaries of the visible object, and when it perceives the size of the area they demarcate on the surface of the sensitive organ, which is [a function of] the size of the angle, and when it also imagines the magnitude of the visible object's distance, then it will immediately imagine the size of the angle and that of the distance together. And when it imagines the size of the angle and the magnitude of the distance together, it will perceive the size of the visible object according to the size of the angle and the magnitude of the distance together. So the faculty of discrimination imagines the magnitude of the distance of any visible object perceived by sight, and it imagines the [radial] lines encompassing its boundaries, and by means of this conceptual process, the form of the visual cone that encompasses the visible object will occur to it along with the size of the cone's base, which is formed by the visible object.[126] And so the size of the visible object will occur to it.

[3.147] Evidence that the perception of a visible object's size will occur through a correlation of the object's [apparent] size to its distance is found in the fact that, when sight perceives two visible objects that lie at different distances but subtend the same angle at the center of sight—i.e., such that the rays passing through the endpoints of the first of those objects extend to the endpoints of the second—and if the first of those objects does not block the second one entirely, and if sight accurately perceives the distance of each of them, the farther visible object will always appear larger to sight than the nearer one. Moreover, the greater the distance of the farther visible object becomes, the larger it will be perceived to be, as long as sight accurately determines the magnitude of its distance. For instance, if an observer looks at a wall that lies at a moderate distance from the eye, and if he accurately determines the distance and size of that wall, and if he accurately determines the magnitude of its breadth, then, if the observer places his hand in front of one of his eyes between the center of sight and the wall and closes the other eye, he will find that his hand will cover a considerable portion of that wall. Yet he will perceive the size of his hand in that situation, and he will perceive that the size [of the portion] of the wall covered by his hand is much larger than the size of his hand, and sight will perceive the radial lines and will perceive the angle formed by these radial lines. In this case, then, sight perceives that the angle subtended by the hand and by the wall is the same angle, and it also perceives that the portion covered by the hand is much larger than the hand. And since this is so, the faculty of discrimination, in arriving at this perception, perceives that the farther of the two visible objects lying at different distances and subtending the same angle is larger.

[3.148] Afterward, if the eye is shifted in this situation, and the observer looks at another wall farther away than that [first] wall, and if he places his hand between the eye and that [second] wall, he will find that the portion of the second wall covered [by his hand] is larger than the portion of the first wall covered [by his hand]. And if he then looks at the sky, he will find that his hand will cover half of what appears of it, or at least a large portion of it. Nonetheless, the observer will not doubt that, as far as sensation is concerned, his hand is nothing in comparison to the portion of the sky that is covered by it. It has therefore been shown on the basis of this experiment that sight does not perceive a visible object's size through a correlation of angles alone, but through a correlation of the visible object's [apparent] size to the magnitude of its distance, as well as through a correlation of angles. Moreover, if perception of the size of a magnitude were determined by angle alone, two visible objects lying at different distances and subtending the same angle at the center of sight would have to appear equal, but such is not the case. Therefore, the size of a visible object is perceived by [the faculty of discrimination] only through its imagining the cone that encompasses the visible object, while imagining the size of the angle of the cone and the length of the cone, and then correlating the [size of the] base of the cone to the size of its angle and its length, all at the same time. This is how size is perceived.

[3.149] Sight is so accustomed to determining the distances of visible objects that, when it senses both the form and the distance of the visible object, it will immediately imagine the size of the location of the form and the magnitude of [the object's] distance, and, by combining these two notions, it will perceive the size of the visible object. Nevertheless, the magnitudes of the distances of visible objects form part of the set of magnitudes that are perceived by sight. And it has already been pointed out that the magnitudes of some distances of visible objects are perceived accurately, whereas others are perceived through estimation,[127] and [it has been pointed out] that those magnitudes that are perceived through estimation are perceived by assimilating the distance of the visible object to distances like it among visible objects whose distances are accurately determined,[128] and [it has also been pointed out] that distances that are precisely determined are ones that are spanned by a continuous, ordered range of bodies.[129] So it is through perception by sight of the continuous, ordered bodies spanning their distances, as well as from the accurate determination of the sizes of those bodies, that the magnitudes of the distances of the visible objects flanking those bodies will be perceived. It remains, therefore, to explain how sight will perceive the magnitudes of the distances of visible objects that are spanned by a continuous and ordered range of bodies and how it accurately determines the sizes of the continuous and ordered bodies that span the distances of visible objects.

[3.150] For the most part, the bodies that are ranged in continuous order over the distances of visible objects consist of portions of the ground. And the familiar visible objects that are continually perceived by sight stand on the earth's surface, and the ground lies between them and the body of the person who is observing. And the magnitudes of the portions of the ground that lie between the viewer and visible objects standing on the face of the earth and that span the distances between those visible objects and the eye are continually perceived by sight. Moreover, the magnitudes of the portions of the ground that lie between the viewer and visible objects standing on the face of the earth are perceived only if sight measures them against one another and measures the portions of the ground far away from the center of sight against portions of the ground that are near it and have had their magnitudes accurately determined. Then, given how often sight perceives [such] portions of ground and how often it measures them, it will perceive the magnitudes of the portions of the ground that are at [the viewer's] feet by recognizing them and by assimilating them to ones like them that have already been perceived. Thus, when sight looks at the portion of the ground lying between it and a visible object, it will realize its magnitude because of how often it perceives portions of ground similar to that one. And this perception is among those that the sensitive faculty acquires from the very beginning of [a person's] development. And so [notions of] the magnitudes of the distances of familiar objects will become impressed in the imagination and ensconced in the soul so that a person does not notice how they have become ensconced there.

[3.151] Now the way in which the portions of the ground between the viewer and visible objects are initially perceived is as follows: the very first portion to have had its magnitude accurately determined by sight is the one at the [viewer's] feet, for the magnitude of the portion at the [viewer's] feet is perceived by sight and by the faculty of discrimination. But that faculty determines [its size] on the basis of the measure of the human body, for what lies at the feet is always measured unconsciously by a person according to his feet when he paces over it, or according to his arm, when he extends his hand to it. So everything on earth that is near a person is invariably measured unconsciously in terms of the human body, and sight perceives this measure and senses it. The faculty of discrimination, meanwhile, perceives this measure and understands it, and on that basis it accurately determines the magnitudes of the portions of the ground immediately surrounding the human body. Thus, the magnitudes of the portions of ground near any person have already been grasped by the sensitive faculty as well as by the faculty of discrimination, and their forms have already been imagined by the faculty of discrimination and ensconced in the soul. But sight perceives these portions of ground continually, and the sensitive faculty senses the [radial] lines that extend from the eye to the extremities of these portions when sight perceives them and when it examines the whole of the ground [before it]; it also perceives the areas on the surface of the sensitive organ where the forms of those portions of ground are projected, and it perceives the magnitudes of those areas on the eye as well as the size of the angles subtended by those areas on the eye. Thus, the angles subtended by the portions of the ground near any person are realized by the sensitive faculty over the course of time, and their forms are imagined in the soul. Also, the lengths of the radial lines extending from the center of sight to the extremities of the portions of the ground near any person are perceived by the sensitive faculty and by the faculty of discrimination, and they are accurately determined by them, for the lengths of those [radial] lines are always measured unconsciously in terms of the human body. Therefore, when a person stands upright and looks toward the ground at his feet, the lengths of the radial lines will depend on the height of the standing person, and the faculty of discrimination will realize with certainty that the distance between the eye and that portion of the ground is the height of the standing person.

[3.152] So the extent of the areas on the ground immediately surrounding the human body is realized and perceived by the faculty of discrimination, and their forms are ensconced in the soul. When sight looks at a portion [of the ground] at the [viewer's] feet, then, the sensitive faculty will immediately perceive the [radial] lines extending out to the extremities of that part, and the faculty of discrimination will imagine the lengths of the [radial] lines extending out to its extremities as well as the sizes of the angles formed by those [radial] lines. And when the faculty of discrimination imagines the lengths of those [radial] lines and the sizes of the angles formed by those [radial] lines, it will accurately perceive the magnitude of the space between the endpoints of those [radial] lines. It is in this way, then, that the magnitudes of the parts of earth encompassing some portion of the ground[130] are accurately determined by the sense of sight.

[3.153] Subsequently, the magnitudes of the portions of ground at the next remove from these portions are perceived by sight through a comparison of the lengths of the radial line-segments that extend to their extremities to the lengths of the rays that extend to the initial portions [of ground] immediately surrounding the person. And thus the faculty of discrimination compares the radial lines reaching a third location to the second rays that mark the dividing-line between the first and second portions [of ground], and it perceives the increase in length of the third ray over that of the second one. And when it senses this, it will sense the length of the third ray, and it will accurately perceive the length of the second ray. The length of the two rays comprehending the second portion of ground will thus have been accurately determined by the faculty of discrimination, and their spatial disposition will have also been accurately determined by it. And when it perceives the length and spatial disposition of the two rays, it will accurately perceive the [magnitude of the] interval between their endpoints.[131] It is in this way, therefore, that the faculty of discrimination will also perceive the extent of the portions of ground at the next remove from those at the [viewer's] feet.

[3.154] Moreover, the portions of ground at the next remove from those at the [viewer's] feet are invariably measured in terms of the human body. For when a person paces over the ground, he will measure the ground over which he paces according to [the measure of] his feet and his pace, and the faculty of discrimination will perceive its extent. And when a person traverses the location where he was and continues to pace over successive portions [of ground] with his feet, when he comes to those successive portions of ground, he will measure them in the same way he measured the previous ones, and he will perceive those successive portions of grounds in the same way he did the previous ones. And this perception will be absolutely determinate, and so his first perceptual determination will be corroborated by this second perceptual determination. Hence, if its extent was not accurately determined by the first perceptual pass, it will be accurately determined by the second. And this comparative measurement is invariably perceived by the sensitive faculty, and it avails itself of such measurement without any conscious effort, and when some portion of ground is scanned by sight, the sensitive faculty and the faculty of discrimination perceive its measure automatically rather than through conscious effort. Then, because of the continual recurrence of this process, the extent of the portions of ground passed over by the feet is accurately determined, as is the extent of the portions next in order. In this way, then, the sensitive faculty and the faculty of discrimination grasp the magnitudes of the portions of ground immediately surrounding a person and lying between his eye and visible objects, and this grasp occurs at the very beginning of a person's development. Subsequently, through their sensitive and discriminative faculties, people grasp the magnitudes of the distances of familiar visible objects standing on the face of the earth. Thus, the perception of the distances of familiar visible objects standing on the face of the earth will be due to recognition and the assimilation of those distances to one another.[132]

[3.155] Now this is not to say that the perception of the magnitudes of the distances of visible objects, which is carried out by the sensitive faculty and the faculty of discrimination, is a matter of perceiving the number of cubits that a given distance is; rather, the viewer derives a determinate, imagined magnitude from some given distance and some given portion of ground, and he compares such determinate magnitudes to the magnitudes of the distances he perceives later. Likewise, it is from the cubit, or the palm's-breadth, or some other measured magnitude that he derives a determinate magnitude. Thus, when a viewer perceives some space and wants to know how many cubits it spans, he will compare the form of that space that has been derived by the imagination to the form of a cubit that has been acquired by the imagination, and, on the basis of this comparison, he will perceive the magnitude of the space in terms of cubits.[133]

[3.156] It is also normal for a person, when he wants to determine some property accurately, to look at it repeatedly, to differentiate its particular characteristics, and to take his time examining it, and thus he will perceive that property as it actually exists. Therefore, when the viewer perceives any visible object on the ground and wants to determine its distance accurately, he will scrutinize the portion of ground lying directly between him and the visible object, and he will move his line-of-sight along it. And so he will move his visual axis over that portion of ground, and he will measure it, and he will perceive it according to its individual parts, and he will sense its small parts when the distance of the outer limit of this space is moderate. And when sight perceives the portions of the ground and perceives their small parts, the faculty of discrimination will perceive the magnitude of the entire space, for, by passing the visual axis over that space, the faculty of discrimination will accurately determine the size of the area on the eye upon which the form of that space is projected, the size of the angle subtended by that area,[134] and the length of the ray that extends to the outer limit of that space. When these last two characteristics are accurately determined by the faculty of discrimination, it will accurately determine the magnitude of the portion of ground that is seen. So too, the distances of objects, such as walls and mountains, that stand above the earth's surface and lie far away [from the viewer] are perceived by sight in the same way as the magnitudes of the portions of the earth are, and sight will perceive the distances of visible objects ranged along them by perceiving the magnitudes of their lengths. This, then, is how sight accurately determines the magnitudes of the distances of visible objects that lie at moderate distances, those distances being spanned by a range of continuous, ordered bodies.

[3.157] Now some visible objects that stand on the ground lie at moderate distances, and the portions of ground lying between them and the center of sight are of moderate extent. But some lie at extreme and inordinate distances, and the portions of ground lying between them and the center of sight are of inordinate extent. But the extent of portions of ground is perceived by sight in the ways we have described. Accordingly, the extent of any of them that lies near [the viewer] and is of moderate size is perceived and accurately determined by sight, whereas the extent of any of them that lies at an inordinate distance is not accurately determined by sight. For when it examines intervals, sight perceives their extent as long as it senses the increase in the length of the rays, and as long as it senses the angles subtended by the small parts of the portions of space as the visual axis scans the space. And it will accurately determine the extent of the space as long as it senses a slight increase in the length of the ray and a slight increase in the angle subtended by the given space. But when the distance is extreme, sight will not sense the slight increase in the length of the ray, nor will it sense the motion of the ray over a small portion of a space that lies extremely far away, nor will it sense the angle subtended by a small portion [of ground] that lies extremely far away, nor will it accurately determine the length of the ray extending to the outer limit of the space, nor will it accurately determine the size of the angle subtended by that space. And since it does not accurately determine the length of the ray extending to the outer limit of that space, and since it has not accurately determined the size of the angle subtended by the space, it will not accurately determine the extent of the space.

[3.158] In addition, when the distance is extreme, the small portions [of ground] that lie at the outer limit of the space are not perceived or distinguished by sight, for a small magnitude disappears from sight at an extreme distance. Thus, when the visual axis is moved over a space that is inordinately far away, and when it reaches the outer limit of that space, it will pass over a small portion of the space, so the sensitive faculty will not sense its motion, because a small portion [of ground] at an extreme distance does not subtend a perceptible angle at the center of sight. So if the visual axis moves over a distant space, and if sight senses that it has just passed over some portion of that space, then the extent of the portion it has passed over will not be the extent perceived through sense; rather, it will be larger.[135] And as the space extends out farther, the portions [of ground] toward the outer limit of the space that disappear from sight will become larger, as will the portions over which the motion of the rays is not sensed. Thus, the extent of extreme distances on the ground are not accurately determined by sight, because it cannot accurately determine the length of the ray[s] extending to their outer limit, nor can it accurately determine the size of the angle subtended by that space.

[3.159] Furthermore, the sensitive faculty senses the fact that the magnitude of the space has been determined, for a visible object that lies near the eye at a moderate distance is seen more clearly [than one lying farther away] precisely because the forms of such [objects] are clearer and are more clearly perceived by sight. Moreover, their color and illumination are clearer to sight, as are the spatial dispositions of their surfaces and the spatial dispositions of their parts, and the form of their parts and the parts of their surfaces are clearer to sight.[136] Also, if there is some design or picture [in them], or [if they have] small subdivisions, those designs or subdivisions will appear more clearly to sight. But such is not the case for visible objects lying extremely far away. For when a visible object lies extremely far away, sight will not determine its form as it actually is but will be uncertain about its color, its luminosity, and the form of its surfaces, and none of the subtle characteristics or small subdivisions in it will appear. And this fact is evident to sense. Therefore, when sight perceives some space on the ground and immediately afterward sees its outer limit along with some visible objects at its outer limit, it will sense that the space lies at a moderate distance or lies inordinately far away. On the one hand, if it accurately determines the form of its outer limit or the form of a visible object at its outer limit with perfect clarity, and if, in addition, it distinguishes the extent of that space in the way previously described, then on that basis the faculty of discrimination will perceive that the extent of that space is accurately determined by perceiving the clarity of the form of its outer limit or the form of the visible object at its outer limit. On the other hand, if it does not accurately determine the form of its outer limit or the form of a visible object at its outer limit [with clarity], then it will not accurately determine the extent of that space. In addition to this, after having examined this space, the faculty of discrimination perceives that the extent of this space is not accurately determined because of the indefiniteness of the form of its outer limit or the form of the visible object at its outer limit.

[3.160] Therefore, the magnitudes of the distances of visible objects will be distinguished by sight while the way in which their magnitudes are perceived is accurately determined at the moment of perception, and if the viewer wants to accurately determine the size of a visible object or to accurately determine the magnitude of the distance of a visible object, he will scrutinize the distance and define it, and thus a determinate distance will be distinguished by him from an indeterminate one. Thus, the only distances of visible objects that are of a determinate size are those distances that are spanned by a continuous, ordered range of bodies and, moreover, that are moderate. The magnitudes of these sorts of distances are therefore perceived by sight in the way we have shown, and no others are accurately determined by sight; instead they are estimated and assimilated—i.e., sight assimilates the distance of a visible object to ones similar to it among familiar visible objects whose distances have already been accurately determined by it. But the moment sight senses the indefiniteness of the form of a visible object that is due to [extreme] distance, it will be uncertain about how far away it is. Now a distance whose magnitude is accurately determined by sight is [considered] moderate when a portion of it that is of a perceptible size in relation to the whole and that lies at its outer limit does not disappear from sight. Moreover, with regard to a visible object whose size is [correctly] perceived by sight, a distance is [considered] moderate when, at its outer limit, a portion of that object that is of a perceptible size in relation to the whole does not disappear from sight if sight focuses on that part by itself. Thus, any space is [considered to be] of moderate extent if, in forming part of a length, it has a perceptible size in relation to the length as a whole, and if it is perceived by sight, so that no portion of the space, except one that has no perceptible size in relation to the length of that space, disappears from sight. A distance that is of inordinate extent, however, is one in which a [quantifiable] portion at its outer limit lacks perceptible size in relation to the length as a whole. And a distance that is inordinate with respect to sight is one in which any magnitude contained by it that has a perceptible size in relation to the whole disappears from sight, or when some characteristic of the visible object [at that distance] is invisible, that invisibility preventing the visual perception of precisely what that visible object is.

[3.161] The sensitive faculty will also perceive the magnitude of a visible object's distance according to the size of the [visual] angle subtended by the visible object. For, when it perceives familiar objects that lie at familiar distances, sight will immediately recognize them at the moment of perception, and when sight recognizes them, it will recognize their sizes, for their sizes will already have been accurately determined on account of the frequency with which any of the familiar visible objects has been perceived, so they [will] have become ensconced in the imagination. Moreover, as soon as it perceives a familiar visible object, sight perceives the area on the eye upon which the form of that visible object is projected and which corresponds to that form. Then, when the sensitive faculty perceives the size of the visible object through recognition, and when it perceives the angle subtended by that visible object at this time, it will perceive the magnitude of the distance of the visible object in that situation, for the angle subtended by that visible object will depend entirely on the magnitude of the distance.[137] And just as the sensitive faculty gets an indication of the size and distance [of the object] from that angle, so too it gets an indication of the magnitude of its distance from the size that is recognized by it along with the angle. For that magnitude subtends that angle at that particular distance alone, or at one equal to it, not at every distance. And since the sensitive faculty perceives the magnitude of the distance of that familiar visible object with great frequency, during which times that visible object subtends a similar angle at the center of sight, and since it will have gotten continual indications of the size of that visible object from the magnitude of the distance of that visible object along with the size of an angle equal to that [currently perceived] angle, the faculty of discrimination will apprehend the magnitude of the distance at which it perceives the size of that visible object in relation to that angle. And when the faculty of discrimination apprehends the magnitude of the distance of that visible object in relation to that angle, and when at that distance it perceives the size of that visible object with respect to that same angle at the time the faculty of discrimination recognizes that visible object, and when it recognizes its size, having perceived it before, and when it immediately perceives the size of that angle subtended by that visible object at this time, it will perceive the magnitude of the distance according to which that particular distance corresponds to that particular angle. Thus, the sensitive faculty perceives the magnitude of the distances of familiar visible objects by correlating the angle to the size of the visible object. Then, from continual reiteration, the sensitive faculty will perceive the distance of a familiar visible object through recognition. At the time the angle is perceived and the familiar visible object is recognized, the size of the angle subtended by the visible object will serve as an indication of the magnitude of the distance of that visible object, and the majority of the distances of familiar visible objects are perceived in this way. But this perception is not particularly accurate, although there is no significant discrepancy between the distance [derived in this way] and the correctly determined distance, so it is from this [type of] perceptual process that the mathematicians have supposed that the size of any visible object is perceived through the angle.[138] Thus, when sight perceives familiar visible objects that lie at familiar distances, and when it recognizes the magnitudes of their distances in this way, it will, for the most part, arrive at the truth of the matter in regard to the magnitudes of their distances, or there will be no significant discrepancy between the magnitudes of their distances as perceived by it and the true magnitudes of their distances.

[3.162] In the case, however, of the magnitudes of the distances of unfamiliar visible objects that it does not perceive with frequency, sight generally errs, although sometimes it may find itself reckoning their sizes [correctly] in this way. According to the ways we have described, then, the magnitudes of the distances of visible objects are perceived by the sense of sight.

[3.163] Having shown how the magnitudes of the distances of visible objects are perceived, and having analyzed the distances of visible objects, we shall now analyze the [kinds of] magnitudes of visible objects that are perceived by sight as well as analyzing their perception by sight. Accordingly, we should say that the [kinds of] magnitudes that sight perceives from a facing position are the magnitudes of visible surface, the magnitudes of the parts of visible surfaces, the magnitudes of the boundaries of visible surface, the magnitudes of the boundaries of the parts of visible surfaces, the magnitudes of the intervals between the boundaries of the parts of visible surfaces, and the magnitudes of the intervals between individual visible objects. These are the only kinds of magnitudes that sight perceives from a facing position. Now the size of the body of a visible object is not perceived by sight from a facing position, for sight does not perceive the entire surface of a body from a facing position; it perceives only that portion of its surface that faces it, even if the body is small. And if sight does perceive the mass of the body, it will perceive not the size of its body but, rather, the shape of its mass. Thus, if the body is moved, or if the eye moves so that sight perceives the body's entire surface [directly] by sensation or through defining features, then the faculty of discrimination will perceive the sizes of its mass by means of a secondary deduction beyond the deduction that is used during the visual process itself. Likewise, when it perceives the size of the mass of any part of the body, the faculty of discrimination will only perceive it by means of a secondary deduction beyond the deduction that is used during the visual process itself. Thus, the magnitudes that sight perceives from a facing position are only the sizes of the surfaces or lines that we have specified.

[3.164] It has already been shown that the perception of size is due only to a correlation of the base of the visual cone encompassing the size to the angle of the cone at the center of sight and to the length of the cone, which represents the magnitude of the distance of the visible object.[139] It has also been shown that certain distances of visible objects are accurately determined, and certain of them are estimated.[140] The sizes of visible objects whose distance is accurately determined are perceived by sight through a correlation of their sizes to the angles subtended by those magnitudes at the center of sight, as well as to their determinate distances. Thus, the perception of the magnitudes of the distances of such visible objects will be a determinate perception. The magnitudes of the distances of visible objects whose distance is estimated, not determinate, however, are perceived by sight through a correlation of their size to the angles subtended by those magnitudes at the center of sight, as well as to their estimated, not determinate, distances. Accordingly, the perception of the magnitudes of the distances of such visible objects will not be accurately determined. When the sensitive faculty wants to determine the size of any visible object with accuracy, then, it will move the line-of-sight over its cross-sections, and so it will move the visual axis over all portions of the visible object. Hence, if the distance of the visible object is extreme, the indefiniteness of its form will be immediately revealed to the sense, and it will be obvious to the sensitive faculty that its size is not accurately determined. But if the distance of the visible object is moderate, then the determinate nature of its visual perception will be immediately revealed to the sense. Accordingly, if the visual axis is moved over a visible object of this sort, sight will measure it correctly, and it will perceive its parts, and it will accurately determine the sizes of its parts. And through [such] motion sight will accurately determine the sizes of the areas on the surface of the sensitive organ upon which the form of the visible object is projected as well as the size of the angle of the visual cone subtended by that part. Then, if it wishes to accurately determine the distance of that object on the basis of some intervening entity, sight will accurately determine the extent of that entity by the [axial] motion [just described], the [overall] extent [of that entity] being virtually equal to the lengths of the radial lines.[141] So when the sensitive faculty accurately determines the magnitude of the visible object's distance and the size of the angle forming the cone that encompasses the visible object, it will accurately determine the size of that visible object.

[3.165] Now the motion of the [visual] axis over the parts of the visible object will not be due to a rotation of the axis from the center of the eye, or through its independent motion over the parts of the visible object, for it has already been shown that this line always extends directly to the place where the nerve to which the eye is attached flexes.[142] And since its situation does not change with respect to the [center of] the eye, but, rather, the entire eye moves in opposition to the visible object while the central location, which is the center of the sense of sight, faces any part of the visible object, and since the entire eye will move in opposition to the visible object, the [visual] axis will pass over every part of the visible object. And so the form of any part of the visible object extends to the eye straight along the [visual] axis when the axis reaches it. Still, the [visual] axis will remain fixed in its situation, so it will not change its situation with respect to any part of the eye as a whole. And, under this condition, its rotation will be due solely to the motion of the entire eye at the place in the eyesocket where the nerve [flexes].

[3.166] So when sight wishes to inspect a visible object and begins to examine it at the extremity of the visible object, the endpoint of the [visual] axis will then lie upon the outer edge of the visible object. In that case, then, the majority of the [form representing the] whole visible object will lie on an area of the surface of the eye that is inclined to, or to the side of, the [visual] axis away from where the axis lies, for the form of the object's edge will be in the middle of the eye where the [visual] axis lies, so the rest of the form will be inclined to, or to the side of, the [visual] axis. Afterward, as sight moves beyond this position over [one or] another cross-section of the visible object, the [visual] axis will be shifted to a part next to that [original] part of the visible object, and the form of the first part will be inclined to the [new] place to which the [visual] axis is moved. Nor at any time after will that form stop inclining away as long as the [visual] axis moves along that cross-section until the axis reaches the endpoint of that cross-section of the visible object and to the opposite side of the visible object from the first part. In this case, then, the form of the entire visible object will be inclined [to the visual axis] on the opposite side of where it was originally inclined, except for the final part at the extremity which [originally] lay on the [visual] axis at the center of the eye['s surface]. But, throughout this motion the [visual] axis will remain fixed in its situation [relative to the eye as a whole], and this motion will be extraordinarily swift, so it is generally imperceptible on account of its swiftness. Furthermore, during its motion, the [visual] axis does not coincide with the endpoints of the angle subtended by the visible object at the center of sight, nor does it mark out a slice corresponding to the angle subtended by any of the cross-sections of the visible object, for this would only occur if the [visual] axis moved on its own account while the rest of the eye remained immobile, which is impossible.[143] Instead, the entire eye moves during inspection, and the axis moves along with its motion. However, the sensitive faculty only perceives the size of the angle subtended by the visible object at the center of sight by perceiving the size of the part of the surface of the eye in which the form of the visible object is delineated and by imagining the angle subtended by that part at the center of sight.

[3.167] Now the sense of sight perceives the sizes of the areas of the eye on which the forms are delineated naturally, and it imagines the angles subtended by those areas naturally.[144] But the sensitive faculty does not accurately determine the form of the visible object or the object's size by the motion of the eye unless, according to that motion, it perceives every portion of the parts[145] of the visible object through its midpoint or the point on the eye where the axis lies. Through this motion the form of the visible object moves over the surface of the eye, and so the area on the eye's surface where the form lies will change, because, as the motion continues, the form of the visible object will shift area-by-area on the eye's surface. Yet every time the sensitive faculty perceives the part of the visible object at the end of the visual axis, it will also perceive the entire visible object, and it will perceive the entire area on the eye's surface upon which the form of the entire visible object is projected, and it will perceive the size of that area, and it will perceive the size of the angle subtended by that area at the center of sight. And so the sensitive faculty will repeatedly perceive the size of the angle subtended by that visible object. As a result, this angle will be accurately determined by the sensitive faculty, while the faculty of discrimination will apprehend the size of the angle as well as the magnitude of the distance, and from these it will perceive the visible object's actual size. This, then, is how the visual inspection of visible objects is carried out by sight and how the size of visible objects is accurately determined through visual inspection.

[3.168] In addition, when sight perceives the lengths of the radial lines extending between the center of sight and the extremities of the visible object or the areas on the surface of the visible object, it will sense the equality or inequality of their lengths. If, on the one hand, the surface of the visible object that sight perceives is oblique, it will sense its obliquity by sensing the inequality of the magnitudes of the distances of its extremities [from the center of sight]. But if the surface faces the eye directly, sight will sense its facing disposition by sensing the equality of the distances [of its extremities from the center of sight]. Accordingly, the size [of the object] does not escape the faculty of discrimination, because it is from the inequality of the distances of the endpoints of the cross-sections of an oblique magnitude [from the center of sight] that the faculty of discrimination perceives the obliquity of the cone that encompasses the object, and from that it will sense the change in the size of its base that is due to obliquity.[146] Moreover, it will not confuse the size of an oblique magnitude with the size of a directly facing magnitude through assimilation unless the correlation is based on angle alone. But if the correlation is based on angle as well as on the lengths of the radial lines extending between the center of sight and the extremity of the visible object, it will be certain about the size of the magnitude.

[3.169] The magnitudes of lines and intervals are perceived by sight through the perception of the magnitudes of the distances of their extremities and through the perception of the inequality or equality of those distances. But the farther, or the farthest, moderate distance with respect to a visible object when that object is oblique is less than the farthest moderate distance with respect to that same visible object when it faces the eye directly. For a moderate distance for a visible object is one at which a part of the visible object that has a perceptible size with respect to the whole does not disappear from sight. But when a visible object is oblique, the angles formed by the two rays extending[147] from the center of sight to any part on the oblique visible object will be smaller than the angle formed by the two rays extending from the center of sight to that same part, at the same distance, when the visible object faces the eye directly. So, when the visible object is oblique, a part that has a perceptible size with respect to the whole disappears from sight at a shorter distance than that same part does when the visible object faces the eye directly. Thus, the farthest moderate distance with respect to an oblique visible object is smaller than the farthest moderate distance with respect to that same visible object when that visible object faces the eye directly. Furthermore, when it is oblique, the entire visible object disappears from sight at a shorter distance than it does when it faces the eye directly, and its size decreases [more quickly] at a shorter distance than it does when it faces the eye directly.

[3.170] Therefore, visible objects have their sizes accurately determined by sight when they lie at a moderate distance and when that distance is spanned by a continuous, ordered range of bodies, and sight perceives their sizes by correlating them to the angles of the cones of rays that encompass them and to the lengths of the radial lines. But [what are considered] moderate distances for any given object depend on the spatial disposition of that object in terms of an oblique or a directly facing orientation. The angles are accurately determined only if sight scans the cross-sections of the surface of the visible object or those of whatever magnitude it wishes to determine, and distance is accurately determined through the motion of the visual axis over the body spanning the distances of the extremities of that surface or that interval. On the whole, the form of the distance, as well as the form of the visible object lying at a moderate distance (provided that this distance is spanned by a continuous, ordered range of bodies), occur simultaneously in the imagination at the moment the visible object is visually inspected, which is when sight perceives the body spanning the distance of the visible object as the visible object is perceived. Accordingly, the faculty of discrimination will perceive the size of the visible object according to the magnitude of the form of its determinate distance along with the visible object's own form. Hence, the sizes of such visible objects alone are correctly perceived by sight. According to the way we have described, then, the sizes of visible objects are perceived by the sense of sight.

[3.171] We shall explain later, in our discussion of visual deceptions, why a visible object is perceived to be smaller than it actually is at an extreme distance, and why a visible object is perceived to be bigger than it actually is from very near, and we shall discuss the causes of these deceptions [at that time].[148]

[Perception of Separation]

[3.172] Separation between visible objects is perceived by sight from the separation of the forms of two bodies or of two distinct visible objects that reach the eye. But in the gap that separates any two distinct bodies there will be light or a colored and illuminated body, or there will be darkness. Therefore, when sight perceives two separated bodies, the form of the light, or the form of a body's color, or the form of the darkness that exists in the gap [between the bodies] reaches an area on the eye that lies between the forms of the two separated bodies that reach the eye. Moreover, there may be light, or color, or darkness in a body that lies between the two bodies and is contiguous with both of them. Therefore, if sight does not sense that whatever light or darkness exists in the gap [between the two bodies] does not exist in a body that is contiguous with the two bodies that flank it, it will not sense the separation of the two bodies. Furthermore, the surface of either of those two bodies slopes toward the area where the separation occurs. Therefore, the sloping of the two surfaces of the two bodies or of the surface of either of the two bodies may be obvious to sight, or it may not be.[149] Accordingly, if the sloping of the two surfaces of the two bodies or of the surface of either of the two bodies is evident to sight, then sight will sense the separation of the two bodies. Hence, sight perceives the separation of the bodies by perceiving any of the things we discussed: either by perceiving light where the separation occurs and sensing that this light lies behind the surfaces of the two separated bodies; or by perceiving a colored body where the separation occurs and sensing that it is different from both of the separated bodies; or by perceiving darkness where the separation occurs and realizing that it is darkness rather than a body contiguous with the two bodies; or by perceiving the slope of both of the surfaces of the two bodies where the separation occurs or the slope of the surface of either of the two bodies. Therefore, no separation between bodies is perceived by sight unless it is done so according to one of these conditions.

[3.173] A separation may exist between two distinct bodies, or it may exist between two bodies that are not [entirely] distinct—e.g., when two bodies, such as the fingers and members of an animal, or the branches of trees, are continuous according to certain parts and separated from one another according to other parts. In either case, though, sight only perceives the separation in the ways that we have described. Now it may happen that the separation of the bodies is [perceived] by recognition or by previous acquaintance, but that perception does not arise from visual sensation.

[3.174] Some separations between bodies are wide, and some are narrow. A wide separation does not generally escape sight because of the appearance of a body spanning the distance of separation, according to which that body appears distinct from both of the separated bodies, or because of [sight's] perception of light or of an illuminated gap in the distance [of separation]. A moderate or narrow separation is only perceived by sight at a distance in which a body the same size as the breadth of the distance [of separation] does not disappear from sight. If, however, the distance between the two bodies is [so] narrow [as to be] invisible, and if its distance from the eye is the same as that at which bodies of the same size as the breadth of the distance [of separation] disappear from sight, sight will not perceive that distance, even if the two bodies lie at a moderate distance from the eye, and sight perceives the two bodies correctly. For a moderate distance is one in which a magnitude that has a perceptible size with respect to the magnitude of the whole distance does not in any way disappear from sight, whereas a correct perception is one in which there is no sensible discrepancy at all between the perception and the reality of the visible object in respect to the visible object as a whole. The extent of the distance, however, may be of such a magnitude that it lacks perceptible size in comparison to the distance of the visible object, or it may lack perceptible size with respect to either of the two separated bodies, for a separation may be the size of a hair; nonetheless, this is not [necessarily] so tiny as to make the distance [represented by it] vanish. Thus, the separation between visible objects is perceived by sight in ways like those we have discussed.

[Perception of Continuity]

[3.175] Continuity, for its part, is perceived by sight from the absence of a distance [of separation]. Thus, if sight does not sense some distance [of separation] in a body, it will perceive the body as continuous, or if there is a hidden distance [of separation] in the body that is not perceived by sight, sight will perceive that body as continuous, even though there is separation in it.

[3.176] Moreover, sight perceives continuity and also differentiates between continuity and contiguity by perceiving the joining of two edges of two bodies. But sight does not judge that there is contiguity unless it has realized that each of the two contiguous bodies is different from the other, for the difference between two contiguous bodies can at times be found in two continuous bodies. Thus, if the sensitive faculty does not sense that each of the two contiguous bodies is different from the other and separate from it, it will not sense contiguity but will judge that there is continuity [between them].

[Perception of Number]

[3.177] Number, as well as what is numbered, is perceived by sight, for at any given time sight perceives many individual visible objects at once, and when sight perceives that they are separate, it will perceive that each of them is different from the other, and so it will perceive a multitude. But the faculty of discrimination will perceive number on the basis of multitude. Thus, number will be perceived by the sense of sight through the perception of many individual visible objects when sight perceives them at the same time, and it perceives their individuality as well as perceiving that each of them is different from the other. This, then, is how number is perceived by the sense of sight.

[Perception of Motion]

[3.178] Motion is perceived by sight through a correlation of the moving object to another visible object, for when sight perceives a moving visible object while it perceives another visible object, it will perceive its spatial disposition with respect to that moving visible object.[150] So when the visible object is moving and the other visible object is stationary, at the time of motion the spatial disposition of the moving visible object will change with respect to [the spatial disposition] of the stationary visible object because of the moving visible object's motion. When sight perceives the moving object and at the same time perceives the other object [that is stationary], and when it also perceives the former's spatial disposition with respect to [that of] the latter, it will perceive its motion. Thus, motion is perceived by sight through the perception of a change in the moving object's spatial disposition with respect to that of the other [stationary] object.[151]

[3.179] Furthermore, motion is perceived by sight in one of three ways: from the relationship of the moving visible object to several [other] visible objects, from the relationship of the moving visible object to one visible object, or from the relationship of the moving visible object to the center of sight itself. In the first case, when sight perceives a visible object and its motion, and when it perceives that object in line with any [other] visible object, then perceives it in line with another visible object different from the first, while the center of sight remains fixed, it will sense the motion of that visible object. Moreover, when a visible object moves with respect to a single visible object, sight perceives the moving visible object, as well as its spatial disposition with respect to the other visible object, and then perceives that its spatial disposition has changed with respect to that other visible object, [sensing] either that it has drawn farther away, or that it has drawn nearer, or that it has moved to the side, while the center of sight remains fixed; or else it perceives a change in the spatial disposition of any of the parts of the moving visible object with respect to that stationary visible object or a change in the spatial disposition of all of its parts with respect to the [stationary] visible object. It is in this last way that sight perceives the motion of a rotating visible object when someone compares it to another [stationary] visible object. Therefore, when sight perceives the [changing] spatial disposition of a moving visible object, or the [changing] spatial disposition of [all of] its parts, or the [changing] spatial disposition of any of its parts,[152] it will perceive the motion of the moving visible object.

[3.180] Finally, when a visible object moves with respect to the center of sight, sight perceives the moving visible object while perceiving its place and its distance [from the eye]. So when the center of sight is fixed, but the visible object moves, the spatial disposition of the moving visible object will change with respect to the center of sight. Thus, if the visible object moves in the plane facing the eye, its place will change, and sight will sense its change of place, and when sight senses its change in place, it will perceive its motion, provided that the center of sight stays fixed.[153] If, on the other hand, the motion of the visible object is along the line-of-sight extending between the object and the center of sight, the visible object will either recede from or approach the center of sight by its motion. Then, when sight senses its receding or its approach, it will sense its motion, provided the center of sight remains stationary.[154] Finally, if the motion of the visible object is rotary, then it necessarily follows that the part of it directly facing the eye will change [place], and when that part of the visible object changes [place], and sight senses its change [of place], it will sense the motion of the visible object, provided the center of sight remains stationary. These, then, are the ways in which sight will perceive motion when the center of sight remains fixed in place.

[3.181] Sight will also perceive motion in one of these ways, even when the center of sight is moving. This will happen when sight senses a change in the spatial disposition of the moving visible object while sensing that this change is not due to the motion of the center of sight and while differentiating between the change in spatial disposition occurring in the visible object that is due to its own motion and the change in spatial disposition occurring in the eye that is due to the motion of the eye. Hence, when sight senses the change in the spatial disposition of the visible object and also senses that its change in spatial disposition is not due to the motion of the center of sight, it will sense the motion of the visible object. Now the form of the moving visible object moves on the eye['s surface] according to the object's motion. But sight does not perceive the motion of the visible object from the motion of its form on the eye alone; on the contrary, sight perceives the motion of a visible object only by comparing the visible object to another according to the ways we described.[155] For the form of a stationary visible object sometimes moves on the eye['s surface] while that visible object remains immobile, and therefore sight does not perceive that it moves, because when sight moves with respect to facing visible objects, the form of each visible object facing the eye will move on the eye's surface according to its motion, whether the object is moving or is stationary.[156] But since sight is accustomed to the motion of the forms of visible objects on its surface [even] when those visible objects are stationary, it will not judge the object to be in motion from the motion of its form unless the form of another visible object reaches the eye, and unless sight perceives the change in spatial disposition of the [form of the] moving visible object with respect to the form of the other visible object, or unless [it perceives] a change of forms at the same place on the [surface of the] eye, which will happen in the case of rotation. Thus, motion is perceived by sight only in the ways we have listed.

[3.182] What kind of motion it is is perceived through the perception of the space over which the visible object moves when it moves as a whole, and sight determines the kind of motion it is when it determines the shape of the space over which the moving visible object moves. So when the visible object rotates, sight will perceive its motion as rotary by perceiving the sequential change of its parts on the eye with respect to some other visible object, or the change of any of its parts in consecutive order with respect to various visible objects, or the change of the parts of one visible object in consecutive order while the visible object, as a whole, remains fixed in place.

[3.183] Moreover, if the motion of the visible object is composed of rotary motion and locomotion,[157] sight will perceive that motion as composite by perceiving the change of the parts of the moving visible object with respect to the eye, or with respect to another visible object, while perceiving the motion of the visible object as a whole from its [original] location. It is therefore in these ways that sight perceives how visible objects move.

[3.184] Furthermore, sight does not perceive motion except over time, for motion occurs only over time, and every part of a motion occurs only over time. Now sight perceives the motion of a visible object only by perceiving the visible object in two different locations or according to two different spatial dispositions. But the location or spatial disposition of a visible object changes only over time. Thus, when sight perceives a visible object in two different places or according to two different spatial dispositions, this will occur only at two different instants. But between any two different instants there is some time-interval. Thus, sight only perceives motion over time.

[3.185] We shall also point out that the time in which sight perceives motion must be perceptible, for sight perceives motion only by perceiving the visible object in two different locations, one after another, or according to two different spatial dispositions, one after another. Therefore, if sight perceives a moving visible object in a second location and does not at the same time perceive it in a first location where it perceived it before, the sensitive faculty will immediately sense that the instant at which it perceives the object in the second place is different from the instant at which it perceived it in the first place, whence it will sense the difference in the two instants. The same applies when sight perceives motion on the basis of the moving object's change in spatial disposition, for when it perceives the moving object according to a second spatial disposition and does not at the same time perceive it according to the first spatial disposition that it perceived before, it will immediately sense the difference in the two instants, whence it will perceive the time-interval between them. Therefore, the time in which sight perceives motion is necessarily perceptible.

[3.186] And since these points have been explained, we shall now recount what can be summarized from them. Accordingly, we shall observe that sight perceives motion by perceiving the moving visible object according to two different spatial dispositions at two different instants between which there is a perceptible amount of time, and this how motion is perceived by sight.

[3.187] Sight perceives variations in swiftness or slowness among motions, as well as equality among motions, by perceiving the spaces over which moving visible objects pass. Thus, when sight perceives two moving visible objects, and when it perceives the two spaces over which those two visible objects move, and when it senses that one of the two spaces passed over by the two moving visible objects in the same time is longer than the other, it will sense the [greater] swiftness of the visible object passing over the longer space. Furthermore, when the two spaces over which the two visible objects pass in the same time, or in two equal amounts of time, are equal, and when sight senses the equality of those spaces, it will sense the equality of the motion of the two moving objects. So too, when sight senses the equality of the two spaces along with the inequality of the two times over which the two motions take place, it will sense the [greater] swiftness of the moving object passing over the space in less time; and, by the same token, when two moving objects pass over equal spaces in equal times, and when sight senses the equality of times and the equality of spaces, it will sense the equality of the two motions. We have now explained how sight perceives motion and how it differentiates motions, as well as kinds of motions and their equality or inequality.

[Perception of Rest]

[3.188] Rest is perceived by sight through perception that the visible object remains at the same location or in the same spatial disposition over a perceptible amount of time. Therefore, when sight perceives a visible object at the same location or according to the same spatial disposition at two different instants between which there is a perceptible time-interval, it will perceive that the visible object is immobile during that time. Moreover, sight perceives the spatial disposition of an immobile visible object with respect to another visible object or with respect to the center of sight itself. This, then is how the perception of the immobility of visible objects will be carried out by sight.

[Perception of Roughness]

[3.189] Roughness is generally perceived by sight from the form of light appearing on the surface of a rough body, for roughness consists of a variation in spatial disposition of the parts of the surface of a body, so, when light shines on the surface of that body, the raised portions will generally cast shadows. Meanwhile, when light reaches the depressed portions, it will also create shadows, so the raised portions will be exposed to light and revealed. If shadows are formed in the depressed portions, but no shadows exist on the raised portions, the form of light will vary on the surface of that body. On a smooth surface,[158] however, such is not the case, for the portions of a smooth surface are uniform in spatial disposition, so when light shines on them, the form of light will be uniform throughout the surface. Thus, the form of light on a rough surface is different from the form of light on a smooth surface. Sight, moreover, recognizes the form of light on rough surfaces and the form of light on smooth surfaces from the frequency with which it sees rough and smooth surfaces. Thus, when sight senses the light on the surfaces of bodies in the way it usually does for rough surfaces, it will impute roughness to that body. But when it senses light on the surface of a body in the way it usually does for smooth surfaces, it will impute smoothness to the surfaces of that body.

[3.190] Yet when the roughness is inordinate, the raised portions [of the surface] will be of a substantial size, and thus sight will perceive the elevation of those parts, and it will perceive the spatial disposition of the surface of the body by perceiving the distance between parts. So when sight perceives the variations in spatial disposition of the parts of the body's surface, it will perceive its roughness without having to evaluate the light.

[3.191] In addition, when the roughness of the body is inordinate, and light shines upon it, the form of light on its surface will vary to an inordinate extent as well. From the variation in the form of light, then, the distance between the parts, as well as the variation in their spatial dispositions, will be seen, and on this basis the roughness of the body will be apparent. Thus, if the light shining on a rough body comes from a location directly opposite the rough surface, and if the light is intense, sight will not perceive the roughness of this body unless it perceives the prominence of some portions [of its surface] and the depression of others.[159] So if the roughness of this body is inordinate, i.e., as great as possible, sight will perceive the separation between parts and the variation in their spatial dispositions, and it will generally perceive the roughness of the body. On the other hand, if the roughness is slight, and the depressed or hollow portions of that body are exceptionally small, the roughness will generally go unseen, and sight will never perceive the roughness of this body unless it carefully scans [all] portions of the body's surface from up close. Thus, when sight discerns the separation between parts of such a body,[160] as well as their elevation or depression, it will perceive its roughness. If, however, sight does not discern the separation between its parts, or the elevation and depression of its parts, it will not perceive its roughness. Roughness is therefore perceived by sight through the perception of variation in the spatial dispositions of the parts of a body's surface or from the form of light that sight is accustomed to seeing on the surfaces of rough bodies. In addition, sight recognizes roughness from an absence of uniformity. Therefore, if sight senses no uniformity in the body['s surface], it will judge it to be rough, but sight frequently errs in [judging] roughness when it tries to recognize it in this way. For a surface may be polished, but its polish may not be apparent because polished objects do not appear polished unless they are placed in a particular way [with respect to the eye].[161]

[Perception of Smoothness]

[3.192] Smoothness,[162] which consists of uniformity in the surface of a body, is generally perceived by sight through the form of light that appears on the surface of a smooth body, sight being used to seeing that [kind of] light on smooth surfaces. So when the light on the surfaces of the body is uniform, sight will recognize the smoothness of the surface through it. Sometimes, too, sight perceives smoothness through close scrutiny. Accordingly, when sight scrutinizes the surface of a smooth body, it will perceive the uniformity of its parts, and so it will perceive its smoothness.

[3.193] Polish, which constitutes extreme smoothness, is perceived by sight through the dazzling light on the surface of a polished body. Thus, smoothness is perceived by sight through the perception of the uniformity of the surface. The uniformity of the surface, for its part, is generally perceived by sight through the uniformity of the light on the surface of the body, whereas polish is perceived by sight from the dazzling light on the surface of the body and from the spatial disposition [of the body] according to which the light is reflected.

[3.194] But sometimes roughness and smoothness coexist in the same surface, insofar as some bodies have surfaces with portions that are raised or depressed according to various spatial dispositions, or some portions of the portions are raised or depressed according to various spatial dispositions whereas others are uniform in spatial disposition, the result being that the surface as a whole is rough, whereas some of its portions are smooth. So the roughness of such a surface is perceived by sight from the perception of variations in spatial disposition among the prominent and depressed portions, whereas the smoothness of the [smooth] portions is perceived through the form of light that is perceived by sight on the surfaces of [those] portions. Sometimes, though, sight perceives the smoothness of such portions through close scrutiny and the [resulting] perception of the uniformity of each of them on the surface. It is in these ways, then, that sight perceives smoothness, polish, and roughness.

[Perception of Transparency]

[3.195] Transparency is perceived by sight through a deduction based on the perception of what lies behind a transparent body. But the transparency of a transparent body is not perceived by sight unless there is some opacity in it, and unless its transparency is less absolute than that of the air intervening between the eye and the transparent body. Indeed, if its transparency is absolute, sight will not perceive its transparency, so it will not perceive anything except what lies behind it.[163] If, however, there is some transparency in it, it will be perceived by sight according to the opacity it possesses. And its transparency is perceived through the perception of what lies behind it, for when there is light or an illuminated, colored body behind a transparent body, it will be seen behind the transparent body. But sight does not sense the transparency of the body when it senses what lies behind it unless it senses that the color and light that are perceived behind the transparent body are light and color [that actually lie] behind the transparent body, not light and color belonging to the transparent body itself. If not, it will not sense the transparency of the transparent body. So if there is neither light nor an illuminated body behind the transparent body, or in its vicinity, and if no light or color appears behind it or anywhere in its vicinity, then the transparency of that body is not perceived. This will be the case when a transparent body is placed against some opaque body that encompasses it or that coincides with it, and the transparent body is of a dark color.[164] For in that case sight will not sense the transparency of this body.

[3.196] The same applies if the region behind the transparent body is dark, and no light appears behind it.[165] Thus, when sight senses that the color it perceives behind the transparent body belongs to a body behind the transparent body, it will sense the transparency of the transparent body. Likewise, when the transparent body is only slightly transparent, and the body that lies behind it is feebly lit, as are the bodies in its vicinity, then its transparency is not perceived by sight unless the form of light is directly behind the transparent body. For if sight apprehends light behind it, it will perceive its transparency. These, then, are the ways in which sight perceives the transparency of transparent bodies.

[Perception of Opacity]

[3.197] Opacity is perceived by sight through the absence of transparency. So when sight perceives a body but senses no transparency in it, it will deduce its opacity.

[Perception of Shadow]

[3.198] Shadow is perceived by sight in relation to the light of an object that casts light or a portion of light, for shadow is the absence of some light in the shaded area, which is illuminated by light other than the light blocked from that shaded area.[166] And when sight senses some object next to that shaded area, and the light on that neighboring object is more intense than the light in the shaded area, it will sense the darkening of that area and the absence in it of the light shining upon the body in its vicinity. For when sight senses any light in any given place, but that place is not exposed to sunlight or some other intense light, it will sense the darkness of the place and the absence of sunlight or any intense light in that place. Moreover, sight may sense the body that casts the shadow, or it may not immediately discern the body casting the shadow. Eventually, though, when sight perceives the area that is feebly lit while it perceives that the bodies abutting on the area of faint light are more intensely lit than that feebly lit area, it will immediately sense the shadow in that area. This, then, is how sight perceives shadow.

[Perception of Darkness]

[3.199] Darkness, however, is perceived by sight through deduction on the basis of the absence of light. Thus, when sight perceives some location and does not perceive any light [whatever] in it, it will sense its darkness.[167]

[Perception of Beauty]

[3.200] Beauty is perceived by sight from the perception of particular characteristics, the means of their perception having already been explained. For each of the aforesaid particular characteristics will create some form of beauty on its own, whereas in conjunction they create other forms of beauty. But sight only perceives beauty in the forms of visible objects that are perceived by the sense of sight, and the forms of visible objects consist of particular characteristics that have already been discussed. So sight perceives forms by perceiving these characteristics; hence, it perceives beauty by perceiving these characteristics.[168]

[3.201] There are many kinds of beauty that are perceived by sight in the forms of visible objects. Accordingly, some are due to one of the particular characteristics in the form, whereas others are due only to a conjunction of characteristics, but not to the characteristics themselves, and others yet are due to the combining of characteristics and their [resulting] combination.[169] So sight perceives each of the characteristics that are in a given form by itself, but it also perceives them together, and it perceives their combination or conjunction. Sight perceives beauty in different ways, then, but all the ways in which sight perceives beauty hark back to the perception of particular characteristics.

[3.202] Whether these particular or conjoined characteristics create beauty (to create beauty means to dispose the soul in such a way as to perceive that what is seen is a beautiful object) will be evident from a brief examination. For light creates beauty, which is why the sun, moon, and stars will appear beautiful, but there is nothing beyond the light in the sun, moon, or stars that will make them appear beautiful. Thus, light creates beauty on its own.

[3.203] Color also creates beauty, for any bright color, such as green, rose-red, or the like, will appear beautiful to sight, and sight delights in them. Accordingly, dyed cloth, flowers, and gardens appear beautiful. On its own, then, color creates beauty.

[3.204] Distance, as well, sometimes creates beauty in an incidental way. For in certain beautiful forms there are spots or wrinkles that disfigure the forms, but when [the objects producing those forms] are removed some distance from the eye, those subtle characteristics that disfigure those forms disappear, and as soon as those characteristics disappear, the beauty of the form will be revealed. So too, in many beautiful forms there are subtle characteristics, such as design or pattern, that make the form beautiful, but many of these characteristics disappear from sight at a variety of moderate distances. When [the objects producing those forms] are near the eye, though, these subtle characteristics will be revealed to sight, and the form's beauty will appear. Thus, remoteness and nearness create beauty.

[3.205] Spatial disposition sometimes creates beauty, and several beautiful characteristics appear beautiful only according to arrangement or spatial disposition, for all distinctive designs that are arranged in tight order appear beautiful only because of their arrangement. Writing appears beautiful only according to its arrangement, for its beauty lies only in the configuration and evenness of the letters as well as the way in which they are conjoined to one another. If, however, the combination of letters and their arrangement are not proportional, so that it forms a hodge-podge, one letter being large, another small, then the writing will not be beautiful, even though the shapes of the letters, taken individually, are well proportioned.[170] Sometimes, too, writing appears beautiful when its overall composition is proportional, even though the [individual] letters are not as well proportioned as they might be.[171] Likewise, several forms of visible objects appear beautiful only because of the relative disposition and arrangement of their parts.

[3.206] Corporeity also creates beauty, which is why the human body and those of many animals appear beautiful.[172]

[3.207] Shape, as well, creates beauty, and it is for this reason that the moon and the beautiful forms of people, as well as of several animals, trees, and plants appear beautiful only according to their forms, or according to the shapes of their parts or to their [overall] shapes, or according to the shapes of the parts of the form.

[3.208] Magnitude creates beauty, which is why the moon appears more beautiful than the stars, whereas large stars appear more beautiful than small stars.

[3.209] Separation, too, creates beauty, and this is why individual stars are more beautiful than clustered stars and more beautiful than the stars in the Milky Way, and it is also why individual candles are more beautiful than a fire.

[3.210] Continuity also creates beauty, which is why continuous vegetation or densely [clustered] plants are more beautiful than individual [plants].[173]

[3.211] Number, as well, creates beauty, which is why places in the sky where there are many stars are more beautiful than places with few stars, and it is why a large number of candles in the same location creates beauty. It is also why places in the sky where there are many stars are more beautiful than surrounding places [with fewer].[174]

[3.212] The motion of a person making a speech or carrying out some task [creates beauty].

[3.213] A person's immobility also creates beauty, and this is why gravity and reserve appear beautiful.

[3.214] Roughness, as well, creates beauty, which is why many shaggy fabrics appear beautiful.

[3.215] Smoothness, too, creates beauty, and it is for this reason that it appears beautiful in fabrics.

[3.216] Transparency creates beauty, which is why transparent objects appear to glitter at night.

[3.217] Furthermore, opacity creates beauty, for color, light, shape, design, and all [other] characteristics that appear beautiful in visible forms are perceived alike by sight on the basis only of opacity or shadow.[175]

[3.218] Shadow also creates beauty, for in many visible forms there are blemishes and tiny pores that render them ugly, and when they are in sunlight their blemishes will be revealed, so their beauty will be obscured. But when they are in shadow or in weak light, those blemishes and wrinkles will disappear, so their beauty is apprehended. Furthermore, the complicated windings that appear in the feathers of birds and in the fabric called "alburalmon"[176] do not appear in shadow or in weak light.

[3.219] Darkness makes beauty appear, for the stars only appear in darkness. Likewise, their beauty only appears in the dark of night or in dark locations, and it disappears in daylight. Moreover, stars are more beautiful on dark nights than on moonlit nights.

[3.220] Similarity also creates beauty, for the members of an animal that are of the same kind, such as one eye in relation to [the other] eye, do not appear beautiful unless they are similar, for when the eyes are of different shapes, e.g., when one is round while the other is oblong, they will be extremely ugly. So, too, if one is black and the other green, they will be ugly, and the same holds if one is larger than the other. Similarly, if one cheek is hollow, and the other is bulbous, they will be extremely ugly; and, in the same vein, if one of the eyebrows is thick and the other thin, or if one of them is long and the other short, they will be ugly. Thus, no members of this kind that belong to animals and are paired will be beautiful unless they are similar. So, too, depictions and letters do not appear beautiful unless letters of the same kind, as well as the equivalent parts of those letters, are similar.

[3.221] Difference creates beauty, as well, for the shapes of the members of an animal consist of different parts, and they are beautiful only because of such difference. For if the entire nose were of the same thickness throughout, it would be extremely ugly, so its beauty is due only to the difference [in thickness] of its two extremities and to the way it flares out [toward the nostrils]. Likewise, the beauty of the eyebrows is due only to the fact that their outer extremities are narrower than the portions toward the front. And the same holds for all the members of an animal; when they are in fact examined, it is found that their beauty is due only to the different shapes of their parts. So, too, with writing, for if the parts of the writing were of equal thickness [throughout], it would not appear beautiful, because the ends of the letters appear beautiful only if they are thinner than the remainder [of the letter], so that, if the ends, middle, and ligatures of the letters were of the same thickness, the writing would be extremely ugly. Thus, difference creates beauty in many forms of visible objects.

[3.222] From our discussion, therefore, it has been shown that, when they are perceived by sight, each of the particular characteristics [of the visible form] can sometimes create beauty on its own. And while the discussion was based on individual instances involving several objects, when all bodies are taken into account, it will be found that each of these characteristics creates beauty in many situations. So we have discussed what we have discussed in these cases only to provide examples so that other examples can be derived from them. Nonetheless, these characteristics do not create beauty in all situations, nor does any one of these characteristics create beauty in every form that possesses it; on the contrary, in some forms it does, and in some it does not. For instance, not every magnitude creates beauty in every body of a given size, and, by the same token, not every color creates beauty, nor, on that account, does a color create beauty in every body that happens to possess that color. Likewise, not every shape creates beauty. Some of the characteristics we have discussed create beauty on their own, but they do so in some situations and not in others, and they do so in certain ways and not in others.

[3.223] Moreover, these characteristics create beauty by being conjoined, for writing is beautiful if the shapes of the letters are beautiful and the way they are combined together is beautiful, for writing in which these two characteristics coexist is more beautiful than writing in which only one of the two characteristics is present. The ultimate in beauty for writing is therefore based solely upon the combination of [appropriate] shape and spatial disposition.[177]

[3.224] Likewise, when bright colors and depictions are arranged in a uniform way, they are more beautiful than colors and depictions that lack uniform arrangement. So too, beauty is revealed in the form of humans or animals through the conjunction or juxtaposition (which is the same thing) of particular characteristics in such forms. For an eye of moderate size that is almond-shaped is more beautiful than an eye that is of moderate size alone or that is only almond-shaped. Likewise, a round face with fine and subtle coloring is more beautiful than a face that has one of these attributes without the other. In the same vein, a small mouth with moderate-sized but slender lips is more beautiful than a small mouth with fat lips or a wide mouth with slender lips. But this case has many variants and subtypes.

[3.225] If you investigate beautiful forms in every type of visible object, you will find that a conjunction of particular characteristics in the forms create kinds of beauty in them that one characteristic does not create by itself. And, for the most part, beauty is created only through a conjunction of such characteristics, for the particular characteristics we have discussed create beauty on their own, but they also create beauty by being combined together.

[3.226] In addition, beauty is created from one [more] characteristic beyond the two we have discussed, i.e., proportionality or harmony.[178] For forms that consist of different members and different parts have different shapes, different sizes, and different spatial dispositions, as well as continuity and contiguity, and in each of them several particular characteristics converge. Still, not all of them are proportionate, for not every shape is beautiful in conjunction with every [other] shape, nor is every magnitude beautiful in conjunction with every [other] magnitude, nor is every spatial disposition beautiful in conjunction with every [other] spatial disposition, nor is every shape beautiful in conjunction with every magnitude, nor is every magnitude beautiful in conjunction with every spatial disposition. On the contrary, every particular characteristic is proportionate to certain characteristics but disproportionate to others. For instance, a flat nose along with deep-set eyes is not beautiful, and, by the same token, a large nose along with very large eyes is not beautiful. Likewise, a bulbous forehead along with deep-set eyes is not beautiful, but neither is a flat forehead along with protruding eyes. Thus, each of the members has a shape that makes its form beautiful, but in addition each shape of each member is proportionate only to some shapes of the remaining members, but not to others. So the form becomes beautiful by the juxtaposition of proportionate shapes.[179]

[3.227] The same holds for magnitudes and spatial dispositions, as well as for their arrangement, for large eyes having a beautiful shape, along with a moderately flat nose whose size is proportionate to that of the eyes, are beautiful. So, too, even if they are small, eyes of an almond shape, having a charming and delicate shape, will be beautiful when they occur along with a narrow nose of moderate shape and size. Likewise, slim lips along with a delicate mouth are beautiful when the delicacy of the mouth is proportionate to the slimness of the lips—i.e., when the lips are not inordinately slim, nor the mouth inordinately small, but the mouth must be moderately small while the lips are slim and, moreover, proportionate to the size of the mouth. So, too, when the width of the face is proportionate to the size of the facial members, it will be beautiful—i.e., when the face is not inordinately broad, and when the facial members are proportionate [in size] to the size of the whole face. For when the face is inordinately broad, but its members are too small to be proportionate in size to it, the face will not be beautiful, even though the size of the members may be proportionate [among each other], and even though they are beautifully shaped. Likewise, if the face is small and thin but its members are large (I mean the members of the face), the face will be ugly. But if the members are proportionate among each other as well as to the breadth of the face, the form will be beautiful, even if the members are not [particularly] beautiful by themselves.[180]

[3.228] Proportionality by itself can create beauty. Accordingly, when there is beauty in the shape of each part of a form, and when the size and arrangement of such parts are beautiful, and when the members are proportionate in shape, size, and spatial disposition, as well as being proportionate to the shape and size of the face as a whole, the face will be extremely beautiful.

[3.229] Similarly, writing will not be beautiful unless the letters are proportionate in shape, size, spatial disposition, and arrangement. And the same holds for every kind of visible object that consists of disparate parts.

[3.230] And when you examine the beautiful forms of every kind of visible object, you will find that proportionality creates beauty more than any other characteristic on its own or, for that matter, any conjunction [of characteristics] on its own.[181] Moreover, when the expressions of beauty created by particular characteristics in combination are examined, it will be found that the beauty that appears through their combinations appears only because of the proportionality of those characteristics that are combined with each other. For combinations of such characteristics will not always create beauty; in some forms they will, but in others they will not.

So the beauty expressed by these characteristics [in combination] is due to the proportionality that obtains among them. Beauty therefore is [ultimately contingent] upon particular characteristics alone, but its perfection comes from the proportionality or harmony that obtains among particular characteristics.[182]

[3.231] From everything we have said, then, it is clear that the beautiful forms perceived by sight are only beautiful by dint of the particular characteristics that are perceived by the sense of sight, the conjunction of those characteristics among each other, and their proportionality to one another. But sight perceives the aforesaid particular characteristics either individually or in combination. Thus, when sight perceives some visible object, if there is a particular characteristic in that visible object that, by itself, makes the object beautiful, and if sight examines that lone characteristic, the form of that characteristic reaches the sensitive faculty after the process of visual scrutiny. Then the faculty of discrimination will perceive the beauty of the visible object possessing that characteristic, for the form of every visible object is composed of several of the characteristics we listed earlier.[183] Accordingly, when sight perceives a visible object but does not discern the characteristics the object possesses, it will not perceive its beauty. When it does discern the characteristics the object possesses, and when any of its characteristics somehow creates the impression of beauty in the soul, as soon as it apprehends this characteristic, sight will perceive that characteristic by itself. And when it perceives that characteristic by itself, that perception will reach the sensitive faculty, and thus the faculty of discrimination will perceive the beauty that it possesses. Moreover, by means of this perception it will perceive the beauty of that visible object. Thus, when sight perceives any visible object, if there is beauty in that object arising from a combination of characteristics, if sight examines that visible object and discerns the characteristics possessed by that object, if it then perceives the characteristics that create beauty by combining together or by being proportionate among one another, and if that perception occurs to the sensitive faculty, then, when the faculty of discrimination correlates those characteristics to one another, it will perceive the beauty of that visible object, which arises from the combination of characteristics the object possesses. Thus, sight will perceive the beauty of that visible object, which arises from the combination of characteristics the object possesses. Sight will therefore perceive beauty in visible objects by correlating those characteristics to one another in the way we explained.

[Perception of Ugliness]

[3.232] Ugliness, for its part, comes about when the form lacks any beautiful characteristic. For it has already been said that particular characteristics create beauty, but not in every situation or in every form; in some it does, but in others it does not. So, too, proportionality does not exist in every form; in some forms it does, but in others it does not. Therefore, forms whose particular characteristics do not create any beauty on their own or in combination, or forms whose parts are disproportionate to one another lack beauty entirely, and so they are ugly, because ugliness of forms consists in the absence of beauty in them. There may be a combination of beautiful and ugly characteristics in the same form, but sight will perceive beauty from what is beautiful and ugliness from what is ugly in the form when it differentiates and evaluates the characteristics the form possesses. Thus, ugliness is perceived by sight in forms that lack any beauty through the absence of beauty [that it senses] when it perceives the form.[184]

[Perception of Similarity]

[3.233] Similarity consists of the equality of two forms or of two characteristics that are identical in an object. Thus, when sight perceives two identical forms or two identical characteristics at the same time, it will perceive their similarity through the perception of each of the two forms or characteristics and the correlation of one to the other. Sight will therefore perceive the similarity of forms or of identical characteristics by perceiving each of the forms or characteristics as they actually exist and by correlating them to one another.

[Perception of Difference]

[3.234] Difference, on the other hand, is perceived by sight in various forms through perception of each of the various forms, comparison of one to the other, and perception of the lack of equality among them. Thus, difference is perceived by the sense of sight through a perception of each of the forms or characteristics by itself, as well as through a comparison of them among each other and [the resulting] sensation of an absence of equality arising in the sensitive faculty.

[3.235] We have now finished, having explained how each of the particular characteristics [of visible objects] is perceived by the sense of sight. Moreover, from all we have discussed it has been shown that some particular characteristics are perceived by brute sensation, some are perceived by recognition, and some are perceived by deduction and implication in the ways we have explained earlier. These are the things we meant to explain in this [chapter of the] work.

[CHAPTER 4]

[4.1] It has now been shown how sight perceives any of the particular characteristics that are perceived by the sense of sight, and sight perceives only the forms of visible objects, which are bodies. But the forms of visible objects are composed of the aforesaid particular characteristics, such as shape, size, color, spatial disposition, arrangement, and the like. Thus, sight perceives any such characteristic only by perceiving the forms of visible objects, those forms being composed of particular characteristics, and sight will perceive each of the forms of visible objects according to all of the particular characteristics that are in them [which it perceives] all at the same time. But sight perceives none of the particular characteristics by itself, because none of the aforementioned particular characteristics exists on its own, for these particular characteristics are all found in bodies, and only in bodies, and there is no body in which any of these characteristics exists by itself without some other. Sight therefore perceives only the forms of visible objects, and each of the forms of visible objects consists of several particular characteristics. Thus, sight perceives many particular characteristics in each of the forms of visible objects, and they will be differentiated individually in the imagination.[185] So, when a visible object is seen, sight perceives each of its particular characteristics in conjunction with some other particular characteristic, and by differentiating among the characteristics that are in the form, it perceives each characteristic by itself.

[4.2] It has already been shown and also explained how sight perceives the forms of visible objects that are composed of particular characteristics.[186] Some of the particular characteristics that comprise the forms of visible objects are seen as soon as the visible object is looked at, but others are seen only after visual scrutiny and careful evaluation, for instance, tiny writing, or subtle designs, or various colors that are almost identical in hue. Generally, no subtle characteristics are seen by sight when the visible object is first looked at, only after visual scrutiny and evaluation. The form of the visible object that is perceived by the sense of sight is composed of all the particular characteristics that can be grasped by the eye from the form of the visible object. So sight does not perceive the proper form of the visible object unless it perceives all the particular characteristics that are in the form of the visible object. And that being the case, the proper form of a visible object that possesses subtle characteristics is perceived by sight only after visual scrutiny.

[4.3] Also, since sight perceives subtle characteristics only through visual scrutiny, and since subtle characteristics are not seen at first glance, then, when sight perceives some visible object and perceives its form, and when that visible object possesses subtle characteristics, those subtle characteristics are not seen at first glance, but only after visual scrutiny. Thus, when sight perceives some visible object that possesses no subtle characteristic, it will perceive its proper form, even though it will not determine that the form is proper until after it subjects each part of the visible object to intense visual scrutiny. It then determines that the object possesses no subtle characteristic, and thus it will determine that the form it is perceiving is the proper form.

[4.4] Without exception, then, sight determines [the true status] of a visible object's form by evaluating all parts of the visible object and by subjecting all of the characteristics that can be seen in the visible object to visual scrutiny.

[4.5] And now that this has been made clear, let us add that the perception of visible objects will occur in two ways: i.e., by superficial perception or by perception based on close visual scrutiny. For when the eye looks at a visible object, it will perceive the obvious characteristics the object possesses at first glance. Then, if it goes on to scrutinize the object and evaluate all of its parts, it will determine [the true status of] its form. On the other hand, if it does not scrutinize its parts, it will perceive its form in an indeterminate way,[187] and that form will either be its proper form (although sight does not determine that the form is proper), or it will not be its proper form. And since this is so, the perception of visible objects by sight will occur in two ways: either [by] superficial perception, which occurs at first glance, or [by] perception based on visual scrutiny. Moreover, perception at first glance is indeterminate, whereas perception based on visual scrutiny is the perception by means of which [the true status of] the forms of visible objects is determined.

[4.6] Having clarified this point, we should say that the visual scrutiny through which the proper forms of visible objects are perceived will be carried out by sight itself, or it will be carried out through differentiation. For it has already been shown in our account of radial lines that the forms perceived by sight along the [visual] axis, or along rays near that axis, are clearer and more determinate than forms that are perceived along the remaining rays.[188] Thus, when the eye faces any visible object, provided that the object is not inordinately small but is of some [perceptible] size, and when the eye, having looked at the object, focuses on the part of it directly opposite the middle of the eye['s surface], so that it lies on or near the visual axis, it will be [seen] more clear[ly] than the rest of the visible object. Moreover, sight perceives this fact, because, when it perceives the whole visible object, it will find that the location directly opposite, whose form reaches the middle of the eye['s surface], is more clear[ly seen] that the rest of the object.

[4.7] It was shown above that this fact is evident to sense when the visible object is large.[189] Therefore, when the eye perceives the entire visible object, it will find that the form of the part directly opposite the center [of its surface] is clearer than all the remaining parts, so when it wants to determine the form of the visible object,[190] it will move in such way that its center lies directly opposite every area on every part of the visible object. Thus, it will perceive the form of every area on every part of the visible object in a clear and determinate way, just as it perceives the part directly opposite its center when it first looks at the visible object. When the sensitive faculty wishes to determine the visible object, then, it will move the eye in such a way that its center lies directly opposite every portion of every part of the visible object, and in this way it will perceive the form of every part of the visible object with utmost clarity.

[4.8] Meanwhile, the faculty of discrimination will differentiate all the forms reaching it, and it will differentiate the colors of the parts, the differences among the colors, and the arrangement of the parts among each other—and generally speaking [it will differentiate] all the characteristics of the visible object that are apprehended through visual scrutiny as well as the form of the entire visible object, that form being composed of its parts and its characteristics. This, then, is how every part of the visible object will be determined according to its actuality and how all the characteristics of the visible object will be determined. But the form of every part of the visible object is not determined unless the eye has scanned all the parts [of the object]. The eye, moreover, is naturally disposed to scan [objects for the sake of] visual scrutiny and to cause the visual axis to pass over all parts of a visible object. Thus, when the faculty of discrimination seeks to scrutinize the visible object, the visual axis will move over all parts of the visible object. And since the subtle characteristics possessed by the visible object are revealed only when the eye moves and the [visual] axis or the radial lines near it pass over every part of the visible object, the form of the visible object that reaches the sensitive faculty (assuming that the object is of a perceptible size) will not be determinate unless the eye moves so that the center of the eye lies directly opposite every part of the visible object.

[4.9] In addition, when the visible object is exceptionally small and does not lie directly opposite the middle [portion] of the eye, the visual scrutiny to which it is subject will not be accomplished until after the eye moves so that the visual axis passes over that visible object; then the form of that visible object will reach the middle [portion] of the eye, and the form of the object may be revealed. And since this is the case, the visual scrutiny through which sight perceives the proper forms of visible objects may occur through sight *per se* or through [sight and] differentiation together. Thus, perception of the proper form of a visible object will occur only through visual scrutiny, and the scrutiny through which the form of the visible object is determined will only be accomplished through the motion of the eye. So when the body of the visible object is of a perceptible size, the scrutiny to which it is subjected will not be accomplished until the visual axis moves over all the cross-sections of the visible object. This is what was meant by whoever supposed that vision occurs only through the motion [of the eye] and that no visible object will be seen as a whole, all at once, for what he meant is that vision cannot be determinate except through visual scrutiny [which occurs] through the motion of the eye and the motion of the visual axis over all the cross-sections of the visible object.[191]

[4.10] How the sensitive faculty determines the form of a visible object through visual scrutiny and the motion [of the eye] is as follows. When the eye faces the visible object, the sensitive faculty will somehow perceive[192] the whole form according to the facing disposition, and it will also perceive the part at the endpoint of the [visual] axis as accurately as possible. But in the process it will perceive every other part of the form in some way. Then, if the eye moves and the [visual] axis shifts its focus from where it was to somewhere else, the sensitive faculty will in that case perceive the form of the whole visible object a second time, and it will also perceive the part at the end of the [visual] axis a second time. Moreover, the part at the end of the [visual] axis will be perceived more clearly in the second case than it was in the first, and in this case the sensitive faculty will again perceive the remaining parts [of the form] in some way. By the same token, when the [visual] axis shifts to a third part, the sensitive faculty will perceive the entire visible object yet a third time, and it will also perceive the part [of the object] at the end of the [visual] axis in this third situation, and under these conditions it will perceive this part more clearly than it did in the first two instances. In this case, moreover, the sensitive faculty will also perceive each of the remaining parts [of the form] in some way. Thus, by moving the eye over the parts of the visible object, the sensitive faculty is affected in two [complementary] ways. First, it perceives the visible object as a whole at numerous reprises, and second, it perceives with clarity each part of the visible object along the visual axis or along a radial line that is near the visual axis. Thus, everything about those parts that can be seen is revealed to the sense [of sight].

And if the sensitive faculty perceives both the visible object as a whole and each of its parts frequently, it will then perceive everything that can be perceived about that visible object.

[4.11] In addition, as the perception occurs repeatedly in terms of the twofold [perception of whole and parts] and the repetition of the perception of the entire visible object, the faculty of discrimination differentiates what is revealed of the color of the parts, their light, their size, their distance, their shape, their spatial disposition, the equality of those things that are identical among what is differentiated, and differences among all these characteristics or among some of them, as well as the arrangement of their parts among one another. Moreover, by differentiating all of these characteristics and comparing these characteristics to ones that are known to be similar to them, it perceives the form comprising all of them. In this way the form comprising all similar characteristics is impressed in the imagination, and thus the visible object's form, which provides the means by which the visible object itself is apprehended by the sensitive faculty, is determined. This, therefore, is how the sensitive faculty determines the forms of visible objects by means of visual scrutiny.

[4.12] We should also say that when sight perceives some visible object, and when its form is determined by the sensitive faculty, the form of that visible object remains in the soul to be impressed in the imagination. So the perception of the visible object will be repeated, and its form will be more firmly implanted in the soul than the form of a visible object that sight perceives only once or on rare occasions. I also say that when sight perceives any individual and then perceives another individual of the same kind, if it perceives such individuals continually, a form of that kind [of individual] will become ensconced in the soul, and the form will come to be impressed as a general representation [of its kind] in the imagination. Evidence that the forms of visible objects persist in the soul and in the imagination is to be found in the fact that, when someone remembers a person he knew before, and when he determines his form and correctly recalls the time and place at which he saw that person, he will immediately imagine the form of that person, as well as the shape of his face and the situation he was in at that time. He will also imagine the place where he saw him, and he may imagine other visible objects that were present at the place where he saw him. This is clear evidence that the form of that person, as well as the form of that place, is implanted in the soul and persists in the imagination. Accordingly, when a person remembers some city that he has seen [before], he will imagine the form of that city, as well as the forms of the places he was in that city and the forms of individuals he knew in that city. And the same holds for all the visible objects a person has seen; when they crop up in [his] memory, he will imagine their forms according to the actual disposition of those objects as they were perceived at that earlier time. Thus, imagining the forms of visible objects that a person saw before and still recalls when they are no longer present indicates that the forms of visible objects that sight perceives reach the soul and are impressed in the imagination.[193]

[4.13] The reason that the form of a visible object that is continually perceived by sight is more firmly planted in the soul and in the imagination than the form of a visible object that is not repeatedly perceived is as follows: When some [sensible] impression comes to the soul, the form of that impression will immediately reach the soul, but as time continues to pass, and that impression fails to recur in the soul, the impression, or something characteristic of it, may be forgotten by the soul. But if it recurs to the soul before it is forgotten, its form is renewed in the soul, and the soul will remember the first form by means of the second form. And as this impression is made time and again on the soul, the soul will remember the impression better, and thus that impression will be more firmly implanted in the soul.

[4.14] In addition, the first time an impression or form of a visible object reaches the soul, the soul may not perceive or accurately determine all of the characteristics that belong to that form. But it will perceive some of the characteristics belonging to it, and when the form recurs a second time, the soul will perceive something about it that it did not perceive the first time, and the more often the form recurs to the soul, the more the characteristics of it that were not apparent before will become evident. And as the soul perceives the form's subtle characteristics and [thereby] determines the form, the more firmly implanted in the soul and imagination it will be than a form in which not all the characteristics belonging to it are [yet] properly perceived by the mind.[194] But when the soul perceives all of the characteristics in the form the first time, and then the form recurs to it, if it perceives the [same] impression a second time, it will more clearly determine that what it perceived the first time is the proper form. But a properly verified and determinate form is more firmly implanted in the soul and the imagination than a form that is not determinate. Therefore, as the form of a visible object is continually perceived, it will become more determinate in the soul and in the imagination. So it is by having their forms implanted in the soul and in the imagination that things are remembered by the soul.

[4.15] That impressions and forms that recur in the soul will be more firmly implanted than impressions and forms that do not recur is clearly borne out by the fact that, when someone wants to learn some speech or some verse by heart, he will rehearse the words over and over again, and they will thus become implanted in his soul. And the more he rehearses the words, the more firmly they will be implanted in the soul, and the less likely they will be to be forgotten. But if he reads it once, the verse will not stay implanted in the soul. Likewise, if he goes through the verse a couple of times in his mind,[195] it [may or] may not be impressed in his soul, but if it is impressed, it will soon be forgotten. From this sort of experience, then, it is clear that the more often forms recur in the soul, the more firmly implanted they will be in the soul and in the imagination.

[4.16] That universal forms of visible aspects occur in the soul and are impressed in the imagination is due to the fact that that there are certain kinds of visible characteristics, such as form or shape, according to which all individuals of a certain kind will be identical, whereas those individuals vary according to [other] particular characteristics that are perceived by the sense of sight. So there may be one color in all individuals of that kind; but form, shape, color, and all the [other] characteristics from which the form of every individual of a given kind derives is a universal form of that kind. So sight perceives that form, that shape, and all the [other] characteristics according to which every individual of a given kind will be identical to all individuals of that kind that are perceived by sight. The particular characteristics by dint of which the individuals of that species differ are perceived as well. It is thus through the effect of perceiving individuals of the same kind by sight that the universal form of their kind will recur [in the soul] along with the various particular forms of those individuals. And when the universal form recurs in the soul, it will be impressed in the soul and will become ensconced there, and from the various particular forms that arrive along with the universal forms after close visual scrutiny the soul perceives that the form according to which all of the individuals of that kind agree is the universal form of that kind. This, then, is how universal forms will arise in the soul and in the imagination from the perception by sight of [various] kinds of visible objects.[196]

[4.17] Accordingly, the forms of individual visible objects, as well as the form of the kinds of visible objects that sight perceives, persist in the soul and are impressed in the imagination, and the more often they are perceived by sight, the more firmly implanted they will be in the soul and in the imagination. Moreover, the sensitive faculty's comprehension of what kinds of things visible objects are is based entirely upon the forms that reach the soul, for the perception of what kinds of things visible objects are will only occur through recognition. Recognition, for its part, depends upon a correlation of the form that sight perceives at the moment to a second form in the imagination that derives from the forms of visible objects that sight has perceived before, and [it also depends] upon a perception of how the form perceived at the moment compares to another of the forms occurring in the imagination. Thus, the perception of what kind of thing a visible object is depends entirely on the perception of the similarity of the form of the visible object to one of the forms ensconced in the soul and implanted in the imagination. In perceiving what kinds of things visible objects are, then, the sensitive faculty depends entirely upon the universal form of the kinds of visible objects that occurs in the soul, whereas the sensitive faculty's recognition of individual visible objects depends entirely upon the forms of individuals that arise in the soul from each of the individuals that sight has perceived earlier, provided that their forms have been imagined and understood before. Furthermore, the faculty of discrimination naturally assimilates the forms of visible objects, as soon as they are seen, to forms that are derived by the soul from the forms of visible objects and that are implanted in the imagination. Hence, when sight perceives some visible object, the faculty of discrimination immediately seeks its counterpart among the forms persisting in the imagination, and when it finds some form in the imagination that is like the form of that visible object, it will recognize that visible object and will perceive what kind of thing it is. But if it does not find a form similar to the form of that visible object among the forms persisting in the imagination, it will not recognize that visible object or perceive what kind of thing it is. Also, on account of the speed with which the faculty of discrimination assimilates the form of the visible object at the moment it is seen, it may err by assimilating the visible object to another visible object [simply] because the visible object has some characteristic that the other object possesses. If it then subjects that visible object to close visual scrutiny and determines its form, it will assimilate that form to one that actually does resemble it, and it will become clear to it while carrying out this second assimilation that it erred the first time. It is in this way, therefore, that the sense of sight perceives what kinds of things visible objects are.

[4.18] Now that all these points are clarified, we should observe that the perception of visible objects through visual scrutiny will occur in two ways: perception through visual scrutiny alone and perception through visual scrutiny along with previous knowledge. Now perception through visual scrutiny alone involves a perception of unfamiliar visible objects that sight has not seen before or visible objects that sight has seen before but does not remember having seen. For when the visual faculty perceives some visible object it has not perceived by sight before, nor anything of its kind, and when the observer wishes to determine the form of this visible object, he will focus upon it and evaluate all the characteristics it possesses through visual scrutiny. Through [such] scrutiny he will then perceive its proper form, but since he never saw that object or anything of its kind before, he will not recognize its form when he perceives it. But in such cases visual scrutiny is necessary for [the perception of] the actual proper form. Thus, the determination of the form of such visible objects occurs through visual scrutiny alone. Likewise, when sight perceives some visible object it has perceived before but fails to remember, it will not recognize its form the next time after visual scrutiny, so this kind of perception of visible objects will occur through visual scrutiny alone.

[4.19] Perception through visual scrutiny along with previous knowledge, on the other hand, is perception of all types of visible objects that sight has perceived before or about whose kind sight has perceived something before, so that the forms of their kinds as well as of their individuals reach the soul. Thus, when sight perceives some visible object it has perceived before, or when it perceives some object of the same kind, as soon as it glimpses that visible object it will perceive its entire form. Then, after a brief scrutiny, it will perceive its overall form,[197] which constitutes its universal form or the form specifying its kind. Therefore, if it has perceived visible objects of this sort before, and if the form specifying what kind of thing that visible object is occurs in the soul, and if the soul remembers the universal form of that kind of visible object, it will recognize the universal form that it perceives in that visible object as soon as it perceives it and recognizes the universal form it perceives in that object, so it will immediately recognize that visible object as of such-and-such a kind. Then, when it scrutinizes the rest of the characteristics possessed by that visible object, it will determine its particular form. If, however, it has not perceived that visible object before, or perhaps it has perceived it but does not remember having perceived it, it will not recognize the particular form. If it does not recognize the particular [form], though, it will not recognize that visible object, and so its recognition of that visible object will be according to kind alone. So it is through visual scrutiny and the determination of its form that the soul acquires the particular form belonging to that individual. If it has perceived that visible object before but has not perceived another individual of that kind, and if it remembers it as well as the form of that visible object that it perceived before, then, when it perceives its particular form it will recognize its particular form as soon as it apprehends it.[198] Moreover, as soon as it recognizes its particular form it will apprehend the visible object, and thus it is through the perception of its particular form that sight will determine the form of the visible object and will accordingly recognize the visible object itself. So its recognition of that visible object will be according to kind and individual at the same time. If, however, it has perceived that visible object before, but it has seen only an individual representation of that visible object and [thus] does not discern the universal form of that sort of visible object, then, when it perceives that visible object and perceives the universal characteristics possessed by that object as well as by all other objects of that kind, it will not recognize that visible object or apprehend what kind of thing it is by perceiving its universal form. Therefore, when it perceives the remaining characteristics possessed by that visible object, and when it perceives its particular form and remembers the particular form it perceives in that visible object, it will recognize the particular form at the moment of perception. So when it recognizes the particular form, it will recognize the visible object itself, but its recognition of that visible object will be on the basis of its individuality. No visible object is perceived through visual scrutiny unless [it is perceived] according to these ways. Thus, the perception of all visible objects on the basis of visual scrutiny will occur in two ways: perception through visual scrutiny alone and perception through visual scrutiny along with previous knowledge. Moreover, such recognition or knowledge will sometimes be according to kind and sometimes according to kind and individual together.

[4.20] Furthermore, perception through visual scrutiny must occur over time. For visual scrutiny will only occur if the eye moves and examines [the object], but differentiation and motion will not take place except over time. Therefore, visual scrutiny will only occur over time. It has also been shown above that perception through recognition and perception through differentiation will occur only over time.[199] And now that it has been shown that the perception of visible objects through visual scrutiny will sometimes occur through visual scrutiny alone and sometimes through visual scrutiny along with previous knowledge, and [now that it has been shown] that whatever is perceived through visual scrutiny as well as whatever is perceived through recognition is perceived only over time, we shall add that perception occurring through visual scrutiny along with previous knowledge will generally take less time than perception through visual scrutiny alone. For, to recognize the impressions existing in the soul that are presented to the memory does not require that all of the characteristics which go into their actual formation be perceived; rather, a perception of certain of their specific properties is sufficient. Thus, when the faculty of discrimination perceives some specific property that characterizes a form reaching it, and when it remembers the first form, it will recognize all forms [of that kind] that reach it, for every specific property that characterizes a given form is a defining feature of such forms.[200]

[4.21] For instance, if sight perceives an individual person but only perceives the outline of his hand, it will immediately perceive that [what it sees] is human before it perceives the outline of his face or before it perceives the outline of his remaining features; and the same thing applies if sight perceives the outline of his face before perceiving his remaining features. From the perception of any of the properties that are specific to the form of a human being, then, sight will perceive that this visible object is a human being without having to perceive the remaining features. For it will perceive the remaining features through previous knowledge on the basis of the forms residing in the soul, i.e., the forms of human beings. Likewise, when sight perceives certain properties that are specific to the particular form of some individual that sight has perceived before, e.g., a flat nose, green eyes, or arched eyebrows, it will perceive that individual when it perceives his entire form, and it will recognize him. So, too, sight will recognize a [given] horse from some spot on his forehead or from some variation in his color. By the same token, when a writer perceives the form of some word in a cursory way, he will recognize it before he examines its individual letters, and all words that the writer sees continually are likewise recognized by him as soon as they are perceived on the basis of his perception of certain of their letters.

[4.22] Hence, visible objects that sight has perceived earlier and whose forms it recognizes and remembers at the present moment are perceived by sight through defining features. On the other hand, unfamiliar visible objects that sight has not perceived before, or visible objects it has perceived before but does not yet remember are not perceived in this way. For when sight perceives some visible object it has not seen before and perceives the outline of some of its parts, it will not thereby perceive what kind of thing that visible object is, because the form of the remaining parts is not ensconced in the soul. Thus, sight does not gain a determinate perception of a visible object it has not seen before unless it evaluates all of its parts and all the characteristics it possesses. Likewise, the form of a visible object the eye has seen before but does not remember is only determined by it after an evaluation of all the characteristics it possesses. But the perception of certain characteristics possessed by a form will take less time than the perception of all the characteristics possessed by the form. Thus, vision that entails visual scrutiny along with previous knowledge will generally take less time than vision entailing visual scrutiny alone, and this is why sight perceives familiar visible objects with such extraordinary speed that the time it takes is imperceptible, so between the time sight is directed at a familiar visible object and the time it perceives what that familiar visible object is there will generally not be a perceptible time-interval. For from childhood and the beginning of his development, a person perceives visible objects, and individual visible objects as well as the universal forms of types of visible objects are continually presented to his sight. It has also been shown that the forms of visible objects perceived by sight reach the soul and are impressed in the imagination, and forms that are seen repeatedly are impressed in the soul so that such impressions become ensconced in the imagination.[201] Thus [the forms of] all familiar objects and all familiar kinds of objects are present in the soul, and they remain impressed in the imagination and present to memory. Accordingly, when sight perceives some familiar visible object and perceives its overall form,[202] and after that it perceives some defining feature that specifies that visible object, it will perceive what kind of thing that visible object is when it perceives that defining feature, and it will perceive the visible object through previous perception as well as through brief visual scrutiny. Therefore, familiar visible objects are perceived by sight through defining features and through previous knowledge, so the perception of what kinds of things they are will generally occur in an imperceptible amount of time.

[4.23] Moreover, the reason that the perception of a visible object's general type takes less time than the perception of the visible object's individual nature is that, when sight perceives some individual human, it perceives him to be human before it will perceive his particular form. And it may perceive him to be human even though it does not perceive the outline of his face; instead sight will perceive him to be human from the upright stance of his body or the arrangement of the members of his body without having seen his face. Likewise, sight may perceive certain kinds of familiar visible objects as general types by means of certain defining features that specify that kind of thing. But this is not the case with the perception of a visible object's individual nature, for a visible object's individual nature will not be perceived until the particular characteristics that define that individual or some of those characteristics are perceived. But the perception of each of the particular characteristics defining that individual does not occur until after [all] or some of the universal characteristics possessed by that individual are perceived. Generally, the characteristics of the universal forms of those sorts of individuals are some of the characteristics possessed by the individual form, but the perception of the part takes less time than the perception of the whole. Thus, the perception by sight of a what kind of thing a visible object is takes less time than the perception of the individual nature of that visible object.

[4.24] Moreover, the time it takes to perceive visible objects (familiar ones, that is) according to general type varies, because certain kinds of familiar visible objects resemble other kinds, and certain do not, e.g., the general type "human" and the general type "horse," for the form of the general type "human" does not resemble the [form of the general type of] other kinds of animal. But that is not the case for a horse, since a horse resembles many animals in its overall form. Thus, the time it takes sight to perceive an individual human according to general type and to perceive that [what it sees] is human is not the same as the time it takes to perceive an [individual] horse according to general type and to perceive that [what it sees] is a horse, especially if it perceives them both at some distance. For, when sight perceives some individual human who is walking, it will immediately perceive him to be an animal from his movement and then, by dint of his upright body, it will perceive him to be human. But that is not how it is when sight perceives a horse, for when sight perceives an individual horse that is moving and, along with that, perceives its motion as well as the number of its legs, it will not perceive it to be a horse on that basis, for those characteristics belong to several quadrupeds that share several characteristics with the horse, especially the mule, because the mule resembles the horse in numerous ways. Hence, the mule is only differentiated from the horse according to characteristics that are not particularly evident, such as the outline of the face, the length of the neck, the speed of the gait, and the length of the gait. But if sight fails to perceive any of those characteristics according to which a horse is perceived when its overall form is apprehended, then it will not perceive it to be a horse. Furthermore, the time it takes sight to perceive the upright posture of the human body is not the same as the time it takes to perceive the form of a horse along with the particular characteristics according to which a horse is distinguished from any other [quadruped]. Thus, the time it takes for a human to be perceived according to general type is less than the time it takes for a horse to be perceived according to general type. For, even though the two time-intervals are small, one of them is still smaller than the other, all things taken into account.

[4.25] Likewise, when sight perceives a rose-red color among the flowers in some garden, it will immediately perceive that the things in which that color inheres[203] are roses because that color is specific to roses and, moreover, because that color is [found] in objects that are in a garden, [and it perceives this] before it perceives the roundness [of the flowers], or the roundness of their petals, or the way their petals fit upon one another, and before the perception of all the characteristics that go into making the form of a rose. But this does not happen when sight perceives a myrtle-green color in the garden. For when sight perceives only the myrtle-green in the garden, it will not perceive the [plant that is] myrtle-green to be myrtle simply from the perception of the green, because several plants are green, and, in addition, several plants resemble myrtle in greenness and shape. Thus, if sight does not perceive the shape of its leaves, its density, or a[ny other] defining characteristic of myrtle, it will not perceive that plant to be myrtle. Moreover, the time it takes sight to perceive the shape of the myrtle's leaves and the characteristics that are specific to myrtle, as well as to perceive its greenness, is not the same as the time it takes to perceive the color of roses alone. Likewise, the essential natures of all kinds [of things] that can resemble others are perceived by sight only after considerable scrutiny. But the essential natures of visible objects that resemble others only a little are perceived by sight after brief scrutiny. And the same holds for individuals, for an individual that does not resemble another individual is perceived by sight after minimal scrutiny on the basis of defining features, but an individual known to sight and resembling another individual known to sight is perceived by sight [only] after considerable scrutiny.[204]

[4.26] Therefore, the general type or individual nature of all familiar visible objects is perceived by sight after minimal scrutiny when [the perception is based] upon previous knowledge, and, for the most part, that perception will take an imperceptible amount of time. Nonetheless, the time it takes to perceive such objects varies according to differences among their general types or their individual natures. The perception of general type will be quicker than the perception of individual nature, whereas the perception of a general type that scarcely resembles others will be quicker than the perception of a general type closely resembling others, and the perception of an individual that scarcely resembles others will be quicker than the perception of an individual closely resembling others.

[4.27] So, too, the time it takes for visual scrutiny varies according to the characteristics one scrutinizes in visible objects. For instance, when sight perceives an animal with several small legs, and if that animal is moving, it will perceive its motion on the basis of minimal scrutiny, and when it perceives its motion, it will perceive that it is an animal. Then, after briefly scrutinizing its legs it will perceive that it has several legs by perceiving the separation between its legs. But nonetheless it will not immediately apprehend the number of its legs, and if it wants to know the number of legs, it will have to spend more time scrutinizing it more intensely. Thus, the perception that it is an animal will take little time. The subsequent perception that the animal has many legs also takes little time, but the number of its legs is not perceived until sight has scrutinized each of its legs and counted them, and that can only happen during some measurable amount of time. Moreover, the amount of time [required] will depend upon how many or how few legs the animal has. Likewise, when sight perceives a circle circumscribing a polygon of many sides, and if the sides of that [inscribed] figure are small but not inordinately different in size, then, as soon as the whole figure is perceived sight will perceive it as circular. Furthermore, it will not immediately perceive that there is a polygon inside it if the sides of that polygon are extremely small, but when it scrutinizes the circular figure more closely, the inscribed polygon will be revealed to it. Thus, the perception of the circularity of the figure will be quicker than the perception of the polygon inside it. After having perceived the polygon, sight will not see the difference in sizes among its sides, nor does it discern whether they are equal or not, nor will the inequality of the sides of the polygon be seen until after a very close scrutiny that takes place in a measurable amount of time.

[4.28] Also, when the sensitive faculty wishes to scrutinize the shape of the entire visible object, it only needs to pass the line-of-sight over the surface of the visible object. Likewise, when it wishes to scrutinize the color of a visible object, it only needs to pass the line-of-sight over it—and the same holds [if it wishes] to scrutinize the roughness of the surface of a visible object, or its smoothness, or its transparency, or its opacity. But such is not the case for the inconspicuous or subtle characteristics possessed by visible objects, characteristics such as the shapes of any of the parts of visible objects, the similarity of their shapes, the size of their parts, differences among their sizes or colors, similarities among them, or the relative arrangement of the small parts; these characteristics are perceived through visual scrutiny only after the eye focuses on every part, evaluates the shapes of those parts, and correlates them one to another. But this will be accomplished not in a short time or through a quick [axial] scan but in a measurable amount of time. Hence, the time it takes to scrutinize the characteristics of visible object varies according to differences among the characteristics that are being scrutinized.

[4.29] And having made this clear, we should add that vision that depends on previous knowledge, or defining features, or minimal visual scrutiny is not truly determinate. For perception of a visible object through previous knowledge or through defining features only involves the object as a whole according to its general nature, and the faculty of discrimination perceives the particular characteristics possessed by that visible object in the way that it apprehended those visible characteristics from the initial form of that visible object that exists in the soul. But these particular characteristics possessed by visible objects change with the passage of time, and, given this fact, sight does not, on the basis of previous knowledge, perceive the characteristics of the visible object that have changed. And when the change is inconspicuous or not very evident, it is not perceived by sight at first glance, nor is it perceived when it is not very evident unless [it is subjected] to visual scrutiny. For instance, when sight apprehends some person whose facial complexion is clear, and if sight determines his form, after which that person disappears from view for a long time, and if a blemish forms on his face, but that blemish is inconspicuous, then, when sight perceives that person after this development, it will recognize him as soon as it perceives him. Nonetheless, on the basis of its perception and recognition of that person, the visual faculty will not perceive the blemish on his face unless it is obvious; if it does not look carefully for that blemish, then, it will not perceive him as he actually exists. But if the visual faculty scrutinizes him with a more intense focus, the blemish on his face will be revealed to it, and then it will perceive his form as it actually exists.

[4.30] By the same token, when sight perceives some tree, scrutinizes it, and accurately determines its form, if it then leaves it for awhile while the tree grows, gets larger, and changes shape, or if, as it grows, some redness in it intensifies (assuming it was there before), and if the change that occurs to the tree is not minimal, then, if sight refocuses on that tree and recognizes it, it will not perceive the slight change occurring in it at the time it perceives and recognizes it. However, if it scrutinizes it a second time and, in addition, remembers the proper form it initially possessed, then it will perceive the change occurring in it and will determine its form [during the] second [scrutiny]. But if sight does not scrutinize it [again in this way], the form that it perceives of the tree on the basis of previous knowledge will not be the proper form, which it acquires after the second scrutiny.

[4.31] Likewise, if sight perceives a wall somewhere, and if that wall is smooth but has depictions or etchings in it, and if sight scrutinizes that wall, accurately determines its form, and then shifts its focus away from it for awhile, and afterward, if there is some change in the texture of the surface of that wall or some change in the design of any of its depictions, but that change is not particularly obvious, then, if sight refocuses on that place and looks at the wall as it remembers the initial form, it will perceive the wall according to how it saw it the first time. But when it perceives and recognizes the wall, sight will not perceive the inconspicuous change occurring in it; so it will recognize its form without any change. Thus, if some roughness has developed in the wall, sight will judge it to be smooth, as it used to be, and if the original depictions in it were properly determined but have since changed, it will judge them to be accurately determined [as they were when previously apprehended].

[4.32] Now all the visible objects around us are susceptible to change in color, shape, size, spatial disposition, smoothness, roughness, arrangement of parts, and many [other] particular characteristics. For they are by nature changeable and disposed to be affected by what happens to them through external influences, and whatever change can be perceived by sight can occur in all of them. So, although there may be some [internal] change occurring in them that cannot be seen by sight, there is no kind of change produced by external agents that cannot be seen by sight.[205] And since all visible objects are disposed to undergo changes that can be perceived by sight, no visible object that sight perceives at [any given] moment and that has been perceived and determined earlier, is accurately determined by sight when it is perceived a second time; that is, sight cannot be certain at that second time that the object did not suffer change, since change is possible in all visible objects. Thus, when sight perceives some visible object it perceived before, and when it scrutinizes it, determines its form, and remembers its form when it perceives it, it will recognize it. And if some obvious change occurs in that visible object, sight will perceive that change as soon as it sees the object. But if the change is not obvious, sight will recognize that visible object and will judge it to be the way it was when it apprehended it the first time. Moreover, if it does not repeat its scrutiny, it will not be certain that the form it apprehended before remained as it was, since an inconspicuous change might occur in it that can only be revealed through visual scrutiny. If, therefore, sight repeats its scrutiny, it will accurately determine the object's form, but if it does not repeat its scrutiny, its perception of that visible object will not be truly determinate. Thus, the perception of visible objects on the basis of previous knowledge, or defining features, or minimal scrutiny is not proper perception; so sight does not properly perceive a visible object unless it scrutinizes the visible object when it perceives it and unless it examines all the characteristics possessed by that visible object and discerns them all when it perceives that visible object.

[4.33] Vision will therefore occur in two ways: vision at first glance and vision based on scrutiny. Through vision at first glance sight will perceive only the obvious characteristics of the visible object, but the form of the visible object is not accurately determined by such a glancing perusal. Moreover, vision at first glance is sometimes based on initial impression alone,[206] whereas at other times it also entails previous knowledge. The kind of vision based on initial impression [alone] is vision of visible objects that sight does not recognize at first glance and does not scrutinize. Vision based on initial impression that also entails previous knowledge is vision of visible objects that sight has apprehended before but whose impressions sight does not scrutinize. In both cases, though, sight does not perceive the visible object as it actually is through initial impression, whether or not it has apprehended that visible object before.

[4.34] Vision based on scrutiny will also occur in two ways: vision based on scrutiny alone and vision based on scrutiny as well as previous knowledge. On the one hand, vision based on scrutiny alone involves visible objects that sight has not perceived before or that it does not remember having perceived before at the moment it scrutinizes them. On the other, vision based on scrutiny as well as previous knowledge is vision of all visible objects that sight has perceived [before] and remembers having perceived when it scrutinizes their impression and examines all the characteristics possessed by them. This kind of vision is also divided into two types, one of which is customary vision of familiar visible objects, this kind of vision occurring by means of defining features that are perceived after minimal scrutiny and after an evaluation of some of the characteristics possessed by that visible object, [and it is accomplished] along with previous knowledge. This type of vision, moreover, generally occurs in an imperceptible amount of time, so the perception of what is perceived in this way is not as determinate as it could be. The second subtype of vision will entail exquisite scrutiny as well as an evaluation of all the characteristics possessed by the visible object when that visible object is perceived, [and it is accomplished] along with previous knowledge. This type of vision will generally occur in a perceptible amount of time, but the amount of time depends on the characteristics the visible object possesses.[207]

[4.35] The type of vision according to which familiar visible objects are perceived in as determinate a way as possible occurs only through a scrutiny of all the characteristics possessed by the visible object, an evaluation of all the parts of the visible object, and a differentiation of all the characteristics possessed by the visible object when it is perceived, whether or not sight has recognized that visible object before. But this determination is determinate relative to the sense, which is to say that, in such situations, the determinateness [of the perception] is limited by what the sense is capable of perceiving. Furthermore, the perception of visible objects by sight depends on the acuity of vision, for the sense of sight varies [in capacity] with the strength or weakness of the eyes.

[4.36] These, then, are the ways in which visible objects will be perceived by sight, and they exhaust the ways in which vision occurs, so this is what we meant to show in this chapter. We have now finished discussing all of the visible objects and all of the visible properties, and we have explained all of the ways in which sight arrives at the perception of visible objects and visible characteristics, and we have laid out all of the categories into which the modes of vision can be subdivided. These are the things we meant to explain in this book.

NOTES TO BOOK TWO

[1]In rendering the Latin phrase *ex verticationibus linearum radialium* as "along radial lines," I have left *verticatio* untranslated, although later on I render it as "direction." Accordingly, it must be understood to imply the specific directionality of such radial lines; see note 63 to book 1, p. 404 above. The term *dispositio* carries a bewildering array of meanings throughout this treatise. In this case, the varying "dispositions" of radial lines involve not only their relative spatial orientations to one another as well as to the physical surfaces they strike (e.g., whether they strike them orthogonally or at a slant), but also the dynamic effect of forms passing along them at their given slant (i.e., the sharper their inclination, the less intense the dynamic effect); see note 64 to book 1, pp. 404-405 above.

[2]I, 6.60, p. 374 above.

[3]I, 5.17, p. 350 above.

[4]I, 5.28, p. 353 above.

[5]I, 5.33, p. 354 above.

[6]I, 6.29, p. 364 above.

[7]I, 6.68, p. 376 above

[8]In other words, being two-dimensional, the form cannot be contained in a point that, by Euclid's definition in book 1 of the *Elements*, has no dimension whatever.

[9]Here, as in I, 6.33-37, pp. 365-367 above, the issue of image-inversion—and the obvious impossibility of its occurrence—forces a fundamental supposition to undergird the resulting visual model: i.e., that the radial lines along which the visual form abstracted at the anterior surface of the *glacialis* continues inward through the eye must be prevented from intersecting at the center of the eye.

[10]I, 5.10, p. 349 above.

[11]Here "form" (*forma*) is to be taken in the sense of "qualitative structure" or "nature."

[12]To this point Alhacen has treated the *glacialis* as a single body, focusing his analysis on its anterior, sensing surface. At this juncture, however, the interface between glacial and vitreous humors assumes crucial importance as the refracting interface between those humors.

[13]Accordingly, the entire front portion of the *glacialis*, which consists of glacial humor only and which forms the crystalline lens, must lie ahead of the eye's center and, therefore, toward the front of the eye itself; cf. note 42 to book 1, p. 402 above; see also 2.10, pp. 420-421 above.

[14]Or, as Proclus asserts when commenting on book 1, def. 7 of Euclid's *Elements*, the plane surface and spherical surface are the only two "simple" or "unmixed" surfaces; see Glenn R. Morrow, trans., *Proclus: A Commentary on the First Book of Euclid's* Elements (Princeton, Princeton University Press, 1970), pp. 94-98.

[15]The reason that the interface between glacial and vitreous humor cannot be

concentric with the eye is that, if it were, it would also be concentric with the anterior surface of the *glacialis*; hence, all of the rays perpendicular to that surface would necessarily be perpendicular to the interface and would therefore intersect at the center of the eye and proceed in reverse order afterward. What Alhacen means by having the interface spherical and of "the right size not to have its curvature affect the arrangement of the form" is not as clear as it might be. For one thing, Alhacen does not specify here or later whether the vitreous humor is more or less refractive (i.e., more or less optically dense) than the glacial humor. For another, he does not specify whether the interface between glacial and vitreous humors, if spherical, has its concave or convex surface facing the anterior surface of the *glacialis*.

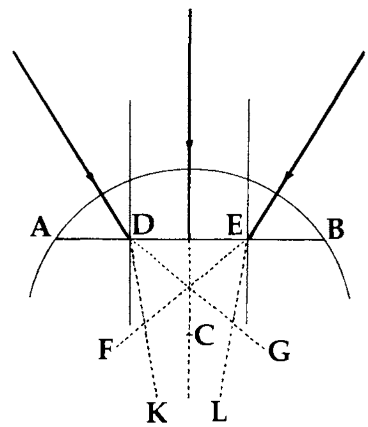

figure 2.1a

Bearing these points in mind, let us examine the three possibilities, assuming first that the interface between glacial and vitreous humors is plane, as illustrated in figure 2.1a, where **AB** represents the interface between the two humors, **C** is the center of the eye, and the two oblique rays pass orthogonally through the anterior surface of the *glacialis* to strike that interface at points **D** and **E**. In that case, if the rays were to be refracted away from the normal along **DG** and **EF**, they would meet in front of the eye's center **C**. In order to avoid intersecting ahead of or at **C**, therefore, they must be refracted toward the normal (e.g., along **DK** and **EL**), which can only happen if the vitreous humor is more refractive than the glacial humor in front of it. As figures 2.1b and 2.1c illustrate, the same will hold if the interface between glacial and vitreous humors is formed from a sphere whose ra-

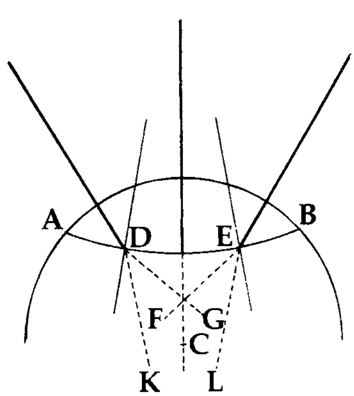

figure 2.1b

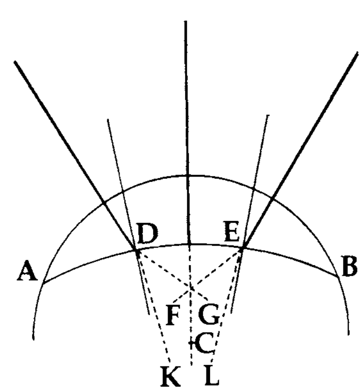

figure 2.1c

dius is larger than that from which the anterior surface of the *glacialis* is formed, no matter whether that interface is concave or convex with respect to that surface. Therefore, if we assume that the vitreous humor is more refractive than the glacial humor, then any of the three surfaces will refract the rays in such a way that they will tend toward convergence beyond the center of the eye. Furthermore, the greater the difference in refractivity between the two humors, or the flatter the interface, the more gradual that convergence will be.

On the other hand, if the interface between the glacial and vitreous humors is formed from a sphere whose radius is less than that of the anterior surface of the

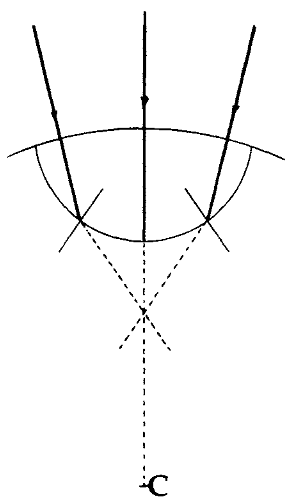

figure 2.2a

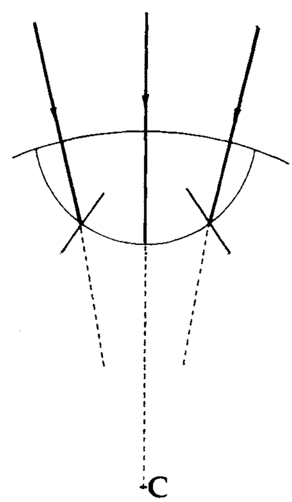

figure 2.2b

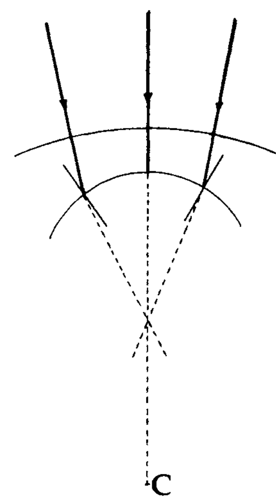

figure 2.3a

glacialis, then there are several possible outcomes, depending upon whether the vitreous humor is more or less refractive than the glacial humor and depending upon whether the interface is concave or convex with respect to the anterior surface of the *glacialis*. If the surface of the interface is concave, as in figure 2.2a, and if the vitreous humor is less refractive than the glacial humor, then the rays reaching the interface will necessarily be refracted in such a way as to converge in front of C, the center of the eye. If, however, we suppose the vitreous humor to be more refractive than the glacial humor, then, as is evident from figure 2.2b, it is possible for the rays to be refracted in such a way as to converge toward the axial ray at a point beyond center **C** of the eye. Conversely, if the interface is convex with respect to the anterior surface of the *glacialis*, as represented in figures 2.3a and 2.3b, the rays will invariably converge ahead of center **C** of the eye if the vitreous humor is more refractive than the glacial humor, whereas the rays may converge beyond point **C** when it is less refractive. Why, then, did Alhacen deny the possibility that the interface between vitreous and

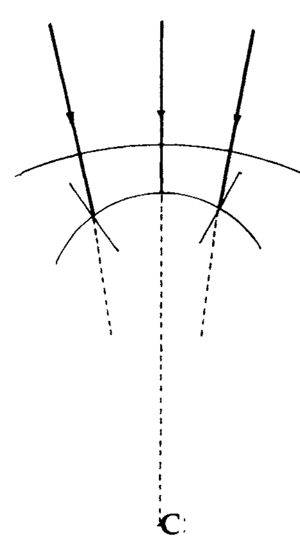

figure 2.3b

glacial humors could be more sharply curved than the anterior surface of the *glacialis*? His own rationale, that "if it were formed from a small sphere, then when the form is refracted at it and continues on, it will be distorted," is unclear and apparently misguided. What is clear, however, is that, in ruling out this possibility, he must have concluded that the vitreous is the more refractive of the two media, even though he never says so explicitly.

[16]I, 6.27, pp. 363-364 above.

[17]Here Alhacen is anticipating the question of how such forms can pass through the windings of the optic nerves in proper order and arrangement; see 2.15, p. 422 above

[18]This claim is only approximately true. Assume, for instance, that the object whose form is projected onto the anterior surface of the *glacialis* is planar. Let **AE** in

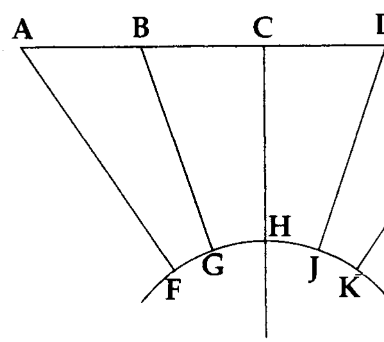

figure 2.4

figure 2.4 represent such an object, and let it be cut into equal segments **AB**, **BC**, **CD**, and **DE**. If the forms of points **A**, **B**, **C**, **D**, and **E** are projected along the orthogonals to points **F**, **G**, **H**, **J**, and **K** on the anterior surface of the *glacialis*, then the arcs they delineate will be unequal, **GH** and **HJ** being larger than **FG** and **JK**. Moreover, unless the interface between vitreous and glacial humors is perfectly flat, the form will remain somewhat distorted when it reaches this second surface. Thus, the form impressed on that surface will maintain the *relative*, but not the *absolute*, arrangement, of the original object-surface.

[19]As Roger Bacon explains it in *Perspectiva* 1.7.1, "since the [optic] nerve running from the vitreous humor to the common nerve contains a humor similar [to the vitreous humor], . . . the species [i.e., form] proceeds uniformly, without refraction; nor does it depart in any way from a rectilinear path, except to follow the twisting of the nerve. And in this we must admire the power of the soul's excellence, whereby it compels a species to follow the twisting of the nerve. . . . For as long as it is in a single inanimate medium, it always proceeds along straight lines, . . . but owing to the necessity and nobility of the works of the soul, a species in an animate medium follows the course of the medium and abandons the common laws of natural multiplications" (trans. Lindberg, *Roger Bacon and the Origins*, pp. 97-99.

[20]See I, 6.69-77, esp. 6.77, pp. 376-378 above.

[21]In other words, if there were refraction at the rear surface of the *glacialis*, then, since that surface is more sharply curved than the anterior surface (see I, 5.9 above), the resulting form would be distorted in the same way it would have if the interface between the glacial and vitreous humor were formed of a sphere with a smaller radius than that from which the anterior surface of the *glacialis* is formed (see 2.9, p. 420 above).

[22]Like Ptolemy's visual flux, then, Alhacen's visual spirit is imbued with a sensitivity that allows it to feel visual stimuli in the form of a "passion" or "pain" that consists of "coloring" and "illumination"; see notes 90 and 97 of book 1, pp. 409 and 410 above; see also 3.9 and 3.47, pp. 430 and 439-440 above. For the Ptolemaic parallel, see *Optics* II, 23-35 in Smith, *Ptolemy's Theory*, pp. 79-81

[23]As we pointed out earlier in note 66 to book 1, p. 405 above, Alhacen's cone of radiation is mathematically equivalent in all respects to Ptolemy's visual cone, the vertex being at the center of the eye (which forms the center of sight) and the base being on the visible object. The axis of this cone thus represents the Ptolemaic visual axis.

[24]Figure 2.5 is provided by *P3* (f 45r) to illustrate this point. The outer arc between points **B** and **D** is labeled *glacialis*; the space inside and above the inner line is labeled *vitreus*, and point **C** is labeled *centrum glacialis* ("center of the *glacialis*"). The legend reads: *Intellige quod superficies ABCD, que est superficies secans, est perpendicularis et super glacialem et super vitreum, et fluit ab axe, qui cum axis solum est perpendicularis super glacialem et super vitreum* ("Understand that surface **ABCD**, which is the cutting surface, is perpendicular to both the [anterior surface of the] *glacialis* and the [interface between the glacial and the] vitreous [humors], and it flows from the axis, so that, with the axis, it alone is perpendicular to the [anterior surface of the] *glacialis* and the [interface between the glacial and the] vitreous [humors]").

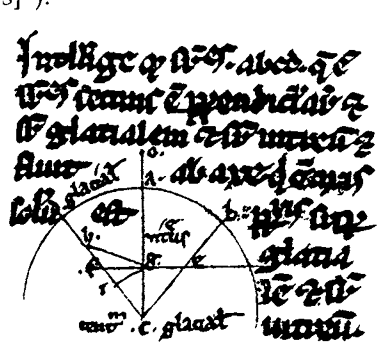

figure 2.5

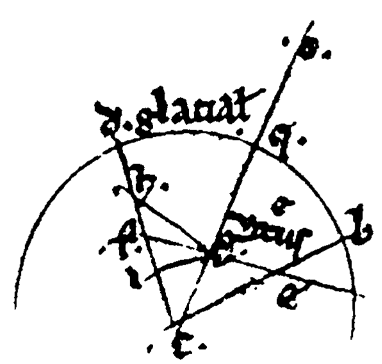

figure 2.6a

[25]Figure 2.6a is provided by *P3* (f 45r) to illustrate this point, although it does so rather ineptly because it grossly understates the obliquity of axis **AC** with respect to interface **FGE**. The point becomes clearer when the figure is redrawn, as in figure 2.6b on the following page. With **FGE** as the interface between the glacial and vitreous humors, **C** the center of the eye, **AGC** the visual axis, and **DFC** and

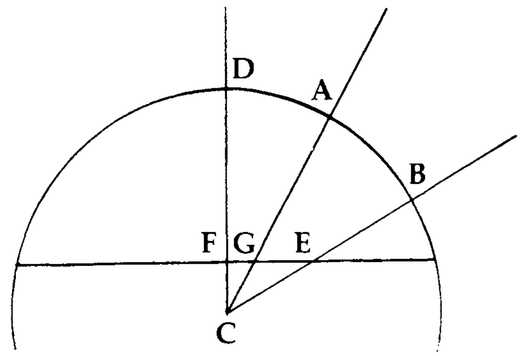

figure 2.6b

BEC flanking rays that are equidistant from the axial ray, then, although arcs **AD** and **AB** are equal, their projected segments, **FG** and **GE**, are clearly unequal.

[26]The gist of Alhacen's argument here and in the following two paragraphs is that, if the visual axis intersects the interface between the glacial and vitreous humors obliquely yet intersects the cornea and the *glacialis* orthogonally, then the point-forms projected along the orthogonals from the anterior surface of the *glacialis* to that interface will be projected upon it in distorted order.

[27]Figure 2.7 is provided by *P3* (f 46r) to illustrate this point. As it shows, the interface, which is represented by arc **EGF** and labeled *vitreus*, is eccentric to center **C** of the eye. Hence, when the axial ray (*axis*) passes orthogonally through anterior surface **DAB** of the *glacialis*, it will strike interface **EGF** obliquely. Accordingly the flanking rays, **DC** and **BC**, while cutting off equal segments **DA** and **AB** on the anterior surface of the *glacialis*, will cut off unequal segments **FG** and **EG** on the surface of the interface between glacial and vitreous humors.

[28]See note 1, p. 531 above, for a discussion of the various meanings of "disposition" (*dispositio*).

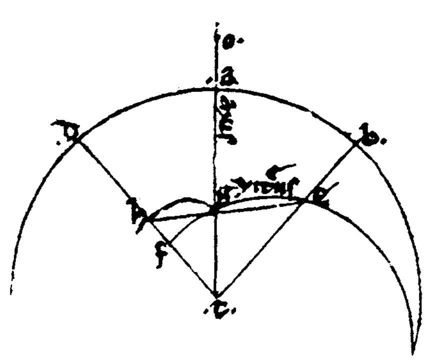

figure 2.7

[29]Hence, visual clarity is directly related to the intensity of the visual impression made, ultimately, on the anterior surface of the *glacialis*; see I, 6.24 and 6.43, pp.

363 and 369 above. This, of course, is why vision along the visual axis is clearest, a point to which Alhacen will have recourse later on in the fourth chapter of this book where he discusses the process of perceptual certification through visual scanning; see also 2.26-30, pp. 428-429 above.

[30]This claim harks back to Alhacen's and Ptolemy's dynamic model, according to which orthogonal projection makes the most intense impression; hence, the less refracted a ray, the more orthogonal its projection both upon and from the surface of refraction; see note 64 to book 1, pp. 404-405 above.

[31]The expression *res visa*, translated here as "visible property," has two fundamental meanings in this treatise. The first, and most obvious, is "visible object" (i.e., "object that is seen"), which is how it has been used to this point. The second is "visible property" (i.e., "object of sight" taken in its broadest perceptual sense). Such "objects"—which include shape, size, and the like—are not visible *per se* but are nonetheless apprehended through vision; see note 90 to book 1, p. 409 above. These particular properties must, of course, have a physical subject within which to inhere—hence, they must be "embodied."

[32]As opposed to inherent properties, which are intrinsic, accidental properties are not only extrinsic, but also contingent. Thus, the light in a self-luminous object represents an inherent property, whereas the light imparted to an opaque body by an external light-source represents an accidental property insofar as it originates elsewhere and is therefore contingent upon that source.

[33]3.44, pp. 438-439 above.

[34]In order to emphasize the fundamental passivity of *sensus solus* ("sense by itself" or "sense per se") in the visual process, I have chosen to render the phrase "brute sensation."

[35]By the form of each of those individuals, Alhacen means the actual physical form embodied in those individuals.

[36]In short, the perception of similarity or difference is discursive and therefore inferential.

[37]Throughout the Latin text color, like light, is qualified by the terms *fortis* ("strong," "intense," "vivid") and *debilis* ("weak," "faint"); see, e.g., chs. 1-4 of book I, pp. 343-347 above. In the case of light, of course, the intent of these qualifiers is obvious: "strong" light has greater illuminative effect than "weak" light. In the case of color, however, the intent is far less obvious. At times—e.g., in this passage—the intensity of the color seems to be a function of its vividness or brightness (*claritas*, as opposed to *scintillatio*, which is its brightness in the sense of dazzle). Thus, a bright-green object (e.g., a lawn) will make a more intense visual impression than one that is dark-green (e.g., a stand of fir trees). At other times, however, the intensity of color seems to be a function of its "depth" or darkness. For instance, in 3.53, pp. 442-443 above, "deep-green" (*viriditas profunda*) and "brown" (*fuscus*) are characterized as "strong," as is the color of robust wine, whose color is of such depth that it renders the transparency of the wine and the containing glass difficult to discern; see I, 4.22, p. 347 above.

[38]See note 22, p. 535 above.

[39]The term *ratio* is most obviously translated as "reason," but I have chosen to render it "judgment" to highlight that fact that, although indeed discursive and

logical, the process of drawing perceptual conclusions is of a relatively low intellectual order in comparison, for example, to the process of logically understanding how solar eclipses occur; see 3.28, p. 433 above.

[40]There are several ways to render the term *distinctio* as it is used in this treatise. Among those that are used in my translation are "distinguishing, " "discerning," "differentiating," "discriminating," and "determining." Whatever the English version, *distinctio* is used throughout the Latin text to denote a process of perceptually homing in on specific characteristics or characterizations inherent in physical objects. Thus, it is through such differentiation (homing in on and isolating specific features) that the faculty of discrimination is able to carry out the comparisons necessary in assimilation ("x is like y") or distinction ("x is unlike y"); see note 66, p. 541 below.

[41]The Latin term here is *scriptor*, i.e., "writer," rather than the expected *lector* ("reader"); see also II, 3.23, p. 432 above. Although Sabra renders it as "literate person," the Arabic term at this point also translates literally as "writer." Presumably, then, Ibn al-Haytham regarded a literate person as one who could write, not just read. Such an understanding of literacy is especially interesting in view of recent attempts to explain how literacy was understood and defined in the Middle Ages and how that understanding changed over time. See, e.g., Rosamund McKitterick, *The Carolingians and the Written Word* (Cambridge: Cambridge University Press, 1989), Brian Stock, *The Implications of Literacy: Written Language and Models of Interpretation in the Eleventh and Twelfth Centuries* (Princeton: Princeton University Press, 1983), and M. T. Clanchy, *From Memory to Written Record, England 1066-1307*, 2nd ed. (Oxford: Blackwell, 1993).

[42]The *virtus distinctiva* ("faculty of discrimination") does not represent a discrete faculty as, for instance, does the imagination. Rather, it designates a peculiar capacity possessed by the final sensor. As such, it serves as an active complement to the more passive sensitive faculty (*virtus sensitiva*); see 3.46, p. 439 above. The final sensor, for its part, does seem to represent a discrete faculty, one that may well be identical, or at least similar, to Aristotle's common sensibility.

[43]*Intentio*, which I have rendered as "characteristic," has a spectrum of meanings, all of them informed by a sense of "proferring" or "holding forth." Thus, an entire argument may have a specific "intention" or "meaning" in terms of the conclusion or understanding that it demands of us as we follow it through its logical steps. In the case of physical objects, they "hold forth" a large variety of specific qualities or characteristics (many of them "signs") that go into defining them. Each such object also carries a general intentionality that indicates its essential "meaning," which tells the perceiver what it is in terms of general or specific kind (i.e., this thing is a "man" and, moreover, the man named "Socrates").

[44]In scholastic Latin parlance, *quiditas* (or *quidditas*, which is often rendered as "quiddity") denotes the essence or nature of a given thing and, therefore, what makes that thing what it is. In terms of its "quiddity," therefore, each member of humankind is what it is by virtue of being animate, rational, and mortal. As will become clear later on (see note 55, p. 540 below), "quiddity," as used in the *De aspectibus*, is neither as abstract nor as intellectual as this: rather, it constitutes the physical denotation—by means of various superficial characteristics—of sensible

objects. Accordingly, individual humans belong to the general type Human (their *quiditas*) by virtue of such superficial attributes as being bipedal or having an upright posture; see 4.22, pp. 522-523 above.

[45]From this and subsequent paragraphs it is clear that Alhacen subscribes to an empiricist epistemology based solely on sense-induction and presupposing little or nothing in the way of innate ideas or conceptual capacities on our part. In this he has far more in common with Aristotle than with Plato.

[46]See I, 6.61, p. 374 above.

[47]See note 39, p. 537-538 above.

[48]Henceforth the term *anima* ("soul") will recur frequently to indicate in a general way where all the interpretive steps of visual perception take place with the arrival of the visible form at the common nerve. As will become clear in due course (esp. chapter 4), several specific faculties, including imagination, memory, and mind, are involved in this process; and "soul" is often used to stand generally for these specific faculties; see note 194, p. 556 below.

[49]That the whole is greater than the part is the fifth common notion listed by Euclid in the first book of his *Elements*. As such, it constitutes a supposedly self-evident (and presumably innate) truth. In deriving it logically from its constituent parts, Alhacen manifests a belief that, as far as logic is concerned, the propositional *content* of any statement is a product of sense-induction alone (i.e., *nichil in intellectu quod non prius in sensu*). Therefore, it is only the capacity to juxtapose such propositional content in logical order that is innate; see 3.38-39, pp. 436-437 above.

[50]I have chosen to render *propositio generalis* as "major premise" to highlight the basic Aristotelian structure of syllogism as reflected in this example. According to Aristotle, the quest for logical understanding starts with the major premise, which, though grasped through sense-induction, is nonetheless universal. Given that, the search for new conclusions depends on the search for appropriate minor premises, which invariably lead to those new conclusions by relating some newly chosen middle term to the two terms in the major premise. Thus, assuming that we do not yet know that the whole is greater than the part but do know that the whole exceeds the part (major premise), then, as soon as it occurs to us that exceeding means "greater than" (minor premise), the conclusion comes to us. See Aristotle, *Posterior Analytics* II, 3.

[51]*Solus intellectus* ("pure understanding") is just like *solus sensus* ("brute sensation") in that it grasps its proper object ("first principles") absolutely immediately, without any deliberation or interpretation.

[52]That is, it will become a first principle that may then be used to form the major premise in a new syllogism.

[53]In this instance "naturally" means "unconsciously" or "without any deliberation whatever"; see note 51 above.

[54]It is difficult to convey the full meaning of *quiescere* ("to be quiet" or "to come to rest") as used here and later in the *De aspectibus*. Such a state of intellectual rest culminates the discursive process (fraught with effort) that leads to understanding. Thus, to achieve a full and true understanding of something is to achieve a *quies mentis* ("a quiet of the mind"). I have chosen to render the term *quiescere* as "to ensconce" in order to convey the underlying notion that a given percept or concept

deriving from the sense eventually finds a niche in the soul or mind where it is subject to mnemonic retrieval.

[55]As used by Alhacen, the universal form represents a distillation of repeated visible impressions. Thus, the universal form of "green" derives from repeated impressions of green, the repetition yielding a sort of vague or general notion of green. The resulting distillate is not equivalent to the Universal as the epistemological construct underlying either Plato's or Aristotle's theory of knowledge. For one thing, as an archempiricist, Alhacen does not share Plato's belief in *a priori*, or innate, knowledge (see notes 45 and 49, p. 539 above). For another, the universal form is not intellectually abstract; it is inextricably tied to the sensible object or characteristic it represents. Yet at the same time it has a sort of nebulous generality. Or, to put it in Roger Bacon's terms, it constitutes a "diffuse particularity . . . that is as common [i.e., as extensive in its representation] as the universal and is convertible with it" (*Perspectiva* I.10.3, in Lindberg, *Roger Bacon*, pp. 156-157). For further discussion, see "Introduction," pp. lxxxvii-lxxxix above.

[56]As Aristotle points out in *De anima* II, 6, brute sense-perception (i.e., *solo sensu*) cannot be true or false; a given sense-impression, such as the impression "green," is logically value-neutral. Judgments about those impressions can, however, be false. Thus, while it cannot be false that, at a given time, I am undergoing the impression of "green," my judgments about that impression ("I see blue" or "That thing I see before me is green") can, and often do, err. Indeed, it is to examine the grounds of such erroneous judgments that Alhacen devotes the third book of the *De aspectibus*.

[57]By *remotio* ("distance") Alhacen has in mind the state of being remote from the viewer. It is, in short, the fact, not the specific measure, of remoteness, which is generally referred to later as *quantitas remotionis* or *mensura remotionis*—i.e., the "extent" or "magnitude" of the remoteness; see, e.g., 3.67, p. 448 above.

[58]*Situs* must be distinguished from *locus*, the latter meaning "place." *Situs* refers to a given object's overall "situation" or relative placement with respect to the viewer—e.g., directly facing him, at a slant to him, far to his left, etc. Place or location, for its part, depends upon the object's distance (in terms of spatial extent) and direction vis-à-vis the center of sight; see 3.67, p. 448 above.

[59]*Corporeitas*, which I have translated as "corporeity," is the property of "bodiliness" in terms of occupying three spatial dimensions (see 3.121, pp. 469-470 above). It could as well be translated by "solidity," except that I wanted to avoid any confusion with the term *soliditas*, which is used throughout the Latin text to mean "opacity" or "capacity to resist the passage of light."

[60]This list of "visible intentions" can, of course, be interpreted as an elaboration on Ptolemy's list of seven "visible properties" (*res vidende*)—corporeity, size, color, shape, place, activity, and rest—that list, in turn, quite likely deriving from Aristotle's list of "commons sensibles"; see Ptolemy, *Optics* II, 2, in Smith, *Ptolemy's Theory*, p. 72. In his commentary on this passage in *Optics*, vol. 2, p. 83, Sabra implies that this lineage may only be apparent. "As things stand," he therefore concludes, "I am not inclined to believe that it would be helpful to try to explain Ptolemy's and Alhacen's treatment of visual perception in terms of Aristotle's own doctrines and concerns. It would seem to me that such an approach can only lead to confusion."

Suffice it to say, I do not share Sabra's misgivings in this regard, although I hasten to add that Alhacen's list goes well beyond Aristotle's common sensible in terms of both quantity and intention inasmuch as transparency, opacity, shadow, darkness, beauty, and ugliness are clearly not accessible or "common" to any sense but sight.

[61]Cf. note 39, pp. 537-538 above.

[62]2.10-12, pp. 420-421 above.

[63]By "relative arrangement" I mean the arrangement of objects or parts among each other.

[64]The visible form presented to the final sensor is thus nothing more than a pointillist depiction of the object it represents, so its actual, physical content is limited to light and color, and color-contrasts. Yet, like a mosaic, this depiction conveys (or "intends") things that are not really contained by it. For those intentions to be grasped, then, that mosaic must be properly interpreted, which is what the faculty of discrimination does, thereby serving as ulterior viewer.

[65]Bear in mind that this notional entity, which comes to rest in the soul, is a proposition (indeed, a "general" or major premise). Thus, the sorts of universal forms that become ensconced in the soul seem to include not only forms of specific visible objects or characteristics, but also propositional forms.

[66]The process of comparison (*comparatio*) adverted to here is more in the way of correlation than of comparison in the strict sense. Hence, in an effort to identify a given color, the faculty of discrimination correlates that color with one already known and ensconced in the soul that resembles it. Later in the text I will render *comparatio* as "correlation" rather than comparison in order to make the distinction crystal-clear.

[67]By "assimilation" (*assimulatio*) is meant not the process of incorporation or absorption but, rather, the process of finding the given object's or characteristic's likeness in memory.

[68]The distinction between "essential" and "accidental" light is basically the same as that between *lux* (intrinsic luminosity) and *lumen* (the physical effect of *lux*) as discussed in note 2 to book 1, p. 395 above. When shining on an opaque body, accidental light acts like essential light in that it radiates omnidirectionally in straight lines from every point on that body and, in the process, confers visibility on the color in that object. Alhacen discusses accidental light and its properties at length in I, 3.22-98, in Sabra, *Optics*, vol. 1, pp. 20-40.

[69]In this case the "strength" of the two listed colors—deep-green and brown—can hardly be due to their vividness. As we shall see later, one key index to the strength of such colors is that, when they tint transparent media, they tend to mask the transparency of those media, rendering them apparently opaque until they are put up against the light.

[70]Figure 2.8, labeled *trocus* ("top"), is provided in ms *P3* (f. 57v) by way of illustration. This, and many of the figures that follow it in *P3*, have minimal explanatory purpose and may have been included more for mnemonic than for pedagogical reasons.

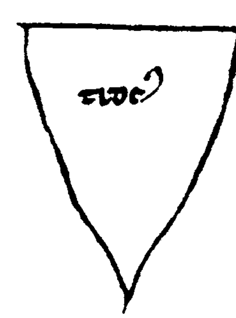

figure 2.8

[71]This example clearly derives from Ptolemy's discussion

of the blending of color on a spinning potter's wheel in *Optics* II, 96, in Smith, *Ptolemy's Theory*, pp. 109-110.

[72]Such distortion can lead to the spot of color's being seen according to the path of its motion (e.g., the circle of revolution) as delineated on the surface of the *glacialis* rather than according to its individual situation in relation to its surroundings.

[73]In other words, the inferential step between sensing color, *qua* color, and differentiating it (i.e., perceiving that it is red or green) is shorter than the inferential step between sensing and perceiving any other visible characteristic except, presumably, light.

[74]Figure 2.9 is provided in ms *P3* (f 58r) by way of illustration. It shows a ray of light, labeled *lumen*, passing from the sun, represented by the circle to the left labeled *sol*, through the opening (*foramen*) in the black rectangle at the center, to the smaller black rectangle to the right, labeled *corpus oppositum* ("facing body").

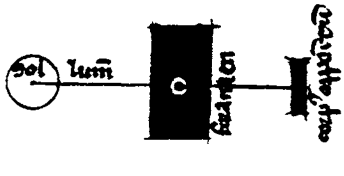

figure 2.9

[75]This putative demonstration of the temporal propagation of light and color is puzzling for several reasons. First, it is far from clear what purpose it serves except, perhaps, to repudiate Aristotle's claim that the transmission of light through transparent media represents an alteration akin to the freezing of water, which occurs instantaneously throughout the medium (see *De sensu* 6, 446b26-447a10). Or perhaps it is meant to establish a kinetic basis, however tenuous, to support the dynamic aspects of light- and color-radiation that are instrumental in Alhacen's account of visual selectivity at the surface of the *glacialis* (see I, 6.27, pp. 363-364 above). The demonstration itself poses some problems insofar as it seems to be based primarily on—and to respond primarily to—the supposition that the air as a whole receives incoming light all at once. At any rate, as Sabra points out in his commentary on 3.60-61 in *Optics*, vol. 2, pp. 87-88, the conclusions to be drawn from Alhacen's argument are as equivocal as the demonstration leading to them. Indeed, whatever is demonstrated, it is not the temporal propagation of light *seriatim* along the line of radiation; see 3.62 and 3.64, pp. 446-448 above. It is worth noting that only one of Alhacen's Perspectivist followers, Roger Bacon, accepted the temporal propagation of light and color; but his rationale in support of that idea had little or nothing to do with Alhacen's; see David C. Lindberg, "Medieval Latin Theories of the Speed of Light," in René Taton, ed., *Roemer et la Vitesse de la Lumière* (Paris: Vrin, 1978).

[76]In other words, as the eye turns toward the light-source, its surface, and with that its interior, is more fully exposed over time to that light, so it takes time for the full, direct effect of that light to be felt by the final sensor at the common nerve. The temporal "passage" here would thus seem to be lateral, not along the line-of-sight, and the motion that underlies it belongs to the eye, not the light.

[77]What Alhacen seems to be getting at here is that the brute sensation of color, *qua* color, and of light, *qua* light, does not constitute realization of the fact that color and light have been sensed; brute sensation is therefore unconscious. The conscious realization that color and light have been sensed comes only after the color

and light have reached the final sensor.

[78]The *quiditas* of the light (i.e., what kind of light it is) depends on its source (e.g., firelight versus sunlight or moonlight), whereas its *qualitas* ("quality") is a matter of its intensity.

[79]Clearly, then, as far as the Latin translator is concerned, *quantitas* and *mensura* are interchangeable in denoting the extent or magnitude of the spatial separation (i.e., distance) between objects; see Sabra, *Optics*, vol. 2, pp. 88-89 for a comparative analysis of the Arabic and Latin terminology used in the subsequent discussion of distance and its measure.

[80]That is, Aristotle and any of his intromissionist followers.

[81]The primary point of this argument, of course, is that, since visual perception is not based on extramission and, therefore, that the visual faculty does not reach out to external objects to get in visual touch with them, the visual perception of the spatial characteristics of things is not immediate in the way our tactile perception of those things seems to be. The ulterior implication of the argument is that there is absolutely nothing intuitive about spatial perception; it is an entirely inferential process. As is clear in 3.73. p. 450 above, even our perception that the visible world lies apart from, and outside of us, depends upon inference.

[82]See I, 6.47, p. 370 above.

[83]3.94-114, pp. 457-466 above.

[84]The process of visual certification (*certificare*) involves a determination whose accuracy is a matter more of certainty (i.e., of careful scrutiny) than of numerical exactitude. Thus, a certified measure of distance is accurate in terms of definiteness (e.g., "within touching distance" or "a hundred paces away") rather than computational precision (e.g., "307 cubits away"). However, as Alhacen establishes in 3.151, pp. 481-482 above, the ultimate yardstick by which we measure distances at ground-level is the size of the human body and its pace or arm's-length.

[85]As will become evident later on, in 3.150, p. 481 above, the intervening body Alhacen has in mind is the ground between eye and object.

[86]When we turn to Alhacen's discussion of the various threshold conditions of visual perception in chapter 3 of the third book, we will see that the range of moderateness for distance is variable, depending on a variety of factors, including the size of the object under scrutiny, how intensely it is illuminated, and so forth.

[87]In I, 8.7, pp. 392-393 above, Alhacen adverts to the limitations of sense-capacity. Thus, sense-capacity represents another threshold condition for visual perception, and it too is subject to variation, depending on such things as the state of the sense-organ itself. By "a continuous, ordered range of bodies" Alhacen means a succession of bodies between eye and object whose sizes and interrelated distances are determined, or at least determinable. An obvious example would be a row of trees, all of roughly the same height and separated by roughly the same interval, stretching between the eye and the visible object whose distance is to be determined. In reality, of course, the heights and intervals of such bodies are considerably less uniform; but the crucial point is that, in order to determine long distances (e.g., between the viewer and a distant building), there must be some intermediate reference-objects to put that distance into proper perspective.

[88]The failure of the visual faculty to determine untoward distances properly,

even when that distance is (or at least seems to be) spanned by a continuous, ordered range of bodies is exemplified in the Moon Illusion, which Alhacen explains much later, in the seventh book, on the basis of our tendency to underestimate the distances (and, thus, the sizes) of celestial objects at zenith and, conversely, to overestimate their distance and size when they lie near the horizon because we refer them to objects that lie far away toward the horizon; see A. I. Sabra, "Psychology versus Mathematics: Ptolemy and Alhazen on the Moon Illusion," in Edward Grant and John Murdoch, eds., *Mathematics and its Applications to Science and Natural Philosophy in the Middle Ages* (Cambridge: Cambridge University Press, 1987), pp. 217-247.

[89]Figure 2.10, which is labeled *nubes* ("clouds"), is provided in ms *P3* (f 62v) by way of illustration.

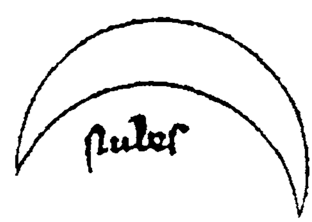

figure 2.10

[90]Note that, in this example, the ground serves as "the continuous, ordered range of bodies" by means of which the distance to and between walls would be measured; see note 85, p. 543 above.

[91]Figure 2.11 is provided in ms *P3* (f 63r) by way of illustration. The viewer to the left looks into the room (or "house," labeled *domus*) through an aperture (labeled *foramen*) at the two walls, which are set up one behind the other. The text

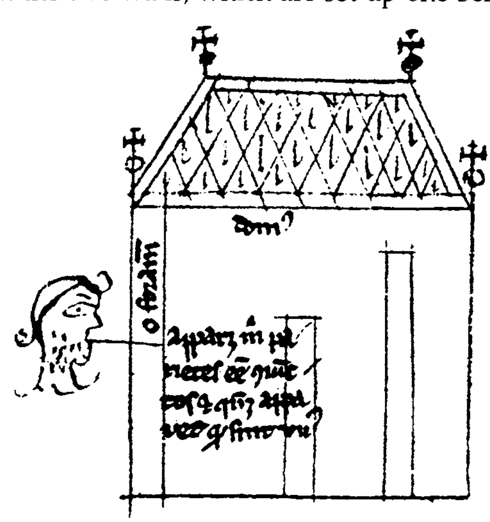

figure 2.11

inside the figure reads: *Apparet mihi parietes esse coniunctes, et quandoque apparet quod sint unus* ("It looks to me as though the walls are joined [i.e., contiguous], and sometimes it looks as though they are one [wall]").

[92]This simple experiment offers a definitive refutation of Ptolemy's idea that we perceive eye-to-object distance on the basis of an innate sense of ray-length; see note 106, p. 546 below.

[93]To this point the measure of distance has been along the line-of-sight, perpendicular to the plane of the visual field. Now the measure of distance is along the horizontal within that plane. Note, incidentally, that for Alhacen, as for Ptolemy, the visual field (or horopter) is planar rather than curved; see III, 2.4, p. 563 below; see also Smith, *Ptolemy's Theory*, p. 34.

[94]See note 88, pp. 543-544 above.

[95]In other words, if we see something that looks like a horse from afar, then we assume that it actually is a horse and, therefore, that it is the same size as horses of which we have had previous experience. On the basis of that experience, which includes seeing horses at different distances and noting how their apparent size varies with those distances, we assimilate the form of the horse we think we see to the equivalent form of a horse we remember (as of such-and-such an apparent size at such-and-such a distance) and conclude that the horse we think we see from afar lies at that remembered distance. Of course the apparent horse could actually be a pony, in which case we might overestimate the distance.

[96]As the analysis continues, it will become clear that an object is in "opposition" when it faces the eye.

[97]This second subtype of spatial disposition involves the orientation or slant of a facing surface or line.

[98]3.74, pp. 450-451 above. Note that for the subsequent analysis of "opposition," distance (*remotio*) is taken as the *fact* of, not the extent of, spatial separation; see note 57, p. 540 above.

[99]I, 6.60, p. 374 above.

[100]I, 6.66, pp. 375-376 above. The actual radial passage is through the body of the *glacialis* only because, as has been established in chapter 2 of this book, the radial lines are refracted at the interface between glacial and vitreous humors. However, and this is the point that is being established here, the form *would* pass along straight, uninterrupted lines to the very center of the eye were it not for that refractive interface.

[101]Here the vectorial implication of *verticatio* is clear; the sensitive faculty does not sense the radial line itself but, rather, the trajectory represented by that line. This sensation is crucial for spatial perception, because it provides the means whereby the final sensor can determine the relative orientation within the visual field (i.e., to determine the relative rightwardness, leftwardness, upwardness, or downwardness) of the object-point seen along that vector.

[102]According to Alhacen's analysis, then, "location" or "place" (*locus*) is a subtype of spatial disposition (*situs*). Indeed, as he defines it in 3.67, p. 448 above, location is specified by three variables: direction, distance (i.e., remoteness), and magnitude of distance; see 3.100, pp. 460-461 above.

[103]In I, 6.61, p. 374 above, the Latin term *signum* was rendered as "defining fea-

ture," whereas here it has been rendered directly as "sign." Whatever its English rendering, however, the term is used throughout the Latin text to designate something (be it defining feature, indicator, or symbol) that implies or betokens something deeper or more complex.

[104]Up to now, location or place (*locus*) has been defined generally in terms of the body's lying at some remove from the eye in a given direction. Here Alhacen makes clear that the full specification of location requires a determination of how far removed the object is. Compare this to Aristotle's definition of place in *Physics*, 4, 4, 212a as "the innermost motionless boundary of what contains it" (trans. R. P. Hardie and R. K. Gaye, in Barnes, *Complete Works*, p. 361).

[105]Such lines include the demarcations between discrete objects or segments that are contiguous, as well as the juncture between intersecting surfaces (e.g., two plane surfaces meeting each other at an angle); the gaps in question include intervals of spatial separation between discrete objects or segments and would presumably extend to channels or troughs cut into a surface.

[106]The "center of sight" is the perceptual counterpart of the physical center of the eye; both of them, of course, lie at the vertex of the cone of radiation, which is mathematically equivalent to the visual cone of Ptolemaic optics; see note 66 to book 1, p. 405 above. When it is a matter of perceptual perspective, then, I will render *centrum visus* as "center of sight."

[107]Figure 2.12a is provided by ms *P3* (f 68r) to explain a directly facing position. The vertex of the triangle within the circle is labeled *centrum visus* ("center of sight" or "center of the eye"). The text applied to the diagram reads as follows: *AB res visa directe est opposita visui si inter centrum oculi et A et B sunt linee equales; tunc axis*

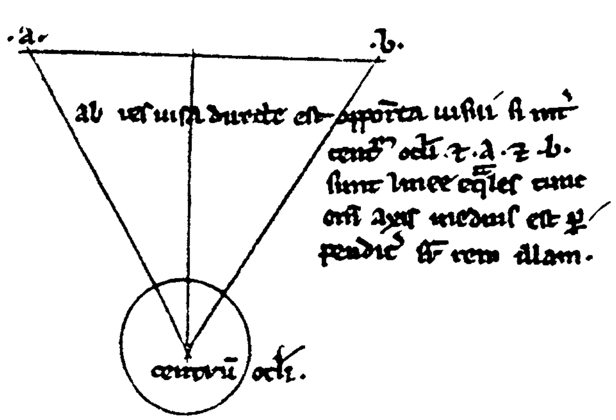

figure 2.12a

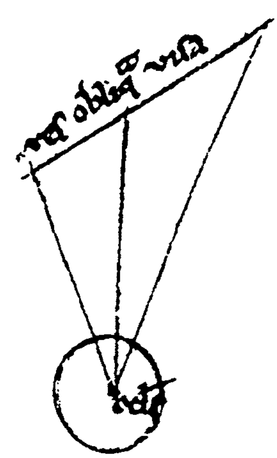

figure 2.12b

medius est perpendicularis super rem illam ("Visible object **AB** faces the eye directly if the lines between the center of the eye and **A** and **B** are equal; in that case the central axis is perpendicular to it"). Figure 2.12b, which occurs on f 69r of the same ms illustrates an obliquely facing disposition, the circle at the bottom being labeled *oculus* ("eye"), and the line at the top being labeled *res obliqua visa* ("slanted visible object").

[108]I take "in the line of opposition" to mean "straight out in a facing direction."

[109]That, of course, is why the moon and sun appear flat, even though we know they are spherical.

[110]Figure 2.13 is provided by ms *P3* (f 74r) to illustrate the visual perception of a convex surface by the eye, labeled *oculus.*

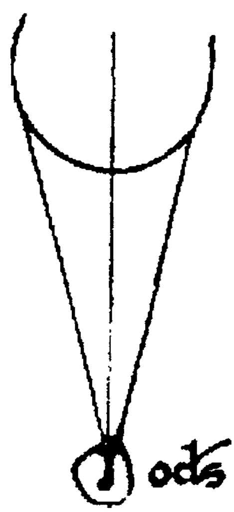

figure 2.13

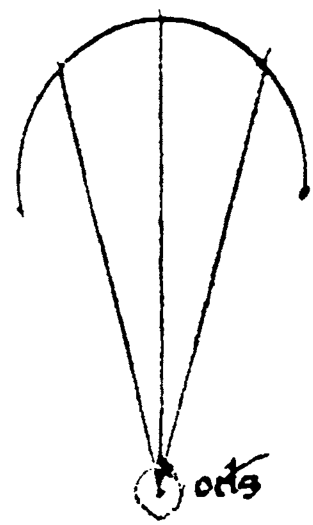

figure 2.14

[111]Why should a concave surface not be perceived as part of a solid body when a convex surface is? Although Alhacen has nothing to say on this score, perhaps he had the following in mind: Even though the visual faculty may perceive that the concave surface extends in depth, it has no way of determining whether that surface stands alone or forms part of a body whose mass lies behind it. It does, however, have a clear perception that the depression facing us is unenclosed (i.e., that it does not envelop a body on the side facing us). With a convex surface, on the other hand, the situation is fundamentally different, because the surface's depression faces in the opposite direction, away from rather than toward the viewer. Unable, therefore, to tell whether it is enclosed from behind (i.e., whether it envelopes a body on the side not facing us), we take it to be solid by default. Figure 2.14 is provided by ms *P3* (f 74r) to illustrate the visual perception of a concave surface by the eye, labeled *oculus.*

[112]Indeed, since it is an established principle that sight perceives nothing unless it is embodied (see 3.1, p. 429 above), then whenever we see something we almost always conclude that it occupies some volume (i.e., exists in three dimensions), even when we cannot actually see its extension in depth.

[113]This, of course, is the configuration of the object's boundary, or the boundary of the given part, as perceived according solely to length and breadth—e.g., the

circularity of a sphere according to its planar representation on the surface of the *glacialis*.

[114]The "form" referred to here is thus the actual volumetric shape of the object—e.g., spherical, conical, cylindrical.

[115]Here Alhacen is discussing the form of the object in three-dimensional, rather than two-dimensional, terms.

[116]It is presumably on the basis of previous acquaintance, deductively achieved, that we perceive the moon as a sphere rather than the flat disk that actually appears to us in the sky.

[117]In this context, *figura* designates the shape of the body's outline whereas *forma* designates its volumetric shape.

[118]In the fourth "definition" (i.e., postulate) of his *Optics* Euclid relates size-perception directly to the size of the angle at the vertex of the visual cone; and nowhere in the subsequent analysis does he cite any other factor in size-perception. Who the others are among the "several" Alhacen mentions here is uncertain, but it presumably included various Arab followers of Euclid.

[119]Foremost among those taking this position (assuming there are others) is Ptolemy, who has size-perception contingent on three interdependent factors: the size of the visual angle, the distance of the object, and the obliquity of the object with respect to the center of sight; see *Optics*, II, 47-63, in Smith, *Ptolemy's Theory*, pp. 90-98.

[120]That is, within the limits of moderation, which allows fairly ample latitude under normal conditions.

[121]In this analysis Alhacen is arguing in support of what modern perceptual psychologists refer to as size-distance invariance, according to which the perceived size of a given object does not vary as it recedes or approaches the center of sight. As far as Alhacen's analysis is concerned, the primary factor that permits us to follow this perceptual principle is familiarity. That is, if a given object is presented to us for the first time and we start by accurately determining its size at some initial distance, then, in knowing throughout all subsequent distance-changes that it is the same object, we "see" it as the same size. Likewise, with familiar objects whose acquaintance we have made earlier (e.g., a given person), when we see such objects over time at varying distances, we "see" them as the same size throughout. However, as Alhacen points out, the invariance of size-perception with distance holds only at moderate distances. It is worth noting, finally, that, in the eighth proposition of his *Optics*, Euclid admits that apparent size (as measured by the visual angle) varies with distance, but not in a one-to-one fashion (i.e., that an object does not appear half as big at twice the distance).

[122]Figures 2.15a and 2.15b on the following page are provided by ms *P3* (ff 77r and 77v) to illustrate the discussion in 3.138-139, pp. 475-476 above, of a square and circle viewed aslant from the eye at right, labeled *oculus*.

[123]3.52, p. 442 above.

[124]3.97, pp. 458-459 above.

[125]3.86-90, p. 454-456 above.

[126]Two things are crucial to the faculty of discrimination's ability to determine the visual angle: 1) the sensation of radial directionality that accompanies the im-

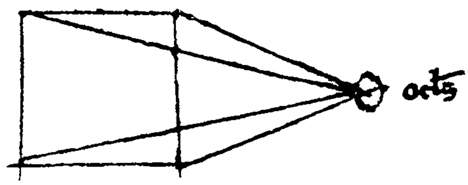

figure 2.15a

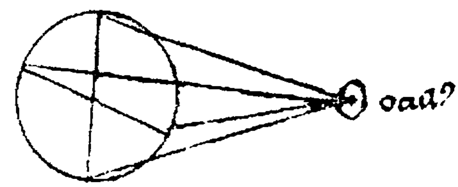

figure 2.15b

pressions of the object's circumferential point-forms on the surface of the *glacialis*, and 2) the perception of the size of the object's overall form on that surface. On the basis of these two givens, the faculty of discrimination is able to imagine the visual cone extending between the center of sight and the form on the surface of the *glacialis* and thereby to imagine the visual angle at the vertex of that cone. Then, granted a determinate perception of the object's distance from the center of sight, the faculty of discrimination is fully prepared to determine the size of that object; see 3.148, p. 480 above.

[127]3.81, p. 454 above.

[128]3.87, p. 455 above.

[129]3.90, p. 456 above.

[130]This portion of ground is presumably the one upon which the viewer stands while measuring the portions immediately surrounding him.

[131]As is clear from the analysis in 3.156, pp. 484-485 above, perception of the spatial disposition (relative orientation) of the two rays is tantamount to perception of the angle they form at the center of sight. Thus, the point of this discussion is that the faculty of discrimination is able to correlate both visual angle and ray-lengths to the size of the portion of ground subtending that angle.

[132]As we have already seen in Alhacen's account of the perception of the spatial separation between ourselves and objective reality (see 3.71 and 3.73, pp. 449-450 above), spatial perception is inferential, not immediate or intuitive for Alhacen. This point is abundantly clear in the analysis of distance-perception in 3.151-154, pp. 481-484 above. But why fall back upon such a complex inferential account when an intuitionist one would have been so much more straightforward? The answer is simple: By rejecting the visual-ray theory and all its entailments, Alhacen left himself no choice. One obvious virtue of the visual ray theory is that it makes spatial perception almost self-explanatory: Using the visual ray as a tactile instrument, we can visually feel things in much the same way we feel them with our hands. Thus, our visual apprehension of space and the spatial characteristics of external objects will be as immediate and intuitive as our tactile apprehension of them—a conclusion that accords with our own unreflective sense that we simply "see" physical space. Accordingly, just as we locate a given object through physical reach ("an arm's-length away") without any, or at least with minimal, inferential mediation, so we locate things visually without inferential mediation. We do so, according to Ptolemy, by an innate sense of ray-length; see *Optics*, II, 26, in Smith, *Ptolemy's Theory*, pp. 81-82. Denied this expedient, Alhacen is forced to fall back upon inferential mediation to account for spatial perception. It is worth noting, however, that his explanation, like Ptolemy's, is based upon a subjective sense

of the place and space we occupy with our bodies.

[133]A cubit is the length of the forearm from elbow to the tip of the middle finger. What Alhacen seems to have in mind in this passage is that the cubit is not some absolute, *a priori* spatial measure but an empirical yardstick that is unconsciously applied when we want to specify particular spatial extents. Our initial perception of spatial extent is therefore not in such specific terms; it is only later in the process of measuring space that we intellectualize it in such terms. Note, however, that the specific measures Alhacen mentions—the pace, the cubit, the palm's-breadth—have the human body as their ultimate referent.

[134]See note 130, p. 549 above.

[135]At such large distances, the sensitive faculty can no longer detect the difference in the lengths of the two rays that flank the portion of ground at its front and rear edges. It can, however, still detect the angle. Therefore, as figure 2.16 illustrates, the visual faculty will perceive the space as if it faced the eye directly rather than obliquely, as it actually does—i.e., in viewing portion **AB** of the ground from **E**, the perceiver will judge its size according to the directly facing segment **AC**. Hence, the actual extent of that portion of ground will be greater than its perceived extent.

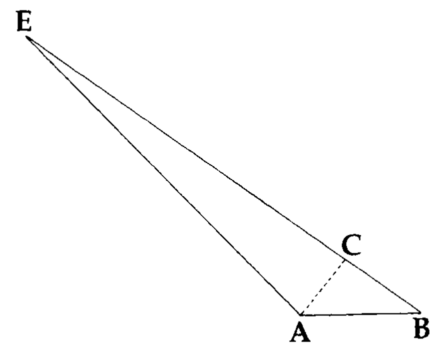

figure 2.16

[136]Here Alhacen is referring to color-perspective in a somewhat oblique way: i.e., the farther from the center of sight an object gets, the less vivid its color becomes. Hence, vividness of color is a gauge for determining, as well as misperceiving, the relative distance of objects—a point that Alhacen makes explicitly in III, 7.250-251, p. 625 below.

[137]This method of determining distance by correlating visual angle and size is a back formation from the method described in 3.146, p. 479 above, for determining size by correlating visual angle and distance. This latter method, of course, depends upon a direct determination of distance that is ultimately grounded in our bodily sense of place and space (i.e., in terms of paces, palm's-breadths, etc.).

[138]See note 118, p. 548 above.

[139]3.143, pp. 477-478 above.

[140]3.87, p. 455 above.

[141]The point of this rather confusing passage seems to be that, if one wants to determine the eye-to-object distance accurately, and if there is some continuous body (i.e., the ground) spanning that distance, the viewer will submit that body to an axial scan that will result in the conclusion that, by the rough reckoning of sense, the overall eye-to-object distance is equal to the length of the radial lines between eye and object.

[142]I, 5.35, pp. 354-355 above.

[143]In other words, the visual axis does not oscillate freely within the visual cone from its anchor-point at the vertex—which is how Euclid seems to conceive of the scanning motion of visual rays in the first proposition of his *Optics*, whose point is

to show that no object is seen at once in its entirety but, rather, viewed segment-by-segment through a radial scan. Against this view, Alhacen argues that, when the eye carries out the axial scan that is necessary to visual certification, it moves the entire visual cone, the axis thus remaining perfectly immobile within it.

[144]These operations are carried out naturally (*naturaliter*) insofar as they are virtually innate and instinctive to the sense of sight. Such "natural" operations, which include simple logical deduction, are therefore unconscious and effortless, even though they may be relatively complex; see 3.38-39, pp. 436-437 above.

[145]In rendering the Latin phrase *pars partium* as "portion of the parts," I am trying to reflect in English the dual meaning of "part" (*pars*) as used throughout the Latin text. On the one hand, it can be taken in the indefinite sense, as a mere quantum within the context of physical whole, in which case I have tended to render it "portion." On the other hand, *pars* can be taken in the specific sense, as a constituent element that helps define the body of which it is a part. In this latter sense, various members or organs, such as hands, feet, eyes, and ears, constitute parts of the human body and thereby define it as such. Unfortunately, beyond context, there is no way to be certain about which sense of *pars* is intended in the Latin text.

[146]Figure 2.17 is provided in *P3* (f 88v) by way of illustration. The accompanying text reads: *Ut AB subtenditur maiori angulo quam GH, que est eis equalis* ("For instance, **AB** subtends a greater angle than **GH**, which is equal to them" ["them" presumably referring to **AB** and all the other cross-sections]).

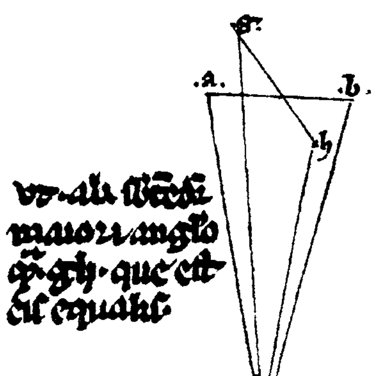

figure 2.17

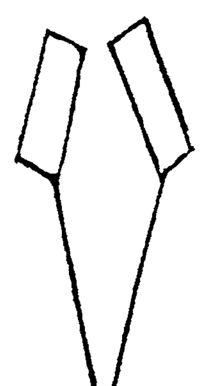

figure 2.18

[147]The Latin term translated as "to extend" here is *exire* ("to go out" or "to go forth"), which of course implies actual physical emission, a point that leads Sabra to charge Alhacen with "lapsing into a terminology [he] had abandoned" (i.e., the terminology of visual extramission); see *Optics*, vol. 2, p. 96. As we have noted, however, Alhacen has no qualms about framing his discussion of visual perception within the structure of what amounts to the Ptolemaic visual cone. Moreover, in the Latin text, at least, *exire* is used in a variety of contexts where it denotes the sort of imaginary extension of a line or plane that is carried out in mathematical con-

struction (cf., e.g., 2.19-23, pp. 423-427 above).

[148]III, 7.13-16, p. 603 below, and III, 7.24-25, pp. 605-606 below.

[149]Figure 2.18 is provided in *P3* (f 89v) to illustrate perception of the spatial separation between two distinct objects that slope toward one another in the direction away from the eye (*oculus*).

[150]Figure 2.19 is provided in *P3* (f 91r) to illustrate both lateral and longitudinal motion. Hence, from the eye (*oculus*), the arcal trajectory will be perceived as lat-

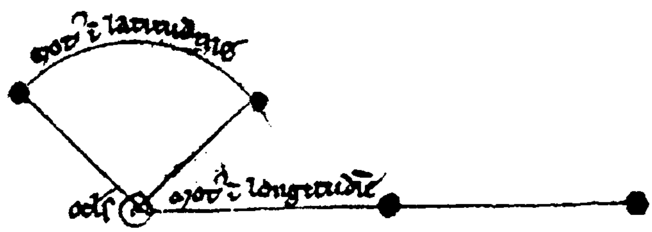

figure 2.19

eral motion (*motus in latitudine*), whereas motion along the line outward from the eye and to its right will be longitudinal (*motus in longitudine*).

[151]As with the perception of distance, so with the perception of motion, Alhacen is forced to explain it in mediate rather than immediate terms. The "immediatist" account, as offered by Ptolemy, has the visual flux sensing the passage of a moving object as it moves through or within the visual cone. Thus, lateral motion is sensed by the visual flux as it feels the crosswise passage of an object, whereas motion toward or away from the center of sight is felt by the flux in terms of the shortening or lengthening of the ray. And we are able to distinguish our own motion from the proper motion of external objects by an innate sense of self-reference; see *Optics*, II, 76-81, in Smith, *Ptolemy's Theory*, pp. 103-105. For Alhacen, of course, there is no flux to sense motion, so motion has to be referred to something other than the center of sight: i.e., to one or more external objects against which the motion of the specific object under scrutiny can be gauged.

[152]An example of motion according to some of an object's parts would be a person waving his arms while standing still.

[153]The account offered here differs from its Ptolemaic counterpart in one fundamental respect. For Ptolemy, the perception of lateral motion depends only on the eye-object relationship, the passage of the object being felt immediately by the flux through which it passes. For Alhacen, on the other hand, the perception of lateral motion depends not simply on the eye-object relationship but on the reference-frame provided by the visual field against which the motion is ultimately detected; see 3.181, pp. 497-498 above.

[154]According to the Ptolemaic account, the perception of motion toward or away from the center of sight is due to a sense of the resultant lengthening or shortening of the visual ray. For Alhacen, on the other hand, perception of such motion along the line-of-sight depends on a perception of the change in apparent size of the object as it approaches or recedes from the center of sight.

[155]See note 151, p. 552 above.

[156]Indeed, such motion of forms on the eye's (or, rather, the *glacialis'*) surface is integral to the scanning process by means of which we regularly certify our visual perception of size; see 3.164-167, pp. 489-492 above.

[157]Although Aristotle includes rotation and rectilinear motion (i.e., pushing, pulling, and carrying) among the four species of locomotion in *Physics*, 7, 2, rotation is fundamentally different from straight-line motion insofar as it involves no change in place, since the rotating object maintains a constant location while rotating. Furthermore, rotary motion has no specific *terminus a quo* or *terminus ad quem*. The Latin text seems to reflect this distinction by referring to circular motion as a change in spatial disposition (*mutatio situs*) and rectilinear motion, or locomotion, as a change in place (*mutatio loci*).

[158]The Latin phrase *superficies plana* would normally be rendered as "flat surface" or "plane surface" but in this case *planus* clearly means "smooth" insofar as it connotes perfectly uniform flatness, which is of course what renders a surface smooth; see 3.192, pp. 501-502 above.

[159]In other words, since no shadows will be cast in this situation, the light on that surface, being perfectly uniform, will provide no indication of its roughness.

[160]This type of separation is due not to spatial separation but to a clear distinction between integral parts; see 3.173, pp. 494-495 above.

[161]Such a placement will allow the viewer to see that the surface is reflective and, on that basis, to infer its polish; see 3.193, p. 502 above.

[162]Note that the Latin term for "smoothness" here is *planities* rather than *lenitas*, which is the term used in the full list of visible characteristics or "intentions" provided in 3.44, pp. 438-439 above; see note 158 above.

[163]It is not so much the perception of *transparency* as the perception of *embodied* transparency that is at issue here. Thus, if a transparent body is just as transparent as the air through which it is looked at, its defining features (e.g., its inherent color and its demarcating boundary) will be invisible, so the body itself cannot possibly be seen. On the other hand, the very fact of seeing any object at a distance necessarily implies that something (or some things) transparent intervenes between eye and object.

[164]According to Sabra's translation, it is the encompassing, opaque body, not the transparent body, that is supposed to be dark, which makes sense in light of 3.196, p. 503 above.

[165]Sabra's translation indicates some ellipsis here. According to his version, the situation entails darkness behind the transparent body and a brightly colored body placed within that dark area so that it can receive adequate illumination to be visible. The body's transparency will then become evident by means of the colored body's showing through it from behind.

[166]Shadow constitutes a relative darkening, so the shaded area must still have some light in it to be recognized as shadow rather than true darkness; see 3.199, p. 504 above.

[167]*Obscuritas* is therefore absolute darkness (or complete absence of light), as opposed to *umbra* which is relative darkness (or partial absence of light).

[168]In other words, beauty is not a distinct primary characteristic, like shape or

size; it is a secondary characteristic derived from such primary characteristics. Or, to put it another way, it is a characteristic of such primary characteristics. As will become clear from the subsequent analysis, Alhacen's aesthetic theory is relativistic (as Panofsky asserts) insofar as it is grounded in a subjective assessment of visible characteristics which may, or may not, seem beautiful to the beholder depending on circumstances. However, *pace* Panofsky and, to some extent, Sabra, there is also a strong undercurrent of absolutism in Alhacen's account. For one thing, although he acknowledges that beauty is what *we* make of it, he implies a universality among human aesthetic judgments that allows for no differences across cultural lines or over time. Thus, for instance, in the Arabic text as translated by Sabra, Alhacen mentions in III, 7.124 such traits as blond hair or blue eyes that "mar [a person's] appearance and detract from his beauty"—a judgment to which a Swede or Norwegian might take exception (suffice to say the Latin version of this passage, admittedly much abbreviated, makes no mention of this example). Furthermore, we have already seen two occasions where beauty is, in essence, predetermined by God: His doubling of the eyes to make the face more comely and His whitening of the sclera for the same purpose; see I, 7.9 and I, 7.14, pp. 388 and 389 above. Hence, though beauty may be subjective or relative by Alhacen's account, it is not subject to choice or change.

[169]The threefold division of beauty by specific causes is thus as follows: beauty that is characteristic of a single visible characteristic; beauty that derives from the conjunction of more than one visible characteristic—such a conjunction being analogous to a chemical mixture, where the integral elements retain their individual characteristics; beauty that derives from the combination of characteristics in such a way that the beauty transcends the individual characteristics, the analogue in this case being a chemical compound.

[170]This an instance of beauty by conjunction insofar as the beauty that is due to the form of the letters is distinct from the beauty that is due to their relative size.

[171]This is a case in which the beauty is due to combination insofar as it transcends the beauty of the individual elements or characteristics.

[172]Here Alhacen seems to be stretching his analysis for the sake of completeness because it is far from obvious how the solidity of something somehow accounts for its beauty.

[173]According to Sabra's version of this passage, the point is that a thickly planted, luxuriant lawn will appear more beautiful that one that is sparsely planted in clumps; see Sabra, *Optics*, vol. 1, p. 201.

[174]This claim for beauty in behalf of number seems to contradict the point of 3.209, pp. 505-506 above, where the Milky Way—which surely represents a place *par excellence* where there are many stars—is claimed to be less beautiful than any individual star.

[175]The phrase "or shadow" seems to be a gratuitous and infelicitous addition. It does not, moreover, show up in the Arabic text as interpreted by Sabra: see *Optics*, vol. 1, p. 202.

[176]See I, 4.25, p. 347 above. Note that the transliteration for *abu qalamun* has changed, from "amilialmon" to "alburalmon," perhaps because of a change in translators.

[177]Characteristics can thus be conjoined to heighten the effect of beauty; accordingly, as Sabra characterizes it—and quite aptly—beauty by conjunction has an "additive effect"; see *Optics*, vol. 2, p. 98.

[178]In citing proportionality or harmony as an aesthetic principle, Alhacen is of course harking back to the Greek aesthetic ideal; see Sabra, *Optics*, vol. 2, pp. 99-100 for elaboration on this point.

[179]It is in the expression of proportionality or harmony that various characteristics combine together in such a way as to create a beauty that is not necessarily in any them taken by itself. This sort of beauty, moreover, is not additive insofar as it transcends any of its individual characteristics, whose contribution to the overall beauty of the form depends entirely upon how and with what characteristics it is conjoined.

[180]The force of proportionality as a principle of beauty is such, then, that it will even confer beauty on an object whose constituent characteristics are not in themselves beautiful.

[181]This suggests rather strongly that, for Alhacen, as for the Greeks, proportionality or harmony is the sovereign aesthetic principle.

[182]Alhacen's account of beauty by proportionality brings to mind Copernicus' criticism of Ptolemaic astronomy at the beginning of the *De revolutionibus orbium coelestium*. Those who follow Ptolemy, he complains in the prefatory letter to Pope Paul III, "are like someone including in a picture hands, feet, head, and other limbs from different places, well painted indeed, but not modelled from the same body, and not the least matching each other, so that a monster would be produced from them rather than a man" (trans. A. W. Duncan, *Copernicus: On the Revolutions of the Heavenly Spheres* [New York: Barnes & Noble, 1976]).

[183]3.44, pp. 438-439 above.

[184]Ugliness would thus seem to be absolute insofar as it consists in the complete absence of beauty, a conclusion that is borne out by Alhacen's claim that the coexistence of beauty and ugliness in a given object does not yield some intermediate aesthetic state. Note, however, the implication in 3.220, pp. 506-507 above, that ugliness can vary in degree, for in that passage Alhacen characterizes a face with one round and one oblong eye as "extremely ugly" (*in fine turpitudinis* = "at the very limit of ugliness").

[185]In other words, the distinction among individual characteristics is intellectual or analytic, not physical or real. Hence, no single physical characteristic can actually subsist by itself, even if it is embodied: e.g., shape cannot effectively exist apart from size, nor motion from separation.

[186]Chapter 3 above, especially, 3.1-48, pp. 429-441 above.

[187]In this case "indeterminate" (*non certificatam*) is to be taken not in the sense of indefinite or inaccurate but, rather, in the sense of not offering grounds for assurance that what we think we see is actually what we are looking at. At first glance, for example, we may think with full certainty that we see a horse, when in fact we are looking at a mule. Our error in that case will be revealed to us only after close inspection.

[188]2.25, pp. 427-428 above.

[189]2.27, p. 428 above.

[190]To "determine" (*certificare*) the object's form is to get a clear sense of what, precisely, that form represents. Hence, certification of forms involves definition, which in turn entails an effective apprehension of *quiditas*, i.e., what the thing looked at actually is.

[191]See note 143, pp. 550-551 above.

[192]By "somehow perceive" Alhacen means to emphasize not the indefiniteness of the perceptual process in this case but, rather, the fact that the perception will depend upon where the form as a whole lies in relation to the point on it that is intersected by the visual axis. Thus, when that point lies roughly at the center of the form, that form as a whole will be seen according to an entirely different perspective than it is when the point of intersection lies at the outer edge of the form.

[193]The imagination, therefore, serves as a mnemonic storehouse for all the forms that are passed to it from the senses, and these forms range in specificity from the most particular to the most general (i.e., universal forms). It is difficult not to understand the process of memorization outlined here in terms of impression or engraving. Accordingly, the more often a given impression occurs in the imagination, the more deeply it is etched there; see, e.g., Aristotle's analogy between memory and etching in *De memoria et reminscentia* 1, 451a26-451b10. On the other hand, it must be emphasized that there is nothing *explicit* in Alhacen's account to indicate that he had that analogy in mind.

[194]With the addition of *mens* ("mind") at this point, we have been introduced to five specific faculties involved in the process of visual perception: 1) the sensitive faculty (*virtus sensitiva*) is responsible for brute sensation; 2) the final sensor (*ultimus sentiens*), which may well correspond to Aristotle's common sensibility, apprehends the sensible form in its physical particularity (via color, light, and formal arrangement in the common nerve); 3) the faculty of discrimination (*virtus distinctiva*) is responsible for differentiating among forms as well as formal characteristics (e.g., shape, size, etc.); 4) the imagination (*imaginatio*) serves as the storehouse of forms abstracted by the differentiating faculty; 5) the mind (*mens*) is presumably responsible for the intellective aspects of perception (i.e., the deductive and judgmental stages). These faculties represent various capacities unified within the soul (*anima*), whose sensitive and intellectual functions are carried out in the brain.

[195]The Latin term is *anima* ("soul"), but clearly what is meant is that place in the soul where internal dialogue is carried out.

[196]The universal form is thus abstracted, or distilled, from particular forms that are brought to the imagination by the various senses. As such, it may represent a physical object or a single characteristics, but, in either case, it will represent that thing by type (man) rather than by individual (Socrates).

[197]By *tota forma* ("overall form") is meant the most comprehensive and general form that can be derived from any given sensible impression.

[198]As it stands, the Latin *cognoscet apud cognitionem formam particularem* is confusing insofar as it translates literally into "it will recognize its particular form at the moment of recognition." I take the intended sense of *apud cognitionem* to be "at the moment of apprehension" or "at the moment of perception," an intention that would have been expressed better—or at least with less confusion—by the Latin phrase *apud comprehensionem*.

[199]3.57-3.59, pp. 444-445 above.

[200]At this point the analysis seems to reflect the Peripatetic distinction between "accidents" (mere *intentiones*), which are inessential attributes or predicates, and "properties" (*intentiones proprie*), which are essential attributes or predicates and, as such, serve as crucial markers of what a given object is. Thus, while skin color is merely accidental to being a human being, the ability to communicate verbally is essential. In the context of Alhacen's analysis, however, "property" is construed quite broadly to include a variety of features (e.g., bipedalism or featherlessness) that might, strictly speaking, constitute mere accidents; see 4.23-24, pp. 523-524 above.

[201]4.11-13, pp. 516-517 above.

[202]See note 197, p. 556 above.

[203]*Substantie illorum colorum*, which I have translated as "in which that color inheres" does not mean "the substances of that color [or, literally, 'those colors']" in the classical sense of the *ousia* (as, e.g., in Aristotle's *Categories* 5) of that color, but, rather, "what underlies" or "what supports" it—i.e., the roses in which it occurs.

[204]An obvious—perhaps too obvious—example would be the differentiation of identical twins, which takes extremely close scrutiny until familiarity teaches one to distinguish them through very subtle defining features.

[205]Such changes by external agent (*ex extrinseco*) are superficial in the most literal sense in that they only occur at, and affect, the surfaces of things. Thus, even though an object may suffer a radical change in temperature on being exposed to the sun, that change will not be visible since it affects the inner recesses rather than the mere surface of the object.

[206]I take vision based on initial impression (*visio fantastica* or *visio per fantasiam* = "vision based on imagination") to be the sort of vision that involves no attention on the viewer's part, the visible forms thus reaching the imagination, where they are "depicted" without having been perceptually analyzed in any but the most superficial way necessary to the basic act of visual perception. An example would be seeing a horse without realizing that a horse is being seen, in much the way we hear ambient sounds without actually listening to them or trying to make sense of them.

[207]See 4.27, pp. 525-526 above.

BOOK THREE OF ALHACEN'S *DE ASPECTIBUS*

Topical Synopsis

THE THIRD BOOK

[This is the third book], and it consists of seven chapters.

The first chapter comprises the prologue.
The second [concerns certain] things that need to be set forth for the analysis of visual illusions.
The third [concerns] the reasons why visual illusions occur.
The fourth describes [the various kinds of] visual illusions.
The fifth [deals with] the sorts of visual illusions that occur during brute sensation.
The sixth [deals with] the sorts of visual illusions that occur during recognition.
The seventh [deals with] the sorts of visual illusions that occur during judgment.

[CHAPTER 1]

[1.1] It has been shown in the first and second books how sight perceives visible objects as they actually exist when they are perceived directly,[1] and [it has been shown] how sight determines the form of the thing seen, how it perceives each particular [visible] attribute as it actually exists, and how it determines every such attribute. But not everything that is perceptible to sight is perceived by it as it actually exists, nor is everything that seems to the viewer to be perceived as it actually exists correctly perceived. On the contrary, sight is frequently deceived about many of the things it perceives about visible objects, and it perceives them other than they really are. Moreover, sight sometimes perceives that it is being deceived even as it is being deceived, but it sometimes does not, thinking, rather, that it is perceiving properly. For when sight perceives some visible object from a great distance, that object will look smaller than it really is, whereas when that [same] visible object lies quite near the eye, sight will perceive it as larger than it really is. Furthermore, when sight perceives a quadrilateral or polygon from a distance, it will perceive it as circular if its diagonals are equal, or oblong, if its diagonals are unequal, and if it perceives a sphere from a very great distance, it will perceive it as flat. Such cases are numerous and variegated, and everything that is perceived by sight in such a way is subject to deception.

[1.2] In addition, when sight looks at some star, it will perceive it to be immobile, even though the star actually moves at the time; but when the viewer thinks about it, he will realize that the star is moving while he looks at it. And when the viewer discerns this fact, he immediately realizes that he is being deceived in his perception that the star is immobile. Also, if someone stares at something standing on the ground extremely far away, and if that thing is moving quite slowly, then, if the observer does not look at it long [enough], he will perceive it as immobile. And if the viewer has not perceived that thing's motion before and does not keep watching it for awhile, he will not perceive that he is deceived in perceiving that thing as immobile, so he will be deceived in this sort of perception. He will nonetheless not perceive that he is deceived. Sight may therefore happen to be deceived about many things it perceives, and sometimes it perceives [that it is deceived], and sometimes it does not.

[1.3] Since it has been shown in the two previous books how sight perceives visible objects as they actually exist, whereas in this chapter it has been shown on the basis of what we have said that sight often happens to be deceived about many things it perceives, it remains for us to explain why, when, and how sight happens to be deceived. In this book, however, we limit ourselves to visual illusions regarding things that sight perceives directly, and we shall explain the reason for such [illusions], the different illusions [that can arise], and how each illusion occurs.

[CHAPTER 2]

[2.1] It was shown in the first book that sight perceives no visible object unless it does so along radial lines and that the arrangement of visible objects and their parts is perceived only according to the arrangement of the radial lines.[2] And it was also pointed out that a single visible object perceived simultaneously by both eyes is perceived as single only when its situation with respect to both eyes is equivalent; if its situation is not equivalent, then a single object will be perceived as double.[3] However, every familiar visible object that is continually perceived by both eyes will always be perceived as single. So we need to explain how a single visible object is generally perceived as single by both eyes in many [different] situations, as well as how the situation of a single visible object will generally be equivalent with respect to both eyes under various conditions. And we shall also explain how the situation of a single visible object may not be equivalent with respect to both eyes, as well as explaining the conditions under which this happens. We have already made this claim in the first book, but we explained it in a general rather than a definitive way.[4]

[2.2] We should point out that, when an observer looks at some visible object, each eye will face that visible object directly, so when the observer directs his gaze on that visible object, he will direct both eyes on that visible object in a corresponding way, and when his sight passes over the visible object, both eyes will pass [correspondingly] over it.

[2.3] Moreover, when the observer directs his gaze on a visible object, the axes of both eyes will meet on that visible object and intersect at some point on its surface, so if the observer passes his sight over that visible object, those two axes will pass together over the surface of the visible object and will scan all of its parts.[5] Generally, the two eyes correspond in all their dispositions, and the sensitive power in each of them is the same, so the way they act and are affected is invariably the same. And if either eye is moved for the sake of viewing [something], the other one will immediately move toward that object with a matching movement, whereas if either eye remains fixed, the other will remain fixed as well; and it is impossible for either eye to move for the sake of viewing [something] while the other remains fixed unless there is interference.

[2.4] It has also been shown in an earlier discussion that, when vision occurs, a cone can be imagined [to extend] between any visible object and the center of the eye, the vertex [of that cone] being the center of sight and the base the surface of the visible object that sight perceives.[6] But this cone contains all the radial lines according to which sight perceives that visible object. Thus, when the [visual] axes of both eyes intersect at some point on the surface of a visible object, the surface of the visible object will form a common base for both visual cones described between the centers of both eyes and the visible object, and thus the situation of the point where the two [visual] axes intersect is equivalent with respect to both eyes, since it faces the middle [of the surfaces] of both eyes, and the [visual] axes extending between the visible object and the two eyes are perpendicular to the surfaces of both eyes.[7] For any [other] point on the surface of the visible object, there are two lines that can be drawn from it to the centers of both eyes so as to be equivalently situated with regard to the [visual] axes as far as direction is concerned—i.e., any two lines imagined [to extend] between the centers of both eyes and the point on the surface of the visible object where the [visual] axes of both eyes meet will incline toward the same side of the two [visual] axes. Now every point on the surface of the visible object upon which the two [visual] axes intersect will lie on the same side of the point where the axes intersect; but the point of intersection lies upon both [visual] axes. Moreover, these [two] lines are equidistant from the two [visual] axes, for any two lines extending from the centers of both eyes to any of the points quite near the point of intersection [of the visible axes] are equidistant from the two [visual] axes as far as sense is concerned. For the two [visual] axes extending to the point of intersection will be equal, or else there will not be a perceptible difference between them when the visible object is not too near the eye, but, rather, its distance from the eye is moderate. And the same applies to the situation of any point that is very near the point of intersection—i.e., any two lines extending from the centers of the two eyes to any point [on the visible surface] scarcely differ in length as far as sense is concerned, and sometimes they will actually be equal [as far as sense is concerned]. However, since the two lines that intersect [somewhere] beside [the point of intersection of the visual axis] lie on the plane of the two [visual] axes, they will be unequal [in length], for the line extending from the point where the two [visual] axes intersect to some point beside it forms unequal angles with the two [visual] axes. But the two axes are equal, while the line joining the two points is common, so the two lines to the side [of the visual axes] will be unequal. However, this difference in length does not affect the sense if the point beside the point where the visual axes intersect is near it. On the other hand, if the two lines lie below or above the [visual] axes, they can be equal, for the two angles formed by the two [visual] axes with the line extended between the two points [of intersection] can be equal if the [other] point lies below or above [the point of intersection of] the [visual] axes.[8] Furthermore, in the situations lying between these two the difference between the two lines beside [the visual axes] will be less than the difference between the first [set of] lines beside [the visual axes], so there will be no effective difference between them as far as sense is concerned.

[2.5] Hence the two lines extending from the centers of the two eyes to points near the point where the two [visual] axes intersect scarcely differ in length as far as sense is concerned. Moreover, the two [visual] axes are equal, and the line joining the point of [their] intersection with the point beside it to which the [other] two lines are extended from the two centers [of sight] is common to both triangles formed by these lines. Therefore, the two angles at the centers of both eyes subtended by that common line on the surface of the visible object will be equal, or else there will be scarcely any perceptible difference between them. And these two angles will always be minimal when the point is extremely close to the point where the two [visual] axes intersect.[9]

[2.6] In addition, if the two lines extending to any point near the point of intersection [of the visual axes] form equal angles with the two [visual] axes, then the distance [from the two visual axes] of any of the two lines extending to the same point among the points that are near the point of intersection [of the two visual axes] will be equal.[10]

[2.7] Hence the situation of every point on the surface of the visible object upon which the two visual axes intersect, assuming that it lies near the point of intersection [of those axes] with respect to both eyes, constitutes a corresponding situation in terms of direction and distance from the two [visual] axes. On the other hand, the situation in the case of points lying far to one side of the point of intersection of the two [visual] axes is such that the angles formed by the two lines extending to some point [on the visible surface] and the two [visual] axes may differ by a measurable amount, so all such points that are [significantly] distant from the point of intersection [of the visual axes] in respect to the eyes have a corresponding situation as far as direction alone is concerned, but not as far as the distance from both [visual] axes is concerned.[11] Hence, as long as a visible object perceived by both eyes is of measurable size and its cross-sections are roughly equal in size, any point on it has a corresponding situation vis-à-vis the two eyes in terms of both direction and distance, so its form will occupy corresponding locations on each of the two eyes. But if the visible object perceived by both eyes is extremely large in cross-section, then the point on it where the two [visual] axes intersect will have a corresponding situation vis-à-vis the two eyes, and the closer to that point the [other] points are on the surface of that visible object, the more those points will have a corresponding situation vis-à-vis the eyes in terms of both direction and distance. However, points on the surface of that visible object that lie far away from the point of intersection and that lie on one side of the two [visual] axes have a corresponding situation vis-à-vis the two eyes in terms of direction, but as far as distance is concerned, they may or may not. Hence, the form of the area on such a visible object where the intersection [of the visual axes] occurs, as well as the form that includes the point of [that] intersection and everything surrounding it, is impressed at two areas on the two eyes that have a corresponding situation under all circumstances. Meanwhile the forms of the remaining parts that are distant from the point of intersection and that surround the area that has a corresponding situation [in each eye] are continuous with the form of the area that has a corresponding situation. Hence, every pair of forms is impressed on two areas on the two eyes that do not differ much in relative situation. And when there is difference, it will only be between the extremities, and it will be slight on account of the continuity of the extremities with the intermediate parts that are correspondingly situated; and this will be the case as long as the two eyes are focused on a directly facing visible object and the two axes remain focused on one of its points. Moreover, as the two eyes move over the visible object and the two [visual] axes are shifted from that point to move together over the surface of that visible object, the situation of every point on that visible object, as well as the situation of the points that are near it relative to the two eyes at the intersection of the two [visual] axes will be in nearly perfect correspondence, so the form of every part of the visible object as the two axes move over its surface will have a corresponding situation at two places on both the eyes. And thus, as movement and visual scrutiny continue, the form of all parts of the visible object will have a corresponding situation in both eyes.

[2.8] So, too, when sight perceives separate visible objects together at the same time, and the two [visual] axes intersect on one of them, if the visible object on which the two [visual] axes intersect has nearly equal cross-sections, then the form of that visible object will be impressed on two correspondingly situated places on the two eyes. Moreover, the form of whatever lies near that visible object, if it is small, will be impressed on two places on the two eyes that do not differ perceptibly in relative situation. However, when both eyes perceive a visible object far from the one on which the two [visual] axes intersect, and if the two [visual] axes remain focused on the original object, the form of the far object will be impressed on two places on the two eyes that are correspondingly situated in terms of direction only, not in terms of distance; not all of its parts will be correspondingly situated with respect to the two [visual] axes as far as distance is concerned, nor will its form be determinate. If the two eyes are then moved along with the two [visual] axes so that they intersect on each of [the other] visible objects perceived at the same time, the form of each of them will be impressed on two places on the two eyes that are correspondingly situated in terms of both direction and distance; and in that case the form of each of those visible objects will be determinate.

[2.9] Furthermore, the axes of both eyes often intersect on some visible object while the two eyes perceive another visible object that is not correspondingly situated with respect to the eyes in terms of direction. This will happen when that other visible object lies nearer both eyes than the visible object on which the two [visual] axes intersect and, moreover, falls between the two axes, or when it lies farther from both eyes than the visible object on which the two visual axes intersect but still falls between the two [visual] axes as we imagine them extended beyond their intersection, provided that the visible object on which the axes intersect does not block the visible object lying beyond it or [only] blocks part of that object.[12]

[2.10] In these ways, then, both eyes perceive visible objects.

[2.11] It was also shown in the second book that the visual axis in each eye constitues a unique and unchanging line, and that it passes through the centers of all the tunics of the eye and extends directly through the center of all the tunics to the middle of the place where the hollow of the nerve to which the eye is attached flexes, this place being at the opening in the eye socket,[13] [and it was shown] that the visual axis is inseparable from all the [ocular] centerpoints, that its situation with respect to all parts of the eye is always the same, remaining unaffected by the motion or immobility of the eye,[14] and that the two axes in the two eyes have a corresponding situation with respect to both eyes from the hollow of the common nerve where the final sensor perceives the forms of visible objects.[15] Let us therefore imagine a straight line joining the centers of the two openings in the two sockets containing the eyes, and let us imagine two lines extending from the centers of both openings in the eyesockets through the middle of [each of] the two hollow nerves. These lines therefore intersect in the middle of the hollow of the common nerve, because both nerves are correspondingly situated with respect to the hollow of the common nerve; so these two lines will be correspondingly situated with respect to the line joining the centers of the two openings [in the eyesockets], because the two nerves will be correspondingly situated with respect to those two openings. Hence, the two angles formed by these two lines and the line joining the centers of the two openings [in the eyesockets] will be equal.

[2.12] Let us also imagine that the line joining the centers of the two openings [in the eye sockets] is bisected, and let us imagine a line extending from the midpoint of the hollow of the common nerve where the two lines passing through the hollows of the two nerves intersect so as to continue to the point where the line joining the centers of the two openings [in the eyesockets] is bisected. This line will therefore be perpendicular to the line joining the centers of the two openings [in the eye sockets]. Now let us imagine that this perpendicular line is extended straight outward from the eye[s]; and so this line will remain fixed, and its situation will not change, because the point at the middle of the hollow of the common nerve where the two lines passing through the middle of the hollows of the two nerves intersect is unique and invariant. In addition, the point where the line joining the centers of the two openings [in the eye sockets] is bisected is also unique and invariant, so the straight line passing through those [two unique and invariant] points has a unique and invariant situation as well. Accordingly, this line will be referred to as the "common axis."[16]

[2.13] Now let us imagine some visible object facing the eye at some point on this line, and let us imagine that the two eyes look at this object while the two [visual] axes intersect at the point on the surface of the visible object where the common axis meets that surface, which is certainly possible for any visible object that is correspondingly situated with respect to the two eyes. When the two [visual] axes intersect at some point on the common axis, then the two [visual] axes, the common axis, the line joining the centers of the two openings in the eye sockets, and the two lines passing through the hollows of the two nerves will all lie in the same plane. For the two [visual] axes pass through the centers of the two openings [in the eyesockets], since they pass through the middle of the hollow of the two nerves where the two nerves funnel outward [toward the front of the eyeball]. Therefore, if the two [visual] axes intersect on the common axis, they will all lie on the same surface as the common axis and the line intersecting it that joins the centers of the openings in the two eye sockets. In addition, the two [visual] axes [extending] from the centers of both openings [in the eye sockets] to the point of intersection on the common axis will be equal. Also, they will be correspondingly situated with respect to the common axis, the two segments of the two [visual] axes [that extend] from the centers of the two eyes to the point of intersection will be equal, and the distance of the centers of both eyes from the openings in the two eye sockets as well as from the centers of those two openings is equal. Meanwhile, the two segments of the two [visual] axes extending from the surfaces of the two eyes to the point of intersection will also be equal. For the radii of the two ocular spheres are equal, and since that is so, the point on the surface of the visible object where the two [visual] axes meet will be correspondingly situated with respect to the two points through which the two [visual] axes pass [through the surfaces of the eye], so its distance from those [two points] will be equal. And these two points on the surfaces of the eyes are the ones upon which the form of the point where the two [visual] axes intersect is impressed.

[2.14] Moreover, the two points on the surfaces of the two eyes that lie on the two [visual] axes will be correspondingly situated with respect to the hollow of the common nerve, and these two points will also be correspondingly situated with respect to any point on the common axis. Thus, the situation of the two points on the surfaces of the two eyes that lie on the two [visual] axes is perfectly uniform and equal with respect to the point on the common axis at the middle of the hollow of the common nerve where the two lines passing [inward] from the centers of the two openings [in the eye sockets] intersect. So when they reach the hollow of the common nerve, both forms that are impressed on the two points where the two [visual] axes intersect the surfaces of the two eyes will be impressed on the point of the common axis that lies in the middle of the hollow of the common nerve, where the lines intersect, so they will produce a single form.

[2.15] Furthermore, when the two forms at the two points where the two [visual] axes intersect the surfaces of the two eyes are impressed on the point of the common axis that lies in the middle of the common nerve, the forms that are [impressed] on points surrounding both of the points where the two [visual] axes intersect the surfaces of the two eyes are impressed on points in the hollow of the common nerve that surround the point on the common axis. And any two points on the surfaces of the two eyes that are correspondingly situated with respect to the points in the middle of the surfaces of the two eyes where the two [visual] axes lie are also correspondingly situated in terms of direction and distance with respect to the same point in the hollow of the common nerve. And points that are correspondingly situated with respect to these points will lie on the same side of the point on the common axis where the lines intersect in the hollow of the common nerve as the two points on the surfaces of the two eyes, and their distance from that point will depend on their distance from the two [visual] axes. So the two forms impressed on the two points that are correspondingly situated with respect to the surfaces of the two eyes reach to that same point in the hollow of the common nerve, and they will be superimposed at that point so as to produce a single form; and every one of the points on the surface of the visible object that are in the vicinity of the point on the common axis is correspondingly situated with respect to the axes of the two eyes.[17] Thus, the form of any of those points will be impressed on both eyes at two locations that are correspondingly situated with respect to the two points where the two [visual] axes intersect the surfaces of the two eyes. Accordingly, the two forms of the visible object upon which the three axes intersect are impressed on the middle of the surfaces of the two eyes, and the two forms of the point where the three axes intersect will be impressed on the two points where the two [visual] axes intersect the surfaces of the two eyes, and any point on the two forms will be impressed on two correspondingly situated locations on both eyes. Afterward, the two forms that are seen will reach the hollow of the common nerve, and the two forms will reach from their [respective] points on the two [visual] axes to a point on the common axis and will produce a single form. Each of the two forms on the two points that are correspondingly situated on the two eyes will then reach the same point among the surrounding points on the common axis, and so the two forms of the whole visible object will be superimposed and will produce a single form, and sight will thus perceive it as single.

[2.16] In this way, then, the two forms of a single object that is uniformly situated with respect to both eyes will be impressed on the two eyes and produce a single form, and so the sensitive faculty perceives the visible object as single, even though two forms of it are impressed on the two eyes.

[2.17] Moreover, when the two forms on the two points in the middle of the surfaces of both eyes where the two [visual] axes lie reach the point on the common axis, both of the forms impressed on the surfaces of the two eyes will be impressed on two points on the two [visual] axes, and they will always reach the same point in the hollow of the common nerve, that point lying on the common axis. For the two points at which the two [visual] axes pass through the[ir respective] eyes do not change, because the situation of the two axes is always the same and invariant with respect to the two eyes. Thus, the point in the hollow of the common nerve reached by the forms impressed on the two points on the surfaces of the two eyes where the two [visual] axes lie is invariably the same point, that point lying on the common axis where the two lines passing from the centers of the two openings in the two eye sockets through the middle of the hollows of the two nerves intersect. Accordingly, this point, which lies on the common axis in the hollow of the common nerve, will be referred to as the "center."

[2.18] This then having been shown, it has been demonstrated that, when the axes of the two eyes intersect on the surface of anything perceived by both eyes, the form of that object is impressed on two places at the very middle of the surfaces of two eyes. Afterward, these two forms reach from the two eyes to the same place in the hollow of the common nerve, where they are superimposed to produce a single form. Moreover, the two forms of the point where the two [visual] axes intersect on the visible object will be impressed on two points on the surfaces of both eyes where the two [visual] axes lie, and they will proceed from these two points to the point in the center of the hollow of the common nerve, and it is irrelevant whether the point at which the two [visual] axes intersect lies on the common axis or beyond it. Nonetheless, if the visible object lies on the common axis and the two [visual] axes intersect on the point where the common axis meets that object, then the two forms of that point will correspond as perfectly as possible.[18] For the distance of that point from the two points on the surfaces of the eyes where the two forms of that point are impressed (and those two points lie on the [visual] axes) will be equal, since the two [visual] axes will be equal in length under these circumstances. Likewise, as far as sense is concerned, every point near that point lies an equal distance from the two points [on the surface of the eyes] where their forms are impressed, and their forms will be in closer correspondence than the two forms of a visible object that lies [farther] beyond the common axis, so, when it is impressed in the hollow of the common nerve, the form of a visible object that lies on the common axis will be as definite as possible. But if what is seen lies outside the common axis, but not too far away, then the two forms of it that are impressed in the two eyes do not differ by much, so the forms of it that are impressed in the hollow of the common nerve will not be doubled.

[2.19] If what is seen lies beyond the common axis at a considerable distance from it, but the axes of both eyes intersect at some point on it, then its form will be impressed singly in the hollow of the common nerve, and the form of its point where the two [visual] axes intersect will be impressed in the central point. Nevertheless, its form will be indefinite rather than definite. Thus, under all conditions, the form of the point on the visible object where the two [visual] axes intersect will be impressed in the point at the center of the hollow of the common nerve, whether the intersection-point lies on the common axis, or whether it lies beyond it. The rest of the form of the visible object, for its part, will be impressed around the central point. Moreover, if what is seen is quite small and of approximately equal cross-sections, and if it lies on or near the common axis, then its form will be impressed in the hollow of the common nerve as a single form; it will also be definite, and each of its points is correspondingly situated with respect to the two eyes, as we explained before. If, however, what is seen is large and has long cross-sections, but if it also lies on the common axis, then the form of that part of it at the spot that includes the point where the two [visual] axes intersect and the surrounding points will be impressed in the common nerve as a single, definite form. The form of the remaining parts [of the object] will be impressed to form a continuum with the form of this part, so the form of the entire visible object will be impressed singly under all circumstances; but the form of its extremities and of those parts that lie far away from the point of intersection will not be definite, for not every point lying far from the point of intersection will have its form impressed on two points whose situations correspond very well with respect to both eyes. Rather, the form of every point that lies far from the point of intersection will be impressed on two points of the two eyes that correspond in direction with respect to those eyes, but they may or may not lie at corresponding distances from the two [visual] axes. The forms of points that do not lie at corresponding distances will be impressed in the hollow of the common nerve at two points lying on the same side of the center, but they will be double; and if the visible object is of one color, then the effect of doubling will hardly be noticed because of the correspondence in color and the sameness of the form. If, however, what is seen is multicolored, or if there is some design, or depiction, or [if there are] subtle features in it, then the effect of doubling will be noticeable, so the form of its extremities will be indefinite rather than definite.[19]

[2.20] Now if what is seen is large and has long cross-sections, and if the axes of both eyes are focused on one of its points and remain fixed, then its form appears single, and the point of intersection, as well as whatever surrounds that point, will be determinate and definite. Its extremities, though, and the points near its extremities will not appear definite for two reasons: first, because the extremities are perceived by rays lying far from the [common] axis, so [what is seen along those rays] will not be clear, and second, because not every one of those points has its form impressed at a single point in the hollow of the common nerve; instead, some of them have their form impressed at two points rather than one. Therefore, [only] when the two [visual] axes are moved over all the parts of such a visible object will its form be defined. But if what is seen lies beyond and at a considerable distance from the common axis, then its form will not be determinate, for none of its points is correspondingly situated with respect to the two eyes because of the unequal distance that any point on such a visible object lies from the two points on the surfaces of the two eyes where the two forms of that point are impressed as well as from the two [visual] axes. Accordingly, [only] when both eyes are inclined toward such a visible object so that the common axis ends up on or near that visible object will its form be determinate.

[2.21] Likewise, when both eyes perceive several visible objects at once, and when the axes of both eyes intersect on one of those visible objects and remain focused on it so that the rest of the visible objects lie outside the two axes, and when the visible object upon which the two [visual] axes intersect is quite small, the form of the visible object upon which the two [visual] axes intersect, [when it is impressed] in the hollow of the common nerve, will be single and determinate. And if the visible object lies upon the common axis, then its form will be more determinate than the form of a visible object that lies outside the common axis. Finally, if the two axes also intersect on that same visible object, then, in this case, if any of the objects lying near the object upon which the two [visual] axes intersect is perceived by sight—assuming that [such neighboring] objects are quite small—its form is impressed in the hollow of the common nerve as a single form that will not be at all indefinite, for its form will lie near the center. On the other hand, in that same situation, when any of the visible objects that lie far from the visible object on which the two [visual] axes intersect is perceived, the form of it that is impressed in the hollow of the common nerve will be indefinite. And so there will be two forms that overlap, because they lie on the same side and the difference between their relative situations in terms of distance will not be inordinate, so the two forms will overlap, or else the form of some of the object's parts will be doubled while the form of others will be single.[20] And so the form of such visible objects will be indefinite under all circumstances because of the difference in relative situation among the rays extending to it and because the rays extending to it will lie far from the two [visual] axes. Moreover, the form of a visible object that lies to the side of the two [visual] axes and far from the intersection-point of the two [visual] axes will not be determinate as long as it lies far from the intersection-point of the two [visual] axes. When, however, the two [visual] axes are shifted to intersect upon that object, its form will be defined.

[2.22] If the axes of the two eyes intersect on some visible object, and, in addition, the two eyes perceive another visible object nearer or farther away from the two eyes than the visible object on which the two [visual] axes intersect, and if that object falls between the two axes, then it will [appear to] lie on opposite sides with respect to the two eyes. For since it lies between the two [visual] axes, it will lie to the right of one axis and to the left of the other, and the rays extending to it from the one eye will lie to the right of the [visual] axis, whereas the rays extending to it from the other eye will lie to the left [of the visual axis]; on that account it will [appear to] lie on opposite sides with respect to the two eyes.[21] So the form of such visible objects is impressed on the two eyes at two spots that are not correspondingly situated, and the two forms of it that are impressed on the two eyes reach two different locations in the hollow of the common nerve, and the [forms] will lie on both sides of the center, so there will be two forms, and they will not be superimposed upon each other.

[2.23] Likewise, if the visible object lies on one [visual] axis but outside the other, its form will be impressed in two locations in the hollow of the common nerve, i.e., one in the center and the other to the side of the center, and those forms will not be superimposed.[22]

[2.24] These, then, are the ways in which the form[s] of visible objects will be impressed on both eyes as well as in the hollow of the common nerve.

[2.25] Moreover, everything we have discussed can be tested by experiment so we will attain certainty about it.

[2.26] Take a smooth wooden plaque that is one cubit long and four digits wide, and let it be perfectly flat, even, and smooth.[23] Let the edges along its length, as well as those along its width, be parallel, and let there be two diagonals intersecting one another at a point through which a straight line is drawn parallel to the edges along the length. Then, through that [same] intersection-point let a straight line be drawn perpendicular to the first line, passing through [the plaque's] middle, and let [each of] these [two perpendicular] lines be painted a different color, both colors being bright so that they are readily visible, but let the two diagonals be painted the same color. Then, in the middle of the bottom edge of the plaque, between the [endpoints of the] two diagonals, let a rounded notch be cut, but one that narrows inward so that, when the plaque is brought up to it, the bridge of the nose can fit into it in such a way that the two corners of the plaque almost touch, but do not actually touch, the two midpoints of the surfaces of the two eyes.

[2.27] Accordingly, let **ABCD** in figure [3.8] represent the plaque, let **AD** and **BC** be the diagonals, and let the intersection-point be **Q**; let line **HQZ** be the line passing longitudinally through the middle of the plaque, and let line **KQT** be the line that intersects this line at right angles. Finally, let the notch in the middle of the bottom edge of the plaque be circumscribed by [curved] line **MHN**.

[2.28] With the plaque thus constructed, take some white wax and make three small, cylindrical pegs out of it, and paint them different colors; then stand one of the pegs on the center of the plaque at point **Q**, fix it to the plaque so that it cannot be displaced, and stand it straight up on the plaque.

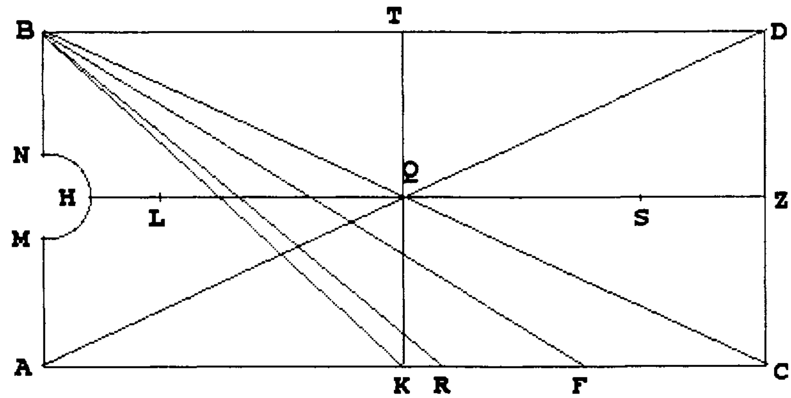

figure 3.8

Now stand the other two pegs at endpoints **K** and **T** of the line [passing through the middle of the plaque] along the width so that the three pegs will lie on a single line. When this is accomplished, the experimenter should lift the plaque and place the notch in the middle of the bottom edge against the bridge of his nose between the eyes so that the bridge of the nose will lie snug against the plaque, while the corners of the plaque will be set at the two midpoints of the surfaces of the eyes and nearly touching them. Then the experimenter should look at the peg placed in the center of the plaque and focus his gaze intensely upon it. Accordingly, when the experimenter stares in this way at the peg placed at the center [of the plaque], the axes of the two eyes will intersect on that peg and will either coincide with, or be parallel to, the two diagonals. Also, the common axis, which we defined earlier,[24] will coincide with line **HZ** drawn lengthwise through the middle of the plaque.

[2.29] Then, maintaining this situation, the experimenter should look at everything[25] on the surface of the plaque. He will then find that each of the three pegs at points **K**, **Q**, and **T** [appears] single, and he will also find that line **KQT** [appears] single. Line **HZ**, however, which is drawn lengthwise through the middle of the table, will appear double, [its two images] intersecting at the peg placed in the center [of the plaque]. Likewise, in the same situation, when the experimenter looks at the two diagonals, they will appear quadruple, that is, each of them [will appear] double.[26]

[2.30] Then the experimenter should direct his gaze toward either of the pegs at the two points **K** and **T** so that the two [visual] axes intersect on [either] one of the pegs placed at the endpoint. Then, in this situation, he should again look around, and he will find that each of the three pegs [appears] single, as well as the line passing [through the middle of the plaque] along the width, but he will find that the line passing lengthwise through the middle [of the plaque appears] double, as does each of the two diagonals.

[2.31] Thus, when the experimenter has perceived these lines and the pegs that are placed on the table, he should remove the two pegs at the two points **K** and **T** and place them upon line **HZ** that extends lengthwise [through the middle of the plaque], one of them at point **L**, which is near the eyes, and the other at point **S**, which lies beyond the peg placed in the center [of the plaque]. Then he should reposition the plaque as before [against his nose] and direct his gaze at the peg placed in the center [of the plaque] . He will then find that the two pegs [appear as] four and [lie] to the sides of the central peg, i.e., two to the right and two to the left, and he will find that [they appear] to lie on two lines which are, in actuality, the one line [**HZ**] in the middle [of the plaque] which nonetheless appears double; he will also find that each of the pairs [of pegs appears to lie] upon one of those two lines.[27]

[2.32] Likewise, if he removes the two pegs from that line and places them upon either of the two diagonals, one on the side of the eye and the other beyond the peg that is placed at the center [of the plaque], he will find that they [appear] quadruple. For each of the diagonals will appear double, so upon each of the two [diagonal] lines that are actually [produced from] one [original] diagonal two pegs will appear, one on the side of the eyes and the other beyond the peg placed in the center [of the plaque].[28] Likewise, if the two pegs are placed on the two diagonals, one upon each, and if they are [both] placed on the side of the eyes, the experimenter will find that they [appear] quadruple, two near [each other] and two far away [from each other].[29]

[2.33] Then the experimenter should remove the two pegs from the plaque and place one of them at the edge of the plaque beyond point **K** but quite near it, e.g., at point **R**, and he should reposition the plaque as before [against his nose] and direct his gaze at the peg that is placed in the center [of the plaque]. In that case, he will definitely find that the peg placed at **R** [appears] single. Then he should remove the peg from point **R** and place it at the edge of the plaque beyond point **K** at a point far from point **K**, e.g., at point **F**, and he should direct his gaze at the peg placed in the center [of the plaque], for then he will find that the peg placed at point **F** [appears] double.

[2.34] Now the experimenter will encounter everything we have described when he directs his gaze at the peg placed in the center [of the plaque], or at a peg placed on the straight line [passing through the middle of the plaque] along the width, or at a point on that line, whatever point it may be, as long as the two [visual] axes intersect at the peg placed in the center [of the plaque] or at some point on the line [passing through the middle of the plaque] along the width. Under these circumstances, then, if the experimenter directs his gaze at the peg that is placed beyond the line [passing through the middle of the plaque] along the width or at a point located beyond that line, and if the two [visual] axes intersect at some point beyond the line passing through the middle, then the peg that is placed in the center [of the plaque] will appear doubled. Meanwhile, if the remaining pegs lie at the two points **K** and **T**, then each of them will also appear double. Then, if the experimenter directs his gaze to the central peg or to some place on the line [passing through the middle of the plaque] along the width, everything will revert right back to the original situation, as represented in the first figure.

[2.35] Accordingly, let lines **BK**, **BR**, and **BF** [in figure 3.8] be drawn from point **B**. Line **KB** is therefore longer than line **BT**, while line **KQ** is equal to [line] **QT**. So angle **TBQ** is greater than angle **QBK**.

[2.36] But angle **TBQ** is equal to angle **KAQ**. Thus, angle **KAQ** is greater than angle **KBQ**.

[2.37] Therefore, line **AK** lies farther from axis **AQ** than line **BK** does from axis **BQ**. But the difference in the distance between these two is minimal because the difference between the two angles **KAQ** and **KBQ** is slight.

[2.38] Now the peg at point **K** always appears single to the two eyes when the two [visual] axes intersect at the peg that lies at point **Q**. Moreover, the two lines **AK** and **BK** are parallel to the two rays extending to the peg at point **K** as long as the two axes intersect at the peg that lies at point **Q**.[30]

[2.39] So, too, the situation of the peg at point **R** is known, for the rays extending to it will line up with the two lines **AR** and **BR**, so it will appear single.

[2.40] Moreover, the two angles **RAQ** and **RBQ** do not differ much in size, whereas angle **KBR** has no perceptible size when point **R** lies very near point **K**.

[2.41] From this example it will be obvious that, when a visible object lies on the same side of the two axes, and the rays extending to that object from the two eyes do not differ very much in their distance [from the visual axes], that visible object will appear single to the two eyes.

[2.42] On the other hand, angles **FAQ** and **FBQ** differ considerably in size, so the peg at point **F** will appear double when the two [visual] axes intersect at the peg that is at point **Q**.

[2.43] From this example it will therefore be evident that, if the rays extending from the two eyes to a visible object lie at significantly different distances from the two [visual] axes, the object appears double, even if it lies on the same side of those axes.

[2.44] Line **HQZ**, however, does not lie on the same side of the two [visual] axes, for the rays extending toward [segment] **HQ** from the right eye lie to the left of [visual] axis **AQ**, whereas the rays extending toward it from the left eye lie to the right of [visual] axis **BQ**. On the other hand, the rays extending toward [segment] **QZ** from the right eye lie to the right of axis **AQ**, whereas the rays extending to it from the left eye lie to the left of axis **BQ**, so the rays extending to it lie on opposite sides [from those extending to **HQ**]. But the distance between the two rays extending to each point on this line from the two eyes and the two [visual] axes is equal; yet this line, and everything that lies on it, except for the peg that is placed in the center, invariably appears double if the two [visual] axes intersect at the peg placed in the center.[31]

[2.45] On this basis it has therefore been shown that a visible object that lies on different sides of the two [visual] axes always appears double, even if the rays extending to it from the two eyes lie at equal distances from the two [visual] axes. For any of the two rays extending from the two eyes to any point on the object will lie on opposite sides [of the eyes], so the two forms of each of its points will be impressed on two points on both sides of the centerpoint in the hollow of the common nerve.

[2.46] The same thing also holds for the two diagonals, i.e., the rays extending to either of them from the eye will follow in order from the center of the eye, being near the [visual] axis, below the [visual] axis, or above the [visual] axis; and the rays extending to the diagonal from the other eye will be inclined to the other axis. The rays extending from the right eye to the left-hand diagonal will lie to the left of the [visual] axis, whereas the rays extending from the left eye to the right-hand diagonal will lie to the right of the [visual] axis.[32] The forms of these diagonals, and everything else that lies upon them, appear double except for the peg in the center [of the plaque] when the two [visual] axes intersect on that central peg.

[2.47] From this it will be clear that a visible object that lies directly opposite the middle of one eye but lies to the side of the middle of the other appears double. For the form of the point that is impressed in the middle of the one eye reaches [straight through to] the center [of the common nerve]. But the form of a point to the side of the middle of the other eye will reach some point other than the center [of the common nerve], and its displacement from the center will depend upon its displacement on the surface of the eye.

[2.48] Thus, on the basis of this experiment and its explanation it is quite evident that if the two [visual] axes intersect on an object, it always appears single; and [it is evident] that, if the rays that converge on an object lie on the same side [of their respective axes], and if their distance from the two [visual] axes does not differ by much, the object appears single; and [it is evident] that, if the rays that converge on an object lie on the same side but at substantially different distances from the two [visual] axes, the object appears double; and [it is evident] that, if the rays that apprehend an object lie on different sides [of the visual axes], the object appears double, even if the rays extending to it are equidistant from the two [visual] axes; and [it is obvious] that all of this will obtain as long as the two [visual] axes intersect on a single visible object.

[2.49] All ordinary visible objects face both eyes, and both eyes look at any such object. Thus, the two axes of the two eyes always intersect on them, and the remaining rays that intersect at a common point on them lie on the same side [of their respective visual axes], and their distances from the two [visual] axes do not differ by much. As a result, any of the ordinary visible objects appears single to the two eyes, and none of them appears double except on rare occasions. For none of the [ordinary] visible objects appears double unless its situation with respect to both eyes is inordinately skewed in terms of direction or distance, or in terms of both; but it is only rarely that the situation of a given visible object with respect to the two eyes is inordinately skewed.

[2.50] Thus, the reason that any of the ordinary visible objects appears single to both eyes has been shown through deduction and experiment.

[2.51] Now, if the experimenter removes the peg at the center of the plaque and focuses on the point of intersection at the plaque's center, and if he then looks at the lines that are drawn on the plaque, he will find that the two diagonals [appear to be] four. He will also find that two of the four diagonals [appear to lie] near each other, and two [appear to lie] far from one another, but still, all of them [appear to] intersect at the centerpoint, which is the point of intersection for the two diagonals and lies on the common axis. He will find, as well, that each of the [apparent] diagonals that lie far apart [from one another] lie farther from the middle than the actual diagonals do. Then, if the experimenter covers one eye, he will see two diagonals, and he will see that the separation between them [seems] larger than it really is according to their actual divergence, and this [divergence] is widest at the top edge of the plaque. Moreover, the diagonal that appears to lie far from the centerpoint will be the one in line with the eye that is covered.

[2.52] From this is is evident that the two diagonals that appear [to lie] near [one another] when vision takes place through either eye are the ones that are seen in line with [their respective] eye, whereas the two diagonals that appear [to lie] far [from one another] are the ones that are seen by the eye that lies to their sides. Moreover, the reason two of the four [appear to lie] near [each other] is that, when the two axes intersect on the peg that is placed in the center [of the plaque], each of the diagonals will be perceived by the eye in line with it according to rays that are quite near the [visual] axis, so their forms will lie quite near the centerpoint in the hollow of the common nerve.[33] But the intersection-point of those diagonals will be at the centerpoint itself, so they appear [to lie] close to one another as well as to the centerpoint. On the other hand, the reason two of the four [appear to lie] far [from one another] is that each of the diagonals will also be perceived by the alternate eye that lies to its side, so it is perceived by rays that lie far from the [visual] axis. Moreover, one of them is perceived by rays that lie to the right of the axis, whereas the other [is perceived] by rays to the left of the other axis, so their forms will be impressed at disparate locations in the hollow of the common nerve. For they are impressed on opposite sides of the centerpoint and far from it, as well, so the two diagonals have two forms [that appear to lie] near each other and two [that appear to lie] far from one another. Now the reason that each [of the diagonals that appear to lie] farther [from one another] appear to lie farther from the centerpoint than they actually do is that the distance between the two diagonals is perceived by each eye to be greater than it actually is. And this is made clear when the experimenter covers either eye and looks with the other. As a result, when the experimenter covers one eye and looks with the other, he will find that the separation between the two diagonals [appears] greater than it actually is, because the separation between the two diagonals is perceived by each eye from up close, and whatever is very close to the eye appears larger than it actually is. But we shall explain the reason for this later when we discuss visual illusions.[34]

[2.53] By thus examining the dispositions of the diagonals on the plaque, as well as of the pegs that are placed upon them apart from the center [of the plaque], one sees that every visible object that is placed on the common axis and that is perceived by sight along the visual axis will be perceived where it actually lies, whether it is perceived with one eye along one of the axes of the two eyes, or whether it is perceived by both eyes along both [visual] axes. And it is evident that, if it does not lie on the common axis, any visible object that is perceived by one eye along the visual axis will be perceived to lie closer to the common axis than it actually does. This is also the case for visible objects that are perceived by the rest of the rays beyond the axis. For, if sight perceives the visible object as it actually exists, and if its form is impressed at one spot in the hollow of the common nerve in continuous order [of parts] according to the continuous order [of parts] in the visible object itself, then, since the point that lies on the visual axis, assuming it does not lie on the common axis, appears nearer to the common axis than it actually is, the remaining points [on the object] also appear nearer the common axis than they really are, because they are continuous with the part at the endpoint of the [visual] axis.

[2.54] If the axes of the two eyes intersect on some visible object lying outside the common axis, the same thing follows, i.e., the object appears to lie nearer the common axis than it actually does. But this situation rarely occurs, for, when the axes of the two eyes intersect on some visible object, it is often the case that the common axis will pass through that visible object. Moreover, the axes of the two eyes will never intersect on a visible object that lies outside the common axis without effort or without some outside interference forcing the eyes into such a situation, but this situation does not show up in the case of ordinary visible objects. For when this occurs in the case of any visible object, it will happen for all the visible objects continuous with that one, so the situation of the visible objects among each other will not be changed on this account.[35] But if the situation of that visible object does not change with respect to neighboring visible objects, then it will not appear to change when the change occurs among ordinary visible objects. Thus, when this is investigated according to the method described earlier, it will be clear from the experiment that this follows for all visible objects that lie outside the common axis when the axes of both eyes intersect on them.

[2.55] Now the experimenter should take three small strips of parchment of equal size, and he should write some clearly lettered word on one of them. On the rest he should write that same word [making it] the same size and shape, and he should place one of the [wax] pegs at the center of the plaque, as before, and he should place another at point **K**. Then he should fasten one of the strips to the peg at the center of the plaque and another to the peg at point **K**, and he should take care to keep it oriented the same way as the first strip. He should then position the plaque [against the bridge of his nose], as he did before, and he should direct his gaze to the strip attached to the central peg and focus on it. In that case, of course, he will have a clear perception of the word written on it. In this same situation, moreover, he will also see the other strip and the word written on it, but not as clearly as he does the identical word written on the middle strip, even though the words are identical in shape, form, and size.

[2.56] Then, keeping the same arrangement, the experimenter should take the third strip with the hand that lies on the side of point **K**, and he should place that strip in line with the two strips that are [already] on the plaque along the extension of the line passing through the [middle of the] plaque along its width and lying on the plaque's surface as far as sense is concerned, but let the strip be [placed] beyond the plaque. Now this sort of alignment will be called a facing alignment. And when he puts it in place, the experimenter should make certain that the third strip and the word written on it are oriented the same way as the two strips on the plaque. He should then focus both eyes on the strip placed in the center and direct his gaze toward it, and in that case he will certainly perceive the third strip if it does not lie too far from the plaque, but he will perceive the form of the word on it in an indistinct and undecipherable way. So he will not find it to be like the form of the word that is identical to it at the center of the plaque, nor does he find it to be like the form of the word at point **K** as long as both eyes are focused on the strip at the center.

[2.57] At this point the experimenter should remove the peg at point **K**, along with the strip attached to it, and he should bring the strip he is holding in his hand nearer [the middle of the plaque] until he can stand it next to the strip that is affixed to the peg placed in the center [of the plaque], and he should take care to stand the strip straight up along the line passing through [the middle of the plaque] along the width. Then, as before, he should direct his gaze toward the strip placed in the center. In that case, he will indeed perceive both words on the two parchment strips clearly and distinctly, and there will be no perceptible difference in clarity and distinctness between the forms of the two words.

[2.58] The experimenter should then slowly move the strip he is holding in his hand along the line passing through [the middle of] the plaque along its width, and he should make certain that its orientation remains as it was before. He should maintain his focus on the middle strip and examine both strips closely as they are so disposed. In that case, he will see that, the farther the moving strip is displaced from the center, the less distinct the word written on it becomes. Thus, when it reaches point **K**, the experimenter will find that the form of the word is [still] decipherable, but not as clearly as it was when it was placed next to the other strip placed in the center.

[2.59] The experimenter should now continue to move the strip, drawing it away from the plaque, and he should move it little-by-little along the line passing [through the plaque's middle] along its width. And he should examine it closely while directing his gaze at the strip placed in the center. In that case he will find that the farther the moving strip is displaced from the center, the less [clearly] the word written on it will appear until it will become wholly undecipherable. And when he moves it beyond this point, he will see that the farther it is moved from the center the less visible the form of the word written on it becomes.

[2.60] The experimenter should now cover the eye that corresponds with point **T**, and he should maintain the plaque in the same arrangement, and he should direct the gaze of the eye corresponding with point **K** at the strip placed in the center. He should then place the other strip beside the strip placed in the center, just as he did before. In that case he will find that the word on that other strip is still clear and that there is no perceptible difference [in clarity] between it and [the word written on] the strip placed in the center. Then he should move the second strip, as he did initially, and focus on the strip placed in the center, directing his gaze at it. In that case he will find that the word on the second strip loses visibility as it is moved, and when it arrives at point **K**, there will be a perceptible difference between its clarity at this position and its clarity when it was placed next to the strip at the center. He should then move the strip, drawing it away from the plaque, as he did before, and he should focus on the strip placed in the center. Accordingly, he will find that the farther the moving strip is displaced from the center, the less distinct what is on it becomes until its form will no longer be decipherable, and the more it continues to be displaced from the center, the less discernible it becomes.

[2.61] From this investigation it is thus evident that a facing visible object is seen most clearly with both eyes when it lies at the intersection of the two [visual] axes, and [it is evident] that what lies nearer to the intersection of the two [visual] axes appears more clearly than what lies farther away from it and that the form of a visible object that lies far from the intersection of the two [visual] axes is indeterminate, even if it is perceived with both eyes. Moreover, if an object in facing alignment is perceived with one eye, it also becomes evident through this investigation that the object is perceived most clearly with one eye along the visual axis, and [it is evident, as well] that what lies near it appears more clearly than what lies farther from it and that the form of any visible object lying far from the visual axis is indistinct and indeterminate. Furthermore, it is apparent that sight does not correctly perceive a visible object that has large cross-sections unless it moves the visual axis over all its cross-sections and all its parts, whether it is perceived with both eyes or with one. For when it is focused on a facing visible object that has exceptionally large cross-sections, sight will not perceive the entire object correctly but [will] only [perceive] what lies on or near the [visual] axis in a determinate way. It will perceive the remaining parts of that object, specifically those parts that lie far from the [visual] axis, but not distinctly, even when the visible object has a facing alignment—and it does not matter whether the perception occurs with both eyes or with one alone.

[2.62] Next, the experimenter should take a square piece of parchment that is four digits on a side with lines of tiny writing on it, but writing that is still clear and decipherable. Then he should remove the peg that is placed on the plaque and position the plaque up to the eyes, as he did before, and stand the parchment [sheet] up on the line passing through the center of the plaque along its width. He should then direct the gaze of both eyes at the middle of the parchment and focus on it. Accordingly, he will find that the writing on the parchment is clear and decipherable but that the writing on the middle of the parchment is even clearer than the writing toward the edges when the eye directs its gaze toward the center of the parchment and does not move over all its cross-sections.

[2.63] He should then incline the parchment so that it intersects the line passing [through the plaque's middle] along the width at the centerpoint of the plaque, which is the point of intersection. But the obliquity of the parchment should be slight with respect to the line passing along the width. The experimenter should then look at the middle of the parchment with both eyes. Accordingly, he will find the writing legible, but not as legible as when the parchment faced him directly.

[2.64] The experimenter should now incline the parchment more sharply than before so that its midpoint stays over the point of intersection, and he should again direct the gaze of both eyes at its middle. In that case, he will see the writing less clearly than before. He should then continue to incline the parchment little-by-little so that its midpoint remains over the point of intersection, and he should examine it at each point as it is turned. He will then find that the writing loses visibility as the parchment is [increasingly] slanted, and the more sharply the parchment is slanted, the less visible the writing will be until the parchment nearly coincides with the line drawn lengthwise through the center of the plaque. At that point the writing on the parchment will appear quite indistinct, [being] wholly indecipherable and indeterminate.

[2.65] The experimenter should then replace the parchment to its original position and stand it up on the line passing [through the plaque's center] along its width, and he should cover one eye and look at the parchment with the other. He will then find the writing to be clear and legible. Then he should incline the parchment, as he did before, and look at it with one eye. In that case he will find the writing to be less visible than it was when it faced him directly. He should then continue to incline the parchment little-by-little while [re]examining it frequently. He will thus find that, the more sharply it is inclined, the less visible the text written [on it] becomes until the parchment nearly coincides with the diagonal that corresponds with the open eye.

[2.66] From this investigation it will thus be obvious that a visible object lying on the visual axis and directly facing the eye is most clearly seen and that one facing the eye more directly is seen more clearly than one that faces it less directly, and [it is obvious] that an object that is sharply slanted with respect to the visual axis appears indistinct and undecipherable, whether vision occurs through both eyes or through one eye.

[2.67] At this point the experimenter should replace the peg that was on the plaque, and he should place it at the middle of the plaque and fasten it at the point of intersection, as it was during the first investigation. Then he should stand the parchment on one side of the line passing [through the plaque's center] along its width so that it faces the eye directly, and he should direct the gaze of both eyes at the peg placed in the center. In this situation he will perceive the parchment, as well as the writing on it, but what lies nearer the peg placed in the center will be clear, whereas what lies far from it is indistinct and lacking in visibility. Moreover, the farther the writing is displaced from the peg, the less visible it gets.

[2.68] The experimenter should also incline the parchment in this situation so that it intersects the line passing [through the plaque's center] along its width at some point on the side [of the center] where it stands, but the inclination should be slight. He should then direct his gaze to the peg placed in the center. In that case, he will see that the writing on the parchment is less visible than it was when the parchment faced the eye directly. Then he should incline the parchment more sharply while directing his gaze at the peg placed in the center. Accordingly, he will see that the writing is indistinct, and [therefore] unclear and illegible.

[2.69] The experimenter should then cover one eye and look with the other eye, and he should replace the parchment in its original position and stand it up on the side of the line passing [through the plaque's center] along its width that corresponds to the open eye, and he should direct the gaze of that eye toward the peg placed in the center. Accordingly, he will perceive the writing on the parchment, but he will see what lies near the peg [at the center] more clearly than what lies far from it, and he will see that what lies farthest from that peg appears indistinct and illegible.

[2.70] Next, he should incline the parchment so that it intersects the line passing [through the plaque's center] along its width at the point on the side where it has been stood, and he should look at the peg placed at the center with that same eye. He will then see that the writing on the parchment is more indistinct and less legible than it was when the parchment faced the eye directly. He should continue inclining the parchment little-by-little, and he will see that the more sharply inclined the parchment is, the less visible the writing becomes.

[2.71] From this investigation it is thus evident that a visible object that faces the eye directly is [seen] more clearly than one that is oblique, even if the visible object does not lie on the visual axis but lies outside the axis. For when a visible object is very sharply slanted, it loses visibility to a considerable extent, even if it lies on the visual axis, whether vision takes place through both eyes or through one alone.

[2.72] The experimenter should now remove the peg from the plaque and stand the parchment at the top edge of the plaque, placing its [left] side flush with side **CD** of the plaque, and he should direct the gaze of both eyes on the middle of the parchment. He will then find that the writing is clear and legible.

[2.73] Then he should incline the parchment so that it intersects the upper edge of the plaque at point **Z**, which bisects the plaque's upper edge, and he should direct the gaze of both eyes at the middle of the parchment. In this situation he will see that the writing is less visible than before. He should then increase the slant of the parchment little-by-little, and he will see the writing become less and less visible until the parchment becomes so sharply slanted that the writing will lose visibility to an inordinate extent, just as was the case when he was examining the parchment in the center of the plaque; and the same holds in this case if he carries out the examination with one eye.

[2.74] At this point the experimenter should place the peg at point **Z** and stand the parchment to one side at the top of the plaque, just as he did in the middle of the plaque, and he will direct his gaze at the peg placed in the center [of the top edge] while looking at the parchment and examining the writing [on it]. He will see that the situation is the same as the one he observed when the experiment was carried out in the middle of the plaque, whether the examination is made with both eyes or with one.

[2.75] The experimenter should then try the three small strips we described earlier, [placing them] at the top edge of the plaque, and he will see the situation in this case to be like the one when the strips were tried in the middle of the plaque, i.e., the word on the middle strip is clearer than the word on a strip that lies away from the middle. And the farther the strip is displaced from the center, the less visible the word [on it] will become. However, he will notice that the distance from the middle according to which the word loses visibility when the experiment is carried out at the top edge of the plaque is proportional to the distance from the middle according to which the word loses visibility when the experiment is carried out at the center of the plaque, for it depends on the length of the ray extending to the top edge along the [visual] axis. Thus, at the point when the form loses visibility, the ratio of the eye-to-object distance to the distance of the object from the middle [of the plaque] is the same whether the examination is carried out at the center of the plaque or at its top edge.[36]

[2.76] So, too, if the experimenter sets the plaque aside and positions the parchment with the writing on it farther away than the length of the plaque, but where he can read it, and if he keeps it directly facing the eye while examining it, then inclines it while it remains in place, he will find that the writing loses visibility. And as he continues to incline the parchment, the writing will lose more visibility so that, when he inclines it so sharply that it nearly coincides in orientation with the rays extending to the parchment's center, he will then see that the writing on the parchment loses a great deal of its visibility until it can no longer be read. And he will observe this whether he looks with both eyes or with one eye only.

[2.77] Likewise, when he focuses on one of the small strips facing the eye at a greater distance than the length of the plaque and holds it so that it faces him directly while he directs his gaze at it with both eyes, then, when he places another strip to its right or left side and stands it so that it faces him directly, he will find that it is less visible [than the middle strip].

[2.78] Then, if someone moves the second strip farther and farther from the strip upon which he directs his gaze, he will find that the farther the remote strip gets from the second strip [in the middle], the less visible the form of the word [on the remote strip] gets until it will become absolutely illegible. So, too, if he carries out the examination with the two strips using one eye, he will get the same results.

[2.79] From all of these investigations, then, it is evident that, whatever its distance [from the eye], an object that lies on the visual axis is [seen] most clearly, while what lies nearer that axis is [seen] more clearly than what lies farther from it, and [it is evident] that when a visible object lies extremely far from the [visual] axis its form is indistinct and indeterminate, no matter whether vision takes place with one eye or with two. It is also evident that a visible object facing the eye directly, whatever its distance from the eye, is [seen] more clearly than one that is inclined and that the closer the visible object gets to a directly facing alignment the more clearly it will be [seen], and [it is evident] that when a visible object is slanted very sharply with respect to the radial lines, its form is quite indistinct and indeterminate, whether vision takes place through one eye or through two, and whether the object lies on the [visual] axis or outside it.

[2.80] Now the reason why a sharply slanted visible object has an indistinct form, even if the object lies at a moderate distance and its size is perceived as it actually is, and the reason why a visible object that faces the eye directly is [seen] more clearly than an oblique one is that the form of a sharply slanted visible object is impressed on the surface of the eye according to the compression that is due to its obliquity. For, if the visible object is sharply slanted, then the angle subtended by the object at the center of sight will be small, and the area on the eye upon which the form of that visible object is impressed will be much smaller than the area upon which the object's form is impressed when it faces the eye directly. So the small parts [of that form] subtend imperceptible angles at the center of sight on account of the sharp slant [of the object], for when [such] a small part is sharply slanted, the two [radial] lines extending from the center of sight to the edges of that small part will form what amounts to a single line; the sensitive faculty will therefore not perceive the angle formed by them or the area on the surface of the eye that they demarcate.

[2.81] Moreover, a visible object that is sharply slanted will be indistinct because the form of it that is impressed in the eye will be inordinately compressed, and its small parts will [then] be imperceptible, so its form will be indistinct. If, therefore, there are subtle characteristics in such a visible object, they will not be perceived by sight because of the invisibility of its small parts as well as the compression of its form. On the other hand, a visible object that faces the eye directly presents the opposite case, for the form of it that is impressed on the eye will be arranged just as it is on the surface of the visible object, and the small parts [on it] that can be perceived by sight will be evident. And since the small parts of the visible object are evident and are arranged on the surface of the eye as they are arranged on the visible object's surface, the form will be clear, not indistinct.

[2.82] Generally, subtle characteristics, subtle parts, and the arrangement of the parts of a visible object are not perceived correctly by sight unless the form is impressed on the surface of the sensitive organ and each of its parts is impressed[37] on a perceptible part of the sensitive organ's surface. But when the visible object is extremely slanted, its form will not be [adequately] impressed on the eye, nor will the form of any of its small parts be impressed on a perceptible part of the eye. For this happens only when the visible object faces the eye directly, or when its inclination is slight and, in addition, it lies at a moderate distance in respect to the characteristics possessed by that visible object.

[2.83] Now the correct perception of the size of a sharply slanted visible object when it lies at a moderate distance, even when its slant is inordinate, is not based solely upon the actual form of the visible object impressed on the eye, but upon a deduction that goes beyond the [simple perception of the] form, i.e., from the perceiver's grasp of the difference in distance [from the center of sight] between the two edges of the object along with the perception of the form's size. When sight perceives the difference in distance [from the center of sight] of the two edges of a sharply slanted visible object and perceives the full amount of this difference, the faculty of discrimination will immediately imagine the orientation of that visible object and will perceive its size according to the difference in distance [from the center of sight] of its two edges, as well as according to the size of the area upon which the form [of the object] is impressed and the size of the angle subtended by that area at the center of sight, [so the overall perception is] not based upon the form alone. And when the faculty of discrimination perceives the difference in distance [from the center of sight] of the two edges of a sharply slanted visible object and [thus] perceives its obliquity, it will immediately perceive the compression of [its] form. Accordingly, it perceives its size when it senses the amount of its obliquity, not according to the size of the form but according to its orientation. But the subtle parts and features possessed by the visible object cannot be perceived through deduction if sight does not sense those parts or those features.

[2.84] Hence the form of the visible object loses visibility because of the compression of the form on the eye as well as from the invisibility of its small parts. The form of a visible object that lies at a moderate distance becomes visible because the form impressed in the eye [represents the object] as it actually is and because sight senses its small parts.

[2.85] Why the form of an sharply slanted visible object is indistinct, whereas the form of a visible object that faces the eye directly is clear has thus been explained.

[2.86] And now that these points have been explained, it is time to begin the discussion of visual illusions and to describe their causes and their kinds.

[CHAPTER 3]

The third chapter [discusses] the causes of visual illusion.

[3.1] In the very first book of this treatise it was demonstrated that sight perceives none of the visible objects that lie in the same air with it and are perceived directly unless all the following conditions are met, namely: [there must be some] distance [between eye and object]; [the object must be] facing [the eye]; [there must be] light; the object must be of some [perceptible] magnitude; the object must be opaque or have some opacity in it; and the air between the object and the eye must be continuously transparent, with no opaque body interposed [between eye and object]. When these conditions are met and the eye that does the looking is free of injuries or obstructions, sight will perceive that visible object. If, however, any of these conditions is not met, sight will not perceive a visible object that lacks that particular qualification.[38]

[3.2] It was also shown in the second book that sight perceives every visible object in some amount of time;[39] time, therefore, is also one of the things necessary for vision to be accomplished.

[3.3] The eye must also be healthy.

[3.4] In the preceding chapter it was also shown that, when the visible object lies far outside the visual axis, it will not be perceived in a determinate way by sight, even if it faces the eye directly.[40] And it was also shown that, if the visible object is sharply slanted with respect to the radial lines, it will not be correctly perceived by sight, even if it lies on the visual axis directly opposite the middle of the eye.[41] Thus, sight does not perceive the visible object as it actually exists, even when it faces the eye, unless the visible object is properly oriented, i.e., unless it is directly facing the eye, or nearly so, and unless it lies on or near the visual axis.

[3.5] The conditions, moreover, according to which a visible object is perceived as it actually exists number eight: first, distance; [then] a facing orientation; light; some bulk; opacity; transparency in the air; time; and a healthy eye. When all of these conditions are met a visible object will be correctly perceived; if the object lacks any of them yet is still perceived by sight, then it will not be correctly perceived.

[3.6] Accordingly, we should observe that, for every visible object, each of these conditions has a range within which sight perceives the object as it actually exists, and as long as all these conditions are met during the visual process, and as long as each of them falls within the normal range according to which the visible object is perceived as it actually exists, sight will perceive that visible object as it actually exists. But if one or more of these conditions falls very far outside that range, sight will not perceive the object as it actually exists. For when a visible object lies too far from the eye, it is not correctly perceived by sight, and, by the same token, when a visible object lies too close to the eye it will not be correctly perceived by sight, but between these limits there are numerous distances at which sight correctly perceives the visible object without any uncertainty. Nevertheless, the distances at which sight perceives a visible object correctly are limited, none of them having been too great or too small in extent; and for each visible object there is a corresponding range of distances. Indeed, a visible object with a large bulk is correctly perceived by sight at a distance in which a visible object of small bulk disappears from sight, and likewise, an intensely luminous visible object is perceived by sight at a distance in which a feebly lit visible object disappears from sight.

[3.7] Furthermore, a visible object that does not face the middle of the eye directly but lies so far to the side that none of its parts touches the visual axis or lies near it is not correctly perceived by sight. Moreover, if a visible object is perceived with both eyes but the axes of both eyes do not intersect on it, or if the rays that are correspondingly situated with respect to the two eyes are not correspondingly situated [on the object], then it will not be correctly perceived by sight. But if a visible object faces the middle of the eye, and the visual axis touches some point on it, or nearly does, then, if that object does not have excessively large cross-sections, it will be correctly perceived by sight, even if the [visual] axis does not scan all of the cross-sections. Also, when an object is perceived by both eyes, and the two visual axes intersect on it, or rays that are correspondingly situated with respect to the two eyes touch it at corresponding locations, it will be correctly perceived by sight. Moreover, a visible object that faces the eye directly or that is [only] slightly oblique [to it] will be correctly perceived by sight, but how slight the obliquity must be for sight to perceive the visible object in a determinate way depends upon the characteristics possessed by the visible object. Likewise, how small the displacement from the visual axis must be for the visible object to be perceived in a determinate way depends upon the characteristics possessed by the visible object, for a visible object that has no subtle characteristics is perceived in a determinate way by sight, even when it lies a small distance from the visual axis. So, too, it is perceived in a determinate way when it is [only] slightly oblique with respect to the radial lines. On the other hand, a visible object with subtle characteristics will not be perceived in a determinate way when it lies outside the visual axis and its distance from the visual axis is the same as the distance at which the form of an [equivalent] visible object with no subtle characteristics is perceived in a determinate way. Likewise, its form will not be perceived in a determinate way when the object has the same obliquity with respect to the radial lines as an [equivalent] object without subtle characteristics does when it is perceived in a determinate way.

[3.8] Moreover, a visible object that is slightly luminous or poorly illuminated will not be perceived by sight correctly, especially if there are subtle features in it. So, too, a visible object that is intensely luminous or shining or a polished body upon which intense light shines will not be correctly perceived by sight. But between faint and brilliant light there are numerous [gradations of] light according to which sight correctly perceives a visible object. But the light according to which sight correctly perceives the form of a visible object will depend on the attributes possessed by the object as well as on its size. For a visible object that possesses no subtle characteristics is perceived by sight in light that is [so] weak that the form of a visible object possessing subtle characteristics may disappear from sight in it.[42] By the same token, a visible object of large bulk is perceived by sight in light that is [so] weak that a tiny visible object may disappear from sight in it.

[3.9] Furthermore, if the visible object is extremely small and there are subtle features or small individual parts in it, it will not be correctly perceived by sight, e.g., animals whose members are distinct, and the shape of their members, as well as the members themselves, are so small that sight cannot perceive [them]. In fact, if such animals are perceived by sight, they are not perceived in a determinate way. When, however, the animal has a large body, its members will be proportionate[ly large], and sight will then perceive each of those individual members. Thus, sight will perceive its form as it actually exists. Similarly, no visible object that possesses extremely small features will be properly perceived by sight. But if those features are proportionate[ly large] in large visible objects, then sight will perceive those visible objects correctly if those features are proportionate to [the size of] the visible objects.

[3.10] Furthermore, if the visible object is transparent but there is just a bit of opacity in it, it will not be correctly perceived by sight. However, if it is not transparent, or if it only has a bit of transparency in it, and its opacity is obvious, it will be correctly perceived by sight. And the fainter the coloring of the transparent object is, the more opacity it will require [to be properly seen], whereas the more intense the color, the more [readily] it can be perceived by sight when its opacity is so slight that a faintly colored visible object [with the same opacity] could not be correctly perceived. Moreover, when the air between the eye and a visible object is hazy or foggy, as [happens when] clouds, smoke, and the like are [present], things in such air will be invisible. Moreover, if those visible objects are subtle or there are subtle features in them, they will not be correctly perceived by sight. Likewise, when a transparent body with some opacity is placed in the air between the eye and a visible object, that visible object will not be correctly perceived by sight. If, however, the air is transparent and clear and of sheer and uniform transparency, and if there is no opaque body placed in it [between eye and objects], then sight will perceive the visible objects in that air correctly. Likewise, if the air is slightly hazy and there are visible objects in it that are not too small and that lack subtle features, sight will correctly perceive those visible objects, and it will not be hindered by the air, even if it is somewhat hazy. However, the amount of haziness in the air according to which a visible object is correctly perceived depends on the features possessed by the visible object, for a visible object that possesses no subtle features will be correctly perceived by sight in air that is hazy enough that another visible object possessing subtle features will not be perceived through it in a determinate way.

[3.11] In addition, when a visible object is moved quite swiftly, and it traverses a space in which it will be perceived by sight in a minimal amount of time, it will not be correctly perceived by sight. For instance, when someone looks through a window outside of which some visible object moves [by] extremely swiftly, if sight perceives that visible object through that window, it will not perceive what kind of thing it is, nor will it determine its form properly. On the other hand, if the object moves in a plane facing the eye along a space that is not too great during a perceptible amount of time, it will be perceived by sight in a determinate way.

[3.12] Also, extremely swift rotary motion, such as the motion of a top, will not be perceived by sight, even though the top is perceived, so it will perceive the top, or a body moving with the top's motion, as if it were immobile. In the same vein, a motion that is extremely slow will not be perceived by sight in a short amount of time, so in a perceptible amount of time it will be perceived as if it were at rest and immobile.[43]

[3.13] The health [of the eye] has a range. For in the case of certain infirmities the minute features of a body that is seen are invisible, whereas in the case of a less [infirm eye] they are perceived.

[3.14] Generally speaking, any spatial disposition according to which the form of a visible object is not defined [according to the object] as it actually exists is a spatial disposition that falls outside the [range of] moderation that is proportionate to that object. In terms of distance,[44] the spatial disposition of a visible object falls outside [the range of] moderation either according to a maximum increase or a maximum decrease in extent. In terms of distance away from the [visual] axis, spatial disposition falls outside [the range of] moderation by exceeding a maximum, whereas in terms of orientation with respect to both eyes, an object falls outside the range of moderation by slanting too much. In the case of light, too great an intensity or excessive faintness causes it to fall outside [the range of] moderation; in the case of magnitude, an [excessive] diminution in the size of a visible object [causes it to fall outside the range of moderation]; in the case of opacity, [too great an] increase in transparency [causes it to fall outside the range of moderation]; in the case of [the transparency of] air, an excess of opacity in it [causes it to fall outside the range of moderation]; in the case of time, an excessive [brevity] in its duration [causes it to fall outside the range of moderation]; and in the case of ocular health, a substantial weakening of the eye or a change produced in it by disease [causes it to fall outside the range of moderation].

[3.15] Now what it means to fall within the range of moderation will be explained as follows. If some object is seen as it actually exists and is moved somewhat farther away from or somewhat nearer to the eye, as long as the difference between appearance and reality is imperceptible, the range is moderate, and it continues to be until the difference is appreciable and there is a perceptible change in appearance. Furthermore, the range of moderation for each condition varies proportionately to the other seven, and according to color as well as to the smallness of the parts of the body. Thus, the range of moderation for distance depends not only on color, but also on the tiny features that are in the body, as well as on the light and the six other conditions that have been mentioned.

[3.16] [The range of moderation for distance] depends on the type of color, for a body that has an intense and bright color is perceived at a greater distance than [one whose color is] dull and faint, so the range of moderation for distance is proportionately greater for an intense color than for a faint one.

[3.17] Similarly, when the distinguishing features of the body of a visible object are noticeable, they are perceived at a greater distance than [they would be] if they were tiny, so [the range of] moderation for distance is greater with respect to the noticeable parts of the body than with respect to the tiny [parts].

[3.18] In the same vein, [the range of] moderation for distance will be proportionately greater for a body that faces the eye directly than for one inclined to it. So, too, it will be greater when the body is closer to the [visual] axis than when the body is farther [from it].

[3.19] Likewise, the range of moderation for distance is greater in intense light than in faint light.

[3.20] And [the range of moderation for distance is] greater if the body that is seen is large than if [it is] small.

[3.21] So, too, a body that is absolutely opaque is perceived at a greater distance than one that is less opaque, so the opacity of the body is proportionate to [the range of] moderation for distance.

[3.22] [The range of] moderation for distance is proportionate to the quality of the air [through which an object is seen], for hazy air can mask bodies from sight at a given distance, whereas at the same or at a greater distance it reveals them when it is clear.

[3.23] [The range of] moderation for distance is proportionate to time, for in a certain amount of time the motion of a body is perceived at a given distance, whereas it will [only] be perceived at a greater distance in a greater amount of time.

[3.24] Likewise, when the eye enjoys a certain modicum of health, a body will be seen at a greater distance than [when the eye is] less [healthy].

[3.26] By the same token, [the range of] moderation for spatial disposition is measured proportionately to distance, as well as to color, to the small features of the body [that is being looked at], to light, and to the other conditions we enumerated.

[3.33] But you [must] examine and adjust each one [to its counterparts], and you will be able to see quite easily [how the range varies for each]. In the same way you will relate the [range of] moderation for each of them to all the rest, and you will see that what has been said applies to every one of them.

[3.34] Thus, when each of the conditions that have been listed falls within its proper range of moderation, the true form of the visible object will appear as it actually exists. However, when the form does not appear as the [object] actually exists, one or more of the aforementioned conditions has fallen outside [the range] of moderation. Thus, the only reason sight errs in perceiving forms is because one or more of the aforementioned conditions has fallen outside [the range of] moderation, and these are the points that were to be established in this section.

[CHAPTER 4]

[4.1] It is evident from the second book that the perception of things is accomplished through [brute] sensation, recognition, or deduction. Now when an error occurs in the case of things that are perceived through brute sensation, we know that this involves an error of sensation alone. When someone errs in the case of things he perceives through recognition, the error will involve recognition alone. Finally, if someone errs in the things that are perceived through deduction, the error will involve deduction alone. Sensation apprehends light and color only, as has been pointed out.

[4.2] Recognition, however, includes everything that has been seen before and that is retained by the sense;[45] for instance, the light of the sun is recognized because it is seen so frequently, and the light of the sun and the light of the moon are differentiated [through such recognition]. And even though the perception of light [itself] occurs through brute sensation, the differentiation of [types of] light still occurs through recognition. Likewise, a grasp of shapes, such as the shape of a triangle, of a square, of a circle, or of the like, occurs through recognition. The same holds for our grasp of roughness, smoothness, shadow, beauty, and the like; these are perceived through deduction, as we explained above, even if the sense [of sight] has not apprehended them frequently.

[4.4] Every perception of objects falls under one of these three heads, and when an error arises in the perception of forms, it occurs in one of these ways alone.

[4.5] An error of [brute] sensation occurs when a body that has many different colors is presented to sight in extremely faint light; for instance, certain clothing of various colors with fine designs will appear to be of a single color. And this error will occur in sensation because the light [falls] outside its [range of] moderation, whereas the remaining conditions will not have fallen outside their [range of] moderation.

[4.6] An error of recognition occurs at times when a person known [to the viewer] is seen at a great distance and is judged to be someone else who is similarly known, so someone seeing his brother at a certain distance thinks he is seeing his father or something of the sort. And this error in recognition is due solely to the fact that the distance has fallen outside [the range of] moderation.

[4.7] An error of deduction occurs, for example, if the moon is judged to be in motion when it is the clouds that are moving. And this error occurs because of inordinate distance, for where the distance is moderate this does not happen, so that, for instance, when a stick is lodged under water, and we see the water moving above it, rather than [seeing] the stick [moving] we perceive the motion of the water as it flows by.[46]

[4.8] The aforementioned error occurs in the case of the moon's motion when there are many clouds in continuous succession, and the reason for this error, as was shown above, is that motion is perceived only when something is seen to approach something else or to recede from something else.[47]

Thus, when there are few clouds, we can discern their motion according to the way each of them approaches or passes beyond some star that is seen. When the sky is covered with clouds, then, we do not perceive their motion because of their close succession; rather, we glimpse the moon [through them, appearing to be] somewhere at one time and elsewhere at another, so we conclude that it is moving very swiftly. In a similar manner, an error will arise when the spatial disposition [of a given object] falls outside [the range of] moderation.

[4.9] And it is according to the eight previously mentioned conditions that perception occurs through [brute] sensation, or through recognition, or through deduction.[48]

[CHAPTER 5]

The fifth part [deals with] the kinds of visual errors that are due to brute sensation according to each of the causes that produce an error of sensation.

[5.1] From what has been said before it is clear that only light and color are perceived through [brute] sensation. Thus, an error of [brute] sensation occurs only in the case of light and color, and an error involving light or color occurs only because of their inordinate weakness or intensity, or according to a difference among tenuous or weak colors. But in faint light this variation in color will reach the eye as a sort of darkness or shadow, and [this happens] even in intense light when the colors are exceedingly tenuous.

[5.4] Distance causes an error in [brute] sensation. When the distance[49] of a body from the eye is moderate, but there are small parts of various colors in the body, and the size of those parts is not proportionate to the distance [of the body from the eye], that body will appear to be of one color only, for the distance falls outside [the range of] moderation in relation to the particular features, even though all of the other conditions fall within [the range of] moderation. So this error is due to sensation since [it is] the sense [of sight that] apprehends color.

[5.7] Spatial disposition causes [brute] sensation to err. When the inclination of a body that is seen is excessive, its small parts will be invisible to sight. Moreover, if the small parts are of different colors, the colors will appear to be blended throughout the whole object. And this error is due solely to spatial disposition, for when a body faces the eye directly with the other [preconditions] unchanged, just as they are, the parts of the body and of the color will be perceived [so the error arises] only if the spatial disposition falls outside [the range of] moderation. The same error occurs on account of an inordinate[ly skewed] spatial disposition when the distance of the small parts away from the [visual] axis is considerable.

[5.8] Extremely faint light causes an error. For the tiny parts of a body are invisible to sight [in such light], and it produces a blending of shadowy colors. But if the light is brought back within [the range of] moderation, the difference in colors or the smallness of the parts will not be obscured [so this error arises][50] when the light alone falls outside [the range of] moderation.

[5.9] Magnitude brings about error. When the smallest parts of a body differ in color from the whole, those parts will disappear from sight on account of their smallness, and the same for their colors. So the color will appear blended in the body when the magnitude alone falls outside [the range of] moderation, but this blending would not appear if the smallness of the parts did not pass beyond moderation.

[5.10] Opacity is a cause of an error in sensation if the opacity is scant, as [it is] in the case of glass, so when a colored body is placed behind it, the glass seems to take on that [body's] color because its opacity is so attenuated as to fall outside [the range of] moderation, but this would not happen if the glass were more opaque.

[5.11] An error of sensation arises from the transparency of the air. When a flame is interposed between the eye and a facing body, even when the color of the body that is seen is intense, that body will appear shadowy, but [it is] only the transparency of the air [that] has fallen outside [the range of] moderation.

[5.12] Time is the cause of error. For, if sight is abruptly directed toward a body of different colors, the body will appear to be of a single color until the glance is prolonged, provided, I [should] add, that the light in which the body is perceived is not intense.

[5.13] Indeed, in faint light sight is not immediately affected by any individual color, as it would be in intense light.

[5.14] Sight [itself] sometimes presents an error. For if an intense light strikes the eye, it disrupts sight; so, as soon as the eye is directed toward the color of any body, it receives that color in a shadowy way until it rests a bit and the disruption fades. By the same token, when the eye suffers an infirmity, the true colors [of objects] will be obscured from sight, so an error arises solely from the fact that the condition of the eye falls short of moderation.

[5.15] It is therefore evident that errors arise in sight according to each of the aforementioned cases under consideration, and they occur in sensation only, because the perception of colors takes place through [brute] sensation.

[CHAPTER 6]

The sixth part [deals with] the kinds of visual errors that occur through recognition according to each of the causes of error in sight.

[6.1] It was claimed in the second book that it is only through recognition that [sight] apprehends what an object is.[51] For [the perception of] what a thing is arises from the similarity or dissimilarity of one object to another in [terms of] a common form.

[6.2] And it is in the nature of recognition to assimilate an object that is currently in view to an object that has been seen before according to an acquired form, and from this assimilation sight apprehends what any thing is. Moreover, recognition is differentiated according to recognition of the individual, or [recognition] of the universal, or [recognition] of both, so every error in recognition will occur in either or both of these categories.

[6.3] Therefore, when some object appears other than it actually is or of another kind than it actually is, there will be an error in ascribing [the proper] definition [to it],[52] and this [type of] error does not occur unless one of the aforementioned conditions falls outside [the range of] moderation.

[6.4-5] For instance, there will be an error of recognition in the case of distance. If a known person is seen from a great distance, he may appear to be another person known to the viewer so that when he sees Peter the viewer sometimes assumes he has seen Martin, since it is unquestionable that both are known to him.

[6.6] There will be error in terms of the common form. If someone sees a horse from some distance and assumes that he sees an ass, there is an error in both forms—i.e., individual and common—as [happens] for instance, when someone sees a horse that is known to him at a considerable distance and assumes he sees an ass that he knows. Similarly, a threefold error occurs in the case of trees: according to individuals, according to common forms, and according to both. Hence, one almond tree is sometimes judged to be another one; or from a great distance a large pear tree sometimes appears to be an almond tree; or at times Peter's pear tree appears to be Martin's almond tree. The same threefold error according to distance often happens in the case of clothing, stones, and other things.

[6.7] Sometimes an unfamiliar thing is seen and an error in recognition arises, as [happens] when someone sees a fire far off in the air and judges that he sees a star. It is, moreover, clear that each of the previously discussed errors occurs in recognition when a definition that does not actually pertain to it is ascribed to the visible object. It is also clear that the aforesaid error occurs because the distance falls outside [the range of] moderation. For if that distance is restored to moderation while other errors and causes, such as they are, persist, the aforementioned error in recognition does not occur.

[6.8] Spatial disposition produces an error in recognition. When some body lies extremely far from the [visual] axis, there will not be a determinate perception of its form. Accordingly, in such a situation Peter may be judged to be Martin; or a horse may be judged to be an ass, as happens with trees and clothing; or a horse that is known will sometimes be assumed to be [the ass] Brunellus.[53] In the case of this indistinct sort of perception, a correct [ascription] may be chosen, or a false one may be. Indeed, if the judgment is indeterminate in this situation, the choice will be fortuitous.

[6.9] This error arises from an immoderate spatial disposition, for if it is restored to moderation, the judgment based on recognition will not be erroneous.

[6.10] By the same token, when a body is slanted to an extreme extent, its tiny parts are not [perceived] distinctly, so in this situation there arises an error [in the judgment] of shape, or color, or size; [in such a situation] in fact, a square may appear circular, and similar errors may arise in the case of size and color.

[6.11] An error in recognition arises from light's falling outside [the range] of moderation. For excessively faint light causes an error [in perception] of the form, so during twilight an error occurs in [the perception of] animals, clothing, or trees—and this error is threefold: according to individual [nature], according to kind, or according to both—and it would not occur in moderate light.

[6.12] Furthermore, when light falls outside the range of moderation that is proportionate to a visible object that faces the eye, the aforementioned error occurs, even when the light is not immoderate in and of itself, as happens in the case of a certain flying creature called "aluerach" in Arabic.[54] For it can be seen only at night. But just as a fire is not clearly discerned when [it is viewed] in daylight, [that creature] may be taken [in daylight] for a moth, which it resembles. And so an error occurs in the definition of the object on account of immoderate light.

[6.14] Size that falls outside its [range of] moderation causes recognition to err, so sometimes, because of its smallness, an ant is judged to be a fly perched on wheat, and sometimes, for the same reason, a mustard seed is taken for a [seed of] water cress.

[6.16-17] Opacity that falls outside the range of moderation causes error. When a red body is placed against [one side of] a [piece of] glass, and the other side of the glass faces the eye, the viewer will judge the color of the glass to be red, so there is an error in recognition because [there is an error] in the definition of [what is] colored.

[6.18] An inordinate decrease in the transparency of the air is a cause of error, so an error in [judging] what a thing is occurs when the air is hazy. Likewise, if an object is placed between the eye and some object that is seen, and if the transparency of that body is immoderate with respect to the moderate transparency of the air, as is glass, the color of the facing body will be judged as a mixture of its own color and the color of the glass. And so there is an error in the definition of [what is] colored. By the same token, if a sheer cloth is placed in front of the eye and a body is seen behind that cloth, the color of the body will appear mixed [with that of the cloth].

[6.20] But there arises the question of how the color of a body facing the eye from behind the cloth appears mixed [with that of the cloth] since the colored spots on the body only reach the eye through the interstices in the cloth, whereas the color of the cloth reaches the eye only from the threads, through which the color of the body does not pass.

[6.21] The truth of the matter is that, even though the spots of color on the body reach [the eye] discretely and fall on their [separate] places [on the eye] so as not [actually] to mingle with the colors of the threads, and even though the colors of these threads are separate from those [other] colors both in and outside the eye so that there is no [actual] commingling of them, nonetheless, since the spots upon which the color of the body's surface and the color of the thread strike [the surface of the eye] are extremely close to one another, there being no perceptible separation between them, the [neighboring spots] appear to coalesce, so their colors appear as a perfect blend.

[6.22] If, however, the interstices in the cloth are large, the actual color of the cloth and of the body will be discerned without mingling, but the narrower these interstices become, the more evident the mingling will be. Accordingly, when a body is viewed through wool cloth, the blend of colors will frequently appear to conform to the color of the threads, for the interstices of wool cloth are narrow in and of themselves, and since the threads are covered with hair, the interstices are made even narrower.

[6.23-24] Another example of an error caused by transparency [is encountered] when an entertainer moves wooden silhouettes while their shadows are viewed through cloth, which is usually woven of fine linen, [in which case] birds or animals will appear in conformance with the forms of the silhouettes, but this error in the ascription of what the thing [that is seen] is derives solely from the decrease in the transparency of the air.[55]

[6.25] An interval of time that falls outside [the range] of moderation is a cause of error in recognition. If someone looks through a window at a body that passes by swiftly, he will not apprehend the form of that body clearly, so an error in [perceiving] its individual [nature], its kind, or both will occur, as [happens] in the case of horses, human beings, and trees. The same thing also happens when there is no window; if someone glimpses something that immediately disappears from sight, he will err in the perception of its form, so there may be an error in [the perception of its] kind, or [of its] individual [nature], or [of] both.[56] But this error will be due solely to time.

[6.27] Sight by itself causes error. If intense sunlight shines on a bright-green or deep-red color, and sight is turned toward it, it will be disrupted. Then, if the eye looks at something else, the object will appear to be something other than it actually is, or of another color than it actually is, because of the continuing disruption. And several errors occur in a similar way.

[6.29-30] Likewise, in the case of disease in the eyes, a horse may look like an ass, and the aforementioned threefold error occurs in many cases. So it is obvious that the error in recognition is due solely to the fact that the eye is in a disturbed state.

[6.31] Hence, it is clear that there are errors of sight that occur in recognition according to the particular causes of visual error.

[CHAPTER 7]

The seventh section [deals with] the kinds of visual errors that occur in deduction according to the particular causes of visual error.

[7.1] Many of the things perceived by sight are apprehended through deduction, as was shown in the preceding book, and what [sorts] of things are perceived through deduction have been explained, and [it has been explained] that, on the basis of these things, a composite of particular forms reaches the sense [of sight]. Thus, when an error occurs in any of those things, there will be an error in perception that is based on deduction. Now deductive error is of two kinds, for it will occur either in the premises [of the deduction] or in the way those premises are arranged together. In the case of premises there are three [types of error]: a false premise is taken for a true one; a particular [premise] is taken for a universal one; or there is an error in the correlation of premises. For instance, if there are parts on a visible object that are apparent and parts that are not apparent but still perceptible to sight, when the form of that object is impressed on the eye and those parts [that are not apparent] are not seen, then the final perception [of the object] is based exclusively on those parts of the visible object that are [actually] apprehended. Moreover, when it examines the final perceptions arising from that object, [the visual faculty] bases its conclusions on the parts that are apparent, for it can only take them into account. However, when a close inspection of that thing reveals the parts that were not apparent before, the visual faculty perceives and recognizes its error. Accordingly, in order to make them clear, I shall list the errors [that pertain to] those things that are perceived through deduction, those things being twenty-two in number. And this listing will be [presented] according to each of the eight previously discussed causes.

[Section 1]
First [we shall deal with errors that occur] on account of distance.

[7.2] Accordingly, I say that when the distance falls outside [the range of] moderation it can cause the viewer to err about distance, as happens when someone looks at trees that are very distant. Even if they are quite far apart from one another, he will see them contiguous to one another or will at any rate judge them to be near one another.[57]

[7.3] For the same reason, it happens that certain stars are assumed to cluster together even though they are very far apart. Accordingly, the planets will be judged by everyone to lie on the same surface as the fixed stars, even though they lie quite far from them. There is thus an error in [the perception of] distance because the distance falls outside [the range of] moderation, and this is an error in deduction since the perception of distance occurs only through deduction.

[7.4] A distance that falls outside [the range of] moderation causes an error in [the perception of] spatial disposition, for from such [an inordinate] distance an inclined body will appear to face the eye directly, and so a square body that is slanted will appear oblong at that distance. By the same token, a circular form will appear oval at that distance if it is inclined, and this error will arise only because the inclination is hidden from sight at such a distance, for if the inclination were apparent, there would be nothing to obscure the actual form of the body. Hence, there is an error in [the perception of] spatial disposition only because of the inordinate distance.

[7.5] The reason that the spatial disposition will not be [properly] apprehended is as follows: The difference in length between [any] one of the rays falling on the side of the square and [any] other [ray] is disproportionate[ly small with respect] to the whole distance of the body from the eye, in terms, that is, of a perceptible ratio; so, on account of the imperceptibility of the difference, no one ray will be judged longer than any other.

[7.6] Thus, the form of the square is deemed to be oblong because the side of the square that is not inclined with respect to the viewer falls on one area of the eye whereas the form of the side that is inclined falls on a smaller area, because it subtends a smaller angle. But the perception of its smallness will depend on the inclination of the square, and since the inclination is unnoticed, one side will be judged longer than the other because [it is seen] under a smaller angle, which is why the form will appear oblong. For the same reason, in the case of a circular form, one diameter appears longer than the other, so it is deemed to be oval. And this error is the result of inordinate distance and would not arise if the distance were moderate.

[7.7] However, if the distance, though immoderate, is not too great, and the inclination of the body is substantial, then the viewer may take the inclination into account, but not the actual inclination; instead, he will judge it to be less [sharp] than it is. And he will analyze the inclination of the side by the angle under which it is perceived, so the side will appear smaller than it is, and he will thus suppose that the form of the square is oblong, but less oblong than [it appeared] before [when the distance was inordinate].[58]

[7.8] An excessive distance produces an error in [the perception] of corporeity, for [the perception of] corporeity is based on the curvature of the surface, so the notion of corporeity is grasped from the notion of this sort of curvature. Thus, when an error arises in regard to corporeity, it will be in regard to the disposition of the surface or surfaces [of an object], for instance, when the curved surface of a body appears flat at a certain distance, or when a flat [surface] is judged to be curved. And this appearance will involve shape, for shape is the arrangement of the surfaces of a body. The arrangement of surfaces also has to do with spatial disposition, so corporeity is a matter of both shape and spatial disposition. Hence, an error in [regard to] corporeity carries with it an error in [regard to] shape and spatial disposition. But, on the basis of inordinate distance, an error in [regard to] shape [can] happen without an [accompanying] error in [regard to] spatial disposition.

[7.9] For instance, a figure with many equal sides facing the eye directly at an inordinate distance appears circular for no other reason than that the corners of the figure are manifold and [thus] imperceptible to sight. For at that distance the [corner segments, while] nonetheless proportional to the whole figure, are invisible to sight, even though the whole figure is not.

[7.10] The very same type of error [occurs] when a curved line is assumed to be straight at this distance, for the [relative] closeness to the eye of one part of the curved line in comparison to the [relative] remoteness of the other is imperceptible, so the curvature of the parts is not apparent, even though no error may arise in [regard to] the spatial disposition of that line.

[7.11-12] Similarly, when a sphere is seen from such a distance, its surface will be adjudged flat, because its outward bulge is nearer [the eye] than its outer edges by an imperceptible amount at this distance, so the nearness of [all] portions [of the sphere] is assumed to be equal—hence the [apparent] flatness of its surface, which is how the solar and lunar surfaces are judged by viewers, an erroneous judgment of shape that would be precluded if the distance were moderate.

[7.13] There will be an error in [the perception of] the size of a body on account of inordinate distance, for it will appear much smaller than it actually is.

[7.14] The reason for this, as we said, is that a distance is inordinate if the parts that are sensibly proportionate to the whole are invisible to sight, and when the perceptible parts [of an object] cannot be sensed, the [visual] angles they subtend are not sensed, even if they are proportionate to the whole [visual] angle.

[7.15] Hence, when the [visual] axis scans the visible object, many of its lines and many of its parts are not apparent to it, so the whole is made to appear smaller [than it actually is].

]7.16] Furthermore, the size of any part of a body is gauged only according to the size of the angle it subtends, and the size of the angle depends on the [size of] the area demarcated on the eye [by the visual cone]. But the size of the area that is demarcated [by the visual cone] is judged exclusively on the basis of the two terminal spots [defining] that area, and those spots are sensible and proportionate [in size] to the area that is demarcated [by the visual cone], because from such a distance the visible object is judged according to limits that are proportionate to the whole of the visible object. Otherwise, in fact, those limits would not be sensible. Now the limits of the area demarcated [by the visual cone on the eye] lie in a direct line with the limits of the areas on the visible object that are proportionate to them. Hence, the terminal spots of the area that is demarcated [by the visual cone on the eye] block out sensible areas on the visible object [that are in line with them]. Therefore, as the axis touches on specific parts among the individual portions of the object, it fails to sense [some] parts that are [proportionately] sensible, and so the whole visible object appears smaller [than it actually is]. But when a body is seen at a moderate distance, the terminal spots of the area that is cut off [by the visual cone on the eye] are tiny and imperceptible relative to that area [as a whole]. Indeed, the judgment of the viewer culls out the imperceptible limits in the visible object [when it is seen] at a moderate distance, so no areas that are proportionate to the whole are invisible, which is why the body does not appear to be smaller than it actually is.[59] Furthermore, as has been said above, size is apprehended in a body only by collating distance and [visual] angle.[60] And it has already been said that, at an inordinate distance, the angle appears smaller because it actually is smaller, but there is no discernment of distance.

[7.17] In fact, it was shown above that a moderate distance is perceived on the basis of intervening bodies, whereas at an inordinate distance [this basis for judgment] does not apply at all.[61] Therefore, when the distance of the visible object is undetermined, it may be assimilated [by the faculty of discrimination] to a determinate distance. And the viewer will judge the object to be smaller [than it actually is] because he will suppose the [visual] angle and the distance to be smaller than they actually are, so [there will be] an error [in the perception of] the size of the body. And as the distance increases, the error is reinforced until the distance can become so great that a body will be judged to be the size of a point, and if the distance is further increased, that body will disappear from view.

[7.19] Likewise, a body can become invisible at a moderate distance, not because of the distance itself but because of the faintness of the body's color. And it is clear that visibility is lost in the case of faint coloring, for if the body [that cannot be seen because of its faint color] is replaced at the same distance by an intensely colored body of the same size, this [latter body] will not be invisible to sight as [was] the faintly colored body, so sometimes it is not distance or smallness but, rather, weak color by itself that causes a body to become invisible.

[7.20] Furthermore, a body may happen to lose visibility because of the similarity between its color and the color of bodies that lie between it and the eye, and this [can happen] at a moderate distance. Accordingly, when snow blankets the intervening ground, a white body lying at a distance will not be discerned, but the distant snow is perceived. And it is obvious that the body will be lost to sight because of the sameness of color, for if the [white] body is replaced at the same distance by an equivalent body of a different color, this [latter body] will not be invisible.

[7.21] Hence, when any object facing the eye fails to be perceived, the reason for its invisibility may be that the distance over which the form is radiated is inordinate [so that the form is projected] upon an imperceptible spot on the eye, or upon a spot that amounts to a point. If, however, the form is projected upon a perceptible spot on the eye, it may escape notice because of a weak color or because the colors of the visible object and the colors of intervening objects are similar.

[7.22] Furthermore, an error [in perceiving] the size of a visible object can occur at a moderate distance. For if some body is seen at a moderate distance, tiny parts of it will disappear from sight, but those parts would be seen at a shorter distance, although perhaps not clearly, and if the distance is increased somewhat, they will be seen even less clearly. And as the distance increases, the clarity of perception decreases until the parts disappear from sight, even though the distance may not fall outside [the range] of moderation.

[7.23] Likewise, at an inordinate distance a certain portion [of the object] is perceived clearly while certain of its tiny parts are invisible, for the distance of the object has fallen outside [the range of] moderation in relation to those parts, even though it has not done so with respect to the whole body or the portion of it that is perceived. Moreover, even though the distance may be known to the viewer, the error in perceiving the size of the parts still occurs because the size of the [visual] angle under which a [given] part is perceived is judged to be less extensive than it actually is. And the reason the angle appears smaller is that the terminal spots of the area that [the forms of] the parts demarcated on the [surface of the] eye are invisible, so the extent of the angle is shrunk [by that much].[62] Therefore, when the [size of] the visible object is inordinate[ly small] with respect to the given [moderate] distance, an error in [the perception of] its size will arise on the basis of two things: the smallness of the [visual] angle and the indeterminate [measure of its] distance. At an inordinate distance, however, the error in [the perception of] the size of the tiny parts will be due to an error [in the perception of the size] of the angle only. These, then, are the reasons why a body is judged to be smaller than it is at a moderate distance.

[7.24] An inordinate distance sometimes causes an error [that leads to an exaggerated perception] of size, so that at an inordinate distance (i.e., one that is too small), when the body that is seen lies very near the eye, the body will appear larger than it does at a moderate distance and larger than it actually is.

[7.25] And this happens for two reasons, for, as has been said, the intellect gauges both the distance and the [visual] angle, and on that basis it deduces the size of the body, but at this [very close] distance the [visual] angle is quite large.[63] Meanwhile, the distance of the body is gauged exclusively from the surface of the eye to the surface of the body, for the distance extending from the visible body to the interior of the eye cannot be taken into account in the judgment of sight, because the interior part of the eye is not affected by the rays, nor does sight try to measure it. Thus, sight carries out its deduction on the basis of the extent of the angle and the determination of distance. Now the actual distance of the body is measured by the line extending from the center of the eye to the body, since the [visual] angle is gauged from the center [of the eye]. And when the body lies at a moderate distance, the radius of the eye, which is the amount by which the actual distance of the body exceeds its apparent distance, is imperceptible in relation to the overall distance of the body, so it does not produce an error in the judgment of distance. But when the body is near the eye, the radius will have a sensible size in relation to the body's distance. Accordingly, it may be greater than, equal to, or less than [the distance between the object and the eye's surface], but it will be proportionate to some extent, e.g., half as large or some such; hence, when the visible object lies near the eye, the increase in the angle of the visual cone along with the perceptible discrepancy between estimated and actual distance leads to the perception that the object is larger [than it actually is].

[7.26] An inordinate distance produces an error [in the perception] of disjunction. Accordingly, if a wall is looked at from afar, and there is some dark color on a portion of it, the viewer will be convinced that this color represents a division between segments, so, on the basis of this error, something that is continuous is taken to be disjoined. Likewise, if tall plants are growing near that wall, the [visible] portions [of the wall] interspersed between the parts [of the wall] occluded by the facing plants will appear to be separated, so the wall will not be judged as continuous.

[7.27] By the same token, when sunlight that is not particularly intense shines on a wall, if some object casts a shadow upon the wall, the same error occurs in [the judgment] that there is a disjunction of segments that [actually] have no intermediate [gaps].

[7.28] It is therefore clear that the error [in perceiving] disjunction is an error of deduction caused by inordinate distance.

[7.29] A distance that falls outside [the range of] moderation is the cause of an error [in perceiving] continuity. For bodies of a similar color that abut one another and are seen from afar are taken to be continuous. Hence, the planks of a wall or bench may happen to appear continuous, even though they are slightly separated, i.e., by disjunction. And this happens when the visible object lies at a moderate distance that is nonetheless inordinate as far as the perception of such a tiny separation is concerned.

[7.30] Thus, on the basis of this error [which stems] from [inordinate] distance, something that is disjoined is taken to be continuous.

[7.31] Moreover, since the perception of number entails a consideration of continuity and discontinuity, an error in [the perception of] number occurs when discrete objects appear as a unity or a single object presents the appearance of being [divided up into] more than one object.

[7.32] Inordinate distance creates an error [in the perception] of motion. For if someone looks toward the moon, or the sun, or some star while he moves briskly [toward it], he notices that the moon gets no closer to him than [it was] at the beginning of his motion. He concludes that it is moving in the same direction [as he] and {therefore] it is [continually] receding from him, and from this [he concludes] that it maintains a constant distance [from him]. And this happens as the moon also hastens in the same direction. The reason for such an error is that the viewer knows that down here, when two bodies are set up so that one moves in a given direction, if each maintains the same spatial disposition with respect to the other, it follows necessarily that the other one [appears] to move in the opposite direction at an equal velocity.[64]

[7.33] Thus, since in the case of celestial bodies the change of the moving viewer's spatial disposition with respect to the moving star is not perceived, the motion [of the star] is unconsciously deduced on the basis of premises that are already known by the soul. So the change in his spatial disposition with respect to the star is imperceptible to the moving viewer, because the path he follows in the course of moving is disproportionate in size to the star itself, [which makes it] all the more [evident that] the difference between his distance from the star at the beginning [of his motion] and his distance from the star at the end [of his motion] is imperceptible with respect to his overall distance [from the star]. The same error occurs in the case of the movement of clouds, for it is the moon that is believed to be moving swiftly, even though it is not, but we have explained this above.[65]

[7.34] A distance that falls outside [the range of] moderation produces an error [in the perception] of rest. If someone who is seen from afar does not move swiftly, he will be judged to be at rest, which is why we take the planets to be immobile, even though they move quickly.

[7.35] And this judgment that the planets are immobile is due to the fact that the paths they follow, even during a substantial time-period, are not perceptible to sight at such a [great] distance, so, since they continue to maintain the same spatial disposition with respect to the observer, they are judged to be immobile.

[7.36] In the same way, if some body [seen] from afar moves along the line-of-sight, either approaching or receding from the eye, it will be judged to be at rest unless its motion is extremely swift. And, as was shown above, this error arises because the motion of a body is not perceived unless at one moment it is seen [in conjunction] with one body and at another moment [in conjunction] with another body.[66] In this case, however, such a perception is precluded, because the path that the moving object follows along the line-of-sight is imperceptible at such an [inordinate] distance.

[7.39] An excessive distance produces an error [in the perception of] roughness. Accordingly, the hair of someone who is depicted in a painting that is viewed at an inordinate distance is judged to have texture because that texture is represented by the painting. Since it is known that real hair has texture, the soul concludes by resemblance that there is texture in the painted hairs according to the way their form is represented. The same error occurs in the case of clothing with designs and with the hair of animals that are represented in paintings.[67]

[7.42] In all these cases, however, instead of actual texture there is utter smoothness; and even though light is reflected from smooth bodies rather than from rough ones, still, [the fact that] light may be seen to reflect from [the surfaces of] paintings does not obviate the conclusion that [the depicted hair has] texture. For to whoever reaches that conclusion it is unquestionable that roughness and reflectivity can coexist in the same body, as happens in the case of human hair that is pitch-black and luxuriant, for it reflects light even though it has texture.

[7.43] Hence, on the basis of this similarity there arises an error in the judgment of texture in the painting because of the inordinate distance in relation to the object that is painted. For the smoothness of a painting cannot be perceived unless it is quite distinct; hence, a moderate distance with respect to other things is inordinate with respect to the apprehension of smoothness.

[7.44] On the basis of inordinate distance an error occurs in [the perception of] smoothness. For if a body that is somewhat rough faces the eye from a considerable distance, it will be judged as smooth, for the roughness of a body is apprehended only through variations in the relative spatial disposition of the [object's] parts or the light of prominent portions and the shadow of depressed portions, as was explained above.[68] But from such a distance variations in the [relative] spatial disposition of the [object's] parts or the casting of shadows upon depressed portions by prominent ones is not apprehended, so the object is judged as smooth.

[7.46] Because of inordinate distance, an error [in the perception] of transparency arises. When a needle or something very thin is stood right in front of the eye, although that needle may appear larger than it [actually] is to sight, it still does not occlude any portion of a wall or other object beyond it. Since the perception of transparency in a body is based on the fact that we can see something behind it, then, transparency will be imputed to a needle, or to anything like it, that is stood [right in front of the eye], because the entire wall can be seen behind it. The reason that the needle appears larger [than it actually is] when placed near the eye has been explained above.[69] The reason it blocks none of the wall beyond it from view at such a close position is that, as far as the needle's [capacity] to block vision is concerned, such a tiny distance is inordinate. For if the needle is brought a little farther away from the eye, a portion of the wall that is larger than the needle itself will be blocked from view.

[7.47] But the reason for this phenomenon will be explained more fully later.[70]

[7.48] An error in [the perception of] opacity occurs on the basis of excessive distance. If someone looks at a transparent body from afar, and a colored body or something dark is placed behind it, that body will not be judged as transparent, but as opaque. And this error stems from the fact that [sight] perceives no other body behind that body. Since it is in the nature of a transparent object that an opaque object can be seen behind it, it will be concluded that the body is not transparent but opaque.

[7.50] On the basis of excessive distance an error in [the perception] of shadow arises. If a white body with a dark area faces the eye at such an [inordinate] distance, and if sunlight shines upon that body, there will seem to be a shadow on the dark area of the object.

[7.51] Moreover, if another body is seen near that one, it will be concluded on the basis of longstanding habit that the apparent shadow is cast by the other body. And it is obvious that this error is due to an excessive distance.

[7.52] An error [in the perception] of darkness is induced by excessive distance. If a white body with a pitch-black section is seen from afar, that section may be judged to consist of darkness, so it will be concluded that right where that section lies there is a hole in the body through which the darkness behind [the surface of] that body seems to show.

[7.54] A distance that exceeds the limits of moderation causes an error [in the perception] of beauty or ugliness. If something is looked at from afar, and if there are small blemishes in it that deform it, it is judged beautiful because those blemishes are rendered invisible by the distance. For the final perception [of beauty] is reached on the basis of appearances alone, and since the blemishes are invisible, the parts really do appear beautiful.

[7.56] Similarly, if an object with designs on it that render it beautiful is seen from afar, and if those designs are tiny with respect to the object as a whole, then, since the features that confer beauty on the object are invisible to sight, that object will be judged ugly, because the [viewer] who is judging [the object] bases his judgment exclusively on appearances.

[7.58] An error in [the perception of] similarity or dissimilarity among objects arises from an excessive distance. If the eyes are directed toward bodies of a similar color that lie far away, and if there are tiny marks or lines drawn on them that are dissimilar and varied, then, if sight fails to notice [those features], the bodies will be judged to be similar overall.

[7.60] On the other hand, if the colors of the bodies are altogether different, but there are identical tiny marks on them, then they will be judged to be dissimilar overall. And this error will arise because the conclusion will be drawn on the basis of appearances only.

[Section 2]

When spatial disposition falls outside the range of moderation it produces an error in [the perception of] any of the things perceived through deduction.

[7.63] In [regard to] distance, if two bodies are seen, one of them being directly behind the other so that the one occludes part of the other, and part of the rear body juts out, and if the distance is moderate but not quite determinate, and if there are no other bodies between them, then the measure of the distance of one from the other will not be gauged clearly, and the observer may judge them to be very near one another.[71]

[7.64] This error involves deduction, because distance is deductively perceived on the basis of spatial disposition alone, for, if part of one of the bodies were not occluded by the other, but, rather, both were completely exposed to view so that the gap between them fell not on the same ray but on different rays, then the distance of one from the other would be discerned. And this error is due entirely to an inordinate spatial disposition, for if the spatial disposition is restored to moderation while everything else remains the same, the error does not arise.

[7.65] An inordinate spatial disposition causes an error in the visual perception of spatial disposition. When the visual axis meets a body that faces the eye at a moderate distance, if another body that is far removed from the axis and somewhat inclined to the imaginary line to which the [visual] axis falls orthogonally is taken, then the viewer does not perceive the inclination of that body because its spatial disposition has fallen outside [the range of] moderation. For bodies that lie far away from the [visual] axis are not clearly perceived, so in the case of this error something that is inclined will be judged to face the eye directly.

[7.67] In [regard to] shape, an error occurs on account of [an inordinate] spatial disposition. If a round body, such as a goblet or bowl, is situated far away from the [visual] axis and somewhat inclined to the imaginary line we [just] mentioned, then, because its inclination is imperceptible, and because one of its diameters is perceived under a greater [visual] angle than the other diameter, for whatever is seen from a facing disposition subtends a larger [visual] angle than it does when it is inclined, and because there is a marked difference in size between the angles, the facing diameter is judged to be longer than the inclined one, so the round body will be judged to have an oval shape.

[7.68] Through the same error a square figure will be judged to be rectangular, since the side of it facing the eye directly appears longer than the side that is inclined.

[7.70] And this is an error in deduction, for it depends on premises that are false—i.e., that neither of the sides is inclined; that, if they subtend unequal [visual] angles, things seen at the same distance according to the same spatial disposition are [invariably] unequal in size; and that when one side is unequal to the other, the form of the object is [invariably] oblong—so the shape is interpreted incorrectly, not as it actually is. For the same reason it is clear that there is an error in [the perception of] size if one diameter of a circular body appears longer than another diameter of the same body, since they are actually equal.

[7.71] Another way, moreover, in which an error in [the perception of] size arises exclusively from an inordinate spatial disposition comes about when someone who is high up looks down on objects of equal size that are placed in a row, one after the other [away from the viewer, for in that case] the ray that falls on the first of these objects will certainly be lower [with respect to the center of sight] than the ray falling on the second. And the height of the rays falling on any of those objects will depend on how far that object lies from the first in line, so the ray falling on the last object in line will be higher than a ray falling on any other of those objects. Accordingly, the last object will be judged by the observer to be taller than all the rest, provided, that is, that the ground lying between any of the two objects is invisible to sight so that the altitude of the person [who is observing from on high] cannot be measured relative to the ground that appears.

[7.72] And this will be an error in deduction, because the observer errs according to the presupposition that whatever appears higher is taller, which applies in most, but not all, cases.

[7.73] And this error is due to an inordinate spatial disposition in regard to the perception of the size of an object set up in this way, for if the ray falling on the first object were parallel to the ground, and if the same ray were to fall on something else as it continued outward, there would be no basis for this error.

[7.75] An error regarding disjunction arises from an inordinate spatial disposition. If the inclination of some body with respect to the rays is great, and there are perceptible black or very dark areas on it, they may be taken to be interstices, and so it will be assumed that there is a disjunction between the parts bounded by [any] such darkened area, even though there is continuity at this point. Moreover, if dark lines are perceptible on this body, the parts on each side will be judged to be disjoined when they are continuous, and so an error arises on the basis of the body's inclination.

[7.77] There will be an error in [the perception of] continuity on the basis of [an inordinate] spatial disposition. If several walls are positioned facing the eye so that one lines up behind another at a slight distance from it, and if all of them lie along the same line-of-sight, the interval between them may be hidden from the viewer.[72]

[7.78] In that case they will be judged to be continuous when they are disjoined, an error that would not arise if the spatial disposition of the walls were changed so that they were not perceived by the same ray.

[7.79] An error in [the perception of] number is prompted by an inordinate spatial disposition when some object is seen double, and this occurs when there is a difference in the body's spatial disposition with respect to the two eyes. So, too, as was explained above, a single body will be judged double when that body falls between the two [visual] axes.[73]

[7.80] And this is an error in deduction, for the viewer supposes that he has seen different bodies outside. When the form reaches to different locations inside the eyes, the viewer concludes on this basis that what is actually identical is different.

[7.81] An error in [the perception of] motion arises from [an inordinate] spatial disposition, as [happens] when someone looks out from a boat floating with the current on a river, [for in that case] if there are trees on the riverbank that lie far to the side of the [visual] axis, they will be judged to be moving.[74]

[7.82] But if the [visual] axes are focused directly upon those trees, they will appear immobile.

[7.83] An error in [the perception of] rest arises from [an inordinate] spatial disposition. If some object is seen far to the side of the [visual] axis, and if that entire object revolves swiftly, it will appear motionless.

[7.84] So it is obvious that this error involves spatial disposition, for, if the spatial disposition were restored [to moderation], the body's motion would be perceived, so the error is due solely to an inordinate spatial disposition.

[7.85] [An inordinate] spatial disposition causes an error in [the perception of] roughness. If light reflects from a painting that represents hair, but the eye does not lie where the reflection occurs, there will be a perception of roughness in the painted hair when there is only smoothness there.

[7.86] And this error is due solely to an inordinate spatial disposition, for when the eye is placed in line with the reflected light, no roughness is perceived in the body that is seen.

[7.87] An error in [the perception of] smoothness will be due to [an inordinate] spatial disposition. If something that lies far to the side of the [visual] axis is slightly rough, it will appear smooth.

[7.88] If the spatial disposition were returned to moderation, the viewer would be able to perceive its roughness.

[7.89] In [the perception] of transparency or opacity an error will occur on the basis of an inordinate spatial disposition. If light shines at a slant on a glass that is full of wine, and if sight fails to see the light pass through the glass, then, if the inclination of the glass with respect to the rays is extreme, and the observer fails to see that there is wine in the glass, the wine will be judged by the observer to be an opaque body that is continuous with the glass. But this error does not occur when the passage of light through the glass is evident, so this error in regard to transparency and opacity is due to [an inordinate] spatial disposition.

[7.92] In [regard to] shadow and darkness: if some object lies far to the side of the [visual] axis, and if it has a dark section on it, that section may be taken for shadow, and if there is some body nearby, it will be assumed that the shadow is cast by it.

[7.94-95] However, if there is an intensely black area on that body, that black area may be taken for a hole through which the darkness [inside the body] shows through, but this will not occur if the body is placed according to a moderate spatial disposition.

[7.96] Furthermore, in [the perception of] beauty and ugliness an error occurs on the basis of [an inordinate] spatial disposition. When some body lies far to the side of the [visual] axis, and there are tiny blemishes in it that disfigure it, they will be invisible, and the body will be judged to possess beauty, so in this situation a freckled face appears beautiful. Likewise, in this situation the shadow inherent in the moon is invisible, so when it is viewed in such a way [perfect] beauty is attributed to the moon.[75]

[7.98] On the other hand, if there are designs on the object that render it beautiful, and if the object is beautiful only when these designs are apparent, then, since they are invisible in this situation, the object will be judged to be ugly.

[7.99] And this error involves deduction, because the conclusion that something is ugly or beautiful depends entirely on appearance.

[7.100] In [the perception of] similarity and dissimilarity an error arises on the basis of [an inordinate] spatial disposition. If two objects are set up far to the side of the [visual] axis [and if they are] of the same kind, color, and shape but possess some small features that are dissimilar, they will be judged to be perfectly identical since those features have escaped the viewer's notice.

[7.102] On the other hand, if those objects are not of the same kind, color, or figure but possess some identical features, they will be judged to be wholly dissimilar, since there is some dissimilarity between them. Accordingly, the error in [perceiving] similarity and dissimilarity is due to the fact that the final judgment [of similarity or dissimilarity] is based solely on appearances.

[7.103] In all of the foregoing cases the error arises exclusively from an inordinate spatial disposition, for if the spatial disposition falls within [the range of] moderation, all other things remaining as they are, the erroneous judgment will not occur.

[Section 3]
Light exceeds the limits of moderation, and on this basis alone an error is produced in [the perception of] everything that is apprehended through deduction.

[7.104] In [the perception of] distance [an error arises] from a deficiency of light. If people are arranged in a line, one after another, at a moderate distance and not too near one another, then, if sight is directed toward them at night while they are so disposed, they will appear to coalesce because the separation between them is imperceptible on account of the deficiency of light, although that separation would be evident in strong light. And if these people move in the same direction at the same velocity, they will invariably be judged to move as one.

[7.106] In [regard to] spatial disposition: If something faces the eye at a slight inclination at night, when it is not too dark, the object will be judged to face the eye directly because of the inordinate weakness of the light.

[7.107] Likewise, a figure with several equal sides will appear circular when viewed at night, for the excessive weakness of the light hides the corners [from sight].

[7.108] By the same token, a sphere viewed under these circumstances is taken to have a flat surface, because its outward bulge is hidden from sight.

[7.110-111] In [regard to] size: If a person is viewed at night, and a grove of trees or a wall that is far away from him is seen, the person will appear to be near the grove or the wall, since sight fails to perceive their distance from each other, even though it is considerable. Moreover, the same ray may pass over the head of the person to the top of the grove according to how far away the grove is, and in this case they will appear to be of the same height, or else the person may appear taller. This would not happen if the light were moderately intense, for the distance between the person and the grove would be discerned, and the height of each would be gauged according to the [intervening] ground that is perceived.

[7.112] An error in [the perception of] disjunction, number, and continuity will arise from an insufficiency of light. If a plank with dark lines drawn on it along its full length is seen at night, an observer may assume that these lines represent junctures or gaps; and so there will be an error in [perceiving] disjunction, because something that is continuous appears disjoined, and [there will also be an error] in [perceiving] number, because something that is single will be taken to be multiple.

[7.114] Likewise, when the eye is placed where strong light is reflected, if it looks at bodies that are somewhat distant, they will appear continuous; so there is an error in [the perception of] continuity on account of light that exceeds limits, whether of intensity or of weakness.

[7.116] In [regard to] motion or rest an error occurs in light [that falls outside the range of moderation]. If a person and a grove of trees that is far away from him are perceived at night, the distance between the person and the grove will be imperceptible. But if the observer moves toward the person, the closer he gets to him the more determinate that distance will appear, so, as before, the person who is seen will appear conjoined with the grove. But the closer the viewer gets to that person, the farther away from the grove the person appears to get, and since the viewer is certain that the grove remains immobile, he will deduce that the person who is seen is moving away from the grove, even though he is actually immobile, but this error would not occur in moderate light.

[7.117] In [regard to} rest: A person who is seen at night is not clearly perceived, so if he moves slowly, his motion will not be discerned, and he will be judged to be immobile.

[7.118] In [regard to] roughness or smoothness an error will occur [on the basis of light that falls out of the range of moderation]. For a rough object that is seen at night may be judged to be smooth, or vice versa, depending on the nature of the visible object.

[7.119] In [regard to] transparency or opacity: At night the transparency of a body that is highly transparent will be judged to have decreased, for, since an opaque object cannot be clearly perceived behind it, the viewer will judge that its lessened transparency prevents sight from seeing through it. An object that is [only] somewhat transparent will in fact be judged to be opaque.

[7.121] In [regard to] shadow or darkness: If there are dark areas on a white wall, and candlelight shines on that wall, an observer may judge such dark areas to be shadows, and it may appear to him that the shadow he sees is projected by a neighboring wall; and so [there is] an error in the judgment of shadow.

[7.122] Likewise, if there is a pitch-black area on the wall, it may be judged as the space of an opening through which the [inner] darkness [of the wall] shows forth. And if the entire surface of the wall is tinged with a pitch-black color, the entire wall may be taken for darkness, as happens in the case of a wall that is covered with soot when it is seen in faint light.

[7.124] In [regard to] beauty and ugliness: It is clear that a face appears beautiful at night, even if there are blemishes, such as freckles, in it.

[7.125] And if there are subtle designs in the visible object that are entirely responsible for its beauty, then, since they are invisible to sight at night, the object will appear ugly.

[7.127] In [regard] to similarity and dissimilarity: In the case of objects of the same kind, color, and shape, when differences among certain of their features are rendered invisible in faint light, those objects will be judged altogether alike.

[7.128] If, however, the objects are different in kind, color, and shape but share certain features, then, since those features are imperceptible because of the decreased light, the objects will be judged to be altogether dissimilar.

[7.130] So it is clear in all the foregoing cases that the error arises from the weakness of light alone, for if the light fell within the limits of moderation, the error would nor occur, assuming that everything else remained the same.

[Section 4]
Size falls outside the range of moderation, and when it does it produces an error in [the perception] of everything that deduction leads us to conclude.

[7.131] An error in [the perception of] distance will arise for the reason just given. If two people are seen from a moderate distance, but that distance extends to the limit of moderation, and if one of the people stands a little in front of the other, the gap between them will not be discerned, so one will appear to be right next to the other. And the error arises from the fact that, since the distance between them is quite small, it is not proportional to their overall distance from the eye, even though that [overall] distance is moderate.

[7.133] Furthermore, it constitutes an error in [the perception of] distance because those people will be judged by sight to be equidistant [from the eye], and thus one distance [is judged] greater than it actually is, so there is an error in [the perception of] distance.

[7.134-135] There is an error in [the perception of] spatial disposition on the basis of smallness. For if a mustard seed is inclined with respect to the eye, it will still appear to face it directly, because the slant of this seed with respect to the imaginary line to which the common axis falls orthogonally cannot be grasped on account of the seed's inordinate smallness. The reason is that the [difference in] distance between this line and the endpoints of the seed is not discerned, because it is miniscule, but it is according to this [difference in] distance that its inclination with respect to that [imaginary] line is gauged. And it is according to this line that the inclination of a visible object is always gauged in relation to the two eyes, so there is an error in [the perception of] spatial disposition on the basis of an inordinate[ly small] size.

[7.137] In [regard to] shape: When the visible object is extremely small, and there are corners on it, those corners will be invisible to sight, so that, even though it is not actually [round], its form may be judged to be round or oblong.

[7.138] And if there is some slight curvature to it, that curvature will be imperceptible to sight, so its surface will be judged to be flat; hence, there is clearly an error in [the perception of] shape.

[7.140] In [regard to the perception of] size, [an inordinate] size induces an error. If two objects are set before the eyes, one slightly larger than the other in length alone or in breadth, they may be judged to be identical in every dimension. And this error arises because the excess of one dimension over the other has passed the limits of moderation with respect to sight since that excess is imperceptible to sight by virtue of its inordinate smallness. Thus, in order for the sizes of objects to be correctly determined, these measurements are necessary, because size cannot be apprehended with certainty by sight [under such conditions].

[7.142] In [the perception of] disjunction an error occurs [if the size is inordinate]. If a hair is stuck on a glass, there will appear to be a disjunction or crack in the glass when, in reality, there is absolute continuity in it. And this error arises from the thinness of the hair, for, if something thick[er] were to adhere to it, the glass would not be judged to be cracked.

[7.143] In [regard to] continuity: If thin sheets of parchment that are of equal length are stacked tightly together, and if the viewer does not know that it is a stack of sheets, he will assume that it forms a single, continuous body. And the reason for this error is that the size of the gaps between the sheets is not perceived by the viewer because of their smallness. Moreover, the same thing that causes an error in [the perception of] continuity will cause an error in [the perception of] number.

[7.145] In [regard to] motion: If two things move, and one of them moves a bit more quickly than the other, an observer will judge their speeds to be equal, because the excess of one over the other is imperceptible to the observer.

[7.146] Similarly, the difference in size between the path that one follows and the path that the other follows is imperceptible to sight, so both the paths and the speeds are judged to be equal.

[7.147] In [regard to] rest: When a very small animal is presented to sight, one of its members may move, but the animal will be judged to be motionless, because the member's movement is invisible to sight.

[7.149] In [regard to] roughness and smoothness: Indeed, when a very small object is seen, it may be judged to be smooth where it is rough, and vice-versa. For, as has been said, roughness is perceived in an object only through the shadow cast by certain parts on others, or the protrusion of such parts and the depression of others,[76] all of which escapes the viewer's scrutiny on account of the inordinate smallness of the body.

[7.151] In [regard to] transparency and opacity: If someone looks at a very small, polished object, like a pearl, from which light can reflect, he will judge it to be transparent when it is not.

[7.152] By the same token, when a very small, transparent object is seen, it may seem to be opaque because no opaque body is perceived behind it.

[7.154] In [regard to] shadow and darkness: If there are separate spots of a pitch-black color on a white wall facing the eye, and if it is exposed to sunlight that falls directly on the wall, or nearly so, then the individual spots will be judged by the viewer to be individual holes behind which darkness shows forth, so there is an error with regard to the judgment of darkness on account solely of the smallness of the spots, and that error would not occur if the blackness, no matter how intense, were to be painted on a sizeable portion of the wall.

[7.155] On the other hand, if the blackness in these spots is not so intense, those spots will be judged to be openings filled with shadow, since light will not penetrate into them, as often happens when light shines on a surface with many openings in it, so there is an error in [the perception of] shadow on the basis solely of the smallness of the spots.

[7.156-157] In [regard to] beauty and ugliness: When blemishes that disfigure an object are invisible to sight because of their smallness, an erroneous judgment of beauty occurs, for it is based on appearances only, as is an error in the perception of ugliness, [which arises] if the designs that render a visible object beautiful are invisible.

[7.159-160] In [regard to] similarity and dissimilarity: When tiny features are the cause of the similarity or dissimilarity between any objects, because those features are unseen on account of their smallness, the bodies will be judged similar or dissimilar in all respects. And this judgment will be based on appearances alone.

[7.162] In all the foregoing cases the error in deduction is based on the smallness of the body; if the size is moderate, all other things being equal, the error does not occur.

[Section 5]

Opacity sometimes falls outside [the range] of moderation and induces an error in [the perception of] any of the things that are perceived through deduction.

[7.163] In [regard to] distance: If the opacity of a body is minimal so that it is exquisitely transparent, like pure crystal, and if some intensely luminous body lies behind it, the crystal is not clearly perceived; rather, the [other] body will be perceived through it as if there were no intermediate body [between it and the eye]. Therefore, since the transparent body is apprehended as if it did not exist, there will not be a clear perception of its distance on that basis, so there is an error [in the perception of] distance, whereby, if the transparent body is disposed at a slant, its inclination will be invisible to the viewer, and it may be judged to face the eye directly, so there is an error in [the perception of] spatial disposition as well as in [the perception of] distance, for one of its extremities will be judged to lie the same distance [from the eye] as the other, although they lie at different distances.[77]

[7.164-165] Moreover, since the size of the object is perceived on the basis of distance and the extent of the angle under which it is seen, when the distance is unknown, an error in [the perception of] size occurs. In a similar way, an error in [the perception of] shape arises, for if a body has corners, they will be invisible to the viewer, so a six-cornered figure[78] will be taken for a sphere. And if there is a slight curvature in the body, that curvature will be unseen, and the body will be judged to be flat.

[7.166-169] In [regard to] disjunction: If a black line is drawn the length of a body, the body will indeed appear to be divided where the line is, so it is judged to be more than one [body]. If, on the other hand, there are two such bodies slightly separated from one another, they will be judged to be continuous, so there is an error in [the perception of] continuity. And it is evident that on this basis there will be an error in the perception of number, since one thing appears to be several, and several appear to be one.

[7.170] There will be an error in [the perception of] motion on the basis of inordinate transparency. If an exquisitely transparent body, such as crystal, is placed before an opening, and if the edges of this body are invisible to sight, then, if some other object moves behind this body, an observer will judge the transparent body to be moving when it is actually motionless, but this would not happen if the body were moderately opaque.[79]

[7.171] An error in [the perception of] rest will occur on the basis of the same inordinate [transparency]. If an exquisitely transparent object is held snugly in the hand, and if it recedes from the hand or is rotated inside it[80] while the hand remains immobile, provided that it appears distinct from the hand, the body will be judged to be motionless. For its motion cannot be perceived unless each of its parts changes its spatial disposition with respect to the hand or with respect to part of it, but since its parts are completely identical or seem to be according to its transparency, the spatial disposition of none of its parts can be discerned, nor on that account can its motion.

[7.173] In [regard to] roughness: If a highly transparent body has some roughness, but not too much, it may be judged to be smooth. On the other hand, if it is smooth, but a rough object or an object of various colors is placed behind it, the transparent body will be judged to be rough, so there will be an error in [the perception of] smoothness.

[7.175] In [regard to] transparency: If a body that is not very transparent but intensely colored lies behind an exquisitely transparent body, the body in front will not appear very transparent; instead, its transparency will be judged according to the transparency of the body placed behind it, so a glass placed behind another glass does not appear as transparent as it does when it is exposed to sight on its own, so there is an error in [the perception of] transparency.

[7.176] If an opaque object is placed behind the first transparent body, though, the first body will be judged to be opaque, so there will be an error in [the perception of] opacity. By the same token, when a highly transparent glass contains wine, if neither light nor some other body is perceived behind it, the glass may be judged to form an opaque body along with the wine.

[7.178-179] In [regard to] shadow an error will arise on the basis of [inordinate] transparency. If sunlight streams into a room through some opening and shines on a glass window [that opens into a second, interior room], and if that [interior] room is still shadowy, that shadow will appear [to lie] on the window, even though light actually shines on it, but this light would certainly be perceived if the window were opaque, because it would not pass through, and it would thus be seen [to shine] on a solid body, so there will be an error in [the perception of] shadow.

[7.180] In [regard to] darkness: If sunlight does not shine on the water of a river, or on the sea, as happens in [the early] morning or evening, and if the water is clear, it will appear dark. And the clearer the water is, the darker it will be judged to be.

[7.182] And this happens because the upper stratum of the water casts shadow on the stratum just below, and that stratum casts shadow on the one just below it, and so on in order to the bottom.

[7.183] And even though the shadow in any of the individual strata is minimal, taken as a whole they form an intense shadow, as clearly happens in the color of wine. For the color in a tiny amount of wine is faint, but when such amounts are multiplied, even though they are the same in kind, the color deepens. Moreover, the reason there seems to be darkness in a clear sea when shadow is cast upon it is that extreme clarity produces transparency, so it can be seen through to a considerable depth. Accordingly, many of the strata that cast shadows can be seen, and in the aggregate these shadows, when perceived, lead to the conclusion that there is darkness [in the water].

[7.184] On the other hand, if the sea is roiled [and muddy], then sight will penetrate only a little because of the water's diminished transparency, and it will perceive [only] a narrow stratum of the water. And even though it casts shadow, since that shadow is attenuated, the color of that stratum overcomes the shadow, for in muddy water the color is apparent, whereas in clear water there is none. Hence, according to both the color that is seen in the muddy water and the attenuated shadow that is seen in the [narrow] stratum [through which sight penetrates], darkness is not perceived in the water, so roiled water will appear clear, whereas clear water will appear dark. Moreover, when a ray of sunshine strikes the surface of the sea, since the ray's passage [into the water] is evident because of the water's transparency, every appearance of darkness or shadow will vanish.

[7.185-187] In [regard to] beauty and ugliness: If tiny features or etchings render a highly transparent glass beautiful, and if cloudy, unappealing wine is poured into that glass, the reason for its beauty will be hidden, and the glass will be judged to be ugly, as sometimes happens in the case of a glass goblet. On the other hand, if some of its tiny features disfigure such a glass, and clear, bright wine of a beautiful color is poured into it, what disfigures the glass will be hidden, and the glass will be judged beautiful when it is ugly.

[7.189] In [regard to] similarity and dissimilarity: If two highly transparent glasses are identical in form, kind, and transparency, but if they differ in the arrangement of certain of their features, then, when they are filled with wine of the same color and clarity, what causes them to differ will be invisible, and they will be judged to be perfectly identical.

[7.190] On the other hand, if they differ in kind and form but are identical in certain [other] features, then, when they are filled with the same kind of wine, they will be judged to be entirely different, so there is an error in [the perception of] similarity and dissimilarity because such a judgment is based on appearances alone.

[7.192] In all of the preceding cases the error arises solely from an inordinate opacity, for, if everything else remains the same, the error does not arise when the opacity is restored to moderation.

[Section 6]

The transparency of the air intervening between the eye and the visible object falls outside its own limits of moderation and produces an error in [the perception of] everything that sight is led to conclude from deduction.

[7.193-194] In [regard to] distance: If the air is misty or dusky, as usually happens in the morning, and if there is a tower facing the eye at a moderate distance, it will be judged by sight to lie farther away than it actually is, so there is an error in [the perception of] distance, for the distance along the [intervening] ground according to which the distance of the tower is gauged is not perceived, and the ground is hidden because of the lessened transparency of the air, so [insufficient] transparency is the source of error.

[7.195] Moreover, if a body that is under scrutiny is somewhat inclined with respect to the eye in this kind of air, the inclination, which would be evident in clear air, will be hidden, so there will be an error in [the perception of] spatial disposition.

[7.196] In addition, if there is a slight bulge in the object, that object will appear flat in such air, and if the object has corners, they will be invisible, so there will be an erroneous judgment of shape.

[7.197] An error in [the perception of] size will arise in such air, for a visible object will appear larger than it would in moderate[ly transparent] air, as happens in the case of bodies that are perceived through transparent water.[81]

[7.198] If, moreover, there is a black line in an object, that line will be judged to represent a split between segments, so there is an error in [the perception of] disjunction.

[7.199] But if two bodies are barely separated, they will appear continuous in such air, so there will be an error in [the perception of] continuity. And it is clear from these [two] cases that there is an error in [the perception of] number.

[7.202] In [regard to] motion: If two things are seen in such air, and if one of them moves a bit faster than the other, they may be judged to move at equal speeds, whereas in moderate[ly transparent] air the difference in speed between them could be discerned. And this error occurs because the difference between the length of the path one follows and the length of the path the other follows is imperceptible.[82]

[7.204] In [regard to] rest: If someone looks at flowing water through such air from a distance that is moderate but not short, either he will judge it to be motionless, or, if it flows swiftly, he will judge it to move less vigorously than it actually does.

[7.206] In [regard to] roughness and smoothness: [It follows] that in this kind of air a rough object will appear smooth because the reason for its roughness will be invisible, whereas if the visible object is polished, since there is no reflection discerned in it, it will be judged to be rough.

[7.207-209] In [regard to] shadow: If a white object with round, black spots on it is seen through such air, and if firelight shines on that object while the same sort of air lies between [the eye and the object], there will seem to be shadow where those spots are, or else they may be taken for holes through which the darkness [inside the object] is allowed to show forth, so there will be an error in [the perception of] darkness, which is why a transparent object will appear less transparent [than it really is] through such air, or it may be judged to be opaque, and so there is an error in [the judgment of] opacity and transparency.

[7.211] In [regard to] beauty and ugliness [an error in perception will arise] because the specific things that render the object beautiful or ugly are invisible in such air.

[7.213] In [regard to] similarity and dissimilarity [an error in perception will arise] because the features that cause two bodies to differ or to be identical are not apparent [in such air].

[7.216] In all these cases the error is due to solely to the inordinate transparency of the air, for, if everything else remained the same, that error would not occur in moderate[ly transparent] air.

[Section 7]

A time-interval that falls outside the limits of moderation can cause an error [in the perception of] each of the things that sight is led to conclude from deduction.

[7.217] [In [regard to] distance: If, from a tower, someone glimpses a distant object that is immediately snatched away from view, he will not be able to determine its distance from the tower properly, so he may judge it to be nearer or farther away from the tower than it actually is. And this happens because, in that brief period of time, the ground between the tower and the visible object according to which the distance is measured is not [properly] perceived by the observer, or else it happens because in such a brief time-span the [visual] axis could not scan the intermediate ground, so it could not apprehend it properly, and there will thus be an error in [the perception of] distance.

[7.218] In [regard to] spatial disposition: When something is glimpsed and then immediately removed, it may be judged to face the eye directly when it is inclined, or vice versa.

[7.221] In [regard to] shape: if there is a slight bulge in an object that is [merely] glimpsed, that bulge will go unseen, so the object will be judged to be flat, or the corners it possesses will be invisible [to sight].

[7.222] In [regard to] size: If someone waves a flaming torch quickly over a short distance so that it oscillates back and forth many times [during a brief time-interval], the path of its motion will appear fiery, because the movement of the torch from one side to the other is almost instantaneous.

[7.223] Accordingly, neither the size nor the motion of the torch can be [properly] discerned because of the brevity of the time, so in this case there will also be an error in [the perception of] motion.

[7.226] In [regard to] disjunction: If something that is glimpsed by sight is [immediately] taken away, and if there is a black line on it, that black [line] will be taken to mark a split between segments [of the object].

[7.227-228] Moreover, if contiguous objects or ones right next to each other are [merely] glimpsed, they will be judged to be continuous, as happens in the case of the planks of a bench that is [merely] glimpsed, so there will be an error in [the perception] of continuity.

[7.230] In [regard to] motion: When one of two objects moves a bit faster than the other, their motions will be judged to be equal when they are perceived over a brief time-span, because the difference [in speed] is not perceptible in such a short amount of time.

[7.232] In [regard to] rest: If a slowly moving object is [merely] glimpsed, it will not appear to move, for the path it follows during the time it is perceived is imperceptible to sight because of its brevity. But it was explained above that the motion of a body is perceived only during a perceptible time-span.[83]

[7.233] The same sort of error happens in the case of a small disk. When it revolves swiftly, it appears motionless because its revolution cannot be perceived in the small amount of time during which it makes a single revolution.

[7.234] The same error occurs in the case of a top, so there will be an error in [the perception of] rest, since the change in spatial disposition of the parts of the top cannot be discerned, which is why its motion cannot be discerned either. Now if the top is of one color only, it is clear that its motion is not perceived. If it consists of several different colors, its motion will still not be seen, because the difference among the colors is invisible, and they are presented as a sort of uniform blend of the colors on account of the inordinate speed [of rotation].[84]

[7.237] In [regard to] roughness: When something rough is [merely] glimpsed, it may be judged to be smooth. Moreover, if something smooth is glimpsed the same way, neither smoothness nor roughness can be discerned in it, so there will be uncertainty and error [in such perception].

[7.239] In [regard to] transparency: If light shines on a transparent object at a slant, and that object is [merely] glimpsed, since the inclination of the light is not perceived, the transparency of the object as it appears may be judged absolute. But if the object is exposed to view a bit longer, the [light's] inclination will be perceived as the cause of the apparent decrease in transparency.[85]

[7.240] In [regard to] opacity: If someone sees a transparent object very briefly and does not discern light passing through it from behind, the object will be judged to be opaque.

[7.241-242] In [regard to] shadow: If portions of a white wall are black, but not pitch-black, and if firelight shines upon that wall, and it is [merely] glimpsed, [those dark portions] will be judged to be shadows. If, however, the black is very deep, they will be judged to be holes that are full of darkness.

[7.244-246] In [regard to] beauty and ugliness: For the minute features conferring beauty or ugliness [on a given object] are not perceptible in such a short time-period, as is the case when someone glances at a face through a window while passing by, [for under those conditions] he may judge it to be ugly [when it is] beautiful, or vice versa. And the same error occurs when the visible object moves while the eye remains immobile.

[7.247] In [regard to] similarity and dissimilarity: For the particular features that cause similarity or dissimilarity are invisible to sight.

[7.249] In all these cases an error occurs on the basis solely of an inordinate[ly short amount of] time, since none of those errors would occur if the time-interval were restored to moderation.

[Section 8]

A weakness or aberration of the eye produces an error in [the perception of] everything that is perceived in sight through deduction.

[7.250] In [regard to] distance: If two objects face the eye, one being of an intense color and lying farther from the eye, the other being of a faint color and nearer the eye, since the perception of their distance [from the eye] depends entirely on comparing the two, weak sight will produce an inconclusive comparison.

[7.251] But since it is certain to everyone that sight has a clearer apprehension of nearer things than it does of farther things, the viewer concludes that, between these two objects, the one that is seen more distinctly is the nearer. And it is obvious that weak sight has a clearer apprehension of an intense color than it does of a weak one, even though [the intensely colored object] lies somewhat farther away.

[7.252] The same error arises when the visual power lies within [the range of] moderation, for at a great distance a body that is more intensely colored is judged to be nearer than one that is faintly colored, provided that it does not lie much farther away.[86]

[7.254] Weak sight errs in [the perception of] spatial disposition. If an object at some moderate distance is slightly inclined, the inclination will not be apprehended [even] when the distance [of the object] is properly perceived.

[7.255] Moreover, an indistinct perception of distance and spatial disposition produces an error in [the perception of] size.

[7.256] In [regard to] shape: For a slight bulge or a multiplicity of corners in a body is invisible to weak sight.

[7.257] Moreover, if there is a black line on an object, it will be judged as a juncture or crack, whereas contiguous bodies will be judged to form a single continuum, so there will be an error in [the perception of] disjunction, continuity, and number.

[7.258] For the same reason someone who suffers from a squint judges a single object to be double if there is a deformity in one eye only, for the visible object will occupy noncorresponding places with respect to his two eyes.

[7.259] Moreover, if the deformity extends to both of his eyes, then, when he chances to move them, they may happen to be oriented differently with respect to the visible object, and so one thing [will be taken as] more than one thing.

[7.261] In [regard to] motion: If someone spins around several times, when he stops he supposes that the walls are moving. And this happens because, when the viewer is moving, the visual spirit within him moves [too]. So even though the viewer has stopped, his visual spirit will not come to rest immediately, but its motion will continue in the motionless viewer, and on this basis a judgment that the [surrounding] visible objects are moving arises.[87] We see an example of this sort of motion in the case of a top, for the top revolves for awhile after the hand that moves it stops. There is also a disease according to which everything seems to the sufferer to revolve [about him].

[7.264] In [regard to] rest: When a body with identical parts revolves slowly, weak sight does not perceive its motion, whereas moderately strong sight will perceive it.

[7.265] On the other hand, if its rotation is swift, its motion is not even perceived by moderately strong sight. If, however, the moving body consists of dissimilar parts, e.g., in the case of a wheel,[88] weak sight will perceive its motion. But if the rotation is swift, the motion will be hidden to weak sight. Since the parts of the wheel are not completely dissimilar, their dissimilarity will not be properly perceived in swift motion, but it is by a dissimilarity of parts that their motion is perceived.

[7.267-268] In [regard to] roughness and smoothness: For something that is [only] moderately smooth will be judged to be rough, or vice versa if there is a difference between the forms of the rough and smooth objects.

[7.269] In [regard to] transparency: When there is a bit of opacity in a transparent body, it will be judged by weak sight to be more opaque than it actually is.

[7.270] In [regard to] opacity: When a transparent body is intensely colored, or when an intensely colored body lies behind it, if its transparency is not too great, [weak] sight will judge it to be opaque.

[7.272] In [regard to] shadow: When light shines on a white wall with small marks that are black, but not intensely so, those marks appear to weak sight as shadows.

[7.273] If, however, those marks are intensely black, they will look like holes through which darkness appears.

[7.275-276] In [regard to] beauty, ugliness, similarity, and dissimilarity [an error arises] because the specific features that render objects beautiful, or ugly, or similar are hidden to [weak] sight.

[7.278] So there is an error in [the perception of] all of the things we discussed on account, solely, of weak sight.

[7.279] We have now explained how an error of [visual] deduction arises according to each of the causes of visual errors in each of the things that are apprehended through deduction. We have now dealt with each kind of error and have adduced an example of each. And even though there is a plethora of visual errors, they have nonetheless all been distilled down to the kinds that have been described and arranged according to the examples adduced. And we have presented each of these errors according to a single cause that produces it.

[7.280] Now [visual] error sometimes arises not from a single cause, but from two or more causes. For instance, if something that is [merely] glimpsed from afar moves slowly, it will appear to be motionless, whereas its motion could be perceived at a moderate distance in the same brief time-span. So too, the motion would not be imperceptible at a moderate distance if the time during which it was viewed were moderate.

[7.281] This error thus arises on the basis of two inordinate conditions, neither one of which suffices by itself [to produce the error].

[7.282] A convergence of three [inordinate conditions] produces [visual] error. If a body of various colors that rotates, but not very fast, is seen in faint light from afar for a brief moment, the body will be judged to be at rest.

[7.283] Yet if [the same body] is looked at from the same distance in the same light, but during a moderate amount of time, the motion will be perceived, and by the same token it will not be imperceptible [if seen] in the same light for a brief moment, but at a moderate distance. And it could also be perceived at that same distance [for a brief moment but] in strong light.

[7.286] In general, then, among all the errors that occur in sight, whether singly or in conjunction, every one is subject to the causes that we described. Moreover, every form of a visible object is a composite of the [visible] attributes we have listed, and since sight apprehends nothing about visible objects except these specific attributes, no error will occur in sight that does not involve one of them. And every error that occurs in recognition occurs because the intellect either assimilates things it perceives [at the moment] with things it somehow perceived [earlier] or distinguishes between them.

[7.287] And every error concerning individuals will occur either in [brute] sensation, in recognition, or in deduction, and error can occur in no other way than according to one, two, or three of these. Moreover, whatever error occurs in any of these three ways will occur only by means of an error of sight concerning particular aspects.

[7.288] So now it has been shown that an error of sight concerning particular aspects will be due only to the causes we have listed, either from one of them alone or from several of them.

NOTES TO BOOK THREE

[1]Objects are perceived "directly" (*recte*) when the radial links between eye and object are uninterrupted and, thus, unbroken by either reflection or refraction.

[2]6.33, pp. 365-366 above.

[3]6.72, p. 377 above.

[4]6.77, p. 378 above.

[5]Figure 3.1, taken from ms *P3* (f 114v), shows how the visual axes from the two eyes, **A** and **G**, intersect at point **D** on the circle to the right, labeled *basis pyramidis*

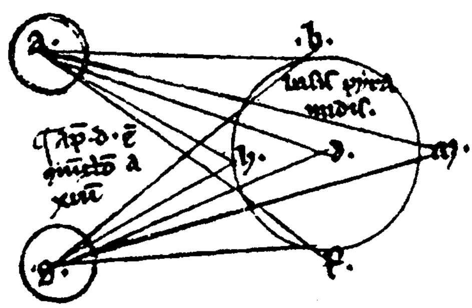

figure 3.1

("base of the [visual] cone"); indeed, the text between the two eyes reads: *Apud D est coniunctio axium* ("The intersection of the axes is at **D**"). Ray-couples **AB**, **GB**; **AH**, **GH**; **AF**, **GF**; and **AM**, **GM** constitute corresponding rays within their respective visual cones.

[6]I, 6.28, p. 364 above.

[7]Evidently, Alhacen followed Ptolemy in assuming that the horopter—i.e, the plane of the visual field—is flat rather than curved, as visual theorists have acknowledged it to be since the establishment of the Vieth-Mûller Circle in the first quarter of the nineteenth century; see Ptolemy, *Optics* II, 61, in Smith, *Ptolemy's Theory*, p. 152. The assumption of a flat horopter raises certain problems: For instance, it makes it extraordinarily difficult to explain how we get a unified visual impression of a sphere when each visual cone comprehends a different segment of that sphere—a point that Galen acknowledges, at least implicity, in his discussion of binocular vision in *De usu partium*; see "Introduction," pp. xlii-xliii above.

[8]As figure 3.2 on the following page shows, any two rays meeting to the side of the point where the visual axes intersect will be unequal in length, the relative inequality increasing the farther to the side they intersect; on the other hand, rays meeting directly above or below the point of axial intersection will be equal. Let the ellipse with center **C** represent the circular base of the two visual cones whose

vertices lie at centers of sight **A** and **B**. Let **XC** be normal to that circle, and let the plane containing points **X**, **C**, and **E** be perpendicular to the plane containing **X**, **C**, and **F**. Finally, let visual axes **AB** and **BC** lie in plane **XCE**, and let them intersect at point **C** so that they are equal. Obviously, then, rays **AE** and **BE** meeting at point **E** to the side of point **C** within plane **XCE**, will be unequal, **AE** being longer than **BE**. On the other hand, rays **AF** and **BF** meeting point **F** within plane **XCF** will be equal. If corresponding rays for each cone are brought to intersection at all the points equidistant from the point of axial intersection (i.e., along the circle's circumference), then, as long as the relative inequality in length between the corresponding rays that intersect to the side of the point of axial intersection is negligible (i.e., insensible), then the entire portion of the object enclosed by those points will appear single and, moreover, relatively distinct.

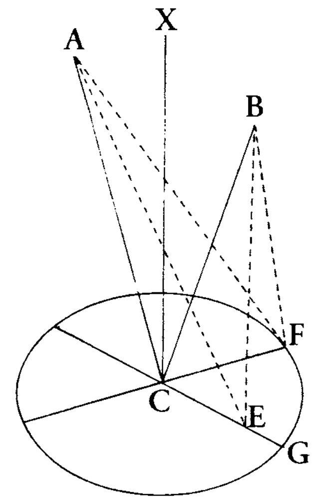

figure 3.2

[9]In other words, if points **C** and **E** in figure 3.2 are right next to one another, angles **AEC** and **BEG** will be so close in size that the difference between them will be undetectable to the visual faculty.

[10]This, of course, is the case when the point lies directly above or below the point of axial intersection along line **CF** as represented in figure 3.2.

[11]Figure 3.3, which is taken from ms *P3* (f 115v), is apparently meant to illustrate this point. Thus, anywhere along line **HM** the axial rays, whether **AH** and **GH**, **AD**

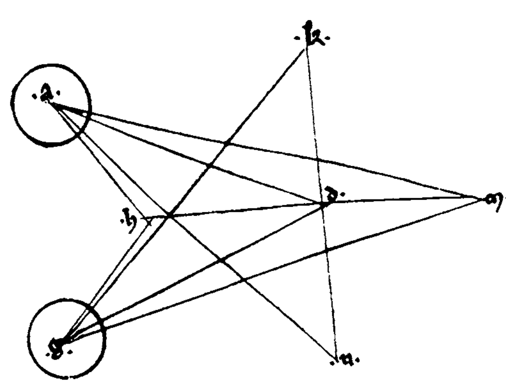

figure 3.3

and **DG**, or **AM** and **GM**, will be equal. On the other hand, if the intersection-point is far off to the side, then the corresponding axes **GK** and **AK** (this latter left undrawn), or **AN** and **GN**, (this latter also left undrawn), will be discernibly unequal.

[12]See 2.22, pp. 572-573 above, for elaboration on this example. Figure 3.4 is provided by ms *P3* (f 116v) to illustrate this point. The two axes, each labeled *axis*,

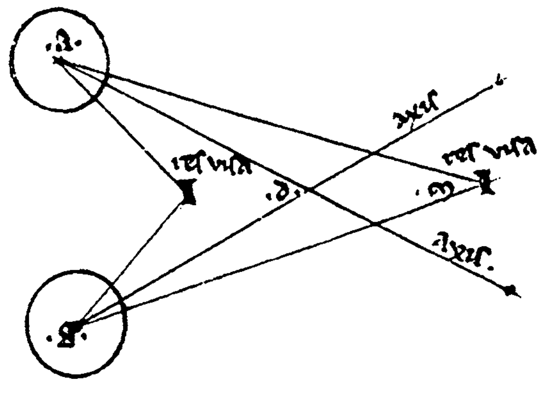

figure 3.4

come to intersection at point **D**. Meantime, the two visible objects (*res visa*) to the left and right of that intersection-point are seen along rays that strike their respective eyes at noncorresponding points. Thus, for instance, ray **AM** extending from the eye at **A** to the visible object at the right intersects that eye's surface to the left of the visual axis, whereas ray **GM** extending from the eye at **G** to the same visible object intersects that eye's surface to the right of the visual axis.

[13]II, 2.2, pp. 417-418 above.

[14]Idem.

[15]I, 5.37, p. 355 above.

[16]See figure 3.5. In this diagram the two visual axes meet at point **B** on the object represented by line **ABC**. To that same point, extending from point **H** at the top of the figure, where the center of the common nerve lies, is a line perpendicular to the line passing through the rear of the eyes and parallel to **ABC**. The center of that line is **X**, so, in passing through it from the center of the common nerve to **B**, **HB** defines the common axis. This description of the common axis and its generation represents an elaboration on Ptolemy's account in *Optics*, III, 35, in Smith, *Ptolemy's Theory*, pp. 144-145; see also "Introduction," pp. xxxiii-xxxiv above.

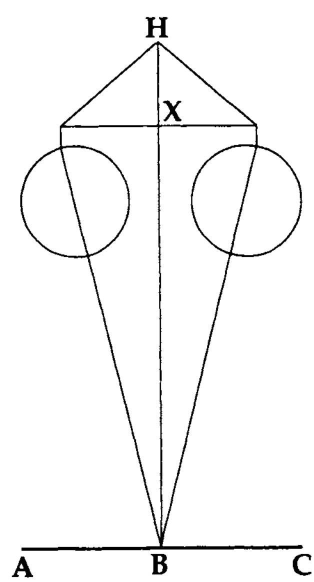

figure 3.5

[17]Taken from ms *P3* (f 117r), figure 3.6 on the following page illustrates the points just made. The explanation, which is provided in the accompanying text, is as follows: *Hec forma C venit ad Z per duas vias: scilicet per OP et SY in alio oculo. Eodem modo A venit ad V per duas vias* ("This form [of] **C** reaches **Z** [in the common nerve] by two routes: i.e., along **OP** [in the eye to the right] and [along **SY** [in the eye to the left]. Likewise, **A** reaches **V** by two routes"). The ulterior purpose of this diagram is, of course, to show that the

images from both eyes can be perfectly fused in the common nerve.

[18]Thus, just as the clearest, most definite monocular visual impression occurs along the visual axis, the clearest, most definite binocular visual impression occurs along the common axis when the two visual axes intersect it on the surface of the object. By extension, then, an object is seen most clearly and most definitely when it is in a perfectly facing position vis-à-vis the viewer; see II, 3.106, pp. 462-463 above.

[19]Thus, the increasing indefiniteness or indistinctness of things seen toward the edge of the visual field is due to the imperfect superposition of their forms as they pass from noncorresponding spots on the two eyes to noncorresponding spots in the common nerve.

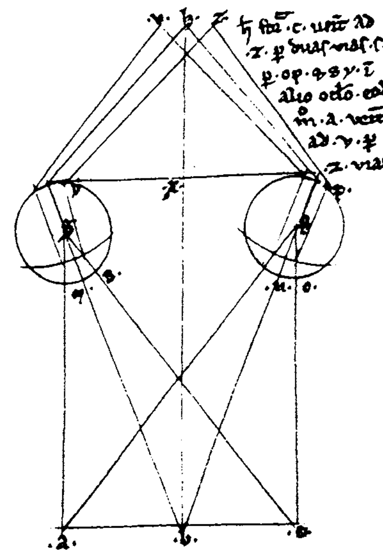

figure 3.6

[20]In short, if it is not inordinate, the doubling of forms conduces to a blurring, rather than a complete fragmentation, of the composite image in the common nerve.

[21]This is, in essence, a recapitulation of Ptolemy's explanation in *Optics*, II, 35-37,

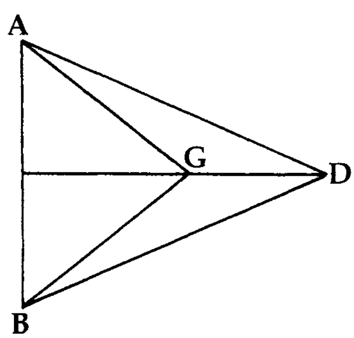

figure 3.7a

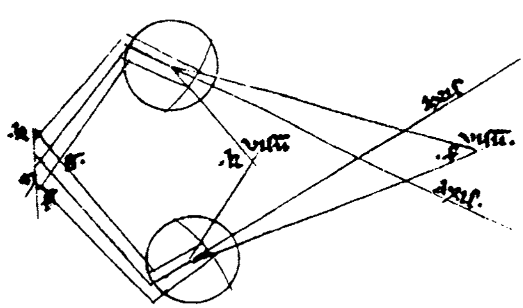

figure 3.7b

in Smith, *Ptolemy's Theory*, pp. 84-85. The gist of the argument is as follows from figure 3.7a (Figure II.1 in *Ptolemy's Theory*, p. 84). If the two centers of sight are **A** and **B**, and if the two visual axes **AG** and **BG** come to focus on **G**, then **D**, which lies beyond **G**, will be seen to the left of **G** by the left eye **A** along ray **AD** and to the right of **G** by the right eye **B** along ray **BD**. If, on the other hand, the visual axes **AD** and **BD** come to focus on **D**, then **G** will be seen to the right of **D** by the left eye **A** along ray **AG** and to the left of **D** by the right eye **B** along ray **BD**. To account for the doubling of such images in the common nerve, *P3* offers figure 3.7b on f 120v. If **F** (labeled *visum* = "visible object") is the object in question, and if it lies beyond the intersection of the two visual axes, then the form of **F** will be projected through the left-hand eye to point **K** in the common nerve. That same form projected through the right-hand eye will be end up at point **F** in the common nerve. Thus, **F** will be seen at two locations flanking the center of the common nerve, its respective forms having crossed paths at **G** in front of the center of the common nerve.

[22]This is just a special case of the situation in 2.22 above, the object now lying on one of the visual axes rather than between them; the essential result (i.e., image-doubling) is the same, however, and for essentially the same reasons

[23]The apparatus described in this paragraph is clearly modeled after the one described by Ptolemy in *Optics* III, 43, in Smith, *Ptolemy's Theory*, p. 147. A "digit" is approximately 3/4" (1.9 cm), and a cubit is approximately 1.5' (45.7 cm).

[24]2.12, p. 567 above.

[25]That is, the experimenter should take notice of everything on the plaque, not shift his gaze around to everything on it.

[26]The doubling of the images described here both for line **HZ** and for the visual axes **BC** and **AD** can be explained as follows on the basis of figure 3.9, which is taken from *P3* (f 121v). From the perspective of the eye at **B**, segment **HQ** of line **HZ** is seen along rays that lie to the right of axis **BQC**, so that segment will appear displaced to the right of point **Q**, the points toward **H** appearing more displaced than the points toward **Q**. Point **Q**, however, will appear at its actual location (see the discussion of Ptolemy's analysis of displacement in "Introduction," pp. xxxiv-xxxv above). On the other hand, according to the same eye at **B**, segment **QZ** will be seen along rays that lie to the left of axis **BQC**, so that segment will appear displaced to the left of **Q**, the points toward **Z** appearing more displaced than the points toward **Q**. Thus, **HZ** will appear at a slant along a line rotated counterclockwise toward **AD** on pivot-point **Q**. For the eye at **A** the situation will be reversed, so **HZ** will appear along a line rotated clockwise toward **BC** on pivot-point **Q**; see 2.44, pp. 576-577 above. Diagonal **BQC** will be seen from point **B** along visual axis **BC**, but from point **A** its lower segment **BQ** will be seen along rays to the left of **Q**, whereas its upper segment **QC** will be seen along rays to the right of **Q**. Hence, according to the eye at **A**, diagonal **BC** will appear along a line rotated counterclockwise toward **HZ**. Accordingly, from point **B** two images of **BC** will be seen, one right in line with **BC** itself, the other aslant to it and intersecting it at **Q**. So, too, diagonal **AD** will be seen double, one image appearing right in line with **AD** itself, the other aslant to it and intersecting it at **Q**; see 2.46, p. 577 above; cf. also Ptolemy, *Optics* III, 43-44, in Smith, *Ptolemy's Theory*, p. 147.

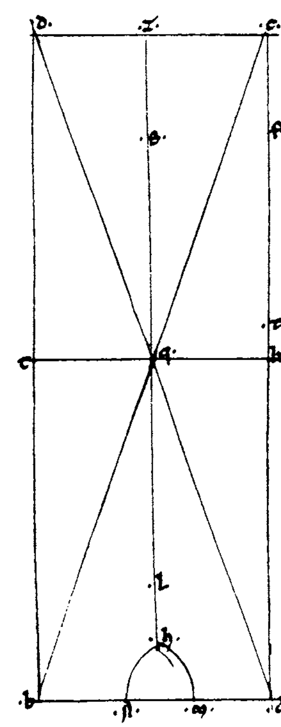

figure 3.9

[27]From **B** the peg at **L** will be seen to the right of **Q** along a ray that lies to the rightward of visual axis **BC**, whereas the peg at **S** will appear to the left of **Q** along

a ray that lies to the leftward of visual axis **BC**. Both pegs, however, will be seen rightward of visual axis **BC**, whereas the peg at **S** will appear to the left of **Q** along a ray that lies to the leftward of visual axis **BC**. Both pegs, however, will be seen along a single line that appears slanted in the same general direction as diagonal **AD** (as in 2.29 above). By the same token, from **A** the peg at **L** will be seen to the left of **Q**, the peg at **S** to the right of it, and both will be seen on a single line that appears slanted in the same general direction as diagonal **BC**.

[28]In figure 3.10, if one peg is placed at **L** and the other at **S** on visual axis **BC**, then, from point **B** both pegs will appear to coalesce at point **Q**. However, from

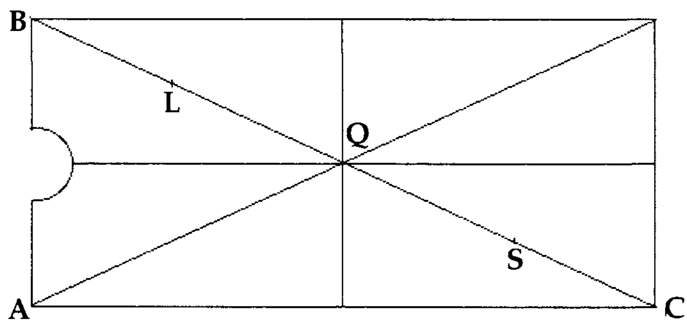

figure 3.10

point **A**, the peg at **S** will appear to the right of **Q** and the peg at **L** to its left. Thus, there will be four images, two of them coalescing at the center and two of them flanking that centerpoint.

[29]In figure 3.11, if **L** is placed on visual axis **BC** between **B** and **Q**, and if **S** is placed on visual axis **AD** between **A** and **Q**, then the peg at **L** will be seen by the eye at **B** in line with **Q**, and the peg at **S** will be seen by the eye at **B** to the right of **Q**.

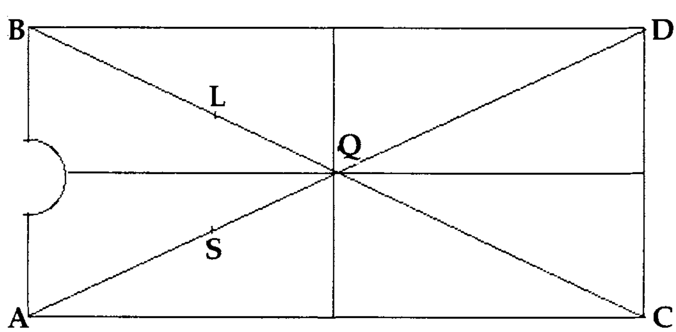

figure 3.11

From the eye at **A**, however, the peg at **S** will appear to lie in line with **Q**, whereas from the eye at **A** the peg at **L** will appear to lie to the left of **Q**. Hence, altogether there will be four images, two of them coalescing at the center and two of them flanking. According to Sabra's version, Alhacen goes on to include the third case, with the pegs placed on the two visual axes beyond point **Q** toward **D** and **C**, respectively, but this case is missing from the Latin version.

[30]That is, the two rays virtually coincide with the lines drawn on the plaque, so those lines, as represented in figure 3.8, can be taken as the rays themselves.

[31]See note 26, p. 633 above.

[32]Clearly, in this discussion Alhacen is not referring to the visual axes in their entirety, but only those segments between the eyes and centerpoint **Q**.

[33]The point here is that neither the diagonals nor the pegs placed on them will coalesce perfectly at the center (see notes 25 and 26, p. 633 above). Instead, they will overlap somewhat while still maintaining some slight lateral separation because they are seen not only along the axial rays, but also along neighboring noncorresponding rays. Hence, they come close to, but do not achieve, true convergence; for elaboration, see Sabra, *Optics*, vol. 2, pp. 124-127.

[34]7.24-25, pp. 605-606 above.

[35]The point here seems to be that there will be no apparent displacement through image-doubling.

[36]*P3* offers figure 3.12 on f 128r to illustrate this point. The text within the triangle reads: *Per hanc poterit explanari quod dicitur hic* ("On the basis of this [figure] what is said here can be explained"). On the right side of the figure (not shown here} there is an explanatory text in two parts. The first part refers to the top line, **CZ**, and reads as follows: *Hec linea ita est longa ut eius extremitas ita sit remota a medio ut lateat visible apud C, quoniam consideratio est apud extremum tabule: id est cum aspicitur Z* ("This line is long [enough] that its endpoint lies far [enough] from the center that the visible object at point **C** loses visibility, for the focus is on the edge of the table: that is, when **Z** is being looked at"). The second part refers to the middle line, **QK**, and reads as follows: *Hec linea est remota a medio ut lateat visible apud K quando consideratio est apud medium tabule. Remotiones autem radiorum exeuntium ab axe ad extrema sunt linee HK [et] HC, et est proportio ZC ad QK secundum proportionem CH ad KH* ("This line is far [enough] from the center that the visible object at **K** loses visibility when the focus is upon the middle of the table. Moreover, the lengths of the rays passing from the axis to the edges are lines **HK** [and] **HC**, and **ZC** : **QK** :: **CH** : **KH**"). We are thus left to infer that no matter how far away the object may lie (within reason) from **H** along **HZ** , as it moves laterally away from the center, its loss of visiblity is a function of the angle **ZBC** rather than of the actual linear distance it moves along **QK** or **ZC**.

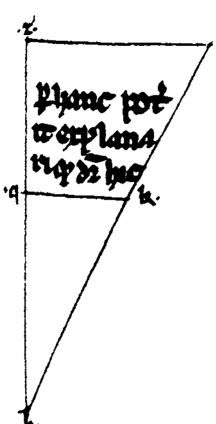

figure 3.12

[37]Here, and once more in this paragraph, the Latin term used is *imprimere* ("to impress" or "to imprint") rather than the usual *figere*; see note 95 to book 1, pp. 409-410 above.

[38]I, 2.21, in Sabra, *Optics*, vol. 1, p. 11.

[39]II, 3.57-59 and 4.20, pp. 444-445 and 521 above.

[40]III, 2.79, p. 586 above.

[41]III, 2.81, pp. 586-587 above.

[42]In this case it is not the object itself, but its defining form that goes unperceived. Without a clear apprehension of such defining forms, the visual faculty is unable to determine what the objects they represent actually are.

[43]This demarcation between 3.12 and 3.13 marks the shift discussed in "Manuscripts and Editing," p. clxviii above, between Latin version 1 (fairly literal) to Latin version 2 (paraphrase). For the sake of textual flow, I have remanded the transitional section from 3.13 (version 1) through 3.12 (version 2) to Appendix 1, pp. 642-651 above.

[44]The use here of *longitudo* instead of the previously used term *remotio* for "distance" seems to reflect the change in translators suggested in "Manuscripts and Editing," pp. clxviii-clxix above. Cf., however, II, 3.156, pp. 484-485 above. Note also the use of *elongatio* for "distance" in 5.4 et passim, as opposed to its previous usage as "distancing" or "drawing away" (see, e.g., II, 3.126, 3.143 and 3.180, pp. 471, 477-478, and 497 above).

[45]"Sense" is taken here broadly to include the entire perceptual apparatus—including the imagination, which serves as a mnemonic storehouse—involved in the visual process.

[46]Cf. Ptolemy, *Optics* II, 131, in Smith, *Ptolemy's Theory*, pp. 123-124, where the problem of distinguishing what is in motion is cast in terms of a boat anchored in a flowing river.

[47]II, 3.178-181, pp. 496-498 above.

[48]Ptolemy, too, subdivides visual illusion under three heads in his analysis of visual illusions in *Optics* II, 83-142, in Smith, *Ptolemy's Theory*, pp. 106-128. By his account, the first kind of illusion is due to physical circumstance (e.g., too much light or too much distance). The second kind, which is due to the visual faculty itself (i.e., the visual flux), includes diplopia and the oculogyral illusion. The third kind is subdivided into illusions that are essentially perceptual in origin (e.g., judging brighter objects to be closer than duller ones that subtend the same visual angle) and illusions that involve intellectual intervention (e.g., interpreting image-reversal in mirrors). Alhacen's subdivisions are somewhat different, in part because his theory of vision is not based upon the emission of visual flux by the eye. As a result, his overall explanation of visual perception entails considerably more psychological/intellectual intervention on the viewer's part than does Ptolemy's. Hence, the vast majority of visual illusions discussed by Alhacen involve the third subtype: illusions that arise during the process of deduction (*syllogismus*).

[49]The Latin term for "distance" here is *elongatio*; see note 44 above.

[50]I assume that there is an ellipsis at this point in the Latin text, and I have taken it upon myself to fill it with the phrase "so this error arises" in order to resolve the obvious contradiction that occurs without it.

[51]II, 3.19, p. 431 above.

[52]To "ascribe definition" in this context simply means to specify what something is; hence, to misascribe such definition is to err in such specification.

[53]Brunellus (or "Brownie") the ass is a stock figure, along with Socrates (*Sortes*), in the construction of various premises for the teaching of logic in the Latin Middle Ages; see, e.g., Norman Kretzmann, Anthony Kenney, and Jan Pinborg, eds., *The Cambridge History of Later Medieval Philosophy* (Cambridge: Cambridge University

Press, 1982), pp. 265 and 433.

[54]*Aluerach* is a Latin transliteration of the Arabic term for "firefly." See note 12 to book 1, p. 396 above.

[55]By "air" here and elsewhere in the text is meant the entire space between eye and object, so any disruption in it—by sheer cloth, intervening flames, vapors, or the like—that affects its ability to be seen through is imputed to the air, even though, strictly speaking, the disruption is due to an outside agent rather than to the air itself, whose inherent transparency remains unchanged.

[56]Cf. Ptolemy, *Optics* II, 130, in Smith, *Ptolemy's Theory*, p. 122.

[57]Although the point is not specified, the separation among trees referred to in this passage is along the line-of-sight, not lateral.

[58]Figure 3.13 is provided in ms *P3* (f 138r) by way, presumably, of illustrating the points made in 7.6 and 7.7.

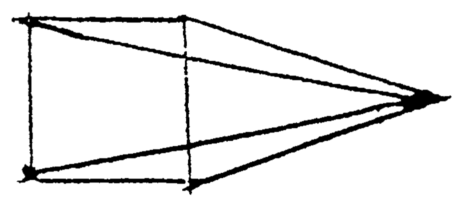

figure 3.13

[59]The explanation offered above is based on the fact that light- and color-radiation originates at individual spots, not points, on the object-surface under scrutiny. Those spots and the forms they generate thus have some breadth, and so do the lines of radiation along which they reach the surface of the eye. The visual angle under which any object is perceived is measured according to the rays bracketing the cross-section of that object, and those rays touch on the terminal spots at each end of that cross-section. Under normal circumstances, when the overall form of the object impressed on the *glacialis* occupies some perceptible area on it, the terminal spot-forms of that overall form are so small as to be negligible in the account of its size. When that overall form is tiny to begin with, however, those spots are relatively sizeable. Thus, when they are ignored, as they are under normal circumstances, a sizeable portion of the overall form is thrown out of the account. The resulting perception of size is thereby deficient by that amount, so the area on the *glacialis* occupied by the overall form will be adjudged smaller than it actually is; see 7.23, pp. 604-605 above.

[60]II, 3.141-146, pp. 476-479 above.

[61]II, 3.76-77, pp. 451-452 above.

[62]See note 59 above.

[63]Figure 3.14, taken from *P3* (f 140r), illustrates an inordinately large visual angle with respect to the distance of the object at the ends of the rays extending out from

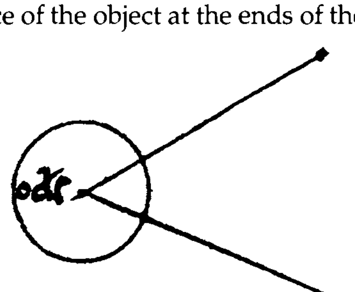

figure 3.14

the eye (*oculus*).

[64]For Ptolemy's roughly equivalent account of this illusion, see *Optics* II, 99, in Smith, *Ptolemy's Theory*, p. 111.

[65]III, 4.7-8, pp. 594-595 above. Ms *P3* offers figure 3.15 on f 140v to illustrate the example of the moon (*luna*) appearing to move through the clouds (*nubes*).

figure 3.15

[66]II, 3.178, p. 496 above

[67]Here, at last, Alhacen explicitly mentions illusionism in painting but offers no account of how it is in fact achieved by artists nor pursues its implications. This is surprising for three reasons. First and foremost is that even the most rudimentary knowledge of the principles of chiaroscuro makes it evident that the interplay between light and shadow provides invaluable clues about such surface-shapes as concavity and convexity as well as about slant and the like. Second, Ptolemy actually discusses such illusionism and explains in a general way how it is achieved; see, e.g., *Optics* II, 127-128, in Smith, *Ptolemy's Theory*, pp. 121-122. Finally, it is clear that Alhacen understood the basic principles of color-perspective insofar as he was aware that a given object appears brighter and more vividly colored at a close distance than it does at a farther one; see, e.g., II, 3.159, p. 486 above and III, 7.250-251, p. 625 above; cf. Ptolemy, *Optics* II, 124., in Smith, *Ptolemy's Theory*, p. 120. Despite his knowledge of these principles, Alhacen was no more forward than Ptolemy in applying them to his account of spatial perception.

[68]II, 3.189-191, pp. 500-501 above.

[69]7.24-25, pp. 605-606 above.

[70]In chapter 6 of the seventh book of the *De aspectibus* (see Risner, *Opticae thesaurus*, pp. 269-270). Alhacen's explanation there is based on the supposition that point-forms from the occluded portion of the wall reach the surface of the eye along rays that are slightly inclined to that surface yet close enough to the orthogonal to make a sensible impression on it. Thus, the needle is seen according to the orthogonal rays emanating from it while, at the same time, the wall behind it is seen according to the almost imperceptibly inclined rays emanating from it.

[71]See II, 3.80, p. 453 above.

[72]Idem.

[73]2.21 and 2.31, pp. 572 and 575 above.

[74]See Ptolemy, *Optics* II, 132, in Smith, *Ptolemy's Theory*, p. 124, for this same example of misattributed motion.

[75]As Alhacen observes in II, 3.202, p. 504 above, even with its distinguishing marks, the moon is still beautiful, though presumably less so than it would be without them.

[76]II, 3.189-191, pp. 500-501 above.

[77]Two quite distinct (indeed, contradictory) things seem to be confused in this passage: being unable to see an exquisitely transparent body at all and being able to see a transparent body but unable to perceive its slant.

[78]Presumably a hexagon (which has six vertices or "corners") is intended here, although, judging by Sabra's version of this passage, the Latin translator confected this example on his own.

[79]According to Sabra's version (see *Optics*, vol. 1, p. 334), the reason the crystal body appears to move is that, being exquisitely transparent, it cannot actually be seen, so it will not be distinguished from the moving object behind it; cf. II, 3.195, pp. 502-503 above.

[80]The phrase *ab ea recedat* makes no sense in this context. According to Sabra's version (see *Optics*, vol. 1, p.p. 334-335), the transparent object in question is spherical. Hence, when it is rotated within the hand, its rotation will be undetected because of the homogeneity of its structure and transparency.

[81]In the seventh chapter of book 7 of the *De aspectibus*, Alhacen discusses the magnification of images that is caused by refraction when the object is placed in an optically denser medium than the viewer; see esp. Risner, *Opticae thesaurus*, pp. 271-272. Under the circumstances described in this passage, the viewer would have to stand in a portion of air that is less hazy (and thus less optically dense) than the portion of air occupied by the object that supposedly appears larger.

[82]On its face, the rationale offered here for the perceiver's inability to distinguish the difference in velocity has nothing to do with the air's lack of transparency; after all, why should air make distance imperceptible? In Sabra's version (*Optics*, vol. 2, pp. 342-343), the situation Ibn al-Haytham describes involves two objects moving toward the eye at slightly different speeds, Ibn al-Haytham offering as an example one horseman overtaking another in a chase. Accordingly, if the air is foggy or dusty, he continues, the difference in their speeds will be undetectable because the intervening ground, which provides the natural reference-frame for judging distance and its change, cannot be seen. The failure of the Latin text to capture the proper sense of Ibn al-Haytham's account is due to the extraordinarily abbreviated nature of the Latin translation, a problem that recurs throughout this chapter of the book.

[83]II, 3.185, p. 499 above.

[84]Cf. Ptolemy, *Optics* II, 96 and 98, in Smith, *Ptolemy's Theory*, pp. 109-111.

[85]The sense of this rather confused passage seems to be that, when the light that is seen behind a transparent body strikes that body at a slant, the body will look less transparent than it actually is because, as Alhacen establishes at the very beginning of chapter 7 of the seventh book, refraction weakens light and color. Presumably, then, since the slanted light will be refracted, and thus weakened, before it reaches the eye, the medium through which it passes will seem less transparent than it would if the light were to pass through along orthogonal rays, which are the most dynamically effective; see note 64 to book 1, pp. 404-405 above.

[86]Here, again, is a clear indication that Alhacen was aware of color-perspective; see note 67, p. 638 above.

[87]This explanation of the oculogyral illusion on the basis of inertial swirl is essentially the same as that provided by Ptolemy in *Optics*, II, 121, in Smith, *Ptolemy's Theory*, pp. 119-120.

[88]The dissimilarity of parts in this case is presumably a function of the disparity among spokes as well as between spokes (discontinuous) and rim (continuous). Accordingly, as Alhacen points out later in the passage, such disparities will keep the spinning wheel from looking perfectly homogeneous and motionless, although the individual elements (i.e., spokes and rim) of the wheel will not be properly perceived as such.

APPENDICES

APPENDIX ONE

[3.13] Et etiam visus, cum fuerit lesus, aut accidet ei aliquod accidens transmutans . . . .

. . . . et ex hoc quodcumque sumatur viso punctum **K**.

[2.53] Non per axem comprehendatur, sed per radium videtur axi communi fixo propinquius loco vero. Cum enim appareat continuitas puncti visi ad punctum super quem cadit axis et discernatur quantitas spatii interiacentis, punctum autem in quo cadit axis videatur propinquior axi fixo quam sit, videbitur punctum sumptum propinquius eidem quam sit.

[2.54] Et quoniam modicum est illius propinquitatis augmentum, et non sentitur in omnibus visis corporibus, non mutatur propter hoc insensibile situs corporum respectu visus.

[2.55-259] Amplius sumantur tria folia pargameni modica, et ponat unum in loco **Q**, et aliud in loco **K**, tertium in loco **T**, et in unoquoque eorum sit aliquid scriptum. Certior erit siquidem comprehensio scripture folii **Q** quam folii **T** vel **K**, et si folium **T** vel **K** accedit ad **Q**, quanto plus accesserit scriptura eius certior apparebit. Si autem folium **T** vel **K** elongatur a **Q** super lineam **TQK** extra tabulam, minor erit scripture verificatio.

[2.60] Clauso enim uno oculo, quecumque dicta sunt in globis cereis patebunt in foliorum scripturis.

[2.61] Palam ergo propter hoc in uno visu sive in duplici inspiciatur manifestissimum est illud cui occurret axis, nec erit verificatio forme corporis nisi super ipsum axis incedat.

[2.62] Amplius, si sumatur folium latitudinis quattuor digitorum, et in eo aliquid scribatur latitudinem folii tenens, et

1 aut: ad *S; om. FP1VatV2*   3 *post* et *add.* est *O*/*post* sumatur *add.* in corpore *O*   5 communi fixo: confixo *O*   6 continuitas: concavitas *FP1VatV2*   8 sit *corr. ex* si *O*   10 propinquitatis *corr. ex* propinquitas *F*/augmentum (11): *corr. ex* augmenta *SVat*   11 non *om. O*/visis *corr. ex* visibus *P1*   12 insensibile: insensibilia *O*/*post* respectu *scr. et del.* sit *Vat*   14 ponat: ponatur *O*/K: E *O*   15 erit siquidem (16) *transp. FVatV2*/siquidem (16) *om. P1*   16 *post* folii *scr. et del.* quinque *F*/Q: quasi *V2*/K: E *O*/et . . . K (17) *om. VatV2*   17 K: E *O*/accedit: accidit *FOP1VatV2*/accesserit: accessit *O*   18 *post* folium *add.* (??) *O*/K: E *O*/elongatur: elongetur *O*   19 TQK: TQE *O*/verificatio (20): certificatio *FP1VatV2*   23 *post* hoc *add.* quod sive *O*   24 inspiciatur . . . cui: inficiatur quod *O*/nec . . . axis (25) *om. VatV2*   27 aliquid: aliquod *P1*/aliquid scribatur *transp. OP1VatV2*/latitudinem *corr. ex* latitudine *O*

[3.13] Moreover, when the eye is injured, or something happens to it that changes. . .

[1]. . . . and on this visible object let some point **K** be taken.

[2.53] It should not be perceived along the axis, but it is seen by a ray nearer to the actual location [of the object] than the fixed common axis. For if the point that is seen appears continuous with the point to which the axis falls, and if the size of the gap between them is discerned, but the point to which the axis falls appears to lie closer to the fixed [common] axis than it is, then the chosen point [**K**] will appear to lie closer to that axis than it actually does.

[2.54] But since the increase in its closeness is very slight, and since it is not sensed in the case of every visible body, the spatial disposition of the bodies with respect to the eyes is not changed by this imperceptible [amount].

[2.55-259] Furthermore, let three small sheets of parchment be taken, and let one of them be placed at **Q**, another at **K**, and the third at **T**, and let something be written on each of them. The writing on sheet **Q** will certainly be clearer than that on sheet **T** or [sheet] **K**, but if sheet **T** or [sheet] **K** approaches **Q**, then the closer it gets, the clearer the writing on it will appear. On the other hand, if sheet **T** or [sheet] **K** is moved away from **Q** and beyond the plaque along line **TQK**, its writing will become less definite.

[2.60] In fact, if one eye is closed, everything that was described in the case of the balls of wax will also be revealed in the case of the writing on the [parchment] sheets.

[2.61] From this it is therefore evident that, whether it is viewed through one eye or through both, an object upon which the [visual] axis falls is [seen] most clearly, and the form of a body will not be distinct[ly perceived] unless the visual axis falls upon it.

[2.62] Furthermore, if a sheet [of parchment] four inches wide is taken, and something is written along its width, and if it is applied

[1]This marks the start of version 2 (paraphrase) of the Latin text. The fact that it starts in *medias res* with a recapitulation of chapter 2 from 2.53 on seems to indicate that, for at least awhile, translator 2 worked in parallel with translator 1 before taking over on his own. If so, then perhaps he was practicing here. Whatever the case, when this portion of version 2, from 2.52 through 3.12, is compared to its counterpart in version 1 (pp. 271-290 above), several things become evident. First and most obvious is how abbreviated version 2 is both by ellipsis within given passages and by the omission of entire swatches of text. Thus, 2.67-2.79 and 2.84-2.86 of version 1, pp. 278-282 and 284-285 above, are missing entirely from version 2.

linee **TQK** directe amplectetur, certior apparebit scriptura que circa **Q** erit quam si remota fuerit.

[2.64] Si autem paululum declinetur folium super lineam **AQD**, minor erit scripture eius cuiusque verificatio, et secundum maioritatem declinationis erit minoritas verificationis. Et semper hec minoritas augmentabitur donec folium linee **AQD** applicatur.

[2.65] Idem penitus videbit si oculum clauseris unum. Si vero applicetur folium linee **TQ**, tantum inspecto **Q**, cadent axes super folii terminum, et eo declinato in hoc situ, minor erit scripture certitudo; similiter si fiat visus tantum cum uno oculo. Pari modo, si non recedat folium a linea **TQK** sed super ipsam declinata incumbat, erit certitudinis debilitatio. Idem accidet si folium linee **DZC** applicetur aut propinquiori aut remotiori tamen linee **TQK** equidistanti et super eam declinetur.

[2.66] Per hoc planum quod, sive in uno visu sive in duplici, certior comprehendetur forma corporis quod occurrerit visui erectum quam concursus axium.

[2.80] Quare autem in corpore multum declinato non accidit forme verificatio que quidem accideret si corpus erectum occurreret, sed in longitudine temperata comprehendatur magnitudo ipsius declinati sicut et recti, hec est ratio. Forma declinati in strictorem cadit oculi partem quam erecti propter angulum visus minorem.

[2.81] Unde partes minute illius forme incidunt in minutissimas oculi partes que propter sui parvitatem sensui imperceptibiles abscondunt sensui et se ipsas et partes forme receptas. Partes vero corporis quod rectum occurrerit visui cadunt in partes sensibiles oculi propter magnitudinem anguli, unde fit earum certitudo sensui.

28 TQK: TQE *O*/*post* directe *scr. et del.* am *Vat*/amplectetur: amplicetur *O*; *corr. ex* amplectebatur *P1* 29 si: in *S* 30 paululum: paulatim *FP1VatV2* 31 AQD: AQZ *O* 33 AQD: TQZ *O* 35 idem: item *P1VatV2*/si oculum *rep. V2* 36 TQ: EQ *O*/Q: quasi *V2* 37 *post* axes *scr. et del.* super *F*/folii *corr. ex* folium *Vat* 38 certitudo *corr. ex* certificatio *Vat* 39 *post* recedat *scr. et del.* super *Vat*/TQK: TQE *O*/ super *mg. F* 40 certitudinis *corr. ex* certudinis *S* 41 accidet: accidit *V1*/linee *inter. O*/DZC: DZQ *O*; DZS *P1* 42 TQK: TQE *O* 45 occurrerit: occurruerit *O*; occurrerint *SVatV2*; *corr. ex* occurrerint *F* 46 erectum *corr. ex* rectum *O*/*post* quam *add.* quod occurrit declinatum sive in ipsum cadat sive non *O*/ concursus *corr. ex* cursus *P1* 47 quare *corr. ex* quando *F*/*post* declinato *scr. et del.* capite *S* 48 *post* forme *scr. et del.* multum *P1*/erectum: rectum *OS* 49 sed: licet *OS*/temperata: separata *FP1SVatV2* 50 recti: erecti *V1*/*post* hec *add.* autem *P1*/ est *om. P1* 51 *post* quam *scr. et del.* eius *O*/erecti *corr. ex* recti *O* 54 partes: partem *V2* 55 abscondunt: absconderunt *Vat*

directly along line **TQK**, the writing at **Q** will appear more definite than it would if it were farther [from it].

[2.64] Moreover, if the sheet is slightly inclined on line **AQD**,[2] any of the writing on it will appear less distinct, and the decreasing distinctness [of the writing] will be a function of the increasing inclination [of the sheet]. This decrease [in distinctness] will invariably intensify until the sheet coincides with line **AQD**.

[2.65] Precisely the same thing will be seen if you close one eye. If, however, the sheet is applied along line **TQ** while only **Q** is looked at, the [visual] axes will fall on the edge of this sheet, and if it is inclined at that spot, the writing [on it] will appear less definite; and the same holds if sight occurs with one eye only. By the same token, if the sheet is not drawn away from line **TQK** but is placed at a slant to it, there will be a decrease in the definiteness [with which the lettering is seen]. The same thing will happen if the sheet is placed on line **DZC**, or on a line nearer to it or farther from it and parallel to line **TQK**, and if it is inclined to that line.

[2.66] From this it is obvious that, whether [it is viewed] with one or with two eyes, the form of a body that stands directly facing the eye and that has the [visual] axes intersecting upon it will be perceived more clearly [than one that does not meet these criteria].

[2.80] The following explains why the form of a body that is sharply slanted does not appear definite, whereas it would if the body faced the eye directly, and why the magnitude of that same slanted body is perceived correctly, as it [would be if it] faced [the viewer] directly, at a moderate distance. The form of an inclined body is projected on a narrower area of the eye than [the form of] a body that faces the eye directly because the [visual] angle [under which it is seen] is smaller.

[2.81] Hence, the small parts of that form are projected on infinitesimal parts of the eye, and since they are imperceptible to sense because of their smallness, these parts, in and of themselves, as well as the parts of the form impressed on them, are invisible to the sense [of sight]. On the other hand, the parts of a body that faces the eye directly are projected on perceptible areas of the eye because of the size of the [visual] angle [under which they are seen], so they are

Second is the relative ineptitude of translator 2, whose Latin is less felicitous (and commensurately harder to follow) than that of translator 1. Third is the apparent failure of translator 2 to understand the point of certain passages and, therefore, to misinterpret, or at least misrepresent, the basic intent of those passages.

[2]Or, more properly, line **TQK**; see figure 3.8, p. 264 above.

[2.83] Magnitudo autem corporis declinati non tantum secundum capacitatem anguli percipitur et consideratur sed, sicut dictum est, per angulum et longitudinis radii et etiam situs estimationem.

[CAPITULUM 3A]

De modis quibus error accidit visui

[3.1] Declaratum est in libro primo quod, ad hoc ut formas corporis visi directe visus comprehendat, necessaria est quorumdam aggregatio que sunt: longitudo; oppositio; lux non multum debilis; soliditas corporis; magnitudo eiusdem; raritas intermedii aeris. Si enim assuerit alicuius horum defectus, non erit visus.

[3.2] Planum est etiam ex libro secundo quod nichil penitus potest visus comprehendere ex corporibus nisi in tempore. Tempus igitur est unum eorum que necessaria sunt ad hoc ut fiat visus.

[3.3] Similiter infirmitas oculi impedit visum, quare sanitas est unum necessariorum.

[3.4] Amplius iam explanatum est in parte precedenti quod corpus multum elongatum ab axe occultatur visui, et si multum tunc fuerit declinatum, non plene comprehendetur. Necessarius est ergo situs ad complementum visus cum non plena fiat comprehensio nisi in situ determinato.

[3.5] Sunt igitur octo necessaria scilicet ad operationem visus, velut: situs, remotio, lux, magnitudo corporis, soliditas, raritas aeris, tempus, sanitas visus.

[3.6] Et quodlibet istorum latitudinem habet proportionatam ad rem visam. Verbi gratia, corpus aliquod ab aliqua distantia plene comprehenditur, ab alia non plene. Inter illas est via lata in qua erit plena comprehensio corporis illius que via

59 corporis *mg. O*/tantum: tamen *VatV2* 60 percipitur *inter. O*/et *om. O* 61 sicut *om. FP1VatV2*/*post* angulum *add.* (??) *O* 1 *ante* de *add.* pars tertia *S* 2 ut: quod *EP3* 3 necessaria: necessarie *P3*/quorumdam (4): quarumdam *Er* 4 *post* longitudo *add.* lux *P1S* (*scr. et del. S*) 8 etiam: et *P3*/penitus *om. C1EErL3P3R* 10 unum *corr. ex* unus *P3* 12 *ante* similiter *add.* et *C1L3*/infirmitas *corr. ex* inut *Er*/quare . . . unum (13) *inter. a. m. S* 13 est: erit *C1EErL3P3R* 14 iam: autem *C1EL3P3*/precedenti: praecedente *R* 15 occultatur: occultabatur *S* 17 est ergo *transp. R*/ad *inter. L3*/cum *corr. ex* tunc *P1* 18 *ante* nisi *scr. et del.* fiat *Er*/nisi *inter. L3; corr. ex* visi *a. m. C1* 19 igitur: ergo *R*/*post* octo *scr. et del.* n *Er*/scilicet *om. ErP1RS*

made clear to the sense [of sight].

[2.83] The size of the inclined body, however, is not perceived and evaluated according to the size of the [visual] angle alone but, as has been said, according to the angle along with the length of the ray as well as the judgment of spatial disposition.

[CHAPTER 3A]

Concerning the ways in which sight happens to err

[3.1] It has been shown in the first book that, in order for the forms of a visible body that is directly seen by sight to be perceived, certain conditions must be met as a whole, i.e.: [there must be] spatial separation [between eye and object]; [the object must] face [the eye]; [there must be] light that is not too weak; the body [must possess some] opacity; the body [must possess some] size; and the intermediate air [must] be transparent. For if any of these is lacking, sight will not occur.

[3.2] In addition, it is obvious from the second book that sight can perceive no body whatever except over time. Thus time is one of those conditions that must be met in order for sight to take place.

[3.3] Likewise, a disease of the eye hinders sight, so a healthy eye is one of those requisite conditions.

[3.4] Furthermore, it has already been explained in the preceding section that a body that lies extremely far from the [visual] axis is hidden from sight, and if it is sharply inclined, it will not be perceived clearly. Thus, a [proper] spatial disposition is needed for perfect sight, since perception is not clear except according to a particular spatial disposition.

[3.5] Eight things are thus specifically needed for sight to operate [properly], i.e.: [a proper] spatial disposition, distance, light, bulk, opacity, transparency in the air, time, and a healthy eye.

[3.6] Moreover, each of these has a range that is proportionate to the visible object. For instance, a given body at a certain distance is clearly perceived, whereas at another it is not. There is a wide range between these [limits] within which that body will be clearly perceived, and this is the range of distances suited to [the perception

20 velut: longitudo *C1EErL3P3R*/remotio *om. C1EErL3P3R* 24 *ante* plene *scr. et del.* distantia *L3*/*post* illas *add.* distantias *R* 25 via lata: latitudo magna *R*/erit: fit *R*/plena *om. S*/ corporis illius *transp. R*/via^2 *om. R*

est latitudo longitudinis respectu tanti corporis, et secundum quod maius fuerit corpus, maior erit latitudo distantie eius.

]3.7] Pari modo, cum magna fuerit corporis alicuius declinatio, non comprehendentur note vel particule que sunt in eo. Si autem in eadem declinatione videatur corpus in quo maioris quantitatis note vel partes minus minute fuerint comprehenduntur. In minori autem declinatione corporis primi videbuntur eius minutie. Inter has declinationes sunt multe in quibus apparebunt note. Similiter corpus parvum circa axem situm videtur, multum elongatum occultatur, et in eadem elongatione corpus maius videbitur. Palam ergo quod situs habet latitudinem proportionatam ad corporis magnitudinem et minutias eiusdem.

[3.8] Lucem planum est habere latitudinem. Fortitudo enim lucis, cum magna fuerit, obfuscat apparentiam corporis, et similiter fortis eiusdem debilitas. Sed erit corporum apparentia in lucibus intermediis. Preterea in luce aliqua quedam partes corporis comprehenduntur, et in eadem luce alie minutissime absconduntur que in luce maiori viderentur. Est igitur latitudo lucis proportionata ad magnitudinem corporis.

[3.9] Magnitudo corporis habet latitudinem. Si enim partes rei vise non fuerint proportionales totali, occultabuntur visui. Si vero sint proportionales, et corpus totale fuerit modicum, abscondentur; unde in avibus minutis particulas aliquas non percipimus etiam proportionales eis. Si autem magnum fuerit corpus visum et partes eius proportionales, non latebunt in tantum. Est igitur latitudo magnitudinis rei vise proportionata ad totale corpus cuius pars fuerit.

[3.10] Soliditas habet latitudinem proportionatam ad rem visam. Si enim in corpore aliquo color acutus fuerit, licet pauce soliditatis, videri poterit, quod eadem soliditate manente non

26 *post* longitudinis *add.* in *C1L3* 27 maius *corr. ex* magis *P1* 28 corporis *corr. ex* corpus *S* 29 comprehendentur: comprehendetur *P1* 30 quo: qua *P1S* 31 vel: in *Er*/*post* partes *add.* et *P1*/*post* minute *add.* et *S*/comprehenduntur (32): comprehendentur *EP3R* 32 videbuntur *om. Er* 33 minutie: minute *L3*/*post* minutie *add.* et est *R*/declinationes: declarationes *Er*/sunt . . . note (34): latitudo *R*/*post* multe *add.* declinationes *C1L3* (*inter. L3*) 34 note *om. EP3*/parvum: unum *P3* 35 elongatum *corr. ex* elongantum *P1*/elongatum occultatur *transp. EP3* 36 corpus maius *transp. P1S*/ergo: igitur *P1* 37 proportionatam *corr. ex* proportionata *P3*/corporis: corpus *S* 38 eiusdem: eius *C1EL3P3R* 40 lucis: lucium *EL3P3* 41 fortis: etiam *R*/sed: et *C1L3* 42 *post* in[1] *add.* pluribus *C1L3*/lucibus: lucidis *P3*; *corr. ex* lucidis *a. m. E*/partes: particule *C1* 43 comprehenduntur: comprehendentur *C1EL3P3* 44 igitur: ergo *R* 45 lucis: lucem *Er* 47 *ante* rei *scr. et del.* ita *C1*/rei *a. m. C1* 48 sint: fuerint *C1R*; sunt *P1S*/et *corr. ex* ad. *C1*

of] such a body, so the larger the body is, the wider the range of distances [within which it will be properly perceived].

[3.7] By the same token, when a body is sharply inclined, its distinguishing marks or small parts will not be perceived. However, at the same inclination one may see a body whose distinguishing marks are larger or whose small parts are not so small, [and so those marks or parts] are perceived. Moreover, if the first body's inclination is not so sharp, its small features will be seen. Between these inclinations there are many according to which the distinguishing marks will be seen. Likewise, a small body lying at the [visual] axis is seen, [whereas] when it lies far away [from the visual axis] it becomes invisible, but at the same distance [from the axis] a larger body will be seen. It is therefore evident that spatial disposition has a range that is proportionate to the size of the body and its small features.

[3.8] It is obvious that light has a range. For the intensity of light, when it is great, renders a body obscure, and, like intensity, feebleness of light [also renders a body invisible]. But bodies will be visible in light of intermediate gradations. Moreover, in a given light certain [small] parts of a body are perceived, whereas in the same light other tiny features that would be seen in brighter light are invisible. For light, then, there is a range that is proportionate to the size of the body.

[3.9] The size of a body has a range. For if the parts of a visible object are not proportionate to the whole, they will be invisible to sight. Moreover, if they are proportionate [to the whole], but the whole body is small, they will be invisible; accordingly, in small birds we do not perceive certain minute parts, even though they are proportionate to the birds [as a whole]. If, however, the body that is seen is large, and its parts are proportionate, they will not be invisible to such an extent. There is thus a range of sizes for the [part of a] visible object that is proportionate to the whole body of which it is a part.

[3.10] Opacity has a range that is proportionate to the visible object. For if the color in some body is bright, even though the body may be [only] slightly opaque, the body can be seen, whereas ifthe body retained the same opacity, this would not happen if its

49 *ante* abscondentur *add.* adhuc *R*/abscondentur: abscondetur *P1R*/in *inter. a. m. Er*/avibus *corr. ex* navibus *L3*/*post* avibus *add.* et animalibus *P1RS* (et: vel *S*) 50 etiam: et *P3*; licet sint *R*/eis: eius *EErL3P3*; *corr. ex* eius *C1* 51 eius: ei *Er*; *om. P1*/in tantum (52): usque ad eo *R* 52 latitudo *corr. ex* latitudin *P1* 53 totale corpus *transp. P1S*/fuerit: fuit *C1* 54 *post* soliditas *add.* autem *P3R* 55 acutus fuerit *transp. P3*

accideret si color esset obtusus. Raritas aeris habet latitudinem. Si enim visui et scripture interponatur aer parum solidus, ut flamma vel fumus, scriptura non discernetur; pargamenum tamen videbitur. Et sic in huiusmodi est igitur proportionata hec latitudo secundum visa.

[3.11] Tempus habet latitudinem. Si quis enim per foramen inspiciet corpus quod statim transeat, non percipietur.

[3.12] Similiter motus troci, quia velocissimus in tempore multum parvo, non attenditur. Similiter in motis accidit multum parvo motu.

58 et: in *P1* 59 flamma *corr. ex* flammas *S* 60 videbitur: videtur *C1L3*/huiusmodi *corr. ex* huius *a. m. S*/*post* huiusmodi *add.* alijs *R*/igitur: ergo *R* 63 inspiciet: inspiciat *P1R*/quod *om. S*/transeat *om. Er* 64 quia *om. P1S* 65 in . . . accidit: accidit in motis *C1ErL3P3R*/motis: motu *EP3R*; moto *Er*; *alter. ex* motu *in* moto *L3* 66 *post* parvo *scr. et del.* non attenditur *P3*/motu *om. EErL3P3R*

color were dull. The transparency of air has a range. For if air that is not particularly opaque, such as flame or smoke, is interposed between the eye and writing, the writing will not be perceived; yet the parchment [on which it is written] will still be seen. In such a case, therefore, the range [of transparency of the air] is proportionate to what is seen.

[3.11] Time has a range. For if somone looks through a window at a body that passes by in a flash, the body will not be [properly] perceived.

[3.12] The same holds for the motion of a top, which, being extremely swift and occurring in a small amount of time, is not noticed. The same happens in the case of moving objects that move quite slowly.

APPENDIX 2

This appendix consists of a complete listing of divisions, by chapters and subchapters, for all seventeen manuscripts as well as for the Risner edition (*R*). The incipits for all of the chapter-heads or subheads to be found in these eighteen exemplars are listed at the top of each table. For books 1-3, the location of each incipit is given by paragraph number in the critical Latin text. For books 4-7 that location is given by page-number in the Risner edition. Below each listing is a tabulation for every exemplar, chapter-by-chapter, or subdivision-by-subdivision. An "x" indicates the presence of that chapter in that particular exemplar. Parentheses around the "x" indicate a weak demarcation in the given text. Table 8, finally, groups the manuscripts according to the divisions and subdivisions they have in common.

TABLE 1

BOOK I: Chapter Divisions

1	Invenimus visum quando inspexerit	(4.1)
1a	Et invenimus etiam inspicientem	(4.6)
2	Et etiam videmus stellas in nocte	(4.8)
2a	Et iterum quando aspiciens aspexerit	(4.11)
3	Et iterum visui multotiens latent	(4.18)
4	Et iterum invenimus multa corpora	(4.20)
5	Et cum luces fortes visibilium occultent	(4.27)
6	Oculus autem est compositus ex telis	(5.1)
7	Iam declaratum est superius quod	(6.1)
8	Tunice quas diximus in declaratione	(7.1)
9	Iam ergo declaratum est superius quod	(8.1)

	CH1	CH1a	CH2	CH2a	CH3	CH4	CH5	CH6	CH7	CH8	CH9
S	x	.	x	.	x	x	x	x	x	x	x
P1	x	.	x	.	x	x	x	x	x	x	x
LE3	----------section missing----------									x	x
PE	x	.	x	.	.	x	x	x	x	x	x
Er	x	.	x	.	x	.	x	x	x	x	x
C1	x	.	x	.	x	.	x	x	x	x	x
E	x	.	x	.	.	x	x	x	x	x	x
R	x	.	x	.	.	x	.	x	x	x	x
O	x	.	x	.	x	.	x	x	x	x	x

L1	x	.	x	.	x	.	x	x	x	x	.
L2	x	x	x	x	.	x	x	x	x	x	x
C2	x	.	x	.	x	x	x	x	.	x	x
P2	x	.	x	.	.	x	x	x	.	x	x
M	x	.	x	.	x		x	x	.	x	x
F	---------- section missing ----------										x
V1	x	.	x	.	.	x	.	x	x	x	x
V2	x	.	x	.	x	x	x	x	x	x	x
Vat	x	.	x	.	x	x	x	x	x	x	x

TABLE 2A

BOOK II: Chapter Divisions

1	Declaratum est qualiter fiat visio	(1.1)
2	Iam declaratum est in primo tractatu	(2.1)
3	Sensus quidem visus nichil comprehendit	(3.1)
3a	Et cum declarata sint omnia ista	(3.43)
4	Iam declaratum est quomodo visus	(4.1)

	CH 1	CH 2	CH 3	CH 3A	CH 4
S	x	x	x	.	x
P1	x	x	x	.	x
L3	x	x	x	.	x
P3	x	x	x	x	x
Er	x	x	x	.	x
C1	x	x	x	.	x
E	x	x	x	x	x
R	x (prol.)	x (ch. 1)	.	x (ch. 2)	x (ch. 3)
O	x	x	x	.	x
L1	x	x	x	.	.
L2	x	x	x	x	x
C2	x	x	x	.	.
P2	x	x	x	x	x
M	.	x	x	.	x
F	x	x	-------- missing --------		x
V1	x	(x)	x	.	x
V2	x	x	x	.	x
Vat	x	x	x	.	x

TABLE 2B

BOOK II: Subdivisions in Chapter 3

1	Et cum declarata sint omnia ista	(3.43)
2	Sed remotio rei vise a visu non	(3.67)
3	Situs vero quem visus comprehendit	(3.94)
4	Corporeitas vero, que est extensio	(3.121)
5	Figura autem rei vise dividitur in duo	(3.127)
6	Magnitudo vero et quantitas rei vise	(3.135)
7	Distinctio vero que est inter visibilia	(3.172)
8	Continuatio autem comprehenditur	(3.175)
9	Numerus vero comprehenditur a visu	(3.177)
10	Motus autem comprehenditur a visu	(3.178)
11	Quies autem comprehenditur a visu	(3.188)
12	Asperitas vero comprehenditur a visu	(3.189)
13	Planities autem est equalitas superficiei	(3.192)
14	Diafonitas autem comprehenditur	(3.195)
15	Spissitudo comprehenditur a visu	(3.197)
16	Umbra vero comprehenditur a visu	(3.198)
17	Obscuritas vero comprehenditur	(3.199)
18	Pulcritudo comprehenditur a visu	(3.200)
19	Turpitudo vero est forma carens	(3.232)
20	Consimilitudo autem est equalitas	(3.233)
21	Diversitas autem comprehenditur	(3.234)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
S	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
P1	.	.	.	x	x	x	.	.	.	x	.	.	.	x	.	.	.	.	.	.	.
L3	.	x	.	x	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
P3	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Er	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
C1	.	.	.	.	.	.	.	x	x	x	.	.	.	.	.	.	.	.	.	.	.
E	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
R	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
O	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
L1	.	x	.	x	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
L2	x	x	x	x	.	x	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x
C2	.	x	.	x	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
P2	x	x	x	x	x	x	x	.	.	x	x	x	x	x	x	x	x	x	x	x	x
M	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F	------missing section------																				
V1	.	(x)	.	(x)	(x)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
V2	.	.	.	x	x	x	.	.	.	x	.	.	.	x	.	.	.	.	.	.	.
Vat	.	.	.	x	x	x	.	.	.	x	.	.	.	x	.	.	.	.	.	.	.

TABLE 3A

BOOK III: Chapter Divisions

1	Declaratum est in primo tractatu	(1.1)
2	Declaratum est in primo tractatu	(2.1)
3	Declaratum est in ipso primo tractatu	(3.1)
3a	Declaratum est in libro primo quod	(Appendix 1)
4	Planum est ex libro secundo quod	(4.1)
5	Ex predictis palam quod non est	(5.1)
6	Dictum est in libro secundo quod	(6.1)
7	Plurima eorum quorum in visu sit	(7.1)

	CH1	CH2	CH3	CH3A	CH4	CH5	CH6	CH7
S	x	x	x	x	x	x	x	x
P1	x	x	x	x	x	x	x	x
L3	x	x	.	x	x	x	x	x
P3	x	x	.	x	x	x	x	x
Er	x	x	.	x	x	x	x	x
C1	x	x	.	x	x	x	x	x
E	x	x	.	x	x	x	x	x
R	x	x	.	x	x	x	x	x
O	x	x	x	x	x	x	x	x
L1	x	.	.	x	x	x	x	x
L2	x	x	.	x	x	x	x	x
C2	x	.	.	x	x	x	x	x
P2	x	x	.	x	x	x	x	x
M	x	x	.	x	x	x	x	x
F	x	x	x	x	x	x	x	x
V1	x	x	.	x	x	x	x	x
V2	x	x	x	x	x	x	x	x
Vat	x	x	x	x	x	x	x	x

TABLE 3B

BOOK III: Subdivisions in Chapter 7

1	In longitudine, si videantur	(7.63)
2	In longitudine ex lucis parvitate	(7.104)
3	Error erit in longitudine ex causa	(7.131)
4	In longitudine: Si minima fuerit	(7.163)
5	In longitudine: Si fuerit aer pruinosus	(7.193)
6	In longitudine: Si subito intueatur	(3.217)
7	In longitudine: Si opponantur visui	(7.250)
8	Iam diximus quomodo accidit error	(7.279)

	1	2	3	4	5	6	7	8
S	.	.	.	x	x	x	x	.
P1	.	.	x	.	.	x	x	.
L3	.	.	x	x	x	x	x	.
P3	.	.	.	.	.	.	.	.
Er	.	.	x	x	x	x	x	.
C1	.	.	x	x	x	x	x	.
E	.	.	.	.	.	.	.	.
R	x	x	x	x	x	x	x	x
O	.	x	x	x	x	x	x	.
L1	.	.	x	x	x	x	x	.
L2	x	x	x	x	x	x	x	x
C2	.	.	x	x	x	.	x	.
P2	.	.	.	.	.	.	.	.
M	.	.	x	x	x	x	x	.
F	.	.	x	.	.	x	x	.
V1	.	.	.	.	.	.	.	.
V2	.	.	x	.	.	x	x	.
Vat	.	.	x	.	.	x	x	.

TABLE 4

BOOK IV: Chapter Divisions

	CH 1	CH 2	CH 3	CH 4	CH 5	CH 5A
S	x	x	x	x	x	.
P1	x	x	x	x	x	.
L3	x	x	x	x	x	x
P3	x	x	x	x	x	.
Er	x	x	x	x	x	x
C1	x	x	x	x	x	(x)
E	x	x	x	x	x	.
R	x	x	x	x	x	.
O	x	x	x	x	x	.
L1	x	x	x	x	x	x
L2	x	x	x	x	x	.
C2	x	x	x	x	x	x
P2	x	x	x	x	x	x
M	x	x	x	x	x	x
F	x	x	x	x	x	.
V1	x	x	x	x	x	.
V2	x	x	x	x	x	.
Vat	x	x	x	x	x	.

TABLE 5

BOOK V: Chapter Divisions

1	Liquet ex quarto libro quod formae rerum	(125)
2	Imaginis cuiuscunque puncti locus est	(125)
2a	In speculis sphaericis extra politis patebit	(134)
2b	Restat iam ut loca imaginum certius	(137)
2c	In speculis exterioribus pyramidalibus	(156)
2d	In speculis sphaericis concavis aliquando	(162)
2e	In speculis columnaribus concavis	(182)
2f	In speculis pyramidalibus concavis	(185)

	CH 1	CH 2	CH 2a	CH 2b	CH 2c	CH 2d	CH 2e	CH 2f
S	x	x	.	.	.	x	.	.
P1	x	x	.	.	.	x	x	.
L3	x	x	.	.	.	x	x	.
P3	x	x	.	.	.	.	.	.
Er	x	.	.	.	.	x	.	.
C1	x	x	.	x	.	.	.	(x)
E	x	x	.	.	.	.	.	.
R	x	x	.	.	.	.	.	.
O	x	x	.	.	x	.	x	.
L1	x	x	.	.	.	.	x	.
L2	x	x	.	.	.	(x)	.	.
C2	x	x	.	.	.	x	x	.
P2	x	x	.	.	.	x	.	.
M	x	.	.	x	.	x	.	x
F	x	x	.	.	.	x	x	.
V1	x	x	.	.	.	(x)	.	.
V2	x	x	x	.	.	x	x	.
Vat	x	x	.	.	.	x	x	.

TABLE 6

BOOK VI: Chapter Divisions

1	Patuit ex superioribus libris modus	(188)
2	Comprehensionem formarum in visu	(188)
3	In singulis speculis erronea formarum	(189)
4	Universitas errorum in speculis planis	(189)
5	Amplius in speculis columnaribus	(205)
6	Amplius in speculis pyramidalibus	(209)
6a	Capitulum sextum de fallaciis que	(not in Risner)
6b	Hoc declarato dicamus cum visus	(211)
7	In hiis vero plures errores accidunt	(214)
7a	Et si habuerit alias imagines forte erunt	(225)
8	In his autem accidunt similes eis qui	(225)
9	In his autem accidunt illae fallaciae	(229)

	CH1	CH2	CH3	CH4	CH5	CH6	CH6a	CH6b	CH7	CH7a	CH8	CH9
S	x	(x)	(x)	x	.	.	.	x	x	.	x	x
P1	x	x	x	x	x	x	.	.	x	.	x	x
L3	x	x	x	x	x	x	x		x		x	x
P3	x	x	x	x	x	x	.	.	.	.	x	x
Er	x	(x)	(x)	x	x	.	.	x	x	.	x	x
C1	x	(x)	(x)	x	.	.	.	.	x	.	x	x
E	x	x	(x)	x	x	x	.	.	(x)	.	x	x
R	x	x	x	x	x	x	.	.	x	.	x	x
O	x	(x)	(x)	x	x	x	x	.	(x)	.	x	x
L1	x	x	.	x	x	x	.	.	(x)	.	x	x
L2	x	x	(x)	x	.	.	.	.	x	.	x	x
C2	x	x	x	x	x	x	x	.	x	.	x	x
P2	x	x	x	x	x	x	.	.	x	.	x	x
M	x	(x)	x	x	.	.	.	.	x	x	x	x
F	x	x	x	x	x	.	.	.	x	.	x	x
V1	x	x	x	x	x	x	.	.	x	.	x	x
V2	x	x	(x)	x	x	x	.	.	x	.	x	x
Vat	x	x	x	x	x	.	.	.	x	.	x	x

TABLE 7

BOOK VII: Chapter Divisions

1	Praedictum est in prooemio quarti tractatus	(231)
2	Quod lumen quidem transeat in aerem	(231)
3	In predicto capitulo declaratum est quod	(242)
4	Quod quicquid comprehendit ultra	(247)
5	Imago est forma rei visibilis quam visus	(253)
6	In praecedentibus iam declaravimus quod	(266)
7	Fallaciae que accidunt secundum refractionem	(270)

	CH1	CH2	CH3	CH4	CH5	CH6	CH7
S	x	x	x	x	x	x	x
P1	x	(x)	x	x	x	x	x
L3	x	(x)	x	x	x	x	x
P3	x	x	x	x	x	x	x
Er	x	.	x	x	x	x	x
C1	x	(x)	x	x	x	x	x
E	x	x	x	x	x	x	x
R	x	x	x	x	x	x	x
O	x	(x)	x	x	x	x	x
L1	x	(x)	x	x	x	x	x
L2	x	(x)	x	x	x	x	x
C2	x	(x)	x	x	x	x	x
P2	x	x	x	x	x	x	x
M	x	(x)	x	x	x	x	x
F	x	(x)	x	x	x	x	x
V1	x	(x)	x	x	x	x	x
V2	x	(x)	x	x	x	x	x
Vat	x	x	x	x	x	x	x

TABLE 8

This table contains all the tabulations from the seven previous tables arranged according to chapter divisions and subdivisions that are common to given sets of manuscripts. Thus, for book 1, *S*, *P1*, *V2*, and *Vat* all have the same divisions, as do *E* and *P3*, etc.

8.1: BOOK I

	1	1a	2	2a	3	3a	4	5	6	7	8
S	x	.	x	.	x	x	x	x	x	x	x
P1	x	.	x	.	x	x	x	x	x	x	x
V2	x	.	x	.	x	x	x	x	x	x	x
Vat	x	.	x	.	x	x	x	x	x	x	x
P3	x	.	x	.	.	x	x	x	x	x	x
Er	x	.	x	.	.	x	x	x	x	x	x
R	x	.	x	.	.	x	.	x	x	x	x
V1	x	.	x	.	.	x	.	x	x	x	x
Er	x	.	x	.	x	.	x	x	x	x	x
C1	x	.	x	.	x	.	x	x	x	x	x
O	x	.	x	.	x	.	x	x	x	x	x
L1	x	.	x	.	x	.	x	x	x	x	.
L2	x	x	x	x	.	x	x	x	x	x	x
C2	x	.	x	.	x	x	x	x	.	x	x
P2	x	.	x	.	.	x	x	x	.	x	x
M	x	.	x	.	x	.	x	x	.	x	x
L3	--									x	x
F	--										x

8.2: BOOK II

	1	2	3	4	5
P3	x	x	x	x	x
E	x	x	x	x	x
L2	x	x	x	x	x
P2	x	x	x	x	x
L1	x	x	x	.	.
C2	x	x	x	.	.
R	x (pr.)	x (1)	.	x (2)	x (3)
S	x	x	x	.	x
P1	x	x	x	.	x
L3	x	x	x	.	x
Er	x	x	x	.	x
C1	x	x	x	.	x
O	x	x	x	.	x
V1	x	(x)	x	.	x
V2	x	x	x	.	x
Vat	x	x	x	.	x
M	.	x	x	.	x
F	x	x	------------------		x

8.3: BK II, CH. 3

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
P1	.	.	.	x	x	x	.	.	.	x	.	.	.	x	.	.	.	.	.	.	.
V2	.	.	.	x	x	x	.	.	.	x	.	.	.	x	.	.	.	.	.	.	.
Vat	.	.	.	x	x	x	.	.	.	x	.	.	.	x	.	.	.	.	.	.	.
L3	.	x	.	x	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
L1	.	x	.	x	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
C2	.	x	.	x	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
P3	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
E	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
R	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
L2	x	x	x	x	.	x	x	x	x	x	x	x	x	x	x	x	x	x	.	x	x
P2	x	x	x	x	x	x	x	.	.	x	x	x	x	x	x	x	x	x	x	x	x
S	.	.	.	.	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Er	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
O	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
M	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
C1	.	.	.	.	.	.	.	x	x	x	.	.	.	.	.	.	.	.	.	.	.
V1	.	(x)	.	(x)	(x)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	.	.	.	.

8.4: BOOK III

	1	2	3	3a	4	5	6	7
S	x	x	x	x	x	x	x	x
P1	x	x	x	x	x	x	x	x
O	x	x	x	x	x	x	x	x
F	x	x	x	x	x	x	x	x
V2	x	x	x	x	x	x	x	x
Vat	x	x	x	x	x	x	x	x
L3	x	x	.	x	x	x	x	x
P3	x	x	.	x	x	x	x	x
Er	x	x	.	x	x	x	x	x
C1	x	x	.	x	x	x	x	x
E	x	x	.	x	x	x	x	x
L2	x	x	.	x	x	x	x	x
P2	x	x	.	x	x	x	x	x
M	x	x	.	x	x	x	x	x
V1	x	x	.	x	x	x	x	x
R	x	x	.	x	x	x	x	x
L1	x	.	.	x	x	x	x	x
C2	x	.	.	x	x	x	x	x

8.5: BOOK III, CH. 7

	1	2	3	4	5	6	7	8
S	.	.	.	x	x	x	x	.
P1	.	.	x	.	.	x	x	.
F	.	.	x	.	.	x	x	.
V2	.	.	x	.	.	x	x	.
Vat	.	.	x	.	.	x	x	.
P3	.	.	.	.	.	.	.	.
E	.	.	.	.	.	.	.	.
P2	.	.	.	.	.	.	.	.
V1	.	.	.	.	.	.	.	.
L3	.	.	x	x	x	x	x	.
Er	.	.	x	x	x	x	x	.
C1	.	.	x	x	x	x	x	.
L1	.	.	x	x	x	x	x	
M	.	.	x	x	x	x	x	.
O	.	.	x	x	x	x	.	.
R	x	x	x	x	x	x	x	x
L2	x	x	x	x	x	x	x	x
C2	.	.	x	x	x	.	x	.

8.6: BOOK IV

	1	2	3	4	5	5a
L3	x	x	x	x	x	x
Er	x	x	x	x	x	x
C1	x	x	x	x	x	(x)
L1	x	x	x	x	x	x
C2	x	x	x	x	x	x
P2	x	x	x	x	x	x
M	x	x	x	x	x	x
S	x	x	x	x	x	.
P1	x	x	x	x	x	.
P3	x	x	x	x	x	.
E	x	x	x	x	x	.
R	x	x	x	x	x	.
O	x	x	x	x	x	.
L2	x	x	x	x	x	.
F	x	x	x	x	x	.
V1	x	x	x	x	x	.
V2	x	x	x	x	x	.
Vat	x	x	x	x	x	.

8.7: BOOK V

	1	2	2a	2b	2c	2d	2e	2f
P1	x	x	.	.	.	x	x	.
L3	x	x	.	.	.	x	x	.
F	x	x	.	.	.	x	x	.
Vat	x	x	.	.	.	x	x	.
C2	x	x	.	.	.	x	x	.
V2	x	x	x	.	.	x	x	.
E	x	x	.	.	.	.	.	.
R	x	x	.	.	.	.	.	.
P3	x	x	.	.	.	.	.	.
V1	x	x	.	.	.	(x)	.	.
L2	x	x	.	.	.	(x)	.	.
P2	x	x	.	.	.	x	.	.
S	x	x	.	.	.	x	.	.
L1	x	x	.	.	.	.	x	.
Er	x	.	.	.	.	x	.	.
C1	x	x	.	x	.	.	.	(x)
M	x	.	.	x	.	x	.	x
O	x	x	.	.	x	.	x	.

8.8: BOOK VI

	1	2	3	4	5	6	6a	6b	7	7a	8	9
S	x	(x)	(x)	x	.	.	.	x	x	.	x	x
P1	x	x	x	x	x	x	.	.	x	.	x	x
E	x	x	(x)	x	x	x	.	.	(x)	.	x	x
R	x	x	x	x	x	x	.	.	x	.	x	x
V1	x	x	x	x	x	x	.	.	x	.	x	x
V2	x	x	(x)	x	x	x	.	.	x	.	x	x
P2	x	x	x	x	x	x	.	.	x	.	x	x
L1	x	x	.	x	x	x	.	.	(x)	.	x	x
L3	x	x	x	x	x	x	x	.	x	.	x	x
O	x	(x)	(x)	x	x	x	x	.	(x)	.	x	x
C2	x	x	x	x	x	x	x	.	x	.	x	x
P3	x	x	x	x	x	x	.	.	.	.	x	x
Er	x	(x)	(x)	x	x	.	.	x	x	.	x	x
C1	x	(x)	(x)	x	.	.	.	.	x	.	x	x
L2	x	x	(x)	x	.	.	.	.	x	.	x	x
M	x	(x)	x	x	.	.	.	.	x	x	x	x
F	x	x	x	x	x	.	.	.	x	.	x	x
Vat	x	x	x	x	x	.	.	.	x	.	x	x

8.9: BOOK VII

	1	2	3	4	5	6	7
S	x	x	x	x	x	x	x
E	x	x	x	x	x	x	x
R	x	x	x	x	x	x	x
P3	x	x	x	x	x	x	x
P2	x	x	x	x	x	x	x
Vat	x	x	x	x	x	x	x
P1	x	(x)	x	x	x	x	x
L3	x	(x)	x	x	x	x	x
C1	x	(x)	x	x	x	x	x
O	x	(x)	x	x	x	x	x
L1	x	(x)	x	x	x	x	x
L2	x	(x)	x	x	x	x	x
C2	x	(x)	x	x	x	x	x
M	x	(x)	x	x	x	x	x
F	x	(x)	x	x	x	x	x
V1	x	(x)	x	x	x	x	x
V2	x	(x)	x	x	x	x	x
Er	x	.	x	x	x	x	x

APPENDIX 3

This appendix provides a listing of all the idiosyncratic and shared variants for each of the seventeen manuscripts, except P3.

Table 1 on the following page gives a summary of results. Each line-couple provides a comparison of all manuscripts by total score. The manuscript listed to the left in each line-couple constitutes the reference-manuscript, so the number next to it represents its score for idiosyncratic variants. In the first line-couple, for instance, O, the reference-manuscript, has an overall score of 1377 for idiosyncratic variants. The next manuscript in line, Er, has a score of 1423 for variants shared with O, and so on down the line. For each line-couple, the manuscripts are listed in descending order by score, from highest to lowest, for shared variants. Again, in the first line-couple Er has the highest score for shared variants, M the next highest, and so on down the line to L3, which has the lowest. The higher the score, then, the more closely related the given manuscript should be to the reference-manuscript.

Tables 2-17 give a complete breakdown of idiosyncratic and shared variants for each reference-manuscript according to type of variant. The format for these tables is precisely the same as that for Table 1 in "Manuscripts and Editing," p. clxiv

TABLE

		Er	M	S	P1	F	C1	L2	V2	P2	C2	Va	V1	E	L1	L3
O	1377	1423	1093	686	582	581	532	469	464	452	445	441	399	395	343	333
		P2	L1	C2	V1	L3	V2	Er	C1	O	P1	M	Va	L2	S	F
E	643	3061	1293	1111	1007	774	593	506	460	395	374	373	274	251	191	185
		E	C2	P2	L3	V1	V2	Er	C1	M	Va	l2	O	P1	S	F
L1	3374	1293	1171	1102	1013	785	687	573	557	438	401	396	343	335	291	207
		P1	Va	F	V2	S	O	M	L1	V1	C2	C1	Er	E	P2	L3
L2	1927	1095	1049	967	851	819	469	397	396	365	308	295	292	251	233	206
		L1	C2	E	P2	C1	V1	Er	M	O	V2	L2	S	Va	P1	F
L3	1219	1013	909	774	768	749	677	432	362	333	319	206	195	191	169	130
		L3	Er	C2	L1	M	V1	O	P2	E	S	L2	V2	Va	F	P1
C1	1344	749	671	587	557	547	536	532	519	460	297	295	276	226	202	179
		L1	E	P2	L3	V1	Er	C1	M	O	V2	L2	Va	S	P1	F
C2	6096	1171	1111	1005	909	901	626	587	461	445	394	308	281	274	265	163
		Va	F	V2	L2	S	O	V1	M	E	L1	P2	C2	Er	C1	L3
P1	1689	2440	2263	1809	1095	879	852	384	376	374	335	330	265	261	179	169
		E	L1	V1	C2	L3	V2	C1	Er	O	M	Va	P1	S	L2	F
P2	1439	3061	1102	1030	1005	768	558	519	516	452	403	386	330	274	233	222
		O	Er	C1	V1	C2	L1	V2	S	P2	L2	P1	E	L3	F	Va
M	2442	1093	778	547	515	461	438	425	422	402	397	376	373	362	350	338
		P1	Va	V2	L2	S	O	M	Er	V1	P2	L1	C1	E	C2	L3
F	154	2263	2159	1476	967	753	581	350	256	233	222	207	202	185	163	130
		P2	E	C2	L1	L3	C1	V2	M	Er	O	Va	P1	S	L2	F
V1	2280	1030	1007	901	785	677	536	527	515	431	399	394	384	380	365	233
		Va	P1	F	S	L2	L1	E	P2	V1	O	M	C2	L3	Er	C1
V2	2038	2467	1809	1476	946	851	687	593	558	527	464	425	394	319	284	276
		O	M	C1	S	C2	L1	P2	E	L3	V1	Va	L2	V2	P1	F
Er	1159	1423	778	671	628	626	573	516	506	432	431	332	292	284	261	256
		V2	P1	F	L2	S	O	L1	V1	P2	M	Er	C2	E	C1	L3
Va	1261	2467	2440	2159	1049	1029	441	401	394	386	338	332	281	274	226	191
		Va	V2	P1	L2	F	O	Er	M	V1	C1	L1	C2	P2	L3	E
S	1101	1028	946	879	819	753	686	628	422	380	297	291	274	274	195	191

TABLE 2

	1	2	3	4	5	6	7	8	9	
O	27.0	16.0	11.0	157.5	144.0		101.5	16.0	97.0	1377
Er	20.5	10.0		65.0	60.5		71.0	42.0	169.0	1423
M	13.5	9.0		43.0	46.0		51.0	56.0	146.0	1093
S	6.0	5.0		39.0	25.5		39.0	13.0	87.5	686
P1	4.0	3.0		27.0	24.5		47.0	7.0	82.0	582
F	8.0	1.0		23.0	20.5		52.0	9.0	86.5	581
C1	2.5	7.5		21.0	27.0		21.0	23.0	79.0	532
L2	6.0	3.0		25.0	9.5		35.0	12.0	64.5	469
V2	5.0	2.0		27.0	12.5		33.5	4.0	69.5	464
P2	1.5	6.0		23.0	13.5		25.0	7.0	96.0	452
C2	2.0	5.5		21.5	15.0		30.0	5.0	79.0	445
Va	6.5	2.0		19.0	16.0		38.0	4.0	50.0	441
V1	3.0	5.5		24.5	15.0		10.0	5.0	66.0	399
E	1.5	1.5		26.0	14.5		22.5	5.0	63.0	395
L1	2.5	1.5		22.0	11.0		16.5	7.0	58.0	343
L3	2.5	6.0		17.0	10.0		13.5	4.0	62.0	333

TABLE 3

	1	2	3	4	5	6	7	8	9	
E	5.0	13.0	1.0	22.0	25.0	2.0	34.0	28.0	64.0	643
P2	26.0	38.0	2.0	140.5	129.0		134.0	153.0	313.0	3061
L1	19.0	9.5	1.0	71.5	40.5		56.0	42.0	155.0	1293
C2	14.0	10.0	1.0	58.5	38.0		52.0	39.0	122.5	1111
V1	10.5	11.0		46.0	48.5		46.5	26.0	114.5	1007
L3	7.5	8.5		37.5	27.0		42.0	25.0	102.0	774
V2	11.5	4.0		19.0	30.5		23.0	24.0	73.5	593
Er	5.0	5.0		32.0	13.0		23.0	12.0	71.0	506
C1	5.0	5.5		16.0	16.0		30.0	19.0	66.5	460
O	1.5	1.5		26.0	14.5		22.5	5.0	63.0	395
P1	3.0	3.0		15.0	28.5		13.0	2.0	47.5	374
M	1.0	4.0		14.0	17.5		19.0	13.0	77.5	373
Va	2.0	2.0		11.0	16.0		14.0	7.0	38.0	274
L2	0.5	1.5		11.5	10.0		17.0	7.0	50.0	251
S	3.0	0.5		12.0	7.0		5.0	4.0	30.0	191
F	1.5	2.0		6.0	10.5		10.0	3.0	31.0	185

TABLE 4

	1	2	3	4	5	6	7	8	9	
L1	83.0	12.0	3.0	190.5	74.0	2.0	163.0	69.0	362.0	3374
E	19.0	9.5	1.0	71.5	40.5		56.0	42.0	155.0	1293
C2	14.0	6.0		69.0	35.5		61.0	41.0	140.5	1171
P2	12.0	9.0		57.5	41.5		44.0	43.0	151.0	1102
L3	11.5	7.5		43.5	37.5		61.5	32.5	151.0	1013
V1	6.0	4.0		38.0	30.5		38.5	35.0	133.0	785
V2	9.5	1.0		47.5	19.5		32.0	13.0	89.0	687
Er	5.0	6.0	1.0	36.0	14.0		22.0	20.0	80.5	573
C1	4.5	3.5		15.5	29.0		36.0	25.0	92.0	557
M	3.0	5.0		20.0	18.0		20.0	12.0	76.5	438
Va	6.5			21.0	18.0		18.5	2.0	66.5	401
L2	4.5			26.0	14.5		16.0	7.0	65.0	396
O	2.5	1.5		22.0	11.0		16.5	7.0	58.0	343
P1	3.0	0.5		19.0	16.5		12.5	5.0	60.0	335
S	1.0	1.0		21.0	9.5		11.0	3.0	61.0	291
F	1.5			13.0	9.0		8.0	1.0	44.0	207

TABLE 5

	1	2	3	4	5	6	7	8	9	
L2	28.0	11.0	3.0	142.0	53.0	9.0	55.0	74.0	102.0	1927
P1	15.5	3.0		56.5	46.0		65.5	29.0	107.5	1095
Va	16.0	4.0		53.0	34.0	1.0	70.5	28.0	113.0	1049
F	14.5	3.0		43.5	38.0		66.0	28.0	107.5	967
V2	12.0	4.0		41.5	38.5		39.0	26.0	100.0	851
S	10.5	5.0		47.0	26.5		45.0	19.0	97.0	819
O	6.0	3.0		25.0	9.5		35.0	12.0	64.5	469
M	3.0	4.0		16.5	19.5		22.0	10.0	55.0	397
L1	4.5			26.0	14.5		16.0	7.0	65.0	396
V1	3.0	1.0		19.5	15.5		19.0	9.0	60.0	365
C2	3.0	3.0		18.0	8.0		15.0	5.0	54.0	308
C1	1.0	1.0		10.0	14.5		24.0	11.0	51.5	295
Er	4.0	1.0		16.0	9.5		14.0	7.0	48.0	292
E	0.5	1.5		11.5	10.0		17.0	7.0	50.0	251
P2		1.0		14.0	10.0		10.5	6.0	47.0	233
L3	2.0	1.0		12.5	8.5		6.5	3.0	36.5	206

TABLE 6

	1	2	3	4	5	6	7	8	9	
L3	11.0	20.0	4.0	51.0	53.0	1.0	50.0	42.0	123.0	1219
L1	11.5	7.5		43.5	37.5		61.5	32.5	151.0	1013
C2	9.5	10.0	1.0	44.5	23.5		54.5	34.0	120.0	909
E	7.5	8.5		37.5	27.0		42.0	25.0	102.0	774
P2	6.0	10.0		39.0	27.5	1.0	32.5	29.0	103.0	768
C1	3.5	11.5		24.0	34.5	1.0	40.0	37.0	111.0	749
V1	6.0	8.0	1.0	29.0	28.0	1.0	33.5	22.0	87.0	677
Er	1.5	6.0		26.5	12.5		21.0	6.0	74.0	432
M	2.0	7.0		15.5	16.5		15.0	7.0	53.0	362
O	2.5	6.0		17.0	10.0		13.5	4.0	62.0	333
V2	4.0	4.0		11.5	16.5		10.0	6.0	57.0	319
L2	2.0	1.0		12.5	8.5		6.5	3.0	36.5	206
S	1.5	3.5		10.5	6.5		3.0		49.0	195
Va	1.0			11.5	6.5		11.5	2.0	55.5	191
P1	1.5	1.5		8.0	6.5		5.5	3.0	40.0	169
F	1.0	2.0		3.5	4.5		5.0	3.0	40.5	130

TABLE 7

	1	2	3	4	5	6	7	8	9	
C1	8.0	34.0	6.0	41.0	71.0	4.0	44.0	64.0	81.0	1344
L3	3.5	11.5		24.0	34.5	1.0	40.0	37.0	111.0	749
Er	2.0	7.0		29.0	26.0		41.0	34.0	101.5	671
C2	2.5	6.0		24.5	25.0		41.0	26.0	69.5	587
L1	4.5	3.5		15.5	29.0		36.0	25.0	92.0	557
M	3.0	8.5		19.5	21.5		27.0	28.0	93.0	547
V1	4.0	8.5		19.5	27.0	1.0	26.0	19.0	59.5	536
O	2.5	7.5		21.0	27.0		21.0	23.0	79.0	532
P2	4.5	7.5		19.5	19.0	1.0	27.0	21.0	79.0	519
E	5.0	5.5		16.0	16.0		30.0	19.0	66.5	460
S	1.0	2.5		13.0	12.5		23.0	3.0	52.0	297
L2	1.0	1.0		10.0	14.5		24.0	11.0	51.5	295
V2	2.5	1.0		5.5	17.0		19.0	6.0	58.0	276
Va	2.0			7.0	12.0		18.5	4.0	42.0	226
F	1.5	1.0		5.0	9.5		15.0	9.0	40.0	202
P1		1.0		5.0	13.5		8.0	6.0	37.5	179

TABLE 8

	1	2	3	4	5	6	7	8	9	
C2	142.0	56.0	19.0	338.0	168.0	20.0	210.0	165.0	329.0	6096
L1	14.0	6.0		69.0	35.5		61.0	41.0	140.5	1171
E	14.0	10.0	1.0	58.5	38.0		52.0	39.0	122.5	1111
P2	8.0	13.0	1.0	49.0	40.5		46.0	45.0	97.0	1005
L3	9.5	10.0	1.0	44.5	23.5		54.5	34.0	120.0	909
V1	8.0	8.0	1.0	46.0	39.0		41.5	33.0	96.0	901
Er	7.0	7.0		34.0	20.0		31.0	19.0	71.5	626
C1	2.5	6.0		24.5	25.0		41.0	26.0	69.5	587
M	4.0	5.0		19.0	21.5		22.5	14.0	68.0	461
O	2.0	5.5		21.0	15.5		30.0	5.0	79.0	445
V2	6.5	2.0		19.5	14.0		20.0	10.0	52.0	394
L2	3.0	3.0		18.0	8.0		15.0	5.0	54.0	308
Va	7.5			14.5	7.0		14.0	4.0	41.0	281
S	5.5	1.0		15.0	10.0		9.0	3.0	43.0	274
P1	5.5	1.0		16.0	8.0		8.0	5.0	37.5	265
F	3.0	2.0		5.0	4.0		8.0	3.0	40.0	163

TABLE 9

	1	2	3	4	5	6	7	8	9	
P1	49.0	6.0	14.0	101.0	42.0	7.0	37.0	23.0	101.0	1689
Va	47.0	10.0	0.5	113.5	84.5	1.0	138.5	67.0	276.5	2440
F	44.5	10.0		96.0	79.5	1.0	139.0	63.0	261.5	2263
V2	30.0	10.0	1.0	81.0	80.0	1.0	78.0	54.0	220.0	1809
L2	15.5	3.0		56.5	46.0		65.5	29.0	108.0	1095
S	13.5	5.0		34.0	38.5	1.0	51.0	19.0	125.5	879
O	4.0	3.0		27.0	24.5		47.0	7.0	82.0	582
V1	4.0	2.0		14.0	25.0		14.0	10.0	61.0	384
M	4.0	1.0		15.0	21.0		26.0	1.0	56.5	376
E	3.0	3.0		15.0	28.5		13.0	2.0	47.5	374
L1	3.0	0.5		19.0	16.5		12.5	5.0	60.0	335
P2	3.0			13.0	22.5		13.0	4.0	65.0	330
C2	5.5	1.0		16.0	8.0		8.0	5.0	37.5	265
Er	4.0	1.0		11.0	11.0		12.0	5.0	50.0	261
C1		1.0		5.0	13.5		8.0	6.0	37.5	179
L3	1.5	1.5		8.0	6.5		5.5	3.0	40.0	169

TABLE 10

	1	2	3	4	5	6	7	8	9	
P2	14.0	8.0	7.0	77.0	61.0	19.0	55.0	55.0	82.0	1439
E	26.0	38.0	2.0	140.5	129.0		134.0	153.0	313.0	3061
L1	12.0	9.0		57.5	41.5		44.0	43.0	151.0	1102
V1	11.5	13.0		43.5	47.5	1.0	46.5	33.0	114.0	1030
C2	8.0	13.0	1.0	49.0	40.5		46.0	45.0	97.0	1005
L3	6.0	10.0		39.0	27.5	1.0	32.5	29.0	103.0	768
V2	7.0	2.0	1.0	19.0	33.5		23.0	20.0	81.0	558
C1	4.5	7.5		19.5	19.0	1.0	27.0	21.0	79.0	519
Er	3.0	9.0		32.0	13.0	1.0	20.0	13.0	70.0	516
O	1.5	6.0		23.0	13.5		25.0	7.0	96.0	452
M	2.0	6.0		16.0	19.0		14.0	10.0	84.0	403
Va	3.0		1.0	17.5	22.5		19.5	9.0	58.0	386
P1	3.0			13.0	22.5		13.0	4.0	65.0	330
S	4.0	2.0		15.0	9.5		9.5	5.0	46.0	274
L2		1.0		14.0	10.0		10.5	6.0	47.0	233
F	1.0	1.0		6.0	11.5		15.0	4.0	58.0	222

TABLE 11

	1	2	3	4	5	6	7	8	9	
M	33.0	18.0	8.0	123.0	86.0	8.0	116.0	80.0	237.0	2442
O	13.5	9.0		43.0	46.0		51.0	56.0	146.0	1093
Er	7.0	6.0		37.0	31.0		35.5	32.0	119.0	778
C1	3.0	8.5		19.0	21.5		27.0	28.0	93.0	547
V1	1.0	8.0		24.0	29.5		17.5	9.0	79.5	515
C2	4.0	5.0		19.0	21.5		22.5	14.0	68.0	461
L1	3.0	5.0		20.0	18.0		20.0	12.0	76.5	438
V2	4.0	3.0		16.5	22.0		27.0	4.0	67.0	425
S	2.0	5.0		18.0	19.5		25.0	6.0	71.5	422
P2	2.0	6.0		16.0	19.0		14.0	10.0	84.0	403
L2	3.0	4.0		16.5	19.5		22.0	10.0	55.0	397
P1	4.0	1.0		15.0	21.0		26.0	1.0	56.5	376
E	1.0	4.0		14.0	17.5		19.0	13.0	77.5	373
L3	2.0	7.0		15.5	16.5		15.0	7.0	53.0	362
F	5.0	2.0		12.0	17.5		19.0	4.0	64.5	350
Va	4.0	1.0		13.5	14.0		24.0	2.0	66.5	338

TABLE 12

	1	2	3	4	5	6	7	8	9	
F		1.0	2.0	5.0	7.0	6.0	4.0	3.0	25.0	154
P1	44.5	10.0		96.0	79.5	1.0	139.0	63.0	261.5	2263
Va	40.5	7.0		101.0	68.5		133.0	54.0	283.0	2159
V2	26.0	8.0		63.5	56.0		79.0	38.0	204.0	1476
L2	14.5	3.0		43.5	38.0		66.0	28.0	107.5	967
S	8.0	4.0		32.0	33.0		50.0	13.0	116.0	753
O	8.0	1.0		23.0	20.5		52.0	9.0	86.5	581
M	5.0	2.0		12.0	17.5		19.0	4.0	64.5	350
Er	7.0	2.0		9.0	7.0		14.0	5.0	36.0	256
V1	2.5	3.0		7.0	13.5		8.0	5.0	43.0	233
P2	1.0	1.0		6.0	11.5		15.0	4.0	58.0	222
L1	1.5			13.0	9.0		8.0	1.0	44.0	207
C1	1.5	1.0		5.0	9.5		15.0	9.0	40.0	202
E	1.5	2.0		6.0	10.5		10.0	3.0	31.0	185
C2	3.0	2.0		5.0	4.0		8.0	3.0	40.0	163
L3	1.0	2.0		3.5	4.5		5.0	3.0	40.5	130

TABLE 13

	1	2	3	4	5	6	7	8	9	
V1	41.0	19.0	7.0	125.0	79.0	4.0	74.0	60.0	207.0	2280
P2	11.5	13.0		43.5	47.5	1.0	46.5	33.0	114.0	1030
E	10.5	11.0		46.0	48.5		46.5	26.0	114.5	1007
C2	8.0	8.0	1.0	46.0	39.0		41.5	33.0	96.5	901
L1	6.0	4.0		38.0	30.5		38.5	35.0	133.0	785
L3	6.0	8.0	1.0	29.0	28.0	1.0	25.5	22.0	87.0	677
C1	4.0	8.5		19.5	27.0	1.0	26.0	19.0	59.5	536
V2	9.0	3.0		22.0	22.5		27.0	13.0	70.0	527
M	1.0	8.0		24.0	29.5		17.5	9.0	79.5	515
Er	3.0	6.0		22.5	14.5		16.0	17.0	66.5	431
O	3.0	5.5		24.5	15.0		10.0	5.0	66.0	399
Va	5.0	2.5		14.0	19.0		21.5	11.0	63.0	394
P1	4.0	2.0		14.0	25.0		14.0	10.0	61.0	384
S	4.0	6.0		15.0	16.5		13.0	9.0	66.0	380
L2	3.0	1.0		19.5	15.5		19.0	9.0	60.0	365
F	2.5	3.0		7.0	13.5		8.0	5.0	43.0	233

TABLE 14

	1	2	3	4	5	6	7	8	9	
V2	48.0	15.0	3.0	91.0	63.0	5.0	87.0	56.0	211.0	2038
Va	49.5	9.5	2.5	123.5	80.5		120.5	67.0	288.5	2467
P1	30.0	10.0	1.0	81.0	80.0	1.0	78.0	54.0	220.0	1809
F	26.0	8.0		63.5	56.0		79.0	38.0	204.0	1476
S	12.0	6.0		42.0	40.5		59.0	17.0	124.5	946
L2	12.0	4.0		41.5	38.5		39.0	26.0	100.0	851
L1	9.5	1.0		47.5	19.5		32.0	13.0	89.0	687
E	11.5	4.0		19.0	30.5		23.0	24.0	73.5	593
P2	7.0	2.0	1.0	19.0	33.5		23.0	20.0	81.0	558
V1	9.0	3.0		22.0	22.5		27.0	13.0	70.0	527
O	5.0	2.0		27.0	12.5		33.5	4.0	69.5	464
M	4.0	3.0		16.5	22.0		27.0	4.0	67.0	425
C2	6.5	2.0		19.5	14.0		20.0	10.0	52.0	394
L3	4.0	4.0		11.5	16.5		10.0	6.0	57.0	319
Er	5.5	2.0		12.0	7.5		16.0	5.0	50.5	284
C1	2.5	1.0		5.5	17.0		19.0	6.0	58.0	276

TABLE 15

	1	2	3	4	5	6	7	8	9	
Er	22.0	3.0	5.0	55.0	33.0	6.0	49.0	35.0	166.0	1159
O	20.5	10.0		65.0	60.5		71.0	42.0	169.0	1423
M	7.0	6.0		37.0	31.0		35.5	32.0	119.0	778
C1	2.0	7.0		29.0	26.0		41.0	34.0	101.5	671
S	10.5	3.0	1.0	31.5	22.0		34.0	7.0	87.0	628
C2	7.0	7.0		34.0	20.0		31.0	19.0	71.5	626
L1	5.0	6.0	1.0	36.0	14.0		22.0	20.0	80.5	573
P2	3.0	9.0		32.0	13.0	1.0	20.0	13.0	70.0	516
E	5.0	5.0		32.0	13.0		23.0	12.0	71.0	506
L3	1.5	6.0		26.5	12.5		21.0	6.0	74.0	432
V1	3.0	6.0		22.5	14.5		16.0	17.0	66.5	431
Va	5.0	1.0		20.0	9.0		18.0	3.0	54.0	332
L2	4.0	1.0		16.0	9.5		14.0	7.0	48.0	292
V2	5.5	2.0		12.0	7.5		16.0	5.0	50.5	284
P1	4.0	1.0		11.0	11.0		12.0	5.0	50.0	261
F	7.0	2.0		9.0	7.0		14.0	5.0	36.0	256

TABLE 16

	1	2	3	4	5	6	7	8	9	
Va	41.0	7.0	3.0	65.0	26.0	7.0	39.0	24.0	102.0	1261
V2	49.5	9.5	2.5	123.5	80.5		120.5	67.0	288.5	2467
P1	47.0	10.0	0.5	113.5	84.5	1.0	138.5	67.0	276.5	2440
F	40.5	7.0		101.0	68.5		133.0	54.0	283.0	2159
L2	16.0	4.0		53.0	34.0	1.0	70.5	28.0	113.0	1049
S	13.5	7.0		45.0	42.0		63.0	18.0	145.0	1028
O	6.5	2.0		19.0	16.0		38.0	4.0	50.0	441
L1	6.5			21.0	18.0		18.5	2.0	66.5	401
V1	5.0	2.5		14.0	19.0		21.5	11.0	63.0	394
P2	3.0		1.0	17.5	22.5		19.5	9.0	58.0	386
M	4.0	1.0		13.5	14.0		24.0	2.0	66.5	338
Er	5.0	1.0		20.0	9.0		18.0	3.0	54.0	332
C2	7.5			14.5	7.0		14.0	4.0	41.0	281
E	2.0	2.0		11.0	16.0		14.0	7.0	38.0	274
C1	2.0			7.0	12.0		18.5	4.0	42.0	226
L3	1.5			9.5	7.0		8.5	2.0	55.5	191

TABLE 17

	1	2	3	4	5	6	7	8	9	
S	35.0	2.0	7.0	52.0	21.0	2.0	50.0	30.0	86.0	1101
Va	13.5	7.0		45.0	42.0		63.0	18.0	145.0	1028
V2	12.0	6.0		42.0	40.5		59.0	17.0	124.5	946
P1	13.5	5.0		34.0	38.5	1.0	51.0	19.0	125.5	879
L2	10.5	5.0		47.0	26.5		45.0	19.0	97.0	819
F	8.0	4.0		32.0	33.0		50.0	13.0	116.0	753
O	6.0	5.0		39.0	25.5		39.0	13.0	87.0	686
Er	10.5	3.0	1.0	31.5	22.0		34.0	7.0	87.0	628
M	2.0	5.0		18.0	19.5		25.0	6.0	71.0	422
V1	4.0	6.0		15.0	16.5		13.0	9.0	66.0	380
C1	1.0	2.5		13.0	12.5		23.0	3.0	52.0	297
L1	1.0	1.0		21.0	9.5		11.0	3.0	61.0	291
P2	4.0	2.0		15.0	9.5		9.5	5.0	46.0	274
C2	5.5	1.0		15.0	10.0		9.0	3.0	43.5	274
L3	1.5	3.5		10.5	6.5		3.0		49.0	195
E	3.0	0.5		12.0	7.0		5.0	4.0	30.0	191

APPENDIX 4

This table provides a cross listing of the marginal illustrations in all of the manuscripts against the full set of illustrations contained in MS *P3*, that set being most extensive of all. The left-hand column lists the figures according to the number designating them in the commentary to the English translation. The top row lists the manuscripts by sigla.

	P3	V1	E	M	L1	P1	Va	C2	L3	S	L2	P2	R	F	O	C1	V2	Er
1.1	x	x	x	x	.	.	.	.	.	x	.	.	.	.	.	.	.	.
1.2	x	x	x	x	x	x	x	.	.	x	.	x	x	.	.	.	.	.
1.5	x	x	x	x	.	.	.	.	.	.	.	x	.	.	.	.	.	.
1.7a	x	x	x	x	x	.	x	.	.	.	.	x	.	.	.	.	.	.
1.7b	x	x	x	x	x	.	x	.	.	.	.	.	.	.	.	.	.	.
2.5	x	x	x	.	x	.	.	.	x	.	.	.	x	.	.	.	.	.
2.6a	x	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.7	x	x	x	x	x	x	.	.	.	.	.	.	.	x	.	.	.	.
2.8	x	x	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.9	x	x	x	x	x	.	.	.	.	.	.	x	.	.	.	.	.	.
2.10	x	.	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.11	x	x	x	x	x	.	x	.	.	.	.	x	.	.	.	.	.	.
2.12a	x	x	x	x	x	x	.	.	.	.	.	.	.	.	.	.	.	.
2.12b	x	x	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.13	x	x	x	x	x	x	.	.	.	.	.	.	.	.	.	.	.	.
2.14	x	x	x	x	x	x	.	x	.	.	.	.	.	.	.	.	.	.
2.15a	x	x	x	x	.	x	.	.	.	.	.	.	x	.	.	.	.	.
2.15b	x	x	x	x	.	x	.	.	.	.	.	.	x	.	.	.	.	.
2.17	x	x	x	x	.	x	x	.	.	.	.	.	x	.	.	.	.	.
2.18	x	x	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.
2.19	x	x	x	x	x	.	x	x	.	.	.	.	.	.	.	.	.	.
3.1	x	x	x	x	x	.	x	x	x	x	.	.	.	.	.	.	.	.
3.3	x	x	x	x	x	.	x	x	x	.	.	.	.	.	.	.	.	.
3.4	x	x	x	x	x	x	x	x	x	x	x	x	.	.	.	.	.	.
3.5	x	x	x	x	.	x	x	.	x	.	x	x	x	x	x	.	.	.
3.7	x	x	x	x	x	x	x	x	.	x	x	.	.	.	.	.	.	.
3.9	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	.	.	.
3.12	x	x	x	x	x	x	.	x	x	x	x	.	.	.	.	.	.	.
3.13	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.14	x	x	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.
3.15	x	x	x	x	.	.	.	.	.	.	.	.	.	.	.	.	.	.

LATIN-ENGLISH INDEX

LATIN-ENGLISH INDEX

The following index is somewhat restrictive in that it does not include pronouns, conjunctions, prepositions, or the copulative (esse). It also includes few adverbs beyond those that are based on listed adjectival forms. Each Latin term is listed according to its occurrence by page and line-number. For instance, the first entry, "**abicere** 328.91" says that *abicere* occurs in some form on line 91 of page 328. Multiple entries follow the format of "**ablatio** 128.1, 11; 129.28," which says that *ablatio* occurs in some form on lines 1 and 11 of page 128, as well as on line 28 of page 129. For each Latin term I have supplied the various English renderings to be found in the translation, each rendering followed by its appropriate page-number(s). In some cases, of course, the translation is too loose to permit such a one-to-one correlation of Latin and English terms, so there will at times be gaps in the English concordance. Finally, certain terms, such as *apparere*, crop up so often that it is not feasible to cite every instance by page and line-number. In such cases, I have cited the term as "frequently recurring," listing its occurrence in the Latin text by page only and giving its various English renderings without appropriate page-references in the translation.

expressio 311.284 **representation** 607

exprimere 311.282, 286; 317.99 **to represent** 607, 612

extendere *frequently recurring* (5, 11, 14, 16-21, 23, 24, 27, 29-34, 37-40, 42, 43, 45, 46, 48-50, 52, 54-57, 70, 75-78, 80-90, 94, 95, 112, 113, 119, 123, 127, 140-143, 158, 169, 174, 175, 178, 186, 195, 207, 253-255, 258, 264, 265, 278) **to arrive at, to continue on, to drop, to enlarge, to extend, to fill (by expansion), to propagate, to reach, to shine**

extensio 29.199; 81.48, 63; 84.140; 85.151; 86.193, 195, 202; 87.220, 223; 88.248; 147.246, 263; 150.54, 55; 151.66, 79, 84; 156.212, 218, 219, 223; 157.247, 248; 158.273, 275, 276, 280, 291; 159.297; 169.300, 18; 235.235; 274.180; 309.216 **continuation** 360, 419, 421 **extension** 422, 463, 465, 466, 469-471, 478, 580 **length** 524 **passage** 422

exterior 11.8; 18.225; 69.25; 317.85 **outer surface/outside** 348, 353, 612

extrahere 8.3[1], 8; 9.10; 15.140; 165.202; 263.180, 181; 267.279; 275.215; 276.237 **to bring out** 346 **to draw/draw away** 476, 573, 576, 581, 582

extraneitas 131.99; 132.122 **excessiveness** 452, 453

extraneus 58.197; 59.228; 102.149; 105.213; 115.232; 118.16; 120.84; 132.120; 133.148; 135.197, 215, 218, 220; 137.276; 148.282; 154.176; 165.192; 178.276, 279; 184.138; 200.25, 32, 41; 204.138; 227.32; 232.149 **considerable** 475 **excessive/exceedingly** 380, 381, 464 **inordinate** 453, 455, 456, 485, 501 **other/unfamiliar** 432, 434, 441, 443, 468, 488, 503, 519, 522

extremitas *frequently recurring* (11-14, 16, 18, 20, 31, 37, 39-43, 47, 67, 70, 75, 80-82, 89, 91-93, 96, 97, 126, 130, 131, 135, 142, 145-153, 158, 159, 161, 168, 169, 172, 174-176, 187, 286, 304, 322, 326) **edge, end, endpoint, extreme, extremity, outer edge**

extrinsecus 12.41; 13.69; 128.9; 129.39; 135.204; 241.94, 97 **external influence** 527 **outer/outside** 349, 450, 451, 454

facere 44.58, 61; 45.104; 48.201; 63.40; 72.126; 88.247; 90.20; 110.70, 73; 128.5; 129.24; 143.152; 163.125; 179.3; 199.6; 204.146; 205.159, 160, 180, 181, 184; 206.187, 188, 192, 193, 195, 196, 204, 205; 207.220, 223, 228, 231, 234, 237, 240, 243; 208.245, 247, 249, 251, 255, 263, 268; 209.282, 297, 1, 2, 4; 210.7, 8, 10, 12, 14, 15, 18; 211.39, 41, 42, 45; 212.65; 213.94, 105, 108; 214.125, 134, 144; 215.156, 159; 220.112; 250.92; 264.196, 203; 273.170; 275.228; 276.231, 238; 277.270; 278.2; 280.74; 292.220; 295.19, 28; 299.68; 300.105, 118; 301.9; 302.27; 308.207; 315.54; 317.99; 319.144; 322.3; 328.80, 84; 334.7 **to accomplish** 574 **to cast (shadow)** 383, 500, 503, 620 **to cause** 370, 423, 438, 514, 595, 596, 598, 600, 601, 612 **to construct** 573 **to create** 370, 371, 450, 504-511 **to do** 450, 580-583, 585 **to form** 424, 564 **to fulfill** 373 **to keep** 390 **to lead to** 616 **to make** 474, 506, 508, 510 **to produce** 605, 625 **to subtend** 485 **to transform into** 461

facialis 274.183; 276.244, 250; 277.263, 284; 278.3, 10, 11; 279.19, 31, 49; 280.53; 281.98, 107, 110; 282.124, 126, 133; 283.139, 152, 165; 284.198; 285.22, 27; 287.73 **facing/directly facing** 580, 582-589

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intuitus 201.47, 68; 214.127; 302.20; 337.22 **process of visual scrutiny** 510

invalescere 306.139; 307.170 **to reinforce** 604

invehere 295.33; 309.216; 314.17; 323.31 **to bring about/cause/induce/produce** 596, 606, 610, 616

invenire 3.1, 10, 14, 19, 21; 4.24, 25, 27, 34, 38, 40, 43, 46, 49, 51; 5.56; 6.31; 8.1[2]; 9.13, 15, 18; 10.37; 27.164; 29.200; 38.195; 42.18; 43.50, 54; 47.179; 57.161; 62.298; 96.174, 177; 100.87; 113.174, 176; 132.127; 136.246, 248, 249; 145.202; 152.98; 171.53, 67, 69; 183.133; 184.140; 193.131; 209.290, 3; 211.40; 213.105, 109; 217.14; 219.87, 91; 227.14, 16; 265.217, 219, 220, 222, 227, 229, 238; 266.239, 241, 246, 251, 257, 262, 264; 270.82; 271.86; 272.117; 274.190, 191; 275.211, 218, 228; 276.233, 239; 277.273, 282; 278.291, 300, 2, 5; 280.61; 281.99, 110; 282.113, 116; 316.58 **to apply** 611 **to arrive at** 488 **to encounter** 440, 453, 575 **to experience** 343 **to find** 343-347, 359, 360, 366, 369, 370, 373, 380, 382, 428, 431, 462, 466, 479, 480, 488, 495, 507-509, 512, 514, 519, 574, 575, 578, 581-586 **to get** 586 **to reach** 455, 456 **to see** 343, 344

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labor 108.2; 109.31, 49; 273.151 **effort** 436, 437, 580

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lacrima 22.29; 111.107 **tear** 438 **tear duct** 355

lampas 7.78 **lamp** 346

lana 300.100 **wool** 599

preservare 274.197; 275.206 **to make certain** 581 **to take care** 581
prestare 331.44 **to show forth** 622
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procedere 37.162; 295.44; 308.204; 318.119; 321.63 **to arise** 596 **to continue by** 366 **to extend** 605 **to project** 615
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propinquus *frequently recurring* (28, 65, 66, 95-97, 115, 118, 132, 133, 140, 146-148, 152, 158, 163, 170, 173, 174, 178, 179, 191, 195, 246, 249-253, 259, 260, 262, 264, 266, 268-273, 276, 281, 282, 286, 300, 302, 309, 314, 328, 332, 334) **close, near**
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ENGLISH-LATIN GLOSSARY

ENGLISH-LATIN GLOSSARY

a little bit/not very much modicum
aberration immoderatio
absence privatio
absent absens
absolute verus
abū qalamūn alburalmon (*see also* **amilialmon**)
abutment coniunctio
to accept recipere
acceptance receptio
to accomplish complere, facere
account distinctio
to account for complere
accuracy veritas
accurate verus
accurate determination certificatio, certitudo
accurately/correctly/precisely determined certificatus
accustomed assuetus
to achieve complere
acquaintance cognitio, scientia
to acquire adquirere, habere, recipere
actual proprius, verus
actuality veritas
acuity fortitudo
to add addere
additional amount augmentatio
to adduce proponere, superponere
to affect immutare, operari, subiacere
affected transmutabilis
to affix/attach applicare, componere, consolidare
to aggregate aggregare
to agree convenire
agreement convenientia
air aer
albugineous albugineus
to alert to the fact significare
alignment verticatio
alike similis
to ally with coniungere
almond shape amigdaleitas

almond shaped amigdalatus
almond tree amigdalus
to alter alterare
alteration immutatio
aluerach *see* **firefly**
amilialmon amilialmon (*see also* **abu qalamun**)
amount quantitas
analysis sermo
analytic procedure divisio
to analyze distinguere
anatomist anatomicus
angle angulus
animal animal
ant formica
anterior anterior
aperture foramen
apparent apparens
to appear apparere
appearance apparens, apparentia
to apply invenire
to apprehend adquirere, cognoscere, comprehendere, intellegere
to apprehend before precognoscere
apprehensible comprehensivus
apprehension adquisitio, cognitio, comprehensio, intuitio
approach appropinquatio
to approach appropinquare
appropriate proprius
aranea aranea
arc arcus
arching arcualitas
area locus, pars
area around/encircled circuitus
to argue ratiocinare
argument/logical argument argumentatio, argumentum
to arise/arise as a perception apparere, contingere, crescere, evenire, oriri, procedere
arising crementum
arm brachium
to arouse inducere, ingerere
to arrange/arrange properly ordinare
arrangement compositio, congregatio, dispositio, ordinatio, ordo
arrival perventio, perventus
to arrive/arrive at extendere, invenire, pervenire
as a whole collocatus
to ascribe assignare
ascribing/ascription assignatio

ass asinus
to assimilate assimilare, assimulare, communicare, confiteri
assimilation assimilatio, collatio, communicatio
to assume existimare, iudicare, putare, reputare
at rest immotus
attachment consolidatio
to attenuate debilitare
attenuated debilis
to attest attestari
attractive/comely pulcher
attractiveness pulcritudo
to attribute ascribere
to avail oneself of uti
axis axis, collum
azure lazuleus

back posterius
barely modice
base basis
to base/base upon sumere, sustentare
to base a conclusion/ perception on concludere
based on mere visual impression fantasticus
based on supposition opinabilis
basis dispositio, radix, sustentatio
basis for conclusion argumentum
to be a function of (a combination) componere
to be accepted/established/given quiescere
to be affected pati
to be apparent/clear/evident/manifest/revealed/visible apparere, patere
to be apprehended apparere
to be based upon componere
to be clarified/explained patere
to be compatible convenire
to be constituted/disposed appropriare, parare, preparare
to be contiguous coniungere, contingere, continuare
to be continually presented iterare
to be continuous continuare
to be currently in view preesse
to be different diversare
to be divisible dividere
to be earlier/previous precedere
to be endowed with habere
to be ensconced quiescere
to be exposed to view apparere
to be hidden/imperceptible/inapparent/invisible/obscured/unclear/

unseen latere
to be high/above/stand above elevare, eminere
to be identical convenire
to be in contact/make contact tangere
to be in line with respicere
to be inordinate egredi
to be insensible/invisible abscondere
to be larger excedere
to be left remanere
to be like assimulare
to be located situari
to be luminous illuminare
to be maintained remanere
to be manifold dividere
to be naturally constituted naturari
to be obligated debere
to be oblique declinare, inclinare, obliquare
to be opposite respicere
to be part of a set/a subtype collocare
to be placed/lie against/upon applicare, existere
to be present/exist existere, preesse
to be prominent eminere
to be removed recedere
to be retained remanere
to be right in front of obicere
to be seen apparere
to be sensitive sentire
to be shown patere
to be small/tiny diminuere
to be specific appropriare
to be successive continuare
to be susceptible to recipere
to be transformed admittere
to be without carere
to be/remain at rest/fixed/immobile /stationary/steady/still quiescere
to bear/hang upon dependere
beautiful formosus, speciosus
beauty pulcritudo, species
to become less distinct diminuere
becoming ensconced quiescentia
to begin incipere
beginning principium
behind posterior
being accustomed to assuetudo
being affirmed affirmatio
being alike similitudo

being an animal animalitas
being deep-set profunditas
being distilled reductio
being ensconced quies
being equal equalitas
being false falsitas
being few paucitas
being fixed/implanted fixio, quies
being flat planities
being identical convenientia
being immobile/motionless/stationary/still/stopped quies
being impressed impressio
being measured collatio
being moderate/ordinate mediocritas, temperantia
being normal assuetudo
being of a certain kind quiditas
being of a kind/general type specialitas
being of another kind diversus
being placed/being put against/opposite oppositio
being toward mediocritas
being unequal inequalitas
to believe credere
to belong to appropriare
bench scannum
bend/bending giratio, obliquatio
to bend declinare, girare
beneficence benignitas
bird avis
to bisect dividere
black niger
blackness nigredo
to blanket with effundere
blemish macula
blended confusus, mixtus
blending unitas
to block cooperire, occultare, opilare, privare, resistere
blocking occultatio
boat navis
bodily corporalis
body corporeitas, corpus, pectus, res
book liber, tractatus
bottom fundus
boundary finis, terminus
bowl scutella
brain cerebrum
breadth amplitudo, latitudo, latus

brevity/shortness brevitas, parvitas
bridge (of nose) cornu
brief/short brevis, modicus, parvus, paucus
brief period instans
briefly instanter
bright acutus, clarus, lucidus
to brighten clarescere
brightness scintillatio
to bring about complere, invehere
to bring back into focus revertere
to bring back to reducere
to bring near/to appropinquare
to bring out extrahere
brown fuscitas
bulbous prominens
bulbousness prominentia
bulge eminentia, gibbositas, tumor
bulging gibbus

to call apellare, vocare
candle candela
capable of being imagined ymaginabilis
capable of being suffered passibilis
capable of retaining retentibilis
capacity virtus
capacity to transmit light diafonitas
cardinal precept magnum
careful subtilis
to carry/carry with defere, gerere, includere
to carry out a deduction sillogizare
to carry out a process iterare
to carry out an experiment experimentare
carrying out adquisitio
carrying out a task operatio
case dispositio, situs, status
to cast a shadow obumbrare
cause causa
to cause/cause to arise/cause to end up causare, efficere, facere, inducere, invehere, procreare
to cause to cease/disappear destruere
to cause to deteriorate corrumpere
to cause to stand erigere
cavity concavitas, concavum
celestial celestis
center/centerpoint centrum, medius

center of sight/center of the eye centrum, centrum visus, visus
certainty certificatio, certitudo
to certify certificare
change ablatio, diversitas, excessus, immutatio, mutatio, transmutatio
to change/suffer change alterare, diversare, immutare, mutare, transmutare
changeable mutabilis
characteristic intentio, proprietas, res
to characterize appropriare
charming nature dulcedo
cheek gena
child puer
childhood pueritas
choice electio
to choose eligere
circle circulus
circle of attachment circulus consolidationis
circle of intersection circulus sectionis
circular circularis, rotundus, spericus
circularity rotunditas
circumference circumferentia, rotunditas
to circumscribe continere
circumstance conditio, dispositio
city civitas
to claim before/earlier predicere
clarity/clearness certificatio, claritas, manifestatio
clear clarus, manifestus, mundus, planus
close/near propinquus
to close claudere
to close over superponere
close succession continuitas
closeness/nearness propinquitas
closure clausio
cloth pannus
cloud nubis, nubula
cloudy turbidus
to cluster together coniungere
to coexist aggregare
coexistence concursus
to coincide/coincide with respicere, superponere
to coincide nearly appropinquare
coincidence applicatio
coincidental continuus
collating collatio
color color, tinctura
to color colorare
coloring coloratio

combination adiunctio, compositio, congregatio, coniunctio
to combine adunare, componere, congregare, coniungere
to come pervenire
to come about evenire
to come back revertere
to come first precedere
to come out exire
commingling confusio
common communis
common axis axis communis
common nerve (optic chiasma) nervus communis
common section differentia communis
comparing/comparison collatio, consideratio, proportio, respectus
to complement complere
to complete complere
complicated windings tortuositas
to compose/comprise admiscere, componere
composite/composition compositio
to comprehend continere
to compress congregare
compression congregatio
concave concavus
concave part/concavity concavitas
concavity of the bone concavum ossis (*see also* **eyesocket**)
to conceive ymaginari
conceptual process ymaginatio
to conclude aggregare, concludere, existimare
conclusion conclusio, fides
condition dispositio, natura, qualitas, status
to **conduce to** iuvare
cone piramis
cone of radiation piramis radialis
configuration figuratio
to confirm affirmare
to confirm/determine experimentally experimentare
to conform convenire
to confuse admiscere
confusion admixtio
to conjoin aggregare, componere, coniungere, consolidare
conjoining/conjunction compositio, coniunctio, convenientia
to connect coniungere, consolidare, continuare
to conserve conservare
to consider considerare
considerable extraneus, longus, magnus
consideration consideratio
to consist of componere, continere

consistency spissitudo
consistent/constant consimilis
to constrain retinere
to construct facere
contact contactus
to contain continere
contiguity coniunctio, continguatio
contiguous/having contiguity contiguus
continuation extensio
to continue/continue on durare, elongare, extendere, prolongare
to continue by pertransire, procedere
to continue to be preesse
continuing outward processus
continuity continuatio, continuitas
continuous continuus
to contract congregare
to converge appropinquare, concurrere
convergence aggregatio, appropinquatio
converging strictus
convex convexus
convexity convexio, convexitas
conviction fides
cornea cornea
corner angulus
corporeity corporeitas
correct rectus, verus
correctness veritas
to correspond convenire, respondere, respicere
correspondence consimilitudo
corresponding consimilis
to corroborate certificare
to count numerare
to counter contradicere
course transitus
to cover continere, cooperire, superponere
crack fissura
crass densus, grossus
to create efficere, facere, operari
to create/have/make an effect contingere, operari
creator operator
crooked curvus
cross-section dyameter
crystal cristallus
crystalline lens *see* **glacialis**
cubit cubitum
to cull out eligere

curvature/curve arcualitas, arcuitas, curvitas, deviatio, incurvatio, spericitas
to curve incurvare
to curve away tendere
curved arcualis, curvus, rotundus
custom consuetudo
customary assuetus
to cut abscidere, distinguere, secare
cylindrical columpnatus

to damage corrumpere
dark (adj.) obscurus, tenebrosus
dark/darkening/darkness fuscus, nigredo, obscuratio, obscuritas, obumbratio, tenebra
to darken obscurare
darkened area tenebrositas
day dies
dazzle/dazzling light scintillatio
to deal with incedere
dearth paucitas
to deceive decipere
deception deceptio
decipherable intelligibilis
to decorate depingere
decrease in distance appropinquatio
decrease in size/diminution diminutio
to decrease/diminish/lessen diminuere
to deduce arguere, sillogizare
deduction/deductive process/reasoning argumentatio, argumentum, ratio, sillogismus
to deem putare, reputare
deep fortis, profundus
deficiency/insufficiency debilitas, parvitas
to define appropriare, determinare, distinguere, figurare, verificare
defining proprius
defining feature significatio, signum
definite certificatus, indubitabilis
definition diffinitio
to deform deformare
degeneration corruptio
deliberation consideratio
delicateness tenuitas
to delight in delectare
to delineate figurare
to demand indigere
to demarcate/mark off/out distinguere, secare

demonstration demonstratio
dense spissus
density spissitudo
to depend/depend upon premittere, sustentare
dependence sustentatio
to depict pingere
depiction pictura, ymago
to depress deprimere
depressed profundus
depression depressio, profunditas
depth profunditas, profundum
to derive adquirere, componere
to describe/describe before/earlier asserere, distinguere, figurare, narrare, predicare, signare
design lineatio, pictura
to design pingere, preparare
to designate ordinare
designed picturatus
to destroy destruere
destruction destructio
to detail dividere
determinant causa
determinate/determined certificabilis, certificatus, notus
determinate perception certitudo
determinateness certificatio
determination distinctio, verificatio
to determine/determine accurately/correctly/precisely affirmare, certificare, determinare, distinguere, verificare
to determine size mensurare
to develop contingere
development crementum, crescentia, distinctio
diagonal/diameter dyameter
to differ diversare, diversificare
difference differentia, dissimilitudo, diversitas, excessus, excrementum, inequalitas
different dissimilis, diversus
to differentiate distinguere, diversificare
differentiating faculty distinctio
differentiation distinctio
digit digitus
to dim eclipsare
dimension dimensio
direct/directly facing directus, rectus, verticalis
direct contact applicatio
direct focus directio
to direct dirigere, ponere

directed conversus
direction verticatio
directly facing disposition directio
directness rectitudo
disagreement diversitas
to disappear aufere, latere, recedere
disappearance destructio, latentia, latitatio, occultatio
to discern comprehendere, distinguere
discernment discretio, distinctio
discontinuity discretio, separatio
discrepancy diversitas
discrete discretus
discretely singillatim
to discuss narrare, predicere
discussion divisio, sermo
disease egritudo, infirmitas
to disfigure deformare, deturpare
disfigurement deformitas, turpitudo
to disjoin/divide/subdivide distinguere, dividere
disjoined discretus
disjunction distinctio, divisio, separatio
disk rota
disparate remotus
to displace aufere, declinare
displacement obliquatio
disposition dispositio, preparatio, situs, status
disproportionate assimetrus
to disrupt cassare, ledere
disruption destructio, lesio
dissimilar dissimilis
dissimilarity dissimilitudo, diversitas
distance distantia, elongatio, longitudo, remotio
distant remotus
distinct certificatus
distinction differentia, distinctio, divisio
distinctness certificatio
to distinguish distinguere
distinguishing notabilis
distorted monstruosus
to distress angustiare
disturbed state immoderantia
divergence piramidalitas, piramidatio
to divert obliquare
dividing communis
division distinctio, divisio
to do facere

to do without vitare
doubled duplex
to draw extrahere, scribere, signare
to draw away extrahere
to draw upon aggregare
drawing pictura
to drop/drop (a line) elevare, exire, extendere
dropped to erectus
dry siccus
dryness siccitas
dull turbidus
dullness debilitas
duration duratio
dusky obscurus
dust pulvis
to dwindle carere
dye tinctura

each/every thing singulus
earth terra
ease of motion velocitas
easily moved levis
edge extremitas, finis, latitudo, terminus
effect immutatio, operatio, passio
efficient temperatus
effort labor
egg white albumen
to elevate/lift/raise elevare
elevation preminentia, prominentia
to emanate emittere, exire
to emerge crescere
to emit exire
to encircle circulari
to enclose/form an enclosure continere, distinguere
to encompass continere, respicere
to encounter invenire
end/endpoint extremitas, finis
to endow dare
engraving sculptura
to enlarge ampliare, extendere
to entail indigere
to enter intrare
entertainer ioculator
to enumerate determinare, enumerare, narrare
to envelop continere

equal consimilis
equality equalitas, equivalentia
equivalent consimilis
to erect elevare, erigere
erroneous erroneus
error error
to escape/escape notice latere, preterire
essential essentialis
essential nature quiditas
estimate/estimation estimatio
to estimate existimare
etching incisura, sculptura
to evaluate considerare, intueri
evaluation consideratio, inductio
evening vespertinus
evenness directio, ordinatio
every universum
evidence significatio
evident manifestus, planus, verus
exact verus
to examine aspicere, considerare, inducere, inspicere, intueri
examination consideratio, inspectio, intuitus
example/instance dispositio, exemplum, verbum
to excede addere, egredi, excedere
exceeding additio
to except deficere
excess augmentum, excessus, excrementum, superfluitas, superhabundantia
excessive extraneus, superfluus
excessiveness extraneitas
to exert uti
to exist preesse
to exist along with admiscere
to expand amplificare, dilatare
expanded/expanding piramidalis
expanding amplificatio
experience experimentatio
to experience invenire
experiment/experimental confirmation/experimentation consideratio, experimentatio, experimentum
experimenter experimentator
to explain determinare
to explain before/earlier predicere
explanation divisio, expositio
to expose/expound exponere
to extend augmentare, continuare, elongare, exire, extendere, penetrare,

procedere
to extend between interiacere
to extend over superponere
extension continuatio, extensio
extent amplitudo, capacitas, longitudo, magnitudo, quantitas
external influence extrinsecus
to extinguish destruere
extramission exitus
extreme (adj.) magnus
extreme/extremity extremitas, terminus
eye/eyeball oculus, pupilla, visus
eyebrow supercilium
eyelash cilium
eyelid palpebra
eyesocket/socket concavitas, concavum ossis, os

fabric pannus
face facies
to face/face directly opponere
to face obliquely obliquare
facing facialis, oppositus, rectus
facing disposition/orientation/position oppositio
fact dispositio
factor radix
faculty virtus
faculty of discrimination distinctio, virtus distinctiva
faculty of sight visus
fading recessus
to fail to meet carere
faint debilis, tenuis
faintness debilitas
to fall cadere, incidere, transire
to fall outside egredi, pertransire
to fall short recedere
to fall to efficere
to fall under (a subdivision) dividere
falling outside/outside of egressio, evagatio
false falsus
familiar assuetus
familiarity consuetudo
far/far away longe, remotus
fast/quick/swift festinus, velox
to fasten applicare
fat pinguedo
to fatigue fatigare

fatness grossitudo
feature intentio, nota, pars, res
to feel pati, sentire
few paucus
fiber filum
fiery igneus
figure figura
to fill/fill by expansion extendere, implere
final judgment conclusio
final perception conclusio
final sensor ultimus/ultimum sentiens, ultimus sensator
to find invenire
fine minutus, subtilis, tenuis
fineness tenuitas
finger digitus
to finish complere
finite finitus
fire ignis
firefly aluerach, noctiluca
firm retentiva
firmness retentio
first glance aspectus
first moment principium
to fit into intrare
fitting together applicatio
to fix/fix upon figere, inspicere
fixed immobilis
flame flamma
flank latus
flaring/funneling outward declinatio, piramidalitas, piramidatio
flat planus
flatness planities, planitudo, simitas
flattening compressio
flex/flexing declinatio, giratio, incurvatio
to flex declinare, girare
to flood ascendere
flooding of light splendor
flow fluxus
to flow/flow by fluere, transire
flower flos
fluid fluxibilis, humidus
fluidity tenuitas
fly musca
focus intuitio, oppositio, visus
to focus/focus upon certificare, dirigere, figere, inspicere, intendere, intueri
foggy turbidus

to follow incedere, peragere, percurrere
forehead frons
forgetting oblivio
form apparentia, forma, genus
to form componere, consolidare, continere, contingere, efficere, facere, figurare, formare
to form a syllogism sillogizare
to form a whole congregare
fortuitous casualis
freckled lentiginosus
frequency frequentatio
front facies, pectus
to fulfill facere
function utilitas
to function accordingly appropriare
funnel rameh
funnel shaped piramidalis

to gain adquirere
gap distinctio, fissura, spatium, vacuitas
garden ortus, viridarium
gauge mensura
to gauge considerare, existimare, mensurare
gauging consideratio
gaze pupilla
general generalis, universalis
general nature universalitas
general type species
generally/in general/on the whole generaliter, universaliter
to generate generare
to get invenire, recipere
to get farther away elongare
to get larger intendere
glacialis (crystalline lens) glacialis
glance inspectio
to glance at/glimpse inspicere, intueri
glass (adj.) vitreus
glass cristallus, vas, vitrum
glimpse aspectus
to glitter micare
to go through an analytic procedure dividere
to go through steps iterare
to go unseen latere
goblet ciphus
goodness bonitas

grape uva
grasp adquisitio
to grasp adquiescere, adquirere, comprehendere, deprehendere, intellegere
to grasp with certainty certificare
grassy segetalis
gravity (of demeanor) gravitas
great magnus
greatness maioritas
green viridis, viror
greening viridificatio
greenness viriditas
grey glaucus
to grind to pieces frustare
ground/ground level facies terre, terra
grove nemus
to grow crescere

habit consuetudo
hair capillus
half subduplus
hand manus
to happen contingere, evenire
to hark back revertere
to harm/hurt dolere, ledere, nocere
harmful residue nocumentum
harmony consonoritas
to have/possess habere
to have to indigere
having a modicum modicum
having reached perventio, perventus
having texture asperus
having the same circumference ysoperimetrus
having to indigentia
haziness spissitudo
hazy spissus
head caput
health salus, sanitas
hearing auditus
heavens celum
height elevatio, erectio, preminentia
hidden occultus
to hide cooperire, occultare
hiding occultatio
to hinder impedire
to hold custodire

to hold in place retinere
to hold snugly includere
hollow (adj.) obticus, profundus
hollow concavitas, concavum, vacuitas
horn cornu
horse equus
human/human being homo
humor humor

ice glacies
identical consimilis, similis
identity similitudo, ydemptitas
illogical falsus
to illuminate/shine upon ascendere, illuminare, oriri
illuminated luminosus
illumination illuminatio, lumen
illusion deceptio
imaginary intellectualis, ymaginabilis
imagination ymaginatio
to imagine ymaginari
imagining ymaginatio
immobile immobilis, immotus
immobility quies
impairment nocumentum
to impede prohibere
imperceptibility/insensibility/invisibility occultatio
imperceptible imperceptibilis
to implant/plant figere
implication signatio, significatio
to impress figere, figurare, imprimere, infigere, instituere, signare
impression figuratio, intentio, intuitio
to impute existimare, iudicare
in tight order punctatim
inclination/slant declinatio, obliquatio
to incline/be inclined/incline toward appropinquare, declinare, inclinare, obliquare
inclined/slanted/sloping declinabilis, obliquus
to include continere
inconclusive incertus
inconspicuous occultus
increase augmentatio, excrementum
to increase addere, augmentare, crescere
indefinite/indistinct dubitabilis
indefiniteness latentia
indentation profundatio, profunditas

indented profundus
indeterminate incertus
indeterminateness incertitudo
to indicate significare
indication significatio, signum
indistinct perception incertitudo
individual (adj.) individualis, individuus, particularis, singularis, singulus
individual individuum
individual nature individualitas, individuitas, individuum
individuality distinctio
to individuate distinguere, separare, signare
to induce inducere, ingerere, invehere
induction inductio
inequality inequalitas
inferential process ratio
infinite infinitus
infinity infinitum
infirmity infirmitas
injury occasio
inner/inner surface anterius, interius, intrinsecus
inordinate evagatus, extraneus, immoderatus
inordinateness immoderamen, immoderantia, immoderatio, superfluitas
inside interius
to inspect intueri
inspection/visual inspection intuitio
instance dispositio
instant hora, instans
instrument instrumentum
intellect intellectus
intellectual grasp notitia
to intend intendere
intense fortis, purus
to intensify intendere, vigorescare
intensity fortitudo
to interfere impedire
interference impedimentum
interior interius
to interpose/be interposed intercidere, interponere
to interpret concludere
to interrupt abscidere, abscindere, secare
interruption abscisio
to intersect abscidere, abscindere, concurrere, coniungere, secare
to intersect obliquely declinare
intersection/intersection-point concursus, coniunctio, sectio
interstice foramen
interval distantia, spatium

to intervene/intervene between intercidere, interiacere, interponere, mediare
intervening medius
to investigate considerare, inquirere
investigation consideratio, inductio
invisible invisibilis, occultus
invisibility absconsio, latentia, occultatio
inward projection fundatio, profundatio
issue questio
to issue exire

jar doleum
to join concurrere, coniungere, consolidare, continuare, copulare
joining aggregatio, coniunctio
joy alacritas
judge/one who judges iudex
to judge distinguere, existimare, iudicare, putare, reputare
judgment argumentatio, estimatio, iudicium, ratio, reputatio
juncture concursus, divisio
to jut out eminere
juxtaposition compositio, congregatio, coniugatio

to keep conservare, custodire, retinere
to keep moist humefacere
to keep on durare
to keep together congregare
kind/like/sort genus, modus, ordo, qualitas, species
to know cognoscere, intellegere
knowledge cognitio, scientia
known notus

lack privatio
to lack carere
lamp lampas
large magnus, remotus
later posterius
laughter risus
to lay out/list distinguere, enumerare
to lay snugly applicare
to lead/lead to efficere, facere, inducere
leaf folium
to leak out resudare
to leave recedere

legible legibilis
length amplitudo, extensio, longitudo, longum
lentil lenticula
letter littera
to lie existere
to lie at continere
to lie beside/to the side of declinare
to lie between interiacere
to lie far from elongare
to lie in front of antecedere
to lie in line with opponere
to lie near propinquare
to lie opposite/directly opposite opponere
to lie upon cadere
to lift away aufere
ligature continuatio
light lumen, lux
to light illuminare
lightness levitas
limit finis, meta, terminus
line linea, lineatio, verticatio
line of radiation verticatio
line-of-sight radius, verticatio, visus
to line up ordinare
lineament lineatio
to linger remanere
to link continuare
lip labium
to list numerare
little paucus
location locus, situs
locomotion motus localis
to lodge infigere
logic ratio
long longus, remotus
look aspectus
to look/look at aspicere, considerare, inspicere, intueri, videre
to look as apparere
loosely textured rarus
to lose discernibility/visibility latere
to lower demittere
luminous lucidus, luminosus
luxuriant lotus
lying apart/away/beyond remotus
lying at the front/in front of antecedens, anterior
lying between interpositio
lying in direct line with directus

magnitude magnitudo, mensura, quantitas
to maintain custodire, durare
to maintain/mention before/earlier predicere
major universalis
to make/make up componere, facere
to make certain preservare
to make clear/evident/manifest/perceptible aperire, apparere, manifestare
to make determinate/sure certificare
to make disappear occultare
to make into efficere
to make more intense augmentare
to make out comprehendere
to make proportionate proportionare
to make vanish abicere, aufere
making out comprehensio
man/mankind homo
manner/means modus, qualitas
mark nota
marked notabilis
to mask abscondere
mass corporeitas
matching consimilis
mathematician mathematicus
mathematics mathesis
matter res
to mean intendere
meaning intentio
measure/measurement mensura, mensuratio
to measure mensurare
to mediate mediare
medical medicinalis
medical science ars medicinalis, medicina
to meet adunare, aggregare, cadere, concurrere, coniungere, existere
to meet as a whole congregare
member membrum
membrane tela
memory memoria
mere visual impression fantasia
middle/midpoint medius
Milky Way galaxia
mind mens
to mingle/mix admiscere
mingling/mixing admixtio, mixtura
minimal modicus
minute minutus

mirror speculum
misty pruinosus
to mitigate temperare
mixed mixtus
mode modus
moderate mediocris, moderatus, modicus, temperatus
moderation moderatio, temperamentum, temperantia
moist humidus
moistness/moisture humiditas
moment hora
moon luna
morning matutinus
moth papilio
motion/movement motio, motus
motionless immotus
mountain mons
mouth os
to move movere, mutare
to move away elongare, incedere
much magnus
muddy turbidus
mule mulus
muscle lacertus
mustard sinapis

naked spoliatus
narrow modicus, strictus, subtilis
to narrow constringere, strictificare
narrowing angustum
narrowness strictura, subtilitas
natural naturalis, proprius
natural philosopher naturalis
nature/nature of a thing diffinitio, genus, natura, proprietas, qualitas
nearness appropinquatio
necessity/need indigentia
neck collum
to need indigere
to need only sufficere
needle acus
nerve nervus
night nox
normal mediocris
nose nasus
not the same diversus
not to apprehend/determine/know/notice ignorare

not to be exposed to carere
not to stand destruere
notch concavitas
to notice aspicere
noticeable manifestus, notabilis
notion intentio, notitia
number numerus

object res, visibile
oblique/obliquely facing obliquus
obliquely facing disposition obliquatio
obliquity declinatio, obliquatio
oblong longus, oblongus
to obscure occultare
to observe videre
observer aspiciens, inspiciens
to obstruct cooperire, opilare
obstruction impedimentum, opilatio
to obviate excludere
obvious manifestus, planus
obviousness manifestatio
to occlude cooperire, occultare
occluded occultus
to occupy statuere
to occur cadere, contingere, evenire
occurrence perventus
of two kinds bipartitus
opacity densitas, soliditas, spissitudo
opaque densus, obscurus, solidus, spissus
to open aperire
to open into pertransire
opening apertio, foramen
opposite contrarius, econversus, oppositus
optic chiasma *see* **common nerve**
order ordinatio
to order/order properly ordinare
ordinary assuetus
ordinate moderatus, temperatus
ordinateness moderamen
organ membrum, res
orientation dispositio
origin principium
to originate exire, oriri
orthogonal perpendicularis, rectus
orthogonally ortogonaliter

to oscillate vadere
other extraneus
outer/outside exterius, manifestus
outer edge extremitas, terminus
outer surface exterior, manifestum
outline lineatio
to outshine eclipsare
outward projection preminentia, prominentia
oval oblongus
to overcome vincere
to overlap penetrare
overshadowing occultatio
to overwhelm vincere
own proprius

pain dolor
painful dolorosus
to paint depingere, inficere, intingere, pingere
painting pictura
paired duplus
palm's-breadth palma
parallel equidistans
parchment pargamenum
part pars
particular particularis, proprius, singulus
particular form forma particularis
to pass beyond/by/out of/over/through exire, intrare, pertransire, transire
passage extensio, penetratio, pertransitus, transitus
passing/passing over motus, pertransitus
passing beyond recessus
passing through pertransitus, transitus
passion passio
path verticatio
pattern ordinatio
peak cacumen
pear tree pirus
pearl margarita
peg individuum
to penetrate penetrare
to perceive comprehendere, cognoscere, percipere
to perceive accurately/clearly/distinctly/precisely certificare, comprehendere, distinguere, verificare
perceived apparens
perceived with accuracy/precision certificatus
perceiving comprehensio, perceptio

perceptible comprehensibilis, perceptibilis
perception/visual perception apparentia, comprehensio, intuitio, perceptio, visio
permanent fixus
perpendicular orthogonal, perpendicular
to persist existere, remanere
person homo
perspicacity discretio
pertinent proprius
petal folium
phenomenon dispositio, res
physical realm natura
picture pictura
pistachio fisticus
place locus
to place/position/put applicare, disponere, ponere, preponere, statuere
to place against continuare
to place at/behind/upon superponere
to place before opponere
to place between interponere, opponere
placement applicatio
plain planum
plane planus, superficies
planet stella erratica
plank tabula
plant herba
plaque tabula
point punctum
point (of discussion) sermo
to point out narrare, predicere
pointed punctatus
polish tersitudo
polished politus, tersus
polygonal lateratus
portion pars
position dispositio, status
to position over/up to superponere
posterior posterior
to pour ponere
power virtus, vis
power of seeing virtus visibilis
to precede precedere
to preclude excludere
premise propositio
to prepare preparare
to present evenire, redere

to preserve conservare
presupposition antecedens
to prevent negare, prohibere
previous antecedens
principle propositio
procedure/logical procedure argumentum, operatio, ratio
to proceed (in argument) arguere
process of visual scrutiny/visual scrutiny intuitio, intuitus
to produce efficere, facere, generare, inducere, ingerere, invehere, procreare, redere
producer causa
to project exire, procedere
to project upon incidere
to prolong prolongare
prominence/protrusion prominentia
prominent prominens
to promise promittere
to prompt affirmare, inducere
to propagate extendere
proper proprius, verus
property intentio, proprietas, res
propinquity propinquitas
proponent ponens
proportion dispositio, proportio
proportional/proportionate proportionalis
proportionality/proportionateness proportionalitas
proposition propositio
to protect conservare
protruding prominens
protrusion eminentia
to provide the means/means of recognition appropriare, mediare
providence bonitas, preparatio
proximity appropinquatio
pure mundus, purus
to put together componere, congregare

quadrilateral quadratus
quadruped quadrupes
to qualify appropriare
quality proprietas, qualitas, res
quantity quantitas
question questio

radial breaking reflexio

radial line linea radialis, verticatio
radial link verticatio
to radiate descendere, dirigere, exire, extendere
radius medietas dyametri, semidyameter
raised prominens
range/range of moderation latitudo, temperamentum, temperantia
to range respicere
rare rarus
ratio proportio
ray radialis, radius, verticatio
to reach evenire, extendere, invenire, pervenire
to reach a conclusion distinguere, intellegere
to reach to cadere
to read legere
real verus
reality veritas
to realize cognoscere, complere, evenire, intellegere, percipere, scire
rear posterior
reason/reasoning causa, ratio
to recall/remember memini, memorare, rememorare
to recede elongare, recedere
receding elongatio, recessus
to receive recipere
reception receptio
recognition cognitio, scientia
to recognize cognoscere, iudicare, precognoscere
to recount narrare
rectangular oblongus
rectilinear rectus
rectilinearity rectitudo
to recur iterare, redere, revertere
recurrence/reiteration/repetition frequentatio, iteratio
red rubeus
redness rubedo, rubor
to reduce to dividere
to refer to vocare
to reflect reflectere
reflection conversio, reflexio
to refocus recedere
to refract obliquare, reflectere
refraction obliquatio, reflexio
regard respectus
to reinforce invalescere
to reject dimittere
to relate appropriare, proportionare
relation/relationship proportio, relatio

to rely upon indigere
to remain/remain fixed existere, quiescere, remanere
remaining the same immotus
remembering/remembrance memoratio, rememoratio
remote remotus
remoteness remotio
removal ablatio, recessus
to remove abstulere, aufere, destruere, elongare, separare
to render ingerere, redere
to render imperceptible/inapparent/invisible abscondere, occultare
to render ugly deformare
to renew renovare
to repeat/repeat steps frequentare, iterare
repeated experience frequentatia
to replace/reposition revertere
to represent exprimere
representation expressio
to require exigere, indigere
resemblance assimulatio, similitudo
to resemble assimulare
reserve taciturnitas
respect dispositio, proportio, respectus
to respond respondere
rest quies
to restore reducere, revertere
result dispositio
to retain habere
to return/return to redere, reducere, revertere
to reveal exponere, manifestare
revealed manifestus
reversal conversio
reversed conversus
to revert back revertere
revolution revolutio
to revolve volvere
right rectus
rigidity retentio
river flumen
riverbank littus
robust fortis
roiled turbidus
room domus
rose roseus
rose-red roseaceus, roseus
rotary/rotating circularis
rotation giratio, revolutio

rough asperus
roughness asperitas, attritio
round/rounded circularis, rotundus
roundness rotunditas
routine assuetus
row ordo

sadness tristitia
same communis, consimilis
sameness ydemptitas
to say before/earlier predicere
scan/careful scan intuitio, intuitus
to scan aspicere, movere, transire
scanning/scanning process motus
scarce paucus
sclera consolidativa
screen coopertorium
to screen cooperire
to scrutinize considerare, intueri
scrutiny/close scrutiny inductio, intuitio, intuitus, iudicium
section pars, sermo
to see aspicere, considerare, inspicere, invenire, percipere, videre
seed granum
to seek quesere
to seem apparere
seen apparens
select proprius
sense sensus, sentiens
to sense sentire
sensing sentiens
sensing/sensitive agent/organ sentiens
sensitive sentiens
sensitive faculty/power virtus sensibilis, virtus sensitiva
sensitivity sensus
sensor sentiens
separate remotus, singularis
to separate disiungere, distinguere, dividere, separare
separation discretio, distantia, distinctio, divisio, remotio, separatio
serous tenuis
to set aside abstulere
to set before/forth proponere
to set up disponere, statuere
to shade obumbrare
shading/shadow umbra
shadowing effect diminutio

shadowy tenebrosus, umbrosus
shagginess villositas
shape figura, forma, ordinatio
sharply different remotus
sheer rarus, subtilis
sheet folium
to shield cooperire
shielding body coopertorium
to shift/shift away alterare, aufere, declinare, mutare, recedere, transfere
to shift back revertere
to shine/shine over/through/upon apparere, cadere, descendere, exire, extendere, fulgere, incidere, oriri, pertransire, scintillare
to shine brightly/brilliantly scintillare
shortfall defectus
to show/show forth/through/up apparere, demonstrare, determinare, egredi, erumpere, manifestare, ostendere, predicere, prestare, significare
showing apparens
to shrink constringere
side dimensio, facies, finis, latitudo, latus, terminus
sight aspectus, visio, visus
sign signum
significant/sizeable/substantial magnus
silhouette ymago
similar consimilis, similis
similarity assimulatio, consimilitudo, similitudo
to simulate assimulare
single singularis, singulus
situation dispositio, intentio, situs, status
size magnitudo, maioritas, mensura, quantitas
skew diversitas
sky celum
sky-blue celestis
to slant declinare
slenderness/slimness gracilitas
slight modicus, parvus
slim gracilis
slope obliquatio
slow subtilis
slowly modice
slowness tarditas
small/tiny minutus, modicus, parvulus, parvus, subtilis
small/tiny feature/part minutia, particula
smallness diminutio, minoritas, parvitas
smoke fumus
smooth lenis, planus, tersus
smoothness lenitas, planities

to snatch away subripere
snow nix
solid densus
someone homo
something harmful nocumentum
somewhat/to some extent modicus
soot fuligo
soul anima, animus
sound vox
soundness sanitas
source causa, principium
space spatium, vacuitas
to span respicere
spatial disposition situs
species species
specific particularis, proprius, singulus
to specify determinare, distinguere
speech sermo
speed/quickness/swiftness festinatio, velocitas
sphere spera
spherical spericus
spider web aranea
to spin/spin around circumgirare, girare, volvere
spirit spiritus
split divisio
to split dividere
spot macula, particula, punctum
square quadrangulus, quadratio, quadratus
squint strabo
to squint adunare
standing upright erectus
star stella
stare aspectus
to stare/stare at aspicere, inspicere, intueri
state dispositio
stationary immotus
to stay remanere
stick baculum, lignum
stone lapis
to stop cessare, quiescere
straight rectus
straight outward direction oppositio
straight-line connection utilitas
straightness rectitudo
to stream from/into descendere, exire
strength fortitudo, vigor

to strike cadere, incidere, percutere
strip scrotula
strong fortis
structure compositio
subject res
subject to debate dubitabilis
subject to deception fallibilis
to subsume collocare
to subtend cadere, continere, respicere, subtendere
subtle subtilis
to suffer dolere, habere, pati
to suffer/undergo an effect pati
suffering an effect receptio
to suffice sufficere
to suit convenire
to summarize aggregare, coacervare
sun sol
superfluous superfluus
to superimpose superponere
to suppose ponere, premittere, putare, reputare, ymaginari
surface facies, superficies
to surround circumdare, continere, continuare
syllogism sillogismus

to take recipere, sumere
to take away divertere
to take care preservare, servare
to take for/to take to be credere, putare, reputare
to take into account cadere, inducere
to take place accordingly appropriare
to teach instruere
tear/tear duct lacrima
tenuous minutus
term vocabulum
term of comparison respectus
terminal terminalis
test probatio
to test experimentare
to testify testari
texture asperitas, textura
that which is responsible causa
that within which something inheres substantia
thick corpulentus, grossus, spissus
thickness grossitudo, spissitudo
thin rarus, strictus, subtilis, tenuis

thing individuum, res
to think putare, reputare
thinness tenuitas
thought cognitio
thread filum
threshold mediocritas
time dispositio, hora, tempus
to the side obliquus
to tinge/tint colorare, intingere, tingere
to tire fatigare
top trocus
touch tactus
to touch applicare, concurrere, contingere, tangere
to touch on incedere
toughness fortitudo
tower turris
tracing sculptura
to transform alterare, facere, immutare
transformation mutatio
transmission reditio
to transmit defere, redere
transparency diafonitas, raritas
transparent diafonus, rarus, translucens
to traverse pertransire
tree arbor
triangle triangulus
true verus
true reckoning rectitudo
truth veritas
to try experimentare, intendere, probare
tunic tela, tunica
to turn aside declinare
twilight crepusculum
type varietas

ugliness deformitas, feditas, turpitudo
ugly fedus, turpis
ultimate (noun) finis
unappealing turpis
unchanged immotus
unconscious occultus
to understand intellegere
understanding intellectus
unequal inequalis
unfamiliar extraneus

uniform consimilis
uniform blend unitas
uniformity consimilitudo, equalitas
union adunatio, congregatio
to unite adunare, unire
unity unitas
universal universalis
universal form forma universalis
upright posture/stance erectio
upward anterior
to use uti
useless otiosus
utensil instrumentum
utter immensus
uvea uvea

vanishing debilitas
variable/various/varying diversus
variant transmutabilis
variation diversitas
to vary alterare, diversare, diversificare, diversitare
vegetation viridale
veracity veritas
to verify affirmare, verificare
vertex caput, conus
vessel vas
vicinity circuitus
view inspectio, visio
to view inspicere, videre
viewer aspiciens, inspiciens
viewpoint visus
vigorous velox
visible apparens, visibilis
visible characteristic/feature/property res visibilis
visible object res, res visa, res visibilis, visibile, visum
vision visio, visus
visual piramidalis, visibilis
visual axis axis, axis radialis
visual cone piramis radialis
visual faculty visum
visual perception visio
visual process visio
visual spirit spiritus visibilis
vitreous/vitreous humor vitreus

vividness fortitudo

wall paries
water aqua
water cress nasturtium
wax cera
way dispositio, modus, qualitas
weak debilis
weakening/weakness debilitas
to wear off aufere
weeping fletus
wellspring incrementum, principium
what is seen visum
wheat triticum
wheel rota
white albus
whiteness albedo
width amplitudo, latitudo
wild marjoram origanum
winding tortuosus
window fenestra, foramen
wine vinum
wine-red vinosus
to wipe away abstergere
wood lignum
wooden ligneus
wool lana
woolen laneus
word dictio, lectio, pars, verbum
wrinkle ruga
to write scribere
writer scriptor
writing scriptura

yellow citrinus

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