VI LIGHT

If we had wished to begin with the first causes of visual perception, a discussion of light should have preceded all others, for without light the eyes can observe no shape, no color, no space or movement. But light is more than just the physical cause of what we see. Even psychologically it remains one of the most fundamental and powerful of human experiences, an apparition understandably worshiped, celebrated, and importuned in religious ceremonies. To man as to all diurnal animals, it is the prerequisite for most activities. It is the visual counterpart of that other animating power, heat. It interprets to the eyes the life cycle of the hours and the seasons.

Yet, since man's attention is directed mostly toward objects and their actions, the debt owed to light is not widely acknowledged. We deal visually with human beings, buildings, or trees, not with the medium generating their images. Accordingly even artists have been much more concerned with the creatures of light than with light itself. Under special cultural conditions light enters the scene of art as an active agent, and only our own time can be said to have generated artistic experiments dealing with nothing but the play of disembodied light.

The Experience of Light

Physicists tell us that we live on borrowed light. The light that brightens the sky is sent through a dark universe to a dark earth from the sun over a distance of ninety-three million miles. Very little in the physicist's description accords with our perception. To the eye, the sky is luminous by its own power and the sun is nothing but the sky's brightest attribute, affixed to it and perhaps generated by it. According to the Book of Genesis, the creation of light produced the first day, whereas the sun, the moon, and the stars were added only on the third. In Piaget's interviews with children, a seven-year-old as-

serted that it is the sky that provides light. "The sun is not like the light. Light illuminates everything, but the sun only where it is." And another child explained: "Sometimes when the sun gets up in the morning, he sees that the weather is bad, so he goes to where it's good."

Since the sun appears as nothing but a shiny object, light must reach the sky from somewhere else. S. R. Driver, in his comment on Genesis, says: "It seems thus that, according to the Hebrew conception, light, though gathered up and concentrated in the heavenly bodies, is not confined to them; day arises, not solely from the sun, but because the matter of light issues forth from its place and spreads over the earth, at night it withdraws, and darkness comes forth from its place, each in a hidden, mysterious way." This is more clearly expressed in the Lord's question to Job: "Where is the way were light dwelleth? And as for darkness, where is the place thereof, that thou shouldst take it to the bound thereof, and that thou shouldst know the paths to the house thereof?"

Instead of being an effect exerted by a few sources upon all other objects, "day" here is a bright thing which arrives from the beyond and moves over the vault of the sky. In the same way the brightness of objects on earth is seen basically as a property of their own rather than as a result of reflection. Apart from special conditions to be discussed below, the luminosity of a house, a tree, or a book on the table does not appear to the eye as a gift from a distant source. At most, the light of the day or of a lamp will seem to call forth the brightness of things, as a match ignites a pile of wood. Things are less bright than the sun and the sky, but not different in principle. They are weaker luminaries.

It follows that darkness is seen either as the extinction of the object's inherent brightness or as the effect of dark objects hiding bright ones. Night is not the negative result of withdrawn light, but the positive arrival of a dark cloak that replaces or covers the day. Night, according to children, consists of black clouds, which move close together so that none of the white can shine through. Some artists, such as Rembrandt or Goya, at least part of the time show the world as an inherently dark place, brightened here and there by light. They happen to endorse the findings of the physicists. But the prevailing view throughout the world seems to have been and to be that light, although originally born from primordial darkness, is an inherent virtue of the sky, the earth, and the objects that populate them, and that their brightness is periodically hidden or extinguished by darkness.

To assert that these are children's and primitives' misconceptions eradicated by modern science would be to close our eyes to universal visual experiences, which are reflected in artistic presentations. Knowledge has made us stop talking like children, ancient chroniclers, or Polynesian islanders. Our image of the world, however, is all but unchanged, because it is dictated by compelling perceptual conditions that prevail everywhere and always. Even so, we have trained ourselves to rely on knowledge rather than our sense of sight to such an extent that it takes accounts by the naive and the artists to make us realize what we see.

Relative Brightness

Another discrepancy between physical and perceptual facts is uncovered when we attempt to answer the question: How bright are things? It has often been observed that a handkerchief at midnight looks white, like a handkerchief at noon, although it may send less light to the eyes than a piece of charcoal under the mid-day sun. Here again, as in the case of the perception of size or shape, we cannot account for the facts by talking about the "constancy" of brightness, certainly not in the simple sense of asserting that objects are seen "as bright as they really are." The brightness we see depends, in a complex manner, on the distribution of light in the total situation, on the optical and physiological processes in the observer's eyes and nervous system, and on an object's physical capacity to absorb and reflect the light it receives.

This physical capacity is called luminance or reflectance. It is a constant property of any surface. Depending on the strength of the illumination, an object will reflect more or less light, but its luminance, i.e., the percentage of the light it throws back, remains the same. A piece of black velvet, which absorbs much of the light it receives, may under strong illumination send out as much light as a dimly lit piece of white silk, which reflects most of the energy.

Perceptually, there is no direct way of distinguishing between reflecting power and illumination, since the eye receives only the resulting intensity of light but no information about the proportion in which the two components contribute to this result. If a dark disk, suspended in a dimly lit room, is hit by a light in such a way that the disk is illuminated but not its environment, the disk will appear brightly colored or luminous. Brightness or luminosity will appear as properties of the object itself. The observer cannot distinguish between the brightness of the object and that of the illumination. Indeed, under such conditions he sees no illumination at all, though he may know that the light source is in action and may even see it. If, however, the room is made brighter, the disk appears correspondingly darker. In other words, the observed

brightness of the object depends upon the distribution of brightness values in the total visual field.

Whether or not a handkerchief looks white is determined not by the absolute amount of light it sends to the eye, but by its place in the scale of brightness values provided by the total setting. Leon Battista Alberti said: "Ivory and silver are white, which, when placed near swan's down, seem pale. For this reason things seem very bright in painting when there is a good proportion of white and black as there is from lighted to shadowy in the objects themselves; thus all things are known by comparison."

The phenomenon of glow illustrates the relativity of brightness values. Glow lies somewhere between the bright sources of light (sun, fire, lamps) and the subdued luminosity of everyday objects. A glowing object is seen as a source sending out light energy of its own. This view, however, may not match the physical condition. Mere reflected light may produce the perception of glow. To do so the object must display a brightness well above that which corresponds to its expected place in the scale established by the rest of the field. Its absolute brightness may be quite low, as we know from Rembrandt's famous glowing gold tones, which shine through the dust of three centuries. In a blacked-out street a piece of newspaper glows like a light. If glow were not a relational effect, realistic painting would have never been able convincingly to represent the sky, candlelight, fire and even lightning, the sun, and the moon.

We can tell the difference between a dark place and a brightly lit one even when no direct comparison is available. But within certain limits we transpose the brightness level of a whole setting in such a way that the difference is not perceived. We may get so accustomed to the dimness of the light in a room that after a while we notice it no more than we do a constant odor. We can also immerse ourselves in an old painting or a television program to such an extent that we are surprised to find how dark the canvas or the image on the tube actually is. To some extent such transposition is due to adaptive mechanisms in the nervous system. The pupils of the eyes enlarge automatically when brightness decreases, thus admitting a greater amount of light. The receptor organs of the retina also adapt their sensitivity to the intensity of the stimulus.

The relative brightness of objects is perceived most reliably when the whole setting is subjected to equal illumination. Under such conditions, the nervous system can treat the illumination level as a constant and credit each object simply with the brightness it exhibits on the total scale leading from the darkest to the brightest object in the setting. Remarkably enough, however, the mechanism works quite well even when the lighting is not homogeneous but ranges, for example, from intense brightness near the light source to dark shadow. If I compare a white envelope on the window sill with one lying in the back of the room, I do not have to rely on knowledge or intellectual calculation to realize that they are both the same white. I see it directly and spontaneously because I see each envelope in relation to the brightness gradient of the whole setting.

This perceptual accomplishment corresponds directly to what we observed about the perception of size in three-dimensional space. Brightness at even illumination can be compared to a spatial situation in which all objects are at equal distance from the observer. A brightness gradient, on the other hand, corresponds to pyramidal space, where the size of any object has to be determined in relation to its position within that space. However, in the case of brightness as well as of size the nervous system can accomplish its remarkable computations only if the perceived unevenness of the total setting is both simple enough in itself and clearly distinguishable from the condition of the objects. Regular gradients are simple enough to be generated by a computer. The computer can impose upon the drawing of a cylinder the gradual crescendo and decrescendo of brightness that imitates the distribution of light and shade and thereby gives the cylinder its three-dimensional roundness.

When objects are of physically identical luminance, as in the example of the white envelopes, their brightness is most easily discriminated from that of the gradient. But if we cunningly painted a black-to-white gradient on a long strip of paper and viewed it in a setting pervaded by a light gradient of similar steepness, the painted gradient would either strengthen or neutralize the gradient of the lighting, depending on how it were placed. This sort of trick is used by stage designers to convey the illusion of lighting or to counteract the effect of light. The same device is operative in both man-made and natural camouflage. "In innumerable animals, belonging to groups as diverse as caterpillars and cats, mackerel and mice, lizards and larks, countershading forms the basis of their coloration. Such animals are colored darkest above, lightest beneath, with graded tones on the flanks. . . . Viewed under diffused lighting from the sky such animals seem to lack solidity." When in a room the walls containing windows are painted a shade lighter than those struck by daylight, the one-sided effect of illumination is partly compensated and the brightness of the room looks more even—which may be soothing or upsetting to the observer, depending on whether he tends to ignore or to consider the world outside the windows.

Another parallel to depth perception relates to the degree of constancy.

Even when the pattern of the illumination is clearly seen, constancy does not eliminate the effect of illumination. We can report with assurance that the two envelopes are both white, but we observe that they look different just the same. In the Rembrandt painting reproduced in Figure 224 we see Potiphar

Figure 224
Rembrandt. *Joseph and Potiphar*, 1655. National Gallery, Washington, D.C.

as darker than his wife. This is essential to the function of light in the composition. To this end, however, it is just as necessary that we see the effect as deriving from the lighting, not from a difference in complexion between husband and wife.

Illumination

The term "illumination" is not self-explanatory. At first thought it might seem as though illumination must be involved whenever we see anything, because unless light falls on an object it remains invisible. This, however, is physicists' reasoning. The psychologist and the artist can speak of illumination only if and when the word serves to name a phenomenon that is directly discerned by the eyes. Is there such a thing, and under what conditions is it observed?

An evenly lighted field shows no sign of receiving its brightness from somewhere else. Its luminosity, as I said earlier, appears as a property inherent in the thing itself. The same is true for a uniformly lighted room. It even seems justifiable to say that a stage viewed from a darkened theater does not necessarily give the impression of being illuminated. When the light is evenly distributed, the stage may appear as a very bright world, a large luminary. But illumination is something else.

I look at the small wooden barrel on the shelf. Its cylindrical surface displays a rich scale of brightness and color values. Next to the left contour there is a dark brown, almost a black. As my glance moves across the surface, the color gets lighter and more clearly brown, until it begins to become paler and paler, approaching a climax at which whiteness has all but replaced brown. Beyond the climax the color reverts back to brown.

But this description is correct only as long as I examine the surface inch by inch, or better, if I scan it through a small hole in a piece of paper. When I look at the barrel more freely and naturally, the result is quite different. Now the whole object looks uniformly brown. On the one side it is overlaid with a film of darkness, which thins out and disappears while an ever thicker layer of brightness begins to replace it. Over most of its surface the barrel shows a double value of brightness and color, one belonging to the object itself and another, as it were, draped over it—a transparency effect. This happens even though the eye receives one unitary stimulation from each point of the object. Perceptually, the unity is split up into the two layers. Here is a phenomenon that requires a name. The bottom layer will be called the object brightness and object color of the barrel. The top layer is the illumination.

Just as in central perspective a system of convergence is imposed upon a setting of shapes, *illumination is the perceivable imposition of a light gradient upon the object brightness and object colors in the setting.* The superposition observed on the surface of illuminated things is, as I have said, a transparency effect. Such transparency can be obtained in painting by actual glazes and superposition. Around 1500, artists often used sheets of colored paper for their drawings as a ground of medium brightness, to which they added highlights by applying white ink, shadows by black hatching. Painters often started with a monochromatic underpainting, which laid out the shadows and was then covered with transparent glazes of local color. This separation of illumination and object color reflected the perceptual split observed by the painter as he looked at things in the physical world; it also manifested a practical, object-oriented attitude, intent on distinguishing properties of the objects themselves from transitory effects momentarily imposed upon them.

Quite a different attitude is expressed by painters of the nineteenth century who represented the sum of local brightness, local color, and the brightness and color of the illumination through a single shade of pigment. This technique not only confirmed the purely visual sensation as the finaly reality; it also asserted philosophically that the being of things is not untouchably permanent. Accidentals are seen as participating in the essence of things just as much as their invariant properties. This pictorial procedure also defined the individual as being partly the creature of its environment, subject to influences that cannot simply be shed like veils.

As in other instances of transparency, the illumination effect is brought about by the tendency toward simplest structure. When illumination is perceived as a superposition, the illuminated object is able to maintain a constant brightness and color, while shading and highlights are attributed to a light gradient, which has a simple structure of its own. It should be noted that there is no obvious answer to the question how the object's brightness-color value is determined. Thinking back to the example of the wooden barrel grazed by light, we realize that what the eyes actually receive is a gamut of shades. Is one of them designated as the "true" color of the object, perhaps because it is the most saturated, the least contaminated by grayness? Delacroix assumed the existence of such a true tone (*le ton vrai de l'objet*) and noted that it is found next to the "luminous point," i.e. the highlight. But perhaps no such tone is actually present in the percept, and object brightness and object color are instead medium values, which serve as common denominators of the various shades.

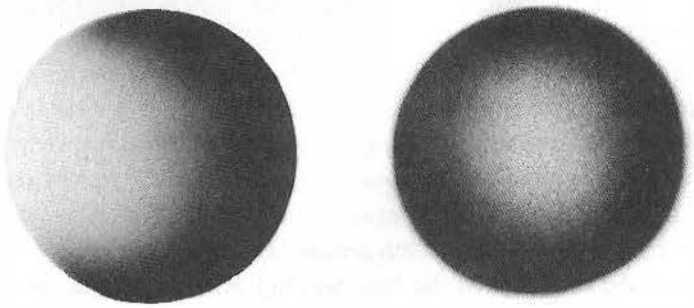
Light Creates Space

All gradients have the power to create depth, and gradients of brightness are among the most efficient. This is true for spatial settings, such as interiors and landscapes, but also for single objects. In an experiment by Gehrcke and Lau, a wooden, whitewashed cone, whose base had a diameter of about five inches was viewed from a distance of thirteen yards. The cone was placed with its vertex toward the observer, whose line of sight coincided with the main axis of the cone. When the cone was lighted evenly from all sides the observer saw no cone, simply a flat white disk. The cone became visible when the light fell from only one side. Evidently a three-dimensional view could provide no structural simplification as long as the lighting was even. When lateral illumination was used, however, it introduced a gradient of shading, which resulted in a strong three-dimensional effect revealing the shape of the cone.

The increase in relief produced by lateral lighting is well known. Goethe says of the sun that it receives an immaculate view of the world "because it never saw the shadow," and the amateur photographer obtains flat pictures when he mounts the flash bulb on his camera. When the moon is full, its mountains and depressions appear as mere spots, but they stand out in bold relief as soon as the light strikes the crescent laterally.

Overwhelming is the testimony of the scanning electron microscope, which has introduced the world of the infinitely small into our common visual experience by providing strong illumination effects. The flat sections supplied by the light microscope or the transmission electron microscope have their own beauty and informative value, but they can hardly be experienced as belonging to the same world as the animals and plants known to the naked eye. Under the scanning microscope, the tiny cones and rods of the retina look like the withered trunks of a petrified forest, and the red cells of human blood look like a field of densely grown fungi or a junkyard of discarded tires. By giving these small objects the tangible volume of things as we know them, the scanning microscope has extended the continuum of visual experience to the limits of the organic and inorganic worlds.

Curved surfaces are obtained by accelerating brightness gradients, which correspond to the fact that the curvature of an object is almost flat where the line of sight strikes it at a right angle but increases ever more rapidly from the center toward the boundary (Figure 225). By varying the steepness of the gradient, one can control the shape of the curvature perceived. A gradient



A B

Figure 225

changing at a constant rate produces the effect of an inclined plane by reflecting the physical fact that the angle of inclination is constant throughout the surface.

In Figure 225, the gradient of *a* tends to create more compelling perceptual volume than that of *b* because in *b* the shading is as symmetrical as the spherical shape itself. Not much structural gain is obtained by perceiving such a symmetrical pattern as three-dimensional. Nor, in this case, does the object convey a strong impression of being lit by an outer light source. In 225*a*, by contrast, the gradient introduces an asymmetry, which can be detached from the object when the pattern is seen as a sphere struck obliquely by a light.

As we look at an object by itself, it is not always clear whether any brightness differences it shows in itself are due to illumination or to actual physical differences between white, black, and gray paint. This was nicely demonstrated long ago by Ernst Mach. When we look at Figure 226, we probably see a white and a dark wing regardless of whether we see a flat pattern or a folded one, and the central edge as in front or in back. If one then takes an actual piece of folded white cardboard and places it on the table, with its central edge toward the viewer and the light falling from the right, the percept will correspond to the physical facts: one sees a white card, shaded on one side by being turned away from the light source. Constancy of brightness is at work. However, if one closes one eye and forces the object to reverse so that it looks something like an open book with the central edge forming a distant groove, the situation changes radically. Now the left wing looks darkly colored, all the more dark because the light should strike it directly, and the rightwing is white, all the more bright because it should be in the shadow. Thus illumination effects are strongly influenced by the light distribution perceived in the total spatial setting.

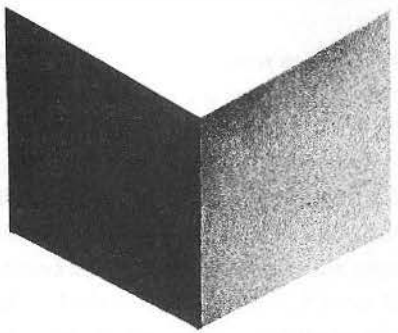


Figure 226

In whole settings as well as in single objects, steady gradients of brightness, like steady gradients of size, make for a continuous increase or decrease in depth. Brightness leaps help to produce distance leaps. The so-called *repoussoirs*, large objects in the foreground intended to make the background look farther away, are reinforced in painting, in photography and film, and on the stage if there is a strong brightness difference between foreground and background.

Since brightness of illumination means that a given surface is turned toward the light source whereas darkness means that it is turned away, the distribution of brightness helps to define the orientation of objects in space. At the same time it shows how various parts of a complex object are related to one another. Areas of similar spatial orientation are correlated visually by their similar brightness. The closer they come to meeting the incident light perpendicularly, the brighter they appear. We know that units of similar brightness are grouped together in perception. Thus a grouping by similarity of brightness indirectly produces a grouping by similarity of spatial orientation. Parallel surfaces are knitted together by the eye at whatever place in the relief they may occur, and this network of relations is a powerful means of creating spatial order and unity. Whereas a fly walking across an object would experience nothing but a bewildering irregular sequence of ups and downs, the surveying eye organizes the whole by correlating all areas of like spatial orientation.

A judicious distribution of light serves to give unity and order not only to the shape of single objects, but equally to that of a whole setting. The totality of the objects appearing within the frame of a painting or on a stage can be treated as one or several large objects, of which all the smaller elements are parts. The strong lateral light used by painters such as Caravaggio simplifies and coordinates the spatial organization of the picture. Roger de Piles, a French

writer of the seventeenth century, said that if objects are arranged in such a way that all the lights are together on one side and their darkness on the other, this collection of lights and shades will keep the eye from wandering. "Titian called it the *bunch of grapes* because the grapes, being separated, would have each its light and shade equally, and thus dividing the sight into many rays, would cause confusion; but when collected into one bunch, and becoming thus but one mass of light and one of shade, the eye embraces them as a single object."

The neat analogy between brightness and spatial orientation is interfered with by cast shadows, because they may darken an area that would be bright otherwise, and by reflections that light up dark places. Differences in local brightness will also interact with the lighting scheme. In sculpture, dirt spots on the marble or irregularities of brightness in the grain of the wood will often distort shape by being subject to misinterpretation as effects of shading.

We are again up against the problem that arises from the eye's inability to distinguish directly between reflecting power and strength of illumination. Roger de Piles writes in a discussion of *claro-obscuro*: "*Claro* implies not only anything exposed to a direct light, but also all such colors as are luminous in their natures; and *obscuro*, not only all the shadows directly caused by the incidence and privation of light, but likewise all the colors which are naturally brown, such as, even when they are exposed to light, maintain an obscurity, and are capable of grouping with the shades of other objects."

In order to avoid the confusion between brightness produced by illumination and brightness due to the coloring of the object itself, the spatial distribution of light in the setting must be understandable to the eyes of the viewer. This is most easily achieved when no more than one light source is used. But often in photography or on the stage several light sources are combined in order to avoid excessively dark shadows.

Such dark shadows, it may be mentioned in passing, will destroy shape not only by hiding relevant portions of the object but also by cutting across the continuity of the curvature with sharp boundary lines between brightness and darkness. In recent years museums and art galleries have taken to murdering sculpture by illuminating it with focused spotlights to create a dramatic effect. Experiments have shown that attached shadows maintain their character of a transparent film only when their borders are blurred gradients. Hering observed: "A small shadow, thrown upon the surface of one's writing paper, appears as a casual spot of blurred gray superimposed upon the white paper. Under normal circumstances the white paper is seen *through* the shadow. There is no suggestion that it forms in any way a part of the genuine

color of the paper. If, now, a heavy black line is drawn around the shadow so as to coincide exactly with its outline, a striking change may be observed to take place. The shadow ceases to appear as a shadow and becomes a dark gray spot on the surface of the paper, no longer a casual spot superimposed upon the paper but an actual part of the color of the paper." The focused spotlight creates the same sharp contours as Hering's black lines and therefore slashes the continuity of the sculptural surface mercilessly and produces a senseless arrangement of white and black shapes. Daylight, on the other hand, makes sculpture so beautifully visible because its diffuseness supplements the direct incidence of the sunlight and creates mellow gradients.

For lighting in art galleries or film studios or on the stage to avoid harsh one-sidedness, it must combine light sources in an organized whole. Several lights may add up to an even illumination, or each of them may create a clearly self-contained gradient of brightness values. The overall result can convey visual order. But the light sources may also interfere with one another by partly increasing or reversing the others' effects. This will make the shape of objects as well as their spatial interrelations incomprehensible. If several light sources are to cooperate, the photographer endeavours to organize them in a hierarchy, giving one of them the leading part of the "motivating source" and clearly weaker supporting roles to the others.

Shadows

Shadows may be either attached or cast. Attached shadows lie directly on the objects by whose shape, spatial orientation, and distance from the light source they are created. Cast shadows are thrown from one object onto another, or from one part onto another of the same object. Physically both kinds of shadow are of the same nature; they come about in those places of the setting where light is scarce. Perceptually they are quite different. The attached shadow is an integral part of the object, so much so that in practical experience it is generally not noted but simply serves to define volume. A cast shadow, on the other hand, is an imposition by one object upon another, an interference with the recipient's integrity.

By means of a cast shadow one house reaches across the street to streak its opposite number, and a mountain may darken the villages in the valley with an image of its own shape. Thus cast shadows equip objects with the uncanny power of sending out darkness. But this symbolism becomes artistically active only when the perceptual situation is made comprehensible to the eye. There are two things the eye must understand. First, the shadow does not belong to the object on which it is seen; and second, it does belong to another object,

which it does not cover. Often the situation is understood intellectually but not visually. Figure 227 indicates the outlines of the two main figures of Rembrandt's *Night Watch*. On the uniform of the lieutenant we see the shadow of a hand. We can understand that it is cast by the gesticulating hand of the captain, but to the eyes the relation is not obvious. The shadow hand has no meaningful connection to the object on which it appears. It may look like an apparition from nowhere, because it acquires meaning only when related to the captain's hand. That hand is some distance away; it is not directly connected to the shadow, and, because of its foreshortening, is quite different in shape. Only if (1) the beholder has a clear awareness, conveyed to him by the picture as a whole, of the direction from which the light is falling, and (2) the projection of the hand evokes its objective three-dimensional shape, can the hand and its shadow be truly correlated by the eyes. Of course Figure 227 is unfair to Rembrandt in singling out two figures and showing one shadow in isolation from the impressive display of light of which it is a part. Nevertheless, shadow effects of this kind strain the capacity for visual comprehension to its limit.

Cast shadows have to be used with caution. In the simplest cases they are directly connected to the object from which they derive. The shadow of a man meets his feet on the ground; and when the ground is even and the rays of the sun fall at an angle of about forty-five degrees, the shadow will produce an undistorted image of its master. This duplication of a living or dead thing

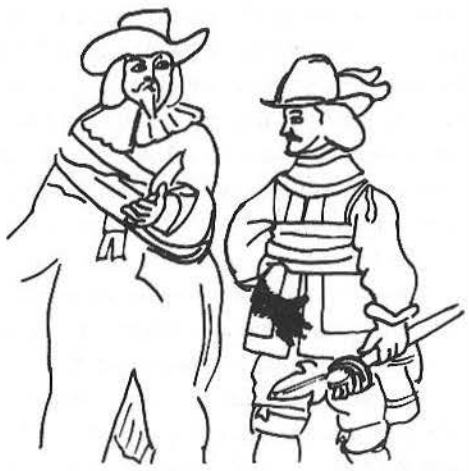


Figure 227

by an object that is tied to it and imitates its motions and at the same time is curiously transparent and immaterial has always attracted attention. Even under optimal perceptual conditions, shadows are not spontaneously understood as an effect of lighting. It is reported that certain tribesmen of western Africa avoid walking across an open square or clearing at noontime because they are afraid of "losing their shadow," that is, of seeing themselves without one. Their knowledge that shadows are short at noon does not imply understanding of the physical situation. When asked why they are not equally afraid when the darkness of the evening makes shadows invisible, they may reply that there is no such danger in darkness, because "at night all shadows repose in the shadow of the great god and gain new power." After the nightly "refill" they appear strong and big in the morning—that is, daylight feeds on the shadow rather than creating it.

Human thinking, perceptual as well as intellectual, seeks the causes of happenings as close to the place of their effects as possible. Throughout the world the shadow is considered an outgrowth of the object that casts it. Here again we find that darkness does not appear as absence of light but as a positive substance in its own right. The second, filmy self of the person is identical with or related to his soul or vital power. To step on a person's shadow is a serious offense, and a man can be murdered by having his shadow pierced with a knife. At a funeral, care must be taken to avoid having a living person's shadow caught by the lid of the coffin and thus buried with the corpse.

Such beliefs must not be ignored as superstitions but accepted as indications of what the human eye spontaneously perceives. The sinister appearance of the ghostly darker self in the movies, on the stage, or in surrealist painting keeps exercising its visual spell even on people who have studied optics in school; and Carl Gustav Jung uses the term "shadow" for "the inferior and less commendable part of a person."

As to the soberer properties of cast shadows, we note that, like attached shadows, they define space. A shadow cast across a surface defines it as plane and horizontal or perhaps as crooked and sloping; thereby it indirectly creates space around the object by which it is cast. It operates like an additional object creating a ground by lying on it. In Figure 228 the rectangle *a* lies flat on a frontal plane or at least creates no articulate space around itself. In *b* there is a clearer detachment from the ground, partly because of the contrast created by the black bar and partly because the obliqueness of the small edge suggests depth. But on the whole, *b* shows much less three-dimensionality than *c* or *d*, for the reason that the rectangular pattern formed by the bar and its shadow is simple and stable and can hardly be further simplified by more depth. In *c*

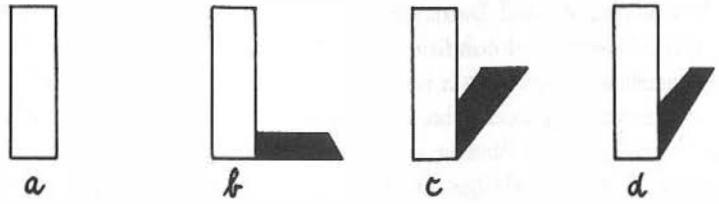


Figure 228

the three-dimensional version eliminates an oblique angle and allows the black bar to be seen as a complete rectangle. In *d* the shadow converges—an additional distortion, which makes straightening-out by depth even more compelling. In other words, the solid and its shadow function as one object, to which the rules for the spatial appearance of objects apply. Figure 229 shows how effectively shadows create space by defining the difference between vertical and horizontal and by contributing to the size gradients of convergent perspective.

A word about the convergence of shadows. Since the sun is so far away that within a narrow range of space its rays are practically parallel, its light produces an isometric shadow projection; that is, lines that are parallel in the object are also parallel in the shadow. But like any perceived thing a shadow is subject to perspective distortion, and therefore will be seen as converging from its base of contact with the object when it lies behind the object and as diverging when it lies in front of it. In addition, a near source of light, such as a lamp or a fire, will produce a pyramidal family of rays and consequently shadows of divergent physical shape. This objective divergence will be either increased, or compensated by perspective, depending upon the position of the shadow in relation to the observer.

Figure 230 shows that illumination adds the effects of another pyramidal system to those resulting from the convergence of shape. Just as the shape of the cube is deformed because its physically parallel edges meet in a vanishing point, so the shape of its cast shadow is deformed by converging toward another focusing point, created by the location of the light source. Illumination also distorts the homogeneous local brightness of the cube by darkening parts of its surface with attached shadows. In both perspective and illumination the structure of the distorting system is simple enough in itself to be distinguished by the eye from the constant properties of the object. The result is a two-fold visual subdivision. Both the shape and the local brightness of the object are

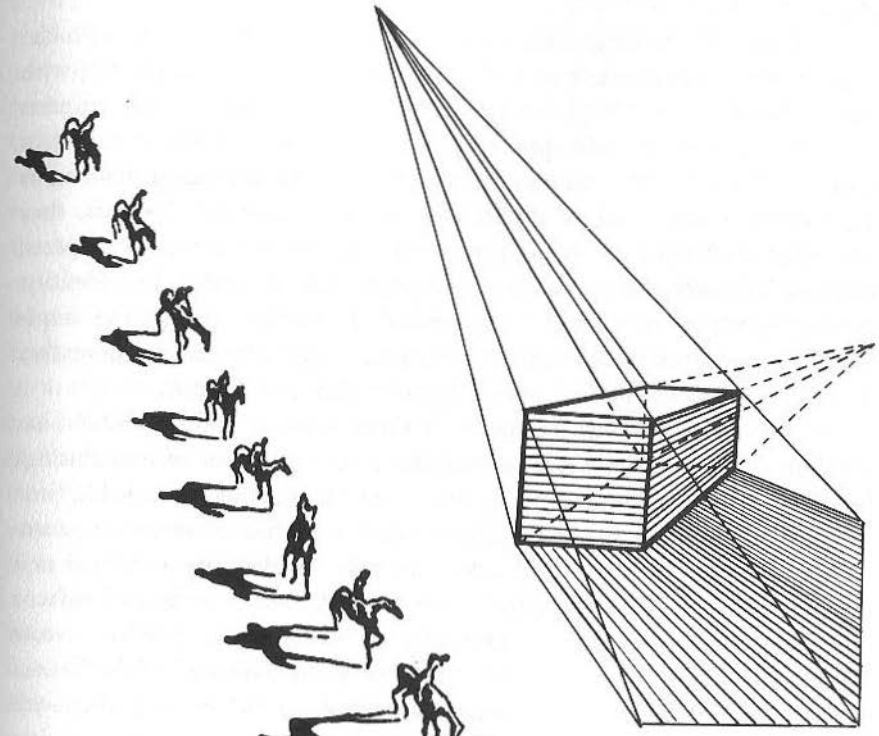


Figure 230

Figure 229

distinguished by the eyes from modifications imposed by spatial orientation and illumination.

Not only do the brightness patterns of shading get entangled with the brightness and darkness values of the object itself, but they also interfere with the clarity of the object's local colors and their interrelations. When painters began to create volume and space by means of illumination effects, this technique of chiaroscuro was soon found to disturb color composition. As long as shadows were conceived as applications of monochromatic darkness, they inevitably muddied and obscured the colors and thereby not only tampered unattractively with the saturation of the colors, but also dulled their identity. A blue coat shaded with black no longer looked truly blue and lost the simple homogeneity of its local color; an arm or leg underlaid with dark paint neither looked the color of skin nor presented a good, clear hue of pink.

It is quite possible that Leonardo da Vinci, whom Heinrich Wölfflin has called the father of chiaroscuro, was unable to complete some of his paintings because the desire to produce strong spatial relief by shading coincided in time with a new sensitivity to color organization. The unification of the two competing systems of pictorial form came gradually. Shadow was redefined as a modification of hue—a development that led from Titian by way of Rubens and Delacroix to Cézanne. "Light does not exist for the painter," wrote Cézanne to Emile Bonnard. In our own century, the color style of the Fauves often eliminated the problem by omitting all shading and by composing with saturated hues.

Painting without Lighting

Although the painter who uses effects of illumination is very much aware of their power, the influence of light and shadow is experienced in everyday life mostly in very practical ways. The seeking or avoidance of light is common at all levels of the animal world, and in the same way man seeks the light when he wants to see or be seen and avoids it otherwise. For these practical purposes, however, light is merely a means of dealing with objects. Light and shadow are observed, but hardly consciously for their own sake. They define the shape and spatial position of things and are consumed in this service. The naive observer is unlikely to mention them when asked to give a carefully detailed description of what he sees; he assumes that he is being asked about objects and their adherent characteristics.

Ernst Mach reports: "In my earliest youth the shadows and lights on pictures appeared to me as spots void of meaning. When I began to draw I regarded shading as a mere custom of artists. I once drew the portrait of our pastor, a friend of the family, and shaded, from no necessity, but simply from having seen something similar in other pictures, the whole half of his face black. I was subjected for this to a severe criticism on the part of my mother, and my deeply offended artist's pride is probably the reason that these facts remained so strongly impressed upon my memory." Early art everywhere represents objects by their outlines, local brightness and local color, and some cultures have retained this practice even at high levels of refinement. In the art work of young children, brightness values serve mostly to mark differences. Dark hair may be set off against a bright face. Light sources, such as the sun or a lamp, are often shown as sending out rays, but no indication is given that it is these rays which make objects visible. The same is true for early Egyptian painting. On Greek vases figures are detached from the background by strong contrast, but these differences appear as the result of object brightness or darkness, not of illumination. Literary sources indicate that in the course of the centuries Greek painters learned the use of shadows, and the results of these discoveries can be seen in the Hellenistic wall pictures or the Egyptian mummy portraits around the second and first centuries B.C. Here the chiaroscuro was handled with a virtuosity not rediscovered until the late Renaissance.

As the need to convey the roundness of solids arises, shading is introduced, later complemented by heightening. In physical space these effects are produced by illumination. But the use of shading does not necessarily originate from the observation of nature, and certainly is not always used in accordance with the rules of illumination. Rather, we can assume that after working for a while with the perceptually simpler means of line contour and homogeneously colored surfaces, the painter will discover the spatial virtues of unevenly distributed brightness. The perceptual effect of gradients becomes apparent to the eyes. Dark shading will make the surface recede toward the contours. Highlights will make it protrude. These variations are used to create roundness or hollowness; they do not necessarily imply a relation to a light source. Often the distribution of "shadows" follows different principles. Shading may issue from the contour all around the pattern, and give way gradually to lighter values toward the center. In the symmetrical compositions of medieval painters the figures at the left often have their highlights on the left side, those on the right on the right side; or in the laterally foreshortened faces the larger half may always appear bright, the narrower dark. Thus, in adapting itself to the requirements of composition and shape, brightness is often distributed in a way that would be termed incorrect if judged by the laws of illumination.

The same is true when brightness differences are used to detach overlapping objects from each other. When a depth interval between objects of

nearly identical brightness is to be shown, shading is often introduced. As Figure 231 indicates, the brightness contrast obtained in this manner serves to enhance the overlapping, and there is no need to justify the result as an effect of illumination. In fact, Henry Schaefer-Simmern has pointed out that a genuine pictorial conception of illumination can develop only after the formal properties of shading have been mastered. Following a lead by Britsch, he gives examples from Eastern paintings and European tapestries in which the principle of Figure 231 is applied to overlapping scales of rocks, buildings, and trees. To speak here simply of "shadows" is to overlook the main pictorial function of the device.

Such an interpretation of shading and contrast becomes particularly compelling when we find that even after the art of rendering illumination realistically has been acquired, some painters will use brightness values in a way that is not derived from the rules, and at time even contradicts them. James M. Carpenter has pointed out that Cézanne separated planes in space "by a gradual lightening or darkening of the further plane where the two overlap." Using an example similar to that of Figure 232, he showed that Titian had the same technique. Particularly striking are the darkening of the buildings next to the sky and the brightening of the castle-like structure in the back, which is thereby set off against the roofs. Carpenter also demonstrates that Cézanne sometimes darkened the ground behind a light figure and rounded a cheek in a portrait by applying a gradient of darkness, which is an "abstract" use of the perceptual device rather than the rendition of an effect of lighting; illustrations from Filippino Lippi and Rembrandt are given to prove that here, too,

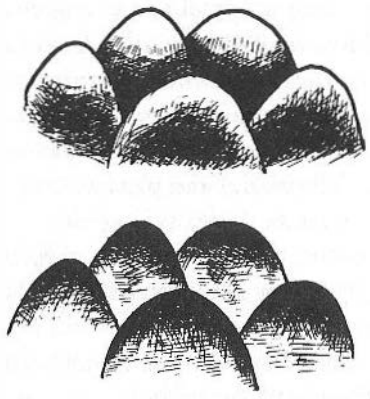


Figure 231

Figure 232
Titian. *Noli Me Tangere* (detail), 1511. National Gallery, London.

Cézanne was following a tradition. Somewhat later the cubists, as I mentioned earlier, used brightness gradients to show the mutual spatial independence of overlapping shapes.

Goethe once drew his friend Eckermann's attention to an inconsistency of the lighting in an engraving after Rubens. Most objects in the landscape were seen as illumined from in front and therefore as turning their brightest side toward the observer. In particular, the bright light falling on a group of laborers in the foreground was set off effectively against a dark foil. This contrast was achieved, however, by means of a large shadow, which fell from a group of trees toward the observer, in contradiction to the other light effects in the picture. "The double light," comments Goethe, "is indeed forced and, you might say, against nature. But if it is against nature, I will say at the same time that it is higher than nature."

The Symbolism of Light

During the early Renaissance, light was still used essentially as a means of modeling volume. The world is bright, objects are inherently luminous, and shadows are applied to convey roundness. A different conception is observable in the *Last Supper* of Leonardo da Vinci. Here the light falls as an active power from a given direction into a dark room, applying strokes of brightness to each figure, to the table top, and to the walls. The effect is pitched to the highest key in paintings by Caravaggio or Latour, who prepare the eyes for the electric spotlights of the twentieth century. This sharply focused light animates space with directed motion. It sometimes fractures the unity of bodies by tracing the boundary lines of darkness across the surfaces. It stimulates the sense of sight by playfully disfiguring familiar shape and excites it by violent contrast. A comparison with Hollywood movies is not entirely out of place, because in the one case as in the other, the impact of the dazzling rays, the dance of shadows, and the secret of darkness give tonic thrills to the nerves.

The symbolism of light, which finds such moving pictorial expression in the work of Rembrandt, probably goes as far back as the history of man. I mentioned earlier that in perception darkness does not appear as the mere absence of light, but as an active counterprinciple. The dualism of the two antagonistic powers is found in the mythology and philosophy of many cultures—for example, China and Persia. Day and night become the visual image of the conflict between good and evil. The Bible identifies God, Christ, truth, virtue, and salvation with light, and godlessness, sin, and the Devil with darkness. The influential philosophy of Neoplatonism, based entirely on the metaphor of light, found its visual expression in the use of illumination by daylight and candles in the churches of the Middle Ages.

The religious symbolism of light was, of course, familiar to the painters of the Middle Ages. However, the gold grounds, halos, and geometric star patterns—symbolic representations of the divine light—appeared to the eye not as effects of lighting, but as shiny attributes; on the other hand, the correctly observed light effects of the fifteenth and sixteenth centuries were essentially the products of curiosity, research, and sensory refinement. Rembrandt personifies the final confluence of the two sources. Divine light is no longer an ornament but the realistic experience of radiant energy, and the sensuous spectacle of highlights and shadows is transformed into a revelation.

Rembrandt's pictures typically present a narrow, dark scene, into which the beam of light carries the animating message of a beyond, unknown and invisible in itself but perceivable through its powerful reflection. As the light

falls from above, life on earth is no longer in the center of the world but at its dark bottom. The eyes are made to understand that the human habitat is nothing but a valley of shadows, humbly dependent upon the true existence on the heights.

When the source of light is located inside the picture, the meaning changes. Now the life-giving energy establishes the center and the range of a narrow world. Nothing exists beyond the corners to which the rays reach. There is a *Holy Family* by Rembrandt in which the light seems to originate in the brilliantly lighted book from which Mary is reading, because the candle itself is hidden. The light of the Bible reveals the sleeping child in the cradle, and the listening Joseph is dwarfed by his own towering shadow, which is cast on the wall behind and above him. In another painting by Rembrandt, the light, again hidden, brightens the body of Christ, which is being taken down from the cross. The ceremony is performed in a dark world. But as the light falls from below, it heightens the limp body and imparts the majesty of life to the image of death. Thus the light source within the picture tells the story of the New Testament—that is, the story of the divine light transferred to the earth and ennobling it by its presence.

In Rembrandt's paintings, the objects receive light passively as the impact of an outer force, but at the same time they become light sources themselves, actively radiating energy. Having become enlightened, they hand on the message. The hiding of the candle is a means of eliminating the passive aspect of what is happening—the illuminated object becomes the primary source. In this way Rembrandt enables a book or a face to send out light without violating the requirements of a realistic style of painting. By this pictorial device he copes with the central mystery of the Gospel story, the light that has become matter.

How does Rembrandt obtain his glowing luminosity? I have already mentioned some of the perceptual conditions. An object appears luminous not simply by virtue of its absolute brightness, but by surpassing the average brightness established for its location by the total field. Thus the uncanny glow of rather dark objects comes about when they are placed in an even darker environment. Furthermore, luminosity results when brightness is not perceived as an effect of illumination. To this end, shadows must be eliminated or kept to a minimum. And the strongest light must appear within the confines of the object. Rembrandt frequently places a bright object in a dark field, keeps it almost free of shadow, and partially lights the objects around it. Thus in his *Wedding of Samson* Delilah is enthroned as a pyramid of light in front of a dark curtain, and the reflection of her splendor is seen on the table and the

people around her. Similarly, in a *Toilet of Bathshebah* the body of the woman is singled out by a strong light, whereas the environment, including the two maids who minister to her, remains in the dark.

Glow is also associated with a lack of surface texture. Objects appear opaque and solid by means of texture, which establishes the frontal surface. A glowing object does not stop the glance by such an outer shell. Its limits are not clearly defined for the eyes. In David Katz's terms, it has "film color" rather than "surface color." Light seems to originate within the object at an indefinite distance from the observer. Rembrandt enhances luminosity by giving little detail to the areas of highest brightness. The indefiniteness of the outer surface endows his glowing objects with a transfigured, immaterial quality.

In a more didactic sense, illumination tends to guide attention selectively, in accordance with the desired meaning. An object can be singled out without having to be large or colorful or situated in the center. Similarly, secondary features of the scene can be subdued at will. All this without "surgical interventions," which would alter the inventory of the scene itself. Light can be made to fall on, or be withheld from, any object A given arrangement of dancers on the stage can be interpreted to the audience in different ways depending upon the scheme of lighting. Rembrandt uses this means of interpretation constantly without being much concerned about a realistic justification of the effect. In the aforementioned *Descent from the Cross* brilliant light falls on the fainting Mary, whereas the bystanders next to her remain relatively dark. Or we see Samson's hands brightly lighted as they explain a riddle to the wedding guests, while his face is kept in the dark because its contribution is secondary. In his representation of the Potiphar story Rembrandt translates the accusing words of the woman into visual language by throwing the strongest light on the bed (Figure 224).

In styles of painting that do not conceive of illumination, the expressive and symbolic character of brightness and darkness is rendered through properties adherent to the objects themselves. Death may appear as a figure clothed in black, or the whiteness of the lily may depict innocence. When illumination is represented, light and shadow tend to assume the task of producing these moods. An instructive example can be found in Dürer's engraving *Melencolia.* Traditionally the melancholic was given a black face, because it was assumed that a darkening of the blood—the word "melancholy" means literally "black bile"—was responsible for a depressed state of mind. Dürer places his melancholy woman with her back against the light so that her face

is in the shadow. In this way the darkness of her face is at least partially justified by the absence of light.

For the realistic painter this method has the advantage of giving an object the degree of brightness that suits his purpose without interfering with its "objective" appearance. He can make a white thing dark without suggesting that it is dark in itself. The procedure is used constantly in Goya's etchings. In the movies also, back lighting serves to give a figure the sinister quality of darkness. The uncanny sensation obtained in this manner occurs in part because the dark figure is not visible positively as a solid material body with observable surface texture, but only negatively as an obstacle to light, neither round nor tangible. It is as though a shadow were moving in space like a person.

When darkness is so deep that it provides a foil of black nothingness, the beholder receives the compelling impression of things emerging from a state of non-being and likely to return to it. Instead of presenting a static world with a constant inventory, the artist shows life as a process of appearing and disappearing. The whole is only partly present, and so are most objects. One part of a figure may be visible while the rest is hidden in darkness. In the film *The Third Man* the mysterious protagonist stands unseen in a doorway. Only the tips of his shoes reflect a street light, and a cat discovers the invisible stranger and sniffs at what the audience cannot see. The frightening existence of things that are beyond the reach of our senses and yet exercise their power on us is represented by means of darkness.

Pictorial objects vanish not only into darkness but also into whiteness. In Far Eastern landscapes, most brilliantly in the "spattered ink" or *haboku* technique of the Japanese painter Sesshu, we see mountains emerge from a base hidden in fog. It would be quite misleading to say that in such instances "imagination completes" what the painter omitted. On the contrary, the meaning of the presentation depends precisely on the spectacle of objects emerging from nothingness to develop more and more articulate shape as they rise toward the peak. The heaviness of the mountain base is paradoxically replaced by the ethereal lightness of the white silk or paper, which acts as figure rather than ground but looks immaterial nevertheless. Thus the most gigantic formations on earth are made into apparitions.

Finally, two modern reinterpretations of illumination in painting should be mentioned. The impressionists played down the difference between light and shadow and blurred the contours of objects. They also replaced the variety of realistic textures with the uniform surface quality of small brushstrokes,

which made the material differences between stone walls, trees, water, and sky vanish into uniformity. All these devices tend to replace the illumination of solid objects with a world of insubstantial luminosity. The effect is particularly strong in pointillism, the extreme form of the impressionist style. Here the pictorial unit is not the represented object. The picture consists of self-contained dots, each of which possesses only one brightness and color value. This even more thoroughly excludes the concept of an external, governing light source. Instead, each dot is a light source of its own. The picture is like a panel of radiant bulbs, each one equally strong and independent of the others.

In a very different way, painters like Georges Braque went beyond illumination, not by creating a universe of light, but by translating the darkness of shadows back into a property of the object. Figure 233*a* shows schematically an image of antagonism, in which black and white share as equal partners. We cannot tell whether we are seeing a black bottle hit by strong light from the right or a white bottle partly in the shade. Instead we see a dematerialized, flat object, independent of any outside source, maintaining its precarious unity against the powerful contrast of the two extreme brightness values. The ancient interplay of the powers of light and darkness is made to seize the single object, in which the conflict between oneness and duality creates a high level of dramatic tension, the clash of two opposites in an unconsummated union.

Light and shadow are no longer applied to the objects but constitute them. In the tracing after Braque's *Painter and Model* (Figure 233*b*), the dark self of the woman is thin, bounded by many concavities, actively presenting the profile of her face and stretching forth her arm. The bright woman is large, rounded by convexities, poised in a more static frontal position, and hiding her arm. In the man the dark self is dominant; his bright self is nothing but a broadening of the subordinate back contour. Both figures are tense, in themselves as well as in their relation to each other, with the antagonism of contrasting forces, which reflects a modern interpretation of the human community and the human mind.

Figure 233*a*

Figure 233*b*