CHAPTER 2

The Gift of Light

Thou sun, of this great world both eye and soul.

Milton

As the beasts of the earth were being created, the Titan Epimetheus (whose name means "afterthought") assumed the task of giving to each some faculty for their protection and survival.[1] To the turtle he gave a hard shell, to the wasp his stinger, to others speed and cunning. When he finally came to the human species, all nature's powers had already been allotted; nothing at all was left for man. In Plato's words, man remained "naked, unshod, unbedded and unarmed." Despondent, the bungling Epimetheus turned to his wise brother Prometheus (whose name means "forethought"). Faced with the helplessness of man, Prometheus daringly stole from Zeus the gift of fire, carrying it to mankind as ancient mariners often carried hot embers, in a giant fennel stalk. From the light of Prometheus' gift, man has kindled his civilizations, his cultures and technologies. The fire and light of Zeus became the possession of mankind.

For his actions on our behalf, Prometheus was cruelly punished by being chained to the mountains of Caucasus, where each day his liver, the seat of life, was torn from his side and

eaten by an eagle sent from Zeus. Nor was mankind left to enjoy in peace the gift of Prometheus. Zeus, angered and jealous, commanded the lame craftsman of the gods, Hephaestus, to fashion a seductive automaton, Pandora, whose infamous box Epimetheus greedily accepted. Too late he saw its evil contents. Against his will Pandora lifted the lid and so unleashed on humanity illness, grief, and pain.[2] The gift of fire and all it symbolizes is invariably linked with the burden of care. Under human control, the fire of the gods burns as well as warms, blinds as well as illumines.

WESTERN CIVILIZATION BEGAN with the song of a blind bard three thousand years ago who, in singing the *Iliad* and the *Odyssey*, gave voice to the Greek imagination, and so begat Western poetry. Homer's blindness lent his words purity and power. His sense world dark, a godly world rose to take its place, and Homer's memory seemed to reach back to archetypal deeds and an eternal heroic age.

Greek vases show the standing bard rocking as he sang, wrapped in an inner glory, listening, as he spoke, to a voice that sang within him. Like Homer, the old wandering minstrels of north Karelia around the Baltic Sea would rock, eyes closed, sitting upon a log bench, arms locked with those of a peasant, chanting antiphonally their ancient epic, the *Kalevala*.

The Bhagavad-Gita, or "song of god," is the sung response of the minister and charioteer Sanjaya to the questions of the blind king Dhritarashtra. The mightiest earthly power, the king, is blind. He sees through the eyes of another, his charioteer and counselor, whose spiritual gifts extend his sight. When the king asks about the happenings on a distant, sacred field where those he loves prepare to battle one another, Sanjaya is able to see and hear the intimate conversation between the accomplished prince Arjuna and the divine Krishna, who like himself

has taken on the form of a charioteer. Here the soul-spiritual faculty of higher sight is separated out, into the person of the charioteer. He becomes the bard who sings to a blind and worldly royalty. The charioteer, like the poet, must see further than others, and speak and steer according to what he sees.

Is it only coincidence that the most renowned soothsayer of antiquity, Tiresias, was blind from his seventh year? He lost his sight for seeing the goddess Athena bathing, that is, for seeing a god unveiled.

The motif is eternal. The light of day makes way for the light of night, of blindness, of inner sight. As Plato wrote: "The mind's eye begins to see clearly when the outer eyes grow dim."[3] The Romantic poet Novalis understood fully the efficacy of darkness. His *Hymns to the Night* begins with a sublime antithesis: "What living, sense-endowed being does not love above all the wondrous appearances spread around him, the glorious light. . . ." And yet Novalis tells us that for all its beauty, he turns away from the day "to the holy, unspeakable, mysterious night." Out of the dark solitude of loss comes the poet's light and voice. In the midst of outer darkness, of blindness, an inner light illumines an imaginal landscape of beauty and reality. The blind bard sings the world he sees into the hearts of his listeners so that they, too, might, for an evening, shed the cares of their world for the beauty of his.

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WHAT IS THE source of poetic light that illumines the night of Homer's blindness? It is imagination, which is also important to common sight. The light of imagination will occupy half of our history, because of its significance for both the ancient world and poetry and the present world and science. No matter how brilliant the day, if we lack the formative, artistic power of imagination, we become blind, both figuratively and literally. We need a light within as well as daylight without for vision: poetic or scientific, sublime or common.

As we will discover, the mind is subtly and usually unconsciously active in sight, constantly forming and re-forming the world we see. Thus, we participate in sight. The habitual patterns by which we see are set down in the first years of life. Even the simplest, most "objective" acts of cognition require our involvement. In addition, the nature of that participation is specific to each culture and historical period. A Coke bottle dropped from an airplane into a society of bushmen may be seen as many things, but never as a container for a carbonated beverage. Human consciousness has changed over time and differs between cultures.

In antiquity, our role in seeing, in granting meaning to the sense world, was felt more keenly than today; the inner light was closer to consciousness. Unlike the ancient Greeks, we live habitually in a scientific world view that too often treats our participatory role in cognition as unessential or illusory. Yet to see, to hear, to be human requires, even today, our involvement, our ceaseless participation. An example will intensify the argument: the puzzling phenomenon of Greek color vision.

The Wine-Dark Sea of Antiquity

> *The sun rose on the flawless brimming sea into a sky all brazen—all one brightening for gods immortal and for mortal men on plowlands kind with grain.*[4]
>
> Homer, *The Odyssey*

The atmosphere and landscape of Homeric Greece appears at once alike and apart from our own. The sun still rises over plowlands kind with grain, but few of us waken to a bronze sky brightened by gods immortal.

Walking on island shores, a captive of the beautiful nymph Kalypso, Odysseus gazed longingly on the "wine-dark sea" yearning to return to his native Ithaka and his beloved wife,

Penelope. Standing today on an island coastline in the Aegean, I see neither a wine-dark sea nor a brazen sky, but the extraordinary blue of water and heavens I so love.

Of the countless epithets attached by Homer to the sky or sea, none, say linguists, can be understood to mean "blue." The sky may be referred to as "iron" or "bronze," the sea as black, white, gray, purple, or wine-dark—but never blue. Did the ancient Greek lack the experience of blue, was he partially color-blind? Or do we perhaps see here another instance of the presence of an interior light, of the activity of vision? Since 1810, when Goethe first pointed to the curious lack of blue in Greek usage, scholars have been puzzled by it and similar absences in the color language of early Greek poetry.[5]

From the careful analysis of color terms that do exist in ancient Greek, and our modern knowledge of color blindness, compelling arguments have been made against the hypothesis that the Greeks possessed a physical eye different from our own. But then we have shown that sight entails more than an operating physical organ. In considering the following examples of color vision in Homer's Greece, bear in mind the significant inner, psychological pole of sight. If we do so, then we may unravel the puzzle that has confounded so many.

Some five hundred years after Homer, the great student of Aristotle, Theophrastus, wrote a treatise on stones in which he described a stone called *kyanos*, a stone we now identify with the precious blue mineral lapis lazuli. When we encounter *kyanos* in its adjectival form, it is natural to think of it as referring to blue (related to our term "cyan"). Although the association seems natural enough, occurrences in Homer defy that interpretation.

In fury and grief at the loss of his friend Patroklos, Achilles slew Hektor, pierced the heels of this noble son of Priam, and attempted to defile his body by dragging it for twelve days on the plains of Troy. In doing so, "a cloud of dust rose where

Hektor was dragged, his *kyanos* hair was falling about him."[6] Are we to understand that Hektor had a head of blue hair? In order to stay his senseless debasement of a worthy prince and warrior, Zeus sent Iris to Achilles' immortal mother, Thetis, on the sea's floor. Iris, "storm-footed," sprang into the sea and, finding Thetis, bade her join Zeus. Ashamed to mingle with the gods, Thetis "took up her *kyanos* veil, and there is no darker garment," and followed Iris to Olympus.[7] From these and many other instances we learn that *kyanos* meant dark rather than blue. Yet there was no other word for blue in Homeric Greek. Homer and other early poets simply lacked a term for blue. To them blue was not a color in our sense, but the quality of darkness, whether describing hair, clouds, or earth.

Similarly for *chloros*, the term that later Greek color theorists call green, a puzzle confronts us. In the *Iliad*, honey is *chloros;* in the *Odyssey*, so is the nightingale; in Pindar, the dew is *chloros*, and with Euripides, so are tears and blood! From its use, we can see it means not green but moist and fresh—alive. We still speak of unseasoned wood or an untrained laborer as green. For the ancient Greek, these connotations were the primary meanings. So disconnected from the external perception of color were they that the psychological quality of "freshness" or "darkness" could become the perceived attribute. They *saw* the moist freshness of tears and so *saw* green. When enraged, we may remark metaphorically that we "see red." I would suggest that we should understand the Homeric world's use of such color expressions not metaphorically but literally. Neither the sunlight nor their eyes were different from ours. Rather, what they brought as the interpretive light of an antique imagination changed the way they saw, just as a similar light continues to shape the way we see today.

A more recent related example is provided by "The Case of the Colorblind Painter" reported by Oliver Sacks and Robert Wasserman in 1987.[8] Jonathan I. had been a successful painter

until, at age sixty-five, he had a minor car accident. He suffered a concussion and the trauma normally associated with such an accident, but took away no lasting physical injury. He did, however, become completely color-blind, a persistent condition whose sudden and unaccountable onset was triggered by the accident. He saw the world, in his own words, as if "viewing a black and white television screen." The case is moving and tragic. An artist whose entire life had been lived through color now saw none. Ophthalmologists and neurologists including Sacks and Wasserman subjected Mr. I. to the full panoply of medical tests to no avail. The cause of his color blindness has remained a mystery. Sacks and Wasserman summarize their study by saying, "Patients such as Mr. I. show us that color is not a given but is only perceived through the grace of an extraordinary complex and specific cerebral process." Moreover, while physiological computations may well be going on, color vision "is infinitely more; it is taken to higher and higher levels, admixed inseparably with all our visual memories, images, desires, expectations, until it becomes an integral part of ourselves, our lifeworld."

The "lifeworld" of Homer on the shores of Troy was profoundly different from our own. His memories, associations, desires, and expectations were unlike those we bring to the battlefield. The mental organ of sight used by the blind bard was then a cultural commonplace, but it was also significantly different from the mind-set with which we see today. We need to soften the notion of ourselves as equipped with fixed vidiconlike eyes and static computerlike brains to produce the equivalent of consciousness. The blossoms of perception unfold out of a far richer and self-reflexive union of mental and natural lights.

In the cases of S.B. and Mr. I., we confront a situation where persons could not see what we would all agree was in fact "there," before their eyes. They lacked an interior light and so remained functionally blind. The opposite situation occurs when someone sees something we would say is "not there." We nor-

mally term such experiences hallucinations. They arise when an individual's psychological state is sufficiently strong to fabricate an experience akin to that produced by the senses. Did the ancient Greeks hallucinate the color of their wine-dark sea? The linguistic evidence suggests otherwise, or we would have to imagine an entire culture collectively hallucinating. Yet, in a certain sense, their inner emotions or stage of development did "color" the world they saw. Study of other language groups, for example Chinese or American Indian languages, supports the interpretation that cultures see the world, down to its very textures and colors, in ways significantly different from our own.[9]

Over millennia, the two lights of nature and mind have interacted to present differing worlds to different ages. Like a blind bard granted sight, we will have difficulty at first imagining

Poseidon.

our way into ancient understandings of sunlight and the sighted eye. They will appear, initially, unfamiliar and even absurd. Yet the strangeness may be largely a reflection of the modern imagination we bring to ancient experiences. At every stage, we will need to reimagine the universe, to participate in it empathetically in order to hear the epic song of light.

The magnificent bronze statue of Poseidon, lifted from the Aegean to grace the National Museum of Athens, has only dark hollows where eyes once were. They were not empty in 450 B.C., when special inlaid gems filled those now sightless pools. Here was the sacred seat of a special glory that brought cognitive life to the supple and powerful figure. When toppled from his pedestal and cast into the sea, the gems—Poseidon's eyes—were stolen. The god who once ruled the sea, now blind, was deposed. Our story of light begins with the ancient and sacred understanding of the eye, so close to light. Empedocles, physician and demi-god, will reset the gemstones in Poseidon's face. Later, others will remove them.

The Lantern and the Eye

> *The light of the body is the eye: if therefore thine eye be single, thy whole body shall be full of light. But if thine eye be evil, thy whole body shall be full of darkness. If therefore the light that is in thee be darkness, how great* is *that darkness!*
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> Matthew 6:22–23

In his book on ancient philosophers, Diogenes Laertius tells the tale of a pestilence that struck the Sicilian city of Selinus in the middle of the fifth century B.C.[10] From the stagnant, sewage-filled waters of the main river there arose disease and death, claiming the lives of "both citizens and women." Hearing of Selinus' distress, the noble physician, scientist, statesman, and

poet Empedocles came from the neighboring town of Acragas dressed in the purple robe of wealth, girded with a belt of gold. On his feet he wore bronze slippers, on his head a laurel wreath; behind him followed a train of young boys to attend his needs. Discovering the source of the pestilence, Empedocles caused two nearby rivers to be rechanneled, mixing thereby their sweet, flowing waters with the rank river water of Selinus, and so relieving the Selinuntines from their ills.

The story is entirely believable, considering the appalling state of rivers around urban centers in present times. Paris, perched upon the Ile de la Cité, was famous even in the Roman period for the stench of the Seine; the Baltic Sea, once a magnificent natural resource, has become the poisonous dumping ground for industrial Poland. For Empedocles to have identified the cause of disease, conceived a plan of action, and then engineered and excavated at his own expense a canal suited to dispersing the fetid waters of Selinus is an action deserving of high commendation. So we are not surprised to learn that when Empedocles appeared to the Selinuntines afterward, he was praised and worshiped as a god. What does surprise us is that, in response to their praises, Empedocles threw himself into a fire, apparently without harm, to confirm their opinion of his divinity.

In Empedocles, we find not only an impressive early scientist whose specific ideas on vision will concern us, but also the last, belated example of a human type that vanished from Greece at his remarkable death when he disappeared into the volcanic crater of Mount Etna, bronze slippers and all. Empedocles was not only a scientist-physician but also a poet and shaman who wrote, in addition to his insightful book *On Nature*, a rather more puzzling spiritual-religious tract, *Purifications*.[11] We possess only fragments of these two works, but from them we can still form an opinion of the range and character of Empedocles' person and thought.

In the *Purifications*, we learn from Empedocles himself of his

divine origins, that he has been condemned to "wander thrice ten thousand seasons far from the company of the blessed, being born throughout the period into all kinds of mortal shapes."[12] He is a god sentenced to live as a bird, a mortal, and in countless other forms for the horrid transgression of eating the human flesh of sacrifice. As we study his account of sight, remember the paradoxical blend that is Empedocles, shaman and scientist in fifth-century Greece, less than one hundred years before Plato. The world of Homer, of the gods, the pageants of mystery religions, and the guarded rites of initiation are not distant from the natural science of early Greece. A spiritual cosmos provided the protecting chambers in which the birth of natural science took place.

According to Empedocles, the divine Aphrodite, goddess of love, fashioned our eyes out of the four Greek elements of earth, water, air, and fire, fitting them together with rivets of love.[13] Then "as when a man, thinking to make an excursion through the night, prepares a lantern," lighting it at the brightly blazing hearth fire and fitting it around with glass plates to shield it from the winds, so did Aphrodite kindle the fire of the eye at the primal hearth fire of the universe, confining it with tissues in the sphere of the eyeball.[14] Marvelous passages were fitted into the eye, permitting it to transmit a fine interior fire through the water of the eye and out into the world, thereby giving rise to sight. Sight proceeded from the eye to the object seen; the eyes rayed out their own light.

When, a few hundred years after Empedocles, the evangelist Matthew wrote, "the eye is the light of the body," he was thinking not only metaphorically but scientifically. The image of the eye as a lantern was a cultural and scientific commonplace when Matthew was composing his gospel.[15]

In the struggle to unravel the mystery of sight, sunlight played a lesser role. Empedocles recognized the existence of the sun's light; that much is clear from other fragments such as "It is the

Earth that makes night by coming in the way of the [sun's] rays,"[16] an astute observation for the time. He seems, however, to have considered sunlight as only part of the whole process, and recognized that something more was required for vision, something essential provided by man: *the light of the body*.

Platonic Sight

Plato, like Empedocles, was permitted to study the secret doctrines of Pythagoras, at least until he (again like Empedocles) betrayed Pythagoras' teachings to the uninitiated through his writings. Plato's account of vision is, not surprisingly, similar to, if fuller than, that of Empedocles. When blended together with the later geometrical tradition of sight begun by Euclid and the medical tradition codified by Galen, Plato's treatment would persist for almost 1,500 years! In this tradition, the light of the eye played fully as important a role as the light of the sun.

According to Plato, the fire of the eye causes a gentle light to issue from it. This interior light coalesces with the daylight, like to like, forming thereby a single homogeneous body of light. That body, a marriage of inner light and outer, forges a link between the objects of the world and the soul. It becomes the bridge along which the subtle motions of an exterior object may pass, causing the sensation of sight.[17]

In this view, two lights—an inner and outer—come together and act as the mediator between man and a dark, cavernous external world. Once the link of light is formed, the message may pass, like Iris, Homer's messenger goddess, from one world to the other. The eye and the sun display to Plato a deep harmony, one still appreciated by the German poet Goethe when, in the introduction to his own *Theory of Color* (1810), he penned the poem:

Were the eye not of the sun,
How could we behold the light?
If God's might and ours were not as one,
How could His work enchant our sight?[18]

Once again, the mind's eye is not passive, but plays its own significant part in the activity of seeing. The image of an interior ocular fire captured vividly the ancient sense of that action, so convincingly that it dominated philosophy for 1,500 years.

We come to know the world, in large part, through sight. Quite naturally, Plato used sight as a metaphor for all knowing, calling the psyche's own organ of perception the "eye of the soul" or "mind's eye."[19] Our word "theory" has its origin in the Greek word *theoria*, meaning "to behold." To know is to have seen, not passively but actively, through the action of the eye's fire, which reaches out to grasp, and so to apprehend the world. Our activity, present in seeing and knowing, is an element integral to the Platonic understanding of vision. Sight entails the seer in an essential, formative action of image making or imagination. To such as Moreau's child or to S.B., the effort of that constructive act was a constant and exhausting reminder of their past blindness. To us who see, the world is instantly and effortlessly intelligible; at least most of the time.

Consider the figure on page 23. It is but one of many similarly "ambiguous figures." Allow yourself time to play with it. At first only one figure shows itself, an old woman or a young girl. Without an iota's change on the "objective" printed page, the delicate chin of the young girl becomes the lumped nose of an old hag. Feel the shift from one picture to the other. It takes place entirely within you. With a little practice you can even control what you see.

The physical difference between one image and the other is nil, while the "soul distance" between them is huge. What has changed? Your own activity; the character of your participation

Old woman or young maid?

can shape and reshape itself, and you can feel it. With every act of perception, we participate unawares in making a meaningful world. In response to outer light, an interior light flashes, bringing intelligence with it. It is the light that did not brighten the newly opened eye of Moreau's child when turned to see its first light.

Times of Transition

In the Bhagavad-Gita, in Homer, Empedocles, and Plato, vision entails an essential human activity of movement out from the eye into the world. In the centuries following Plato, a shift gradually took place that only reached its conclusion with René Descartes in the seventeenth century. The concerns of science changed during this long period. The influence of Plato and then of Aristotle lingered long into the medieval period. As long as this was the case, sight was as much or more a soul-spiritual

process as a physical one. By the sixteenth century, however, a profound shift seems nearly mature. Natural philosophers such as Kepler and, to a much greater extent, Galileo are less concerned with the soul's translation of external stimulation into meaningful perception, and more preoccupied with the physics of the eye viewed as an inanimate, physical instrument. The change is not universal, swift, or uniform, but a watershed is crossed nonetheless, first by those few scientists in the oft-dangerous vanguard of research. In their hands, sight becomes a question of mechanics rather than a species of soul-spiritual activity so characteristic of many earlier thinkers.

The shift is characteristic and of central importance. We meet it first in the evolution of man's experience of seeing. We will discover it again when we study light itself. What begins as a lively, soul-spiritual experience, be it of light or sight, attenuates, clarifies, and divides into optics and psychology. More than an interesting historical observation, our changing view of light is symbolic of a major change in consciousness, an important threshold crossed in the history of the mind.

Like the ambiguous figure, nature presents herself in indefinite guises. How we see her depends as much on us as on her. Only together do meaningful worldly images arise. The watershed crossed, therefore, is not the divide between ignorance and wisdom, but more like the ambiguous shift from young girl to old woman. Therefore as we read the history of science, we must be ever conscious of the individuals who enacted it. Their eyes saw, their hearts yearned for knowledge, and out of their being ways of seeing the world were born, flourished, and died. One way of seeing became for a time the way of many, until a fresher, more congenial view appeared.

The delicate beginnings of the transition to a mechanical conception of seeing were evident by 300 B.C. in the optical studies attributed to the great Alexandrian mathematician Euclid. In his book *Optics* he provided a brilliant geometrical

treatment of sight. Euclid continued to believe that a visual ray was primary to the whole process of vision, and advanced several very sensible arguments in favor of the position.

For example, we often do not see things even when looking at them. Drop a needle on the ground, Euclid suggests, and then wonder as you search for it why you don't see it immediately. Your field of view certainly encompasses the needle. In modern terms, the needle is certainly imaged on the retina, but remains unseen. Then suddenly, in a flash, you see it. If sight depends only on light from outside falling on objects, and then traveling into the eye, one would see it immediately. Obviously light was being reflected from the needle and into the eye throughout the search, so, reasoned Euclid, sight cannot in the first place depend on external light. The puzzle is solved, however, if we adopt the doctrine of the visual ray. In searching for the needle, the eye's own visual ray reaches out and passes back and forth across the ground. Only when it strikes the needle do we see it!

The visual ray of Euclid is different in important ways, however, from the luminous and ethereal emanation of Plato and Empedocles. In Euclid's hands, the eye's fiery emanation has become a straight line, a visual ray, susceptible to deductive logic and geometric proof. His extensive mathematical studies yielded many fruits and became the basis for later Arab investigations and for laying the foundation for the discovery of linear perspective by Brunelleschi, Alberti, and Dürer centuries later. But mathematization came at a price. It distanced man from the earlier and more immediate experience reflected in the Platonic understanding of vision.

The significance of mathematization should not be underestimated. Without abstraction, science as we know it cannot exist. Yet in order to analyze one must stop experiencing and go on to represent the object of study with thoughts of crystalline clarity, for example, with mathematical concepts. Euclid did

just this. Plato's somewhat elusive, immaterial bridge of light between object and eye, became through Euclid a geometry of visual rays, cones, and angular measurement. Everything needed for the study of geometrical optics was developed, but in the process one can detect an important distancing from the subjective human experience of seeing. Euclid's meticulous mathematical style of argumentation has replaced the more poetic treatment of Empedocles or Plato. As every physicist knows, the elegant forms of mathematics can easily outshine the dull stirrings of experience, and eventually come to replace the phenomena they originally were invented to describe. Euclid's handling of light foreshadows the growing separation of sight as lived experience from sight as a formal object of investigation. The history of light has turned a corner, and with it the mystery of sight entered a new phase, one that blossomed first in Arab lands, to culminate finally in the work of another great geometer and mathematician, René Descartes.

The Arab Connection

Toward the end of the Roman empire the stage was set for further developments in the history of the mind. The closing of the Platonic Academy in A.D. 529 by Justinian was the final death knell of Greek philosophy in the West and the dawn of the Dark Ages. For many centuries, the Academy had been a sanctuary in which the ideas of Plato and his followers flourished. With the rise of Christianity, however, pagan thought was in danger of being eradicated. In A.D. 389, the great library in Alexandria with its half-million scrolls was destroyed by rioting Christians. Under a state that sanctioned the Roman Church, the Platonists, who still revered the pagan gods, were persecuted and hounded as dangerous heretics. When Justinian's soldiers swept into the Platonic Academy, the last disciples of Plato had to

flee Athens. The seven great sages of the Academy departed with their precious books bound for Persia where the emperor Khurso I received them graciously at his magnificent summer palace in Jundishapur (near what is today Dizful, Iran).[20]

In the court of Khurso I, and at the illustrious Academy of Jundishapur, literature, the arts, science, and philosophy flourished. The Athenian refugees found here a cosmopolitan atmosphere of remarkable tolerance. The indigenous religions of Zoroastrianism and Manichaeism mingled with eastern religious thought, as well as pagan, Christian, and Jewish influences. Jundishapur was founded as a prisoners' camp following the defeat of the Roman emperor Valerian in A.D. 260 by Shapur I. By the sixth century it had become the greatest center of learning in the world, boasting an outstanding astronomical observatory, medical school, and the world's first hospital. Jundishapur was known then, and for centuries thereafter, for its physicians and wise counselors. The rise of Islam blunted the impact of Jundishapur, but the leaders of Jundishapur's Academy were the nucleus around which the scholarship and learning of Islam formed.

With the rise of Islam in the seventh century, a cultural revolution of unprecedented scope took place on the Arabian peninsula. Following the establishment of the new religion by Mohammed and a system of governance for the vast empire won through holy wars, Islamic scholars became tremendously active in collecting and translating Greek manuscripts. Baghdad, during the ninth century under the guidance of the scholar and translator Hunayn ibn Ishaq, became a great center of learning, and Arab science and scientists rose quickly in importance. While thinkers in the West forsook the concerns of Hellenism for religious questions, especially the matter of salvation, philosophers and physicians of the Islamic Near East, under the influence of Jundishapur, were busy mastering, commenting on, and furthering the knowledge of antiquity.

The famous philosopher, mathematician, astronomer, and optician Ibn al-Haytham figured prominently in these developments.[21] In his hands, the history of sight took another significant step away from earlier and more spiritual or psychological views and toward a mathematical and physical theory of vision.

Born in Basra (Iraq) in A.D. 965, Ibn al-Haytham, or Alhazen as he came to be known in the West, became the greatest optical scientist of his age. As a child and young man, Alhazen had attempted to attain knowledge of truth through the Islamic religious sciences of his day. Dismayed by the elusiveness of this goal and the rancor he saw between competing religious sects, he resolved to concern himself with a "doctrine whose matter was sensible and whose form was rational."[22] Truth was one, he felt, and throughout the following decades he maintained his initial resolve to avoid the vagaries of the spiritual sciences. Instead, he produced dozens of treatises on mathematical and scientific subjects, the most influential of which was his *Optics*. One hundred and fifty years after his death in 1040, the *Optics* was translated into Latin and subsequently became the foundation for future optical research. Two aspects of his work will be of special concern to us: his replacement of the Platonic theory of vision with his own quite different theory, and his study of the *camera obscura*. Both reflect Alhazen's reimagination of light.

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THE PROMINENT GREEK accounts of vision had given full weight to the inner activity of the seer. As we have seen, this came to be embodied in their view that a pure fire, essential to sight, resided within the eye and rayed out, sunlike, to illuminate the world. This view was taught in various forms in the West until the twelfth century, for example by the great teacher William of Conches at the cathedral schools of Chartres and Paris. A profound student of Plato, Conches also drew from Galen the

view that food was transformed from matter into a spiritual light in a series of stages. Its first transformation occurred in the liver, where it became "natural virtue." Passing then on through the heart, it became "spiritual virtue," moving finally into the brain, where it was refined into a luminous wind that animated the organs of sense and provided the interior ray of the eye.[23]

Another important Greek school of thinking held that vision occurred by the transmission of husks or forms (called *eidola* or *simulacra*) from the object to the eye. The atomists of the Greek world believed that films or images peeled off objects, or were impressed onto the air by them, and streamed to the observer, where they entered the eye. The tiny reflected image of the world that is visible when we look at the dark pupil of our neighbor's eye was taken by them as evidence of these husks. Obvious problems existed with this theory. How, for example, did a husk the size of a mountain become small enough to enter the eye?[24] This view likewise found its reflection in the Middle Ages, but setting it aside for the moment, we can return to the Arab connection.

In the Near East, a view of vision was being developed that was complementary to Plato's view as taught at Chartres. It emphasized outer light, and received a special impetus in the Arab world. Alhazen marshaled a series of logical arguments in support of the view that sight proceeded not partly, but entirely by means of light entering the eye from objects around us. He considered the following situation. One cannot long look at the sun without great pain. If one maintained a theory in which the flow was away from the eye, then how could there be pain? If, however, there were some kind of transmission from the sun to the eye, its overwhelming action on the eye could account for the discomfort. Another of his arguments concerned afterimages.

Stare at a bright light or a window for thirty seconds and then close your eyes. A clear sense impression floats in view with the same contours as the original but usually showing colors

complementary to those of the lights seen. Again Alhazen took this as evidence that something affects the eyes from without, impressing itself on the eye so strongly that an effect persists even after the light is extinguished. These, and many other phenomena, were joined with carefully reasoned arguments to reject the visual theories of Plato and others. Alhazen conceded that mathematicians may still find it useful to draw "visual rays" from the eye to the object for the geometrical study of light, but in doing so they "use nothing in their demonstrations except imaginary lines . . . and the belief of those who suppose that something [really] issues from the eye is false."[25]

Thus have the rays of Empedocles' interior fire been quenched. In their place Alhazen offers a carefully elaborated theory of exterior, physical rays that can be combined with Euclid's precise language of mathematics to provide a compelling scientific account of vision. The eye, once the site of a sunlike, divine fire, fast became a darkened chamber, awaiting an external force to enlighten it.

Vision in a Dark Chamber

At this time, a device known as the *camera obscura*, which literally means "darkened chamber," affected the scientific imagination so greatly that by the seventeenth century it had become *the* model for the eye. While antecedents can be found earlier, its first clear description appears in the writings of Alhazen.[26]

On a bright day, stand within a darkened room. Punch a small hole the size of this letter "o" in an opaque curtain over a window in the room. Outside is a bright world, inside a dark room; they are connected only by the light filtering through a single small aperture. On the wall of the darkened chamber opposite the hole, a wonderful inverted image of the outside scene appears

in full detail. In his study of the *camera obscura*, Alhazen arranged several candles in a row on one side, their flickering images then appearing in a similar but now inverted row on the screen. If one held a theory of "husks," they all must pass through the same small aperture without interfering with one another. Somehow the light from each candle passes simultaneously through the same single point without obscuring the image. Amazingly, an entire landscape, rich in color and detail, can make its way undisturbed into a *camera obscura* through a single tiny hole. In fact, make the hole too large and the image, though brighter, becomes blurred.

The specific connection of this experiment with vision had to wait four hundred years, until the Renaissance genius Leonardo da Vinci made the extraordinary suggestion that the eye itself is a *camera obscura*. The eye, too, according to da Vinci, is a dark chamber into which an image of the world is projected.

In the first years of the seventeenth century, the mathematician and astronomer Johannes Kepler developed a complete geometrical explanation for the *camera obscura*, and went on to give a detailed and successful explanation of the optics of the eye and vision in terms of it. As in the *camera obscura*, the outer world was projected onto an inner screen in the eye. Kepler declared that "vision occurs when the image of the whole hemisphere of the world that is before the eye . . . is fixed on the reddish white concave surface of the retina."[27] Yet Kepler, like so many scientists before him, was deeply disturbed by one fact: the image on the screen of a *camera obscura* is inverted! How can the image on the retina be upside down when we see the world right side up? Innumerable fantastic schemes had been invented to rectify the image, but Kepler's geometrical arguments were so tightly reasoned that, even in the absence of direct observational evidence, there was simply no escaping the conclusion: the retinal image must be inverted. Kepler accepted this and left to others to explain how the image could be righted.

Today we locate the solution to this problem in the mind, associating it with psychology of vision. In Kepler's words,

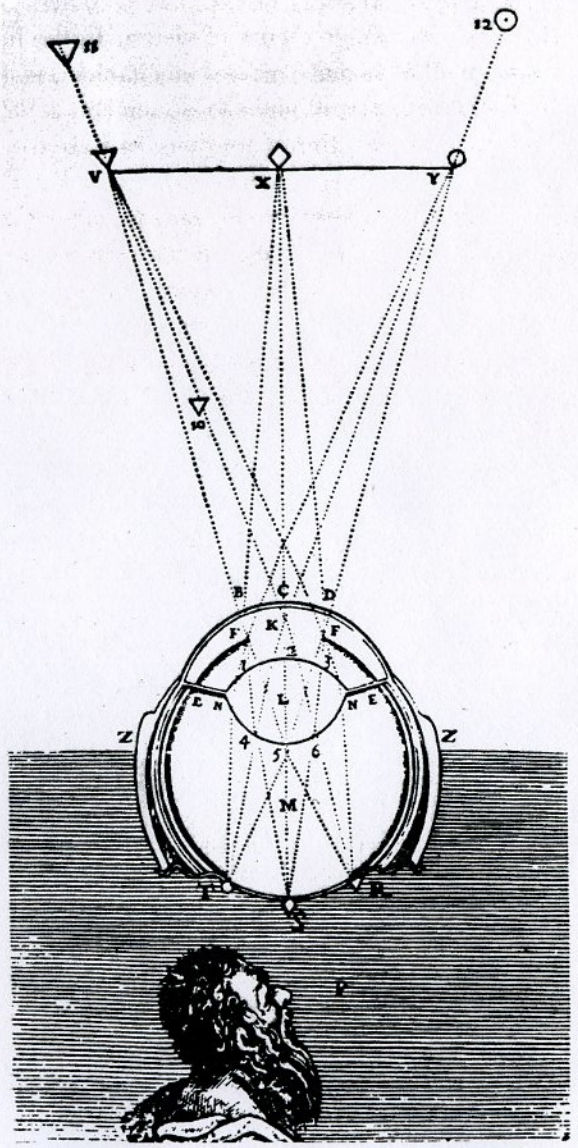
> How the image or picture is composed by the visual spirits that reside in the retina and the optic nerve, and whether it is made to appear before the soul or the tribunal of the visual faculty by a spirit within the hollows of the brain, or whether by the visual faculty . . . all this I leave to be disputed by the physicists [philosophers]. For the armament of opticians does not take them beyond this first opaque wall encountered within the eye.[28]

At this point optics ends and the light of the body, that is the soul's activities, must be engaged in order for us to see the world right side up.

Descartes

Experimental verification of Kepler's deductions was finally achieved by René Descartes. Descartes's optical studies contain a revealing illustration of the visual system that unwittingly depicts not only Descartes's understanding of the anatomy of the eye and of visual optics, but also his philosophy of perception.[29]

Above and at some distance from an enormous eye are arranged three geometrical objects: a circle, a diamond, and a triangle. Rays are drawn from them through the lens of the eye below, and are focused on the retina. The rear membranes of the eye have been removed in order that the philosopher (Descartes himself?) can view the three images projected onto the rear surface. The external world depicted in the upper part of the picture is shown in light; the lower part surrounding the observer is dark. As with Alhazen, for Descartes the world is bright, and the eye dark.



Optical analysis by Descartes. The philosopher viewed the world through an ox's eye whose back had been scraped to make it transparent. The image he saw was inverted.

The illuminating interior ray or fire had vanished. Yet Descartes still holds a two-stage theory of vision. In the first, light (which he conceived of as material and mechanical) is conveyed through the physical organ of sight to a common sensorium in the body. The mechanical stimuli are then, in Descartes's view, "perceived" by a spiritual principle within man. For Descartes the world of extension, of substance—*res extensa*—reached all the way into the body but could not of itself complete the process of vision. A spiritual principle, the mind or soul—*res cogitans*—was still required. Like the philosopher in the illustration observing the flickering retinal images from his dark vantage point, the immaterial mind observed the mechanical proddings of the world in the sensorium.

Although the light of the eye that reached out and granted meaning to raw sensation had retreated from the body, it remained in Descartes's dualist position as a disembodied spirit, a vestige of the past. Yet even this faint echo of a Greek heritage was destined for at least temporary extinction.

Modern Sense Physiology

We shall, sooner or later, arrive at a mechanical equivalent of consciousness.

Thomas Huxley

The final development in the evolutionary drama of sight (and I must leave much out) occurred in our century. By the mid-1900s, the neurophysiology and psychology of vision had advanced to an extraordinary degree. The detailed knowledge we now possess of brain structure and function, of the neural anatomy of the eye and visual pathways, is truly staggering. In the flush of excitement that naturally accompanies a century of discovery, many feel that they hold now in their hands "the mechanical equivalent of consciousness," as Thomas Huxley called it.

The Harvard biologist and Nobel laureate David Hubel speaks for many scientists when he states that the brain is a machine "that does tasks in a way that is consonant with the laws of physics, an object that we can ultimately understand in the same way we understand a printing press."[30] Moreover, contrary to Descartes, we have no need to appeal "to mystical life forces—or to the mind" to account for perception, thought, or emotion. They are purely and simply states of the physical brain.

Hubel rightly recognizes the profound implications of this view for everything we do. Our image of the mind sets the agenda for everything from education to love relationships. According to Hubel, once we understand that mind is an illusion, and that brain is the sole reality, then we can restructure our systems of education and social institutions to serve the brain, not an antiquated notion of "spiritual man."

In traditional language, the substitution of a purely material and sensual image for a spiritual reality is idolatry. In his insightful little book *Saving the Appearances*, Owen Barfield suggests a connection between the biblical injunction against idolatry and the veneration of models so common to modern scientific practice.[31] Scientific models certainly have their rightful place. But when does a model become an idol, that is, when is it taken for something other than a model, becoming "reality"? The model of an atom as a miniature planetary system is helpful only as long as it is not taken literally. Quantum physicists discovered long ago the dangers of idolatry. Neurophysiologists have yet to learn the lesson. For many of them, the brain has become an idol; it has become quintessential man.

The dangers associated with this kind of adulation of the brain are innumerable. The image we have of ourselves is a powerful thing; it shapes our actions, and so also the world we fashion for us and for our children. It is important, therefore, patiently and carefully to distinguish between idol and fact.

I am not suggesting a simplistic Romantic return to the past. There is no turning back. Yet are Hubel and the legions of scientists who think like him right to reduce our humanity to brain function? The answer is, quite simply, no. The brain as described by Hubel is a carefully crafted and dazzling image fashioned from the fruits of scientific research, one full of insights, but which is ultimately mistaken for something it is not. Is it possible to embrace the results of science without falling into such idolatry? Yes, but this, perhaps more than any other, is the challenge we confront in our times. Our success or failure in fashioning a nonidolatrous science will determine much for our future.

Rekindling the Fire of the Eye

The movements we have traced are like a contrapuntal harmony where one melody sounds against the other. As the light of the eye dims, that of the world brightens. As the beacon of the eye gradually retreats, the power of sunlight projects itself deeper and deeper into the human being until finally the ethereal emanations of Plato, and even the Cartesian spectator, vanish from the Western scientific sense of self. Yet some data and scientific developments indicate the possibility of a "postmodern" view of self and vision that has room in it for the light of the eye. In them, the interior ray may once again find a place, even if under another guise.

We have learned that our consciousness is not immutable. Our habits of thought become perceptions, and while powerful and pervasive, these are not universal or "true." We should learn to take responsibility for them. Do they accord with our deepest intentions and the good of our society and planet? Or do we need to "reimagine" ourselves and our world? In this way Matthew's remarks make real sense: "If thine eye be evil, thy

whole body shall be full of darkness. If therefore the light that is in thee be darkness, how great *is* that darkness!" Our light, a light of meaning, fashions a world, forms it from the light of day. If our light be darkness—be evil—then we bring darkness and evil into our whole body, personal and social. If it be light—be good—then health flows into us, and into the world.

Plato's light of the eye was a light of interpretation, of "intentionality," as modern phenomenologists would say; a light that grants meaning. Cognition entails two actions: the world presents itself, but we must "re-present" it. We bring ourselves, with all our faculties and limitations, to the world's presentation in order to give form, figure, and meaning to that content. The beautiful and productive images we craft on the basis of experience are images only—fruits of the imagination. They are no less true for being so. If in our enthusiasm we forget this, then images become idols demanding propitiation at their high altars. Nor should these reflections become grounds for abandoning the path of knowledge, because it is a philosophy of growth and development. The organs of insight we bring are neither fixed nor limited, but malleable and expansive. Thus the importance of integrating the insights into light gained by artistic and spiritual disciplines as well as scientific ones.