



Ibn al-Haytham. (University of Cairo)

ONE

Boyhood in Basra

At the beginning of *Kitab al-Manazir*, or *The Book of Optics*, the medieval scholar Ibn al-Haytham expresses skepticism about the ability of human beings to understand the complex workings of nature. “When inquiry concerns subtle matters, perplexity grows, views diverge, opinions vary, conclusions differ, and certainty becomes difficult to obtain,” he wrote. One of the problems with discovering the truth about nature, Ibn al-Haytham realized, is that human beings have physical limitations that can affect their observations. “The premises are gleaned from the senses,” he wrote, “and the senses, which are our tools, are not immune from error.”

Haunted by doubts about human perception and reason, Ibn al-Haytham searched for new ways to establish the validity of observations, theories, and conclusions.

before. “Aristotle has discussed the nature of the physical world,” he wrote. “He has analyzed causality and teleology, the celestial beings, plants and animals, Universe and Soul.” What impressed Ibn al-Haytham most, however, was Aristotle’s commitment to logic and reason. “He has analyzed the terminology of logic and has divided it into primary kinds,” Ibn al-Haytham observed. “Furthermore, he has analyzed those aspects which are the material and elemental bases of reasoning, and he has described their classes. . . . This analysis is essential for his discussion of truth and falsehood.”

Never again would Ibn al-Haytham spend his time studying matters that were unknowable and unprovable. “I saw that I can reach the truth only through concepts whose matter are sensible things, and whose form is rational,” he wrote. “I found such theories present in the logic, physics, and theology of Aristotle.”

Equipped with Aristotle’s outlook and techniques, Ibn al-Haytham renewed his commitment to better understanding the world. “It became my belief that for gaining access to the effulgence and closeness to God, there is no better way than that of searching for truth and knowledge,” he wrote. Rather than studying the words of men, he would examine the works of God. “There are three disciplines which go to make philosophy: mathematics, physical sciences, and theology,” Ibn al-Haytham declared. “As long as I live, I shall keep myself pressed into the service of these disciplines.”

Ibn al-Haytham could not have chosen a better place to



Islamic scholars sitting in a library discuss a book in this illustration from al-Hariri's Assemblies written in the year 1237. (Bibliothèque nationale de France, Paris)

embark on his journey of discovery than his own hometown of Basra. Located on the western bank of Shatt Al Arab, the waterway that connects the Tigris and Euphrates rivers with the Persian Gulf, Basra had grown from a small military outpost into a busy port city, teeming with a variety of cultures and beliefs. Merchants from Asia, Africa, and the islands of the Indian Ocean sailed to Basra to profit from its growing trade. A few of the foreign merchants decided to stay in Basra and make it their home. Small communities of Africans, Indians, Persians, and Malays flourished in the busy port city. These groups practiced their own religions and followed their own customs and traditions.

vision and light that scholars had believed for centuries. For example, many of the ancient Greeks believed that human beings were able to see because the eyes sent out rays that sensed objects. Ibn al-Haytham showed that the opposite was true: vision occurs when rays of light enter the eye and stimulate the optic nerve. It was the first time in history that a person had accurately described the mechanics of sight. Ibn al-Haytham did not stop there, however. Building on the work of earlier scholars such as Aristotle, Euclid, Ptolemy, Theon of Alexandria, and Ya'qub ibn Ishaq as-Sabah al-Kindi, Ibn al-Haytham created a unified theory of light, correctly describing its propagation, reflection, and refraction. *The Book of Optics* remained the leading source of knowledge about optics for the next five hundred years.

The most important thing about *The Book of Optics* is not the discoveries it contains but the way in which Ibn al-Haytham arrived at and supported those discoveries. He was the first person to systematically construct devices—such as the camera obscura—to test hypotheses and verify the accuracy of his findings. By using concrete, physical experiments to support his conclusions, Ibn al-Haytham helped establish the modern scientific method.

The Book of Optics was not Ibn al-Haytham's first book about vision. In the introduction to *The Book of Optics*, Ibn al-Haytham states that he wrote a treatise on optics earlier in his career. This work was probably a commentary on another book, such as Ptolemy's *Optics*. Ibn al-Haytham admits that he "followed persuasive methods of reasoning"

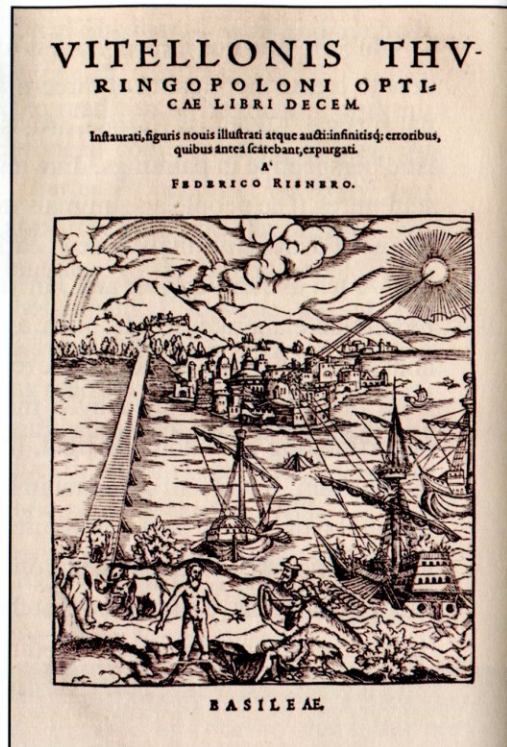
in his earlier work, but he did not verify his findings with what he called "true demonstrations." The lack of experimental proof in the first book was such a great flaw, Ibn al-Haytham wrote that anyone who finds the work should disregard it.

At some point, Ibn al-Haytham came up with a new way to test and prove the facts about optics. How did this breakthrough occur? One clue emerges from the text of *The Book of Optics*: it is a very solitary book. In it Ibn al-Haytham describes dozens of experiments, but only one—an experiment using a wooden block drilled with two holes to let light into a room—calls for the use of



A leaf from Al-Haytham's *The Book of Optics*, complete with illustrating diagram. (Staatsbibliothek zu Berlin)

Risner's 1572 *Opticae* thesaurus included a Latin translation of al-Haytham's *The Book of Optics*. Risner's frontispiece uses a rainbow, a bridge vanishing into the distance, a man whose legs appear bent in water, and Archimedes's trick of using mirrors to burn enemy ships to illustrate properties of light and vision. (University of Oklahoma)



learning known as the Renaissance. Scholars in many fields made tremendous advances. For example, in 1543 the Polish astronomer Nicolaus Copernicus proposed the theory that the earth rotated on its own axis every twenty-four hours and that it and the other planets revolved around the sun. In 1572, the same year Risner published Ibn al-Haytham's work, the Danish astronomer Tycho Brahe observed the birth of a new star in the constellation Cassiopeia, a finding that challenged the widespread belief that the stars were permanently fixed in the sky. In 1610 the Italian

mathematician and astronomer Galileo Galilei used the newly invented telescope to discover four moons revolving around Jupiter—a discovery that helped to confirm the Copernican model of orbiting planets and moons. Galileo also used mathematics and experimentation to prove wrong many of Aristotle's theories about motion. He was another prominent advocate of experimental science.

As scientific learning in Europe increased, so did appreciation and recognition of Ibn al-Haytham. For the first time, Europeans had the skills to fully appreciate the higher mathematics contained in *The Book of Optics*. Seventeenth-century mathematicians such as Pierre de Fermat of France, Thomas Harriot of England, Isaac Beckman and Willebrord van Roijen Snell of the Netherlands, and Johannes Kepler of Germany all referred to Alhazen by name in their works.

Kepler used Ibn al-Haytham's own methods to disprove one of the Iraqi scholar's theories about vision. Kepler filled a glass sphere with water to represent an eye filled with fluids. He then placed the glass sphere near the aperture of a camera obscura and observed the result. He found that the rays entering through the aperture were bent by the glass and the fluid in a way that created a "*pictura*," or image—upside down and backwards—on the back of the sphere. This experiment led Kepler to propose that the eye works like a camera obscura, with the pupil serving as an aperture and the retina as the receiving screen. The optic nerve carries the image from the retina to the brain, which inverts the image so that it perceives objects right side up.



In the frontispiece to Hevelius's *Selenographia*, Ibn al-Haytham represents *Ratione* (the use of reason) with his geometrical proof and Galileo represents *Sensu* (the use of the senses) with his telescope. The two scientists hold the book's title page between them, suggesting a harmony between the methods. (University of Oklahoma)

for the frontispiece of the book. The engraving shows two standing figures holding a large scroll bearing the title of the book, *Selenographia*. One of the figures is Galileo; the other is Ibn al-Haytham. Galileo holds a telescope, a symbol of observation. Ibn al-Haytham holds a geometrical drawing, a symbol of mathematical proof. The two men and the objects they hold represent two steps of the scientific method that both men pioneered.

Four years after Hevelius honored Ibn al-Haytham on the frontispiece of his lunar atlas, another scientist went

a step further: he put the Iraqi scholar's name a map of the moon. In 1651 a Jesuit priest named Gianbattista Riccioli published a book entitled *Almagestum Novum* that included new maps of the lunar surface. Riccioli began the tradition of naming craters after scientists and other scholars. He named one of most prominent craters for Copernicus, and two others for Galileo and Kepler. He reserved some sections of his map for ancient Greeks, some for ancient Romans, some for his contemporaries, and some for medieval and Arabic scholars. About fifteen degrees north of the Moon's equator, just to the east of Mare Crisium, stands a circular impact crater about thirty kilometers wide. Riccioli named this crater Alhazen. In 1935 the International Astronomical Union (IAU), the internationally recognized authority for naming celestial bodies and their surface features, standardized the names of six hundred lunar features, including the crater Riccioli had named for Ibn al-Haytham.

With the passage of time, Ibn al-Haytham's name and achievements faded into history, but around the beginning of the twentieth century things began to change. Scholars such as Carl Brockelmann, Heinrich Suter, and Eilhard Wiedemann—all from Germany—traveled to Istanbul and other centers of Muslim learning and unearthed long-forgotten works by the Iraqi scholar. In 1936 Max Krause, another German scholar, published a list of manuscript copies of *Kitab al-Manazir* that included a reference to the manuscript that had been copied by Ibn al-Haytham's son-in-law, ibn Ja'far al-'Askari. Since then, scholars have