A millennium of science as we know it

By Bradley Steffens

A thousand years ago, a mathematician and scholar from Basra named Abu 'Ali al-Hasan ibn al-Hasan ibn al-Haytham was controversially judged to be insane and placed under house arrest. To make the most of his simple surroundings, he began to study the physiology of vision and the properties of light. Upon release, he described his investigations in a massive, seven-volume treatise titled *Kitâb al-Manâzir*, or *Book of Optics*. Although missing from the many lists of the most important books ever written, *Kitâb al-Manâzir* changed the course of human history, giving mankind a new and effective way of establishing facts about the natural world—an approach known today as *the scientific method*.

650 -704

Egyptian alchemical works translated into Arabic by Khalid ibn Yazid

715 -815

Arab caliphs absorb the southern Byzantine Empire, the Middle East, North Africa, Iberia, Persia and Central Asia, paving the way for the development of a Muslim-Arabic intelligentsia in this region

750's

Chinese papermaking technology makes its way across modern-day Iraq, and a paper mill immediately makes parchment and papyrus obsolete, avails writings to the masses and prompts a literacy movement

754 → First Arab psychiatric hospitals appear in Bahgdad and Fez, Morocco

First pharmacies appear in Baghdad and are adopted across the Arab world

763 -809

Founded by Caliph Harun al-Rishad, the House of Wisdom (Baytu al-Hikma)--a formidable library and translation society--attracts scholars from Persia, India and Greece to Baghdad and establishes the city further as a hub of scientific discourse

early 800

Appearance of early Arab-Muslim medrasa-universities

Al Jahiz suggests a theory of natural selection in his "Book of Animals"

900

Al Zahrawi, the "father of modern surgery," revolutionizes medical treatment with surgical procedures and instruments that had a huge impact and are in some cases still applied in medicine today

1000

Abu Ishaq Ibrahim al-Zarqali notes that the orbits of the planets are ellipses and not circles and publishes an almanac based on this revelation

600 700 800 900 1000

Jabir ibn Hayyan, Yaqub ibn Ishaq al Kindi, Muhammad ibn Zakariya Razi and other Arab scientists develop laboratory tools such as scissors, tongs, bellows, metal compounds and catalogues detailing metals, minerals and other substances

721-900

First Arab-Muslim hospital opens in Baghdad, featuring around 25 staff physicians and wards for different conditions; medical schools emerge shortly thereafter, founded in Baghdad, under al Mamun

770 → Indian astronomer Kanka visits the House of Wisdom bringing manuscripts, including work by Brahmagupta, founder of zero

Al Khwarizmi introduces the Hindu-Arabic numerals: the zero, negative numbers and algebraic concepts as well as calendars and star tables reflecting a refined geography of the world

796 → Muhammad Al Fazari creates the first Islamic astrolabe

late 700

Banu Musa brothers in Baghdad invent the on-off switch, float valve, gas masks, and other devices

Al Battani develops higher astronomical and mathematical concepts that influence Copernicus, 600 years later

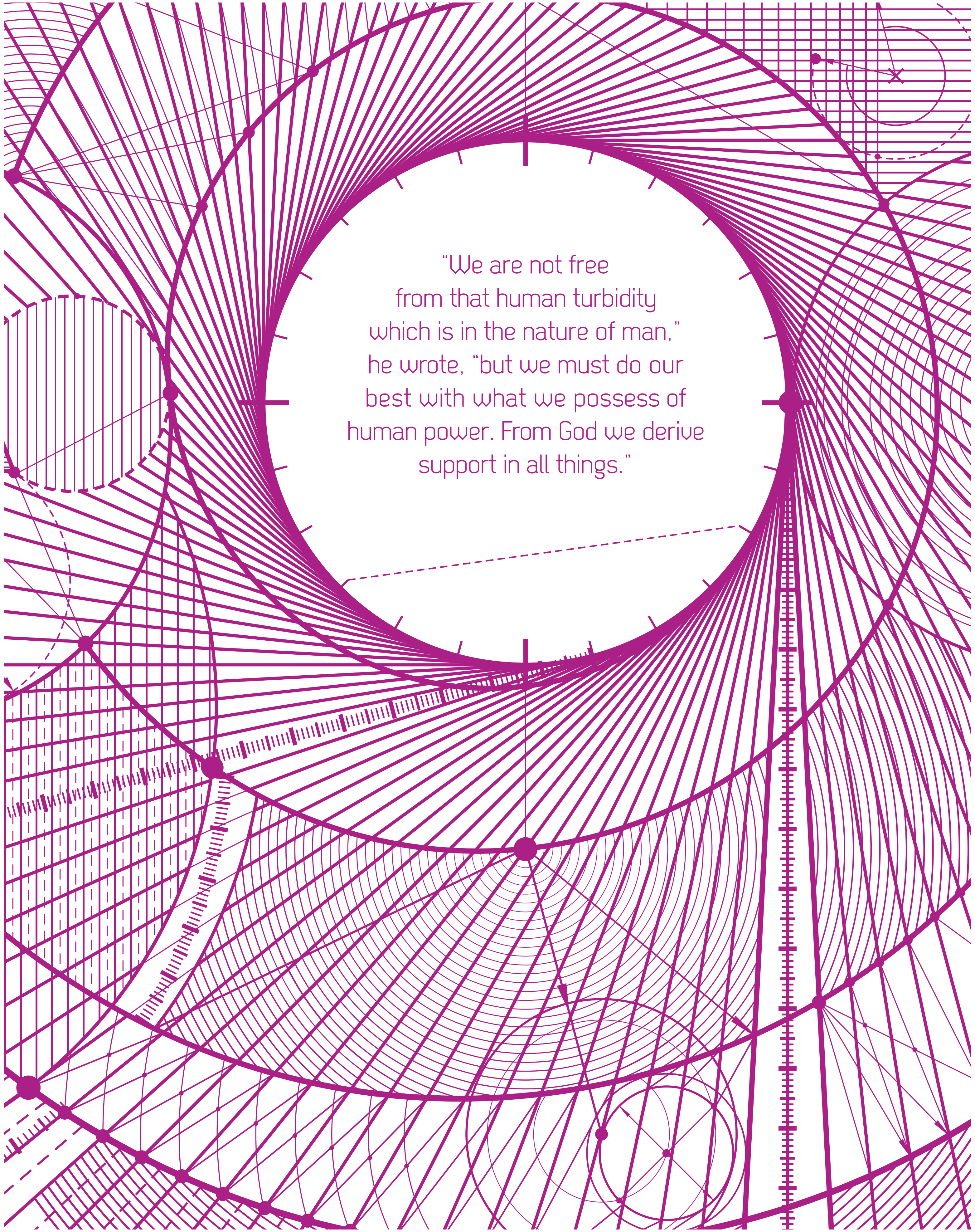
Al Razi writes medical books revered in Medieval Europe

850 - 900

Ibn Al Haytham, father of modern optics and the empirical scientific method works and studies in Basra and Cairo

Ibn Sina, the "Prince of Medicine," writes the medieval world's most comprehensive medical encyclopedia, the "Canon of Medicine"

950-1000



What sets *Kitâb al-Manâzir* apart from earlier investigations into natural phenomena is that Ibn al-Haytham included only those ideas that could be proven with mathematics or with concrete manifestations that he called "true demonstrations," what we refer to nowadays as experiments. The use of physical experiments to establish the validity of scientific claims was a departure not only from the works that formed the foundation of *Kitâb al-Manâzir*, such as Claudius Ptolemy's *Optics*, but also from Ibn al-Haytham's earlier works.

"We formerly composed a treatise on optics in which we often followed persuasive methods of reasoning," wrote Ibn al-Haytham in the introduction of *Kitâb al-Manâzir*, "but when true demonstrations relating to all objects of vision occurred to us, we started afresh the composition of this book." Thus we can pinpoint the advent of experimental science not just to the lifetime of Ibn al-Haytham, but to the precise moment, one thousand years ago, when the Islamic scholar realized that reason alone was no longer sufficient grounds for knowing the truth about the natural world.

Kitâb al-Manâzir was the first fruit of this new investigative approach, but it would not be the last. Translated into Latin as *De aspectibus*, or *The Optics*, by an anonymous scholar working in a center founded by Gerard of Cremona in Toledo in the twelfth or thirteenth century, *Kitâb al-Manâzir* became one of the most copied works of medieval Muslim scholarship. Roger Bacon, the thirteenth century English friar who is sometimes credited as the first true scientist because of his advocacy of experimentation, not only read De aspectibus but summarized its findings in part five of his *Opus Majus*, or *Greater Work*, referring to Ibn al-Haytham by his Latinized name, Alhazen, and describing his experiments in detail.

Thirteenth-century scholars John Peckham and Erazmus Witelo also wrote summaries of *De aspectibus*, both entitled *Perpsectiva*. After the advent of the printing press, the German mathematician Friedrich Risner published a book entitled *Opticae Thesaurus*, in Basel, in 1572, which paired Ibn al-Haytham's *De aspectibus* and Erazmus Witelo's *Perspectiva* in one volume. Through Risner, scholars across Europe, including Johannes Kepler, Christiaan Huygens, and René Descartes, became familiar with Ibn al-Haytham's ideas and methodology, which they applied not just to optics but to other fields of study as well. In fact, Ibn al-Haytham was so well known in Europe that when the Polish astronomer Johannes Hevelius published an atlas of the moon in 1647, the frontispiece of the book bore the likenesses of the two pillars of science up to that time: Galileo, shown holding a telescope, and Ibn al-Haytham, depicted with a geometric drawing in his hand.

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Ibn al-Haytham repeated the experiment, arranging lamps outside a door and admitting light rays into a room through a narrow opening. In addition, he described the experiment in such a way that others could test his findings (Step 8: Verification).

As it turned out, Ibn al-Haytham's conclusion was correct for all light rays except those of the same wavelength. It would be another 800 years before British scientist Thomas Young used Ibn al-Haytham's own methodology to prove this exception to the Islamic scholar's findings. In 1803, Thomas published a paper entitled *Experiments and calculations relative to physical optics* that described how he used an apparatus similar to

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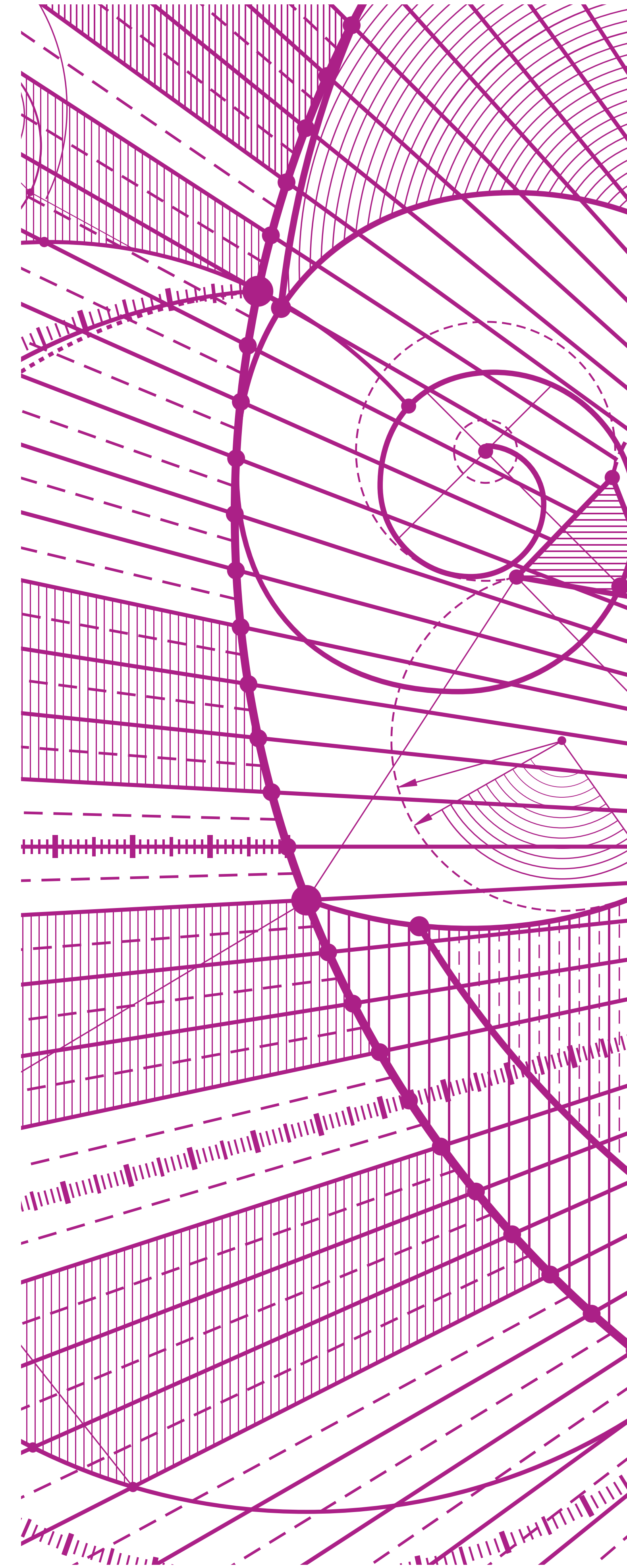
the camera obscura, outfitted with two apertures instead of one, to demonstrate that light rays of the same wavelength interfere with each other.

As we celebrate the millennial anniversary of the advent of experimental science, it is reasonable to ask if Ibn al-Haytham's religion had anything to do with his breakthrough. I believe it did. His skepticism toward human reason was a direct outgrowth of his Muslim faith. Ibn al-haytham believed that only God is perfect and that human beings are inherently flawed.

"Truth is sought for itself," he wrote, "but the truths are immersed in uncertanties, and authorities are not immune from error, nor is human nature itself." To establish facts about the universe, Ibn al-Haytham reasoned, one had to eliminate the human element as much as possible and allow nature to speak for itself through physical experiments.

Despite the challenges posed by this new method of inquiry, Ibn al-Haytham remained optimistic about its success. "We are not free from that human turbidity which is in the nature of man," he wrote, "but we must do our best with what we possess of human power. From God we derive support in all things."



Over the centuries Ibn al-Haytham's reputation waned in the West. Even today, many people have a hard time accepting that he originated the scientific method. For example, reviewing Jim al-Khalili's new book, *House of Wisdom: How Arabic Science Saved Ancient Knowledge and Gave Us the Renaissance*, Jonathan P. Berkey, a reviewer for the San Francisco Chronicle, wrote: "Ibn al-Haytham was, the author claims, the true father of the scientific method, who turned experimentation 'from a general practice of investigation into the standard means of proof of scientific theories.'"

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Even a cursory examination of *Kitâb al-Manâzir* reveals that Ibn al-Haytham's true demonstrations are full-bodied experiments, exhibiting all eight steps of the scientific method. For example, after establishing that light rays emanate from primary sources of light in all directions and reflect off of objects, also in all directions, Ibn al-Haytham reasoned that light rays must intersect. If they intersect, he wondered, do they interfere with each other? (Step 1: Statement of the problem.) The apparent answer would be no, they do not interfere (Step 2: Formulation of a hypothesis), because we see things clearly, despite the countless intersections of light beams everywhere we look (Step 3: Observation, collection of data). But even the obvious had to be proven in Ibn al-Haytham's new discipline (Step 4: Experimentation).

The experiment Ibn al-Haytham devised to test his hypothesis that light rays do not interfere with each other was ingenious. He built what is now known as a camera obscura, featuring an opaque screen with a small aperture that would admit a limited number of light rays. He placed three light sources on a table, "all being opposite a single aperture leading to a dark place." He observed that images from the lamps were visible on the wall beyond the screen. "If one of the lamps is screened," Ibn al-Haytham observed, "only the light opposite that lamp in the dark will vanish. When the screen is moved away from the lamp, that light will return to its place." The manipulation of the light sources established that light rays were traveling in straight lines and, thus, intersecting at the aperture. Ibn al-Haytham observed that the images on the wall across from the unscreened light sources were not affected by the blocking and unblocking of another light source (Step 5: Analysis of the results), indicating there was no interference between the light rays (Step 6: Conclusion). He summarized in *Kitâb al-Manâzir* (Step 7: Publication):

> All the lights that appear in the dark place have reached it through the aperture alone… therefore the lights of all those lamps have come together at the aperture, then separated after passing through it. Thus, if lights blended in the atmosphere, the lights of the lamps meeting at the aperture would have mixed in the air at the aperture and in the air preceding it before they reached the aperture, and they would have come out so mingled together that they would not be subsequently distinguishable. We do not, however, find the matter to be so; rather the lights are found to come out separately, each being opposite the lamp from which it has arrived.