THE OPTICAL SCIENTIST

HUNDREDS OF YEARS BEFORE GALILEO, NEWTON AND MANY OTHER WELL-KNOWN WESTERN SCIENTISTS, AN IRAQI THEOLOGIAN WAS WORKING OUT EXACTLY HOW LIGHT WORKS. BY BRADLEY STEFFENS

Al-Hākim Bi-amr Allah, a strange and unpredictable caliph, ruled over the Fatimid dynasty in Egypt for 25 years from 996. Among his more unusual acts was to order the slaughter of all dogs in Cairo because their barking annoyed him. Not surprisingly, he was nicknamed the "Mad Caliph" by some historians.

But he wasn't all bad and mad. He considered taming the Nile's waters for irrigation and to alleviate flooding – one of the first Egyptians to do so. But for this al-Hākim needed a visionary who understood water.

Luckily for the Mad Caliph, a relatively unknown Iraqi scholar and theoretician called Ibn al-Haytham, who lived and worked in Baghdad around 969, had written a treatise on civil engineering. By a curious coincidence, he had set out his ideas on the possibility of building a system of dams, levees and canals that would prevent the Nile from overflowing during the flood season. According to his irrigated vision, the Nile would preserve its waters for irrigation during the hot, dry summer.

"Had I been in Egypt," wrote Ibn al-Haytham, "I could have done something to regulate the Nile so that

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the people could derive benefit [from its water] at its ebb and flow." He was just the man the Mad Caliph was looking for.

So in 1010, a stranger showed up at Ibn al-Haytham's door carrying a message from al-Hākim. The Egyptian caliph wanted to discuss his plan in person, so Ibn al-Haytham was to come to Egypt immediately. It wasn't the kind of request anybody could refuse; al-Hākim was one of the most powerful men in the entire Muslim world at that time.

In early 1011, the Iraqi scholar left for Egypt. According to medieval historian Jamāl al-Dīn ibn al-Qiftī, he arrived and immediately outlined his Nile control scheme to al-Hākim. The Egyptian leader was so impressed by the dam project that he agreed to give Ibn al-Haytham all of the workers and money he would require to complete the project. Having secured al-Hākim's backing, Ibn al-Haytham collected the essential items he needed to start work and travelled to the village of al-Janādil, near Aswān, where he wanted to build the dam.

There was, however, a snag. By Ibn al-Haytham's original calculations, the river itself was 548 metres wide and capable of being dammed. But the gap in the valley that needed filling to make the dam work when it was full of water was almost twice that: over 975 metres and way beyond his capability and resources. He realised he had to go back to Cairo and tell the caliph the bad news - not an attractive prospect.

Luckily for the Iraqi scholar, al-Hākim took the news calmly. He offered him a consolation position in the government, which Ibn al-Haytham accepted "out of fear", according to a contemporary report. But he was still wary, and worried there might be a change of heart and an order for his execution; al-Hākim wasn't called the Mad Caliph for nothing. So, according to al-Qiftī, Ibn al-Haytham pretended to be mad in the hope of being released from his duties. Unfortunately, his ruse didn't go to plan: al-Hākim instead placed him under house arrest.

For 10 long years, Ibn al-Haytham was confined to his quarters. But the

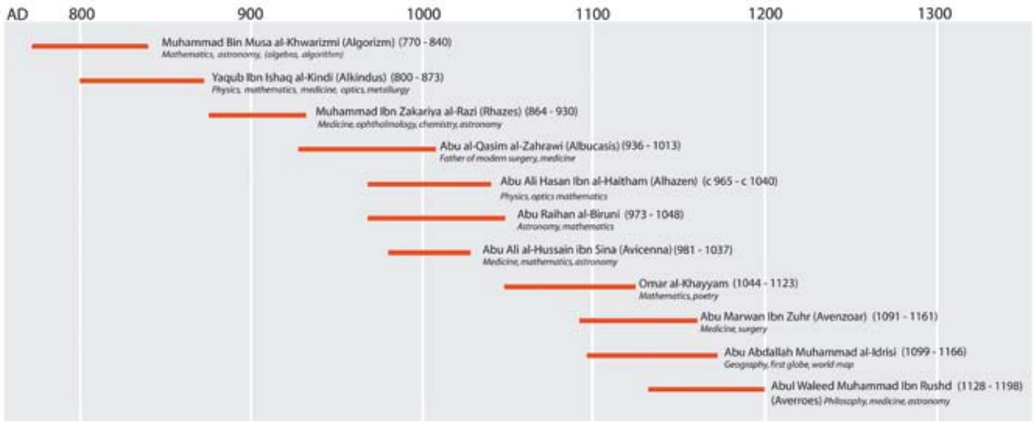
GOING IT ALONE

One of the key elements about *The Book of Optics* is not the theories it contains but the way in which Ibn al-Haytham arrived at and supported them. He was under house arrest, and so could not rely on the usual equipment and assistants to help him prove his theories.

He was the first person to systematically construct devices such as the light ray test, 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.

He describes dozens of experiments, but only one of them (an experiment using a wooden block drilled with two holes to let light into a room) calls for the use of an assistant. The other experiments relied on simple objects: bare walls, stopped-up windows, screens, lamps and tubes, and were designed to be carried out by one person in such a way as to absolutely prove the revolutionary theories he was proposing.

GOLDEN AGE OF ARABIC SCIENCE



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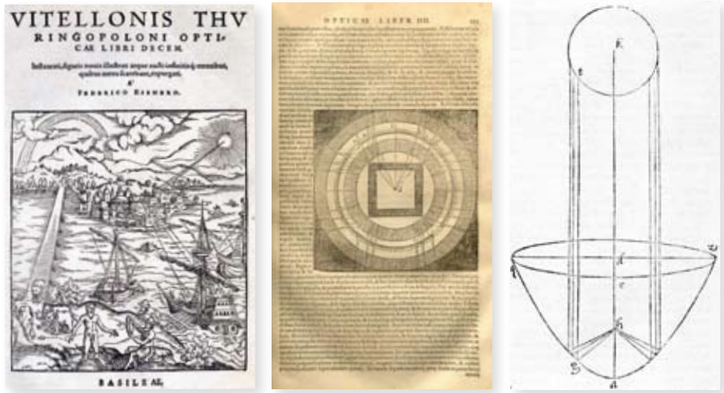
"HAD I BEEN IN EGYPT," WROTE IBN AL-HAYTHAM, "I COULD HAVE DONE SOMETHING TO REGULATE THE NILE"

Ibn al-Haytham originally arrived in Egypt to build a dam on the Nile that would prevent it flooding.



The writings and diagrams of Ibn al-Haytham, considered the father of modern optics, provided the first accurate description of the parts of the eye, as well as the first account of atmospheric refraction and reflection from curved surfaces.

time wasn't wasted. He worked on what is now recognised as the greatest breakthrough of his career: a book called *Kitāb al-Manāzir*, or *The Book of Optics*. This book was to remain the leading source of knowledge about optics for the next 500 years.

LET THERE BE LIGHT

In his ground-breaking work, the Iraqi scholar corrected many misconceptions about vision and light that had been accepted by intellectuals for centuries. For example, the ancient Greeks believed that human beings were able to see because the eyes sent out rays that sensed objects. Ibn al-Haytham worked out that the opposite was true: that rays of light enter the eye and stimulate the optic nerve. This was the first time that anybody had described the mechanics of sight accurately.

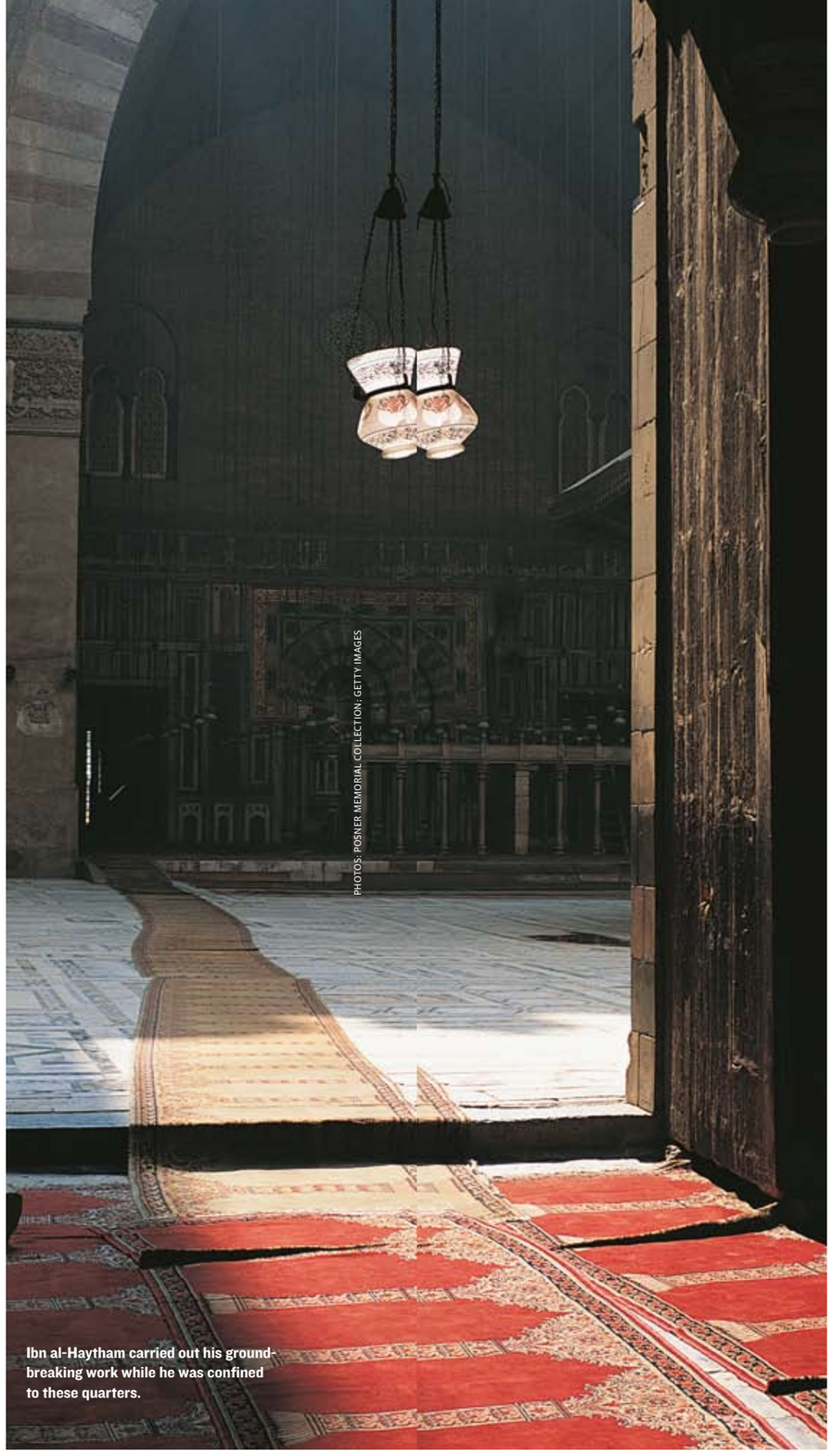
And he didn't stop there. Building on the works of earlier scholars such as Aristotle, Euclid, Ptolemy, Theon of Alexandria and Ya'qub Ibn Ishaq as-Sabah al-Kindi, Ibn al-Haytham created a unified theory of light, correctly describing its propagation, reflection and even refraction.

He went on to divide light into two basic groups: primary and secondary. Primary light is the light radiated by an illuminating body, such as a lamp, a fire, the stars or the sun. Secondary light is primary light that has been reflected off another surface. During the day, Ibn al-Haytham theorised, the sun provides primary light, while every other visible object - for example a bird, a tree, a stone, a blade of grass - reflects the light of the sun. He suggested that even the atmosphere reflects light, which is why the sky brightens even before the sun rises. All these ideas, and the concept that light radiates in all directions from its source, were revolutionary.

In addition to descriptions of the properties of light, Ibn al-Haytham's work also contains a chapter on "the structure of the eye".

He described the parts of the eye in detail, and correctly guessed how the cornea refracts, or bends, light rays as they enter the eye. He also suggested that an optic nerve carries visual sensations to the brain. It was the first time anybody had suggested that vision occurs in the brain, not the eyes. Even more impressive, he came up with these theories while permanently confined, most probably in a single room, for 10 long years.

Then, in February 1021, Ibn al-Haytham's captor, the Mad Caliph, went for a walk in the Muqattam Hills and never returned. He simply vanished. According to historian al-Qifti, government officials informed Ibn al-Haytham, restored his possessions and released him.



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Ibn al-Haytham carried out his ground-breaking work while he was confined to these quarters.

BY APPLYING SCIENTIFIC METHODS TO HIS RESEARCH, IBN AL-HAYTHAM HELPED TO LAUNCH A NEW ERA IN THE HISTORY OF LEARNING

For the first time in a decade he was free to go anywhere he pleased, but after years of incarceration he had no money and no place to stay. Al-Qiftī reports that Ibn al-Haytham made his way to the Azhar mosque in Cairo, Egypt, where clerical leaders allowed him to take up residence in a domed room or tent by the gate of the mosque. There, he made a living copying manuscripts and continuing his work on theoretical science.

After his release from captivity, it is estimated that the Iraqi scholar may have written as many as 182 treatises, on mathematics, philosophy and physics.

Around 1040, according to contemporary historian al-Bayhaqī, the elderly Ibn al-Haytham developed a persistent case of diarrhoea. Despite intense pain, he clung to life for a week, but finally succumbed.

The first scientist of the Middle Ages left the world he had worked so hard to understand and explain to others. His life was over, but the revolution he had founded had scarcely begun. ■

SOLVING THE MYSTERY

Probably the most important discovery in *The Book of Optics* appears in this sentence: "Sight does not perceive any visible object unless there exists in the object some light, which the object possesses of itself or which radiates upon it from another object." With this simple observation, Ibn al-Haytham solved the mystery of vision that had baffled scholars for centuries. It was light, not the physical "forms" described by ancient physicists, that travelled from visible objects to the eye. The rays that create vision do not travel out of the eye, as the mathematicians said, but into it. Those rays were – and still are – light rays.

"The light shining from a self-luminous body into the transparent air," he wrote, "radiates from every part of the luminous body facing that air, it issues from every point on the luminous body in every straight line that can be imagined to extend in the air from that point."