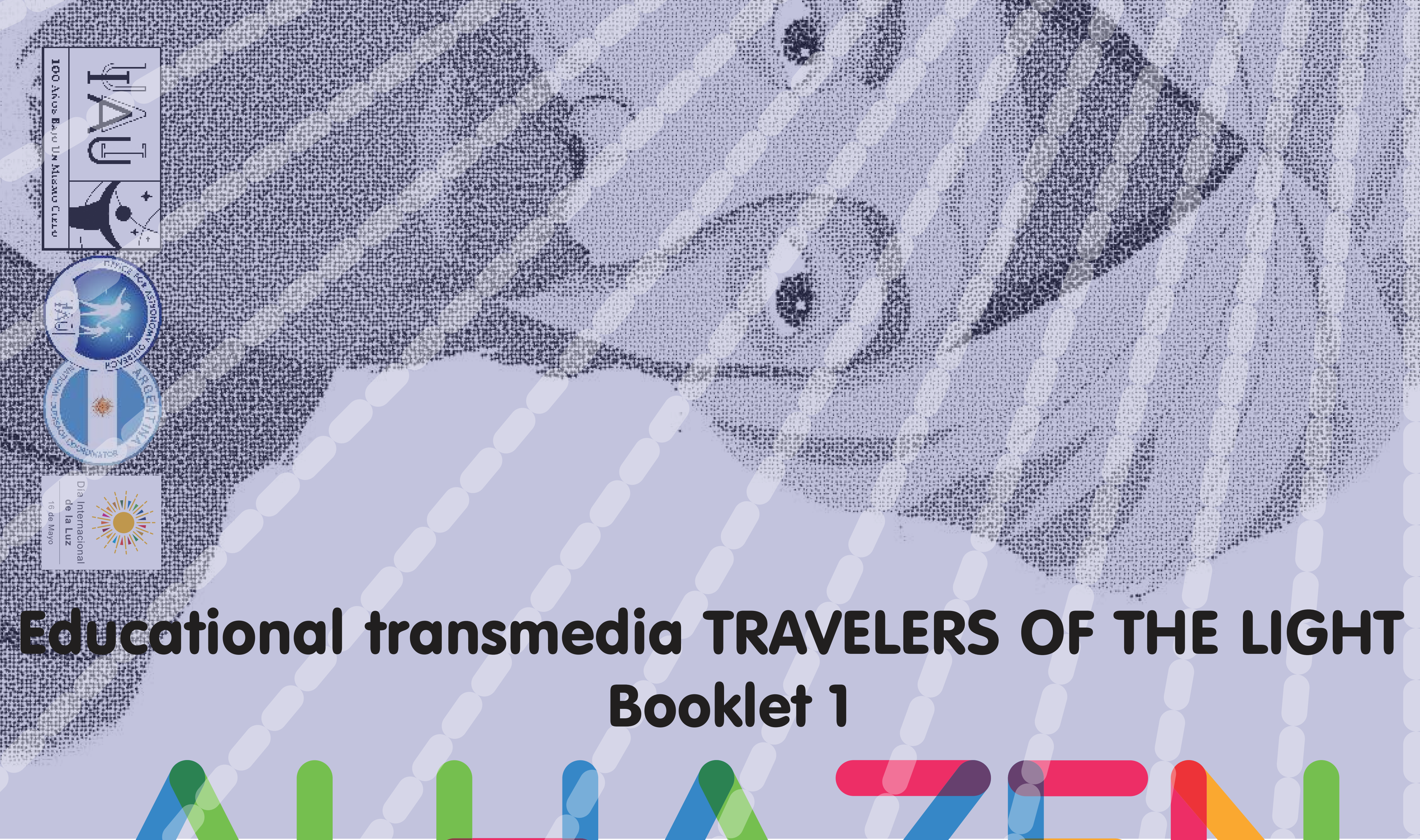

IAU

100 Años Bajo Un Mismo Cielo

Día Internacional de la Luz

16 de Mayo

Educational transmedia TRAVELERS OF THE LIGHT

Booklet 1

ALHAZEN

Ibn al-Haizham, Alhazen for his friends

“It is essential to carry out experiments to verify what has been written instead of blindly accepting it as true” Alhazén.

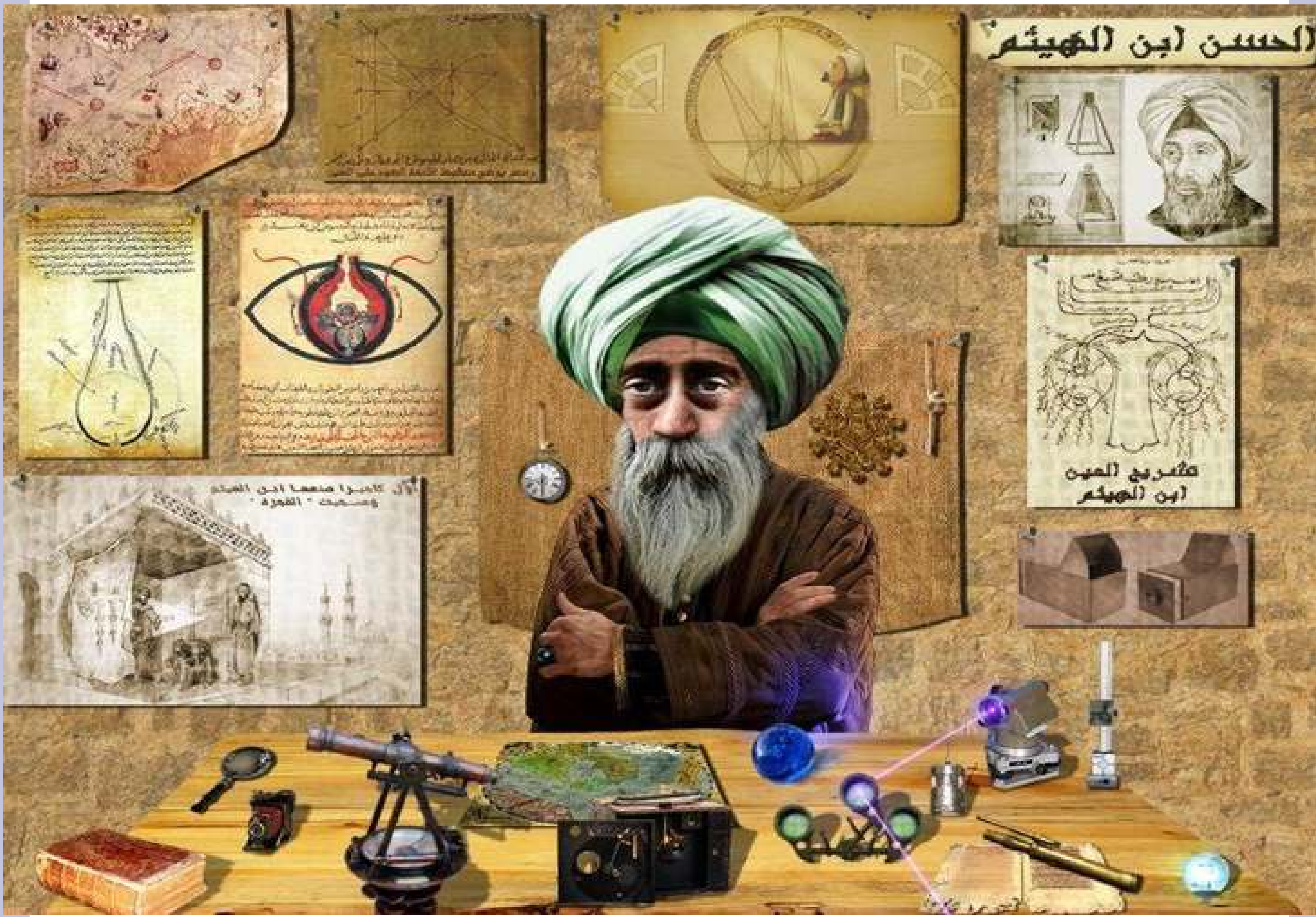

Figure 1. Alhazen in his “Lab”.

Ahazen was born during the golden age of the Muslim Empire. He is said to be the first person that can be called scientist because he was the first one to apply a methodology based on experimenting in order to prove a statement right or wrong. Alhazen contributed to the fields of Physics, Math, Medicine, Anatomy and Astronomy which made him one of the most important figures of the history of sciences (Fig.1). He was born in Basora, currently part of the Iranian territory, in 965 A.D. where he was educated and later on he would continue to learn in Bagdad. After a life full of successes, he died in Cairo, Egypt in 1039.

He attempted to gain a good reputation so he promised to develop a machine that would control River Nile so that floods would stop. This idea was very appealing for the Egyptian caliph so that he pronounced Alhazen in charge of the project. Unfortunately for Alhazen, the reigning caliph was al-Hakim who was said to be the most dangerous in history, just like Caligula or Ivan the Terrible. Al-Hakim had no patience and wanted the machine immediately after pronouncing Alhazen otherwise he would be condemned and punished. Alhazen had to pretend mental insanity to avoid being punished until 1021 when Al-Hakim died. After Al-Hakim´s death, Alhazen proved he was not crazy and became one of the most significant scientists of the Medieval Period.

Contributions

Alhazen lived most of his life in Azhar mosque, in Cairo, where he developed most of his scientific research and worked as a teacher. He wrote a great deal of books, around 92 different works. He preferred Astronomy, Math and Optics among a wide variety of topics. From the latter, he developed a theory about light and how human vision worked.
Moreover, he wrote a series of seven volumes about Optics called Kitab al-Manazi (1021) which is considered one of his best works. It was translated into Latin in 1270 under the name of Opticae Thesaurus Alhazeni.

This treaty is made up of seven volumes about Optics organized the following way:
Book I – Theories about light, colours and vision.
Book II – Theories about Visual Perception.
Book III and IV – Ideas about Visual Perceptions Mistakes.
Book V and VI – Evidence about Experimentation on Theories of Reflection.
Book VII – Concepts about refraction.

Figure 2. Opticae Thesaurus Alhazeni Cover (1270).

In the first volume, Alhazen established that his research on Light would be based on experimentation rather than mere abstract theory. He stated that light was always the same no matter the origin of it. Sun light, the light from the fire or the one reflected by mirrors were exactly the same in their nature.

His book about Optics is considered one of the most influential treaties in the history of Physics. For the first time in history, procedures from a scientific method were applied in order to prove that light spreads as a straight continuum.

He dealt with all the branches of Optics in such deep way that he modified the meaning of it. Optics was no longer just about vision but also about light, the way it spread and its effect on matter.

Alhazen was the first scientist who explained human vision correctly (figure 3) when he proved that light was reflected by objects towards the eyes and not projected from objects to the eyes as Ptolemy and Euclid had stated previously.

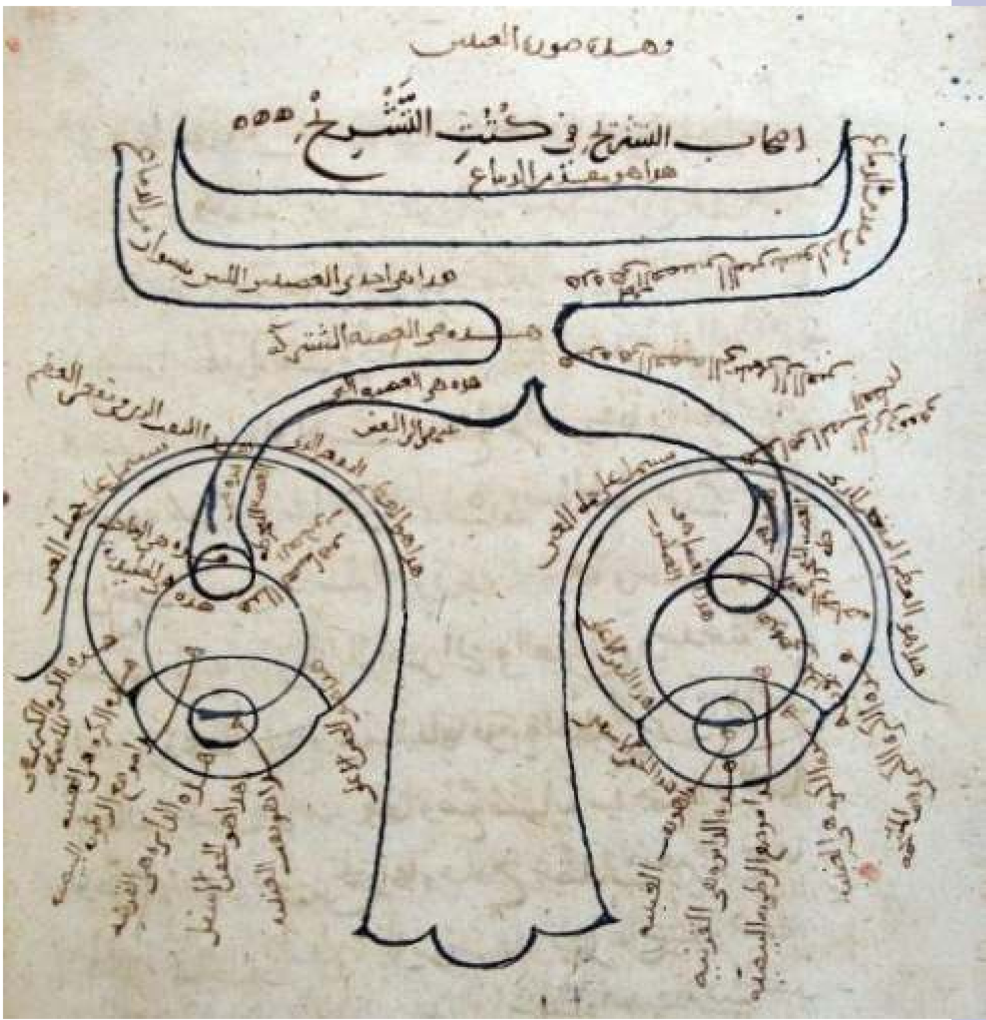

Figure 3. Human eyes according to Alhazen.

Even though Alhazen was the first to describe the constituents of the human eye, he made a mistake by not considering the crystalline lens as such.

He attempted to describe binocular vision and also explained that the Sun and the Moon seem to become bigger when they are closer to the horizon because of an optical illusion.

Based on his enquiries, he proposed the usage of a Camera Obscura (figure 4), becoming the first person to mention this device. When he used it, he could project an inverted image of an object by letting light in through a tiny hole.

In other of his treaties, he analyzed the visual perception, the necessary conditions for a healthy vision and the causes of medical problems in human vision.
Alhazen considered light as a straight ray that could be explained by Geometry which implied optical consequences.

While studying reflection and refraction effects, he could decompose white light into its conforming colours. He even found out the basis for Snell´s Law of refraction; however he could not express the phenomenon through a mathematical equation.
He also studied physical phenomena as shadows, eclipses, rainbows and the physical nature of light. He built up parabolic mirrors that are still used in telescopes.

In addition, in one of his books he dealt with atmospheric density. When he studied refraction in atmosphere he came to the conclusion that sun dusk stops when the Sun is 19 degrees under the line of the horizon. Based on that, he measured the atmosphere which according to his calculations, it was fifteen kilometers high. But what he actually measured was the troposphere that is the lowest layer of atmosphere.
What´s more, he worked on Mass attraction theories and apparently, he was aware about the acceleration due to gravity.

It is also important to mention that he studied light coming from the Moon. He stated that the Moon shines as if it produced light even though it is just reflected from the Sun.

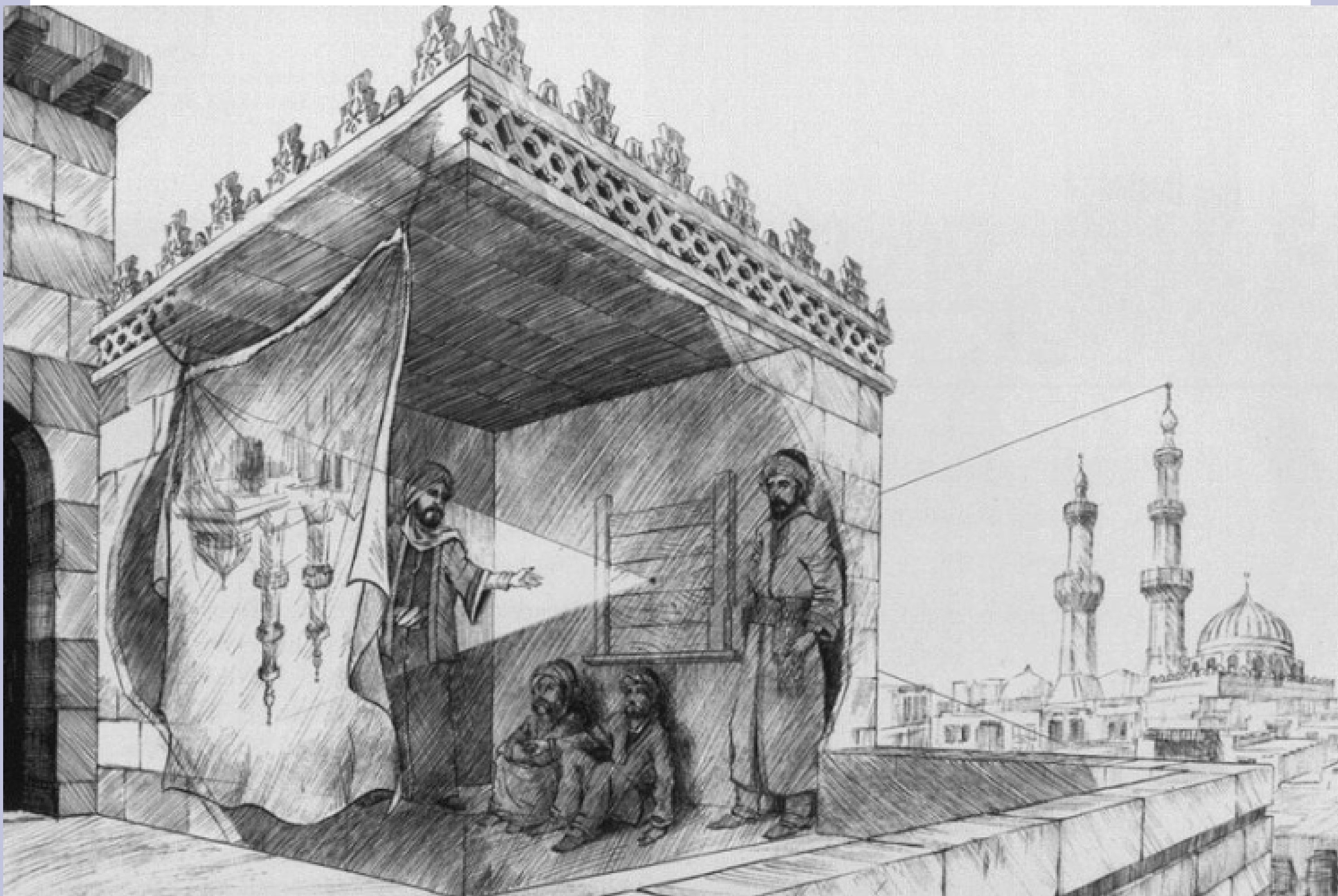

Figure 4. Alhazen´s Camera Obscura.

Alhazen was the first person who gave a clear explanation about the functioning of the Camera Obscura which consisted in a small box with a tiny hole in one of its walls through which light travelled and projected an inverted image of the external world. A model of the human eye was functioning was suggested from this experience. The human vision (eyes) was thought to work the same way. Rays of light reflected by different objects traveled through the tiny opening in the human eye and created an image in the "inner screen" inside the eye. (figure 5).

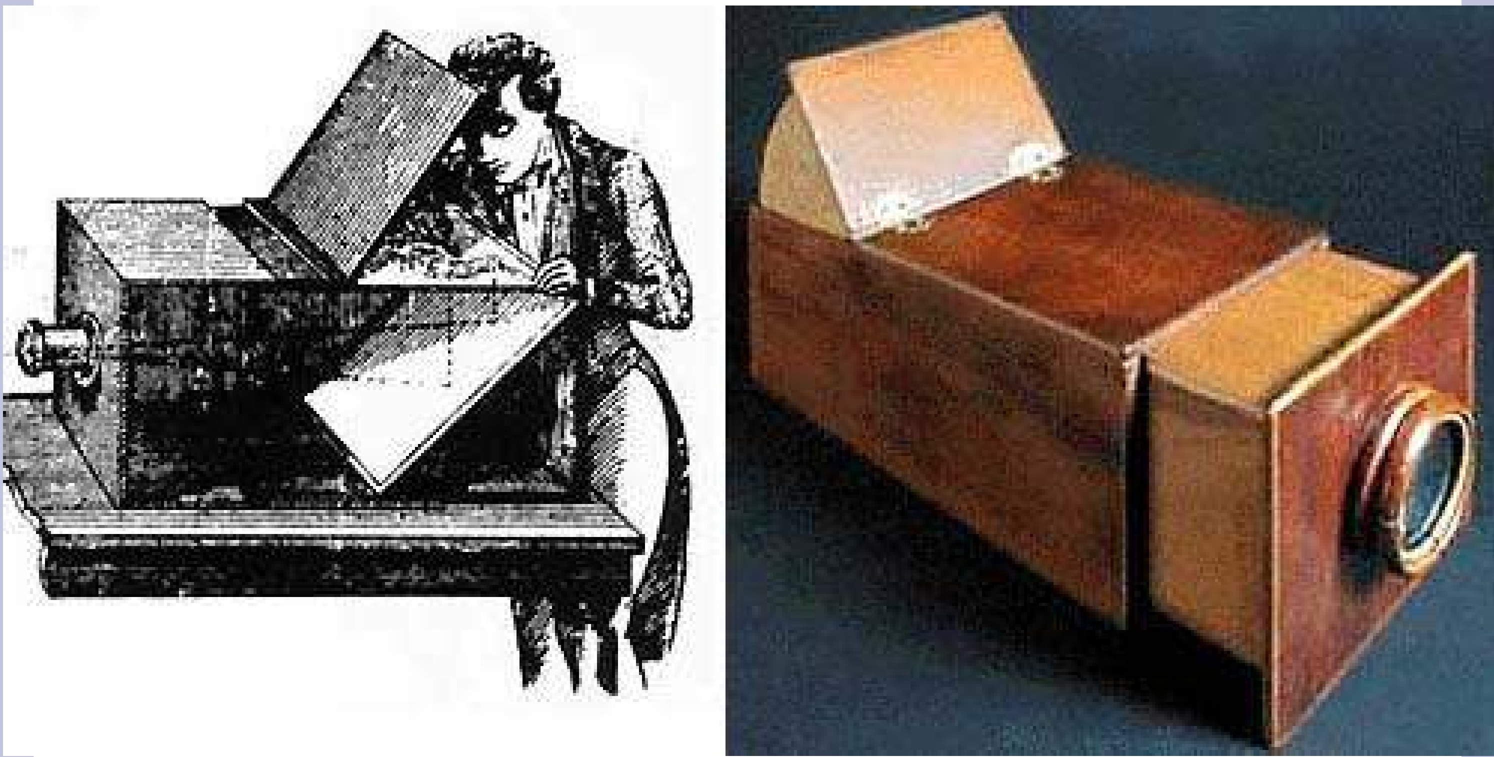

Figure 5. Alhazen´s Camera Obscura preceded the photographic camera.

He brought back Plato and Democritus' corpuscular theory which assumed that light was made of tiny particles that traveled as a straight continuum.

Alhazen considered that every ray of light could be understood from geometry because of its optical consequences.

He helped explain the visual phenomenon we perceive when an object goes underwater.

Alhazen is considered nowadays, as one of the most significant philosopher of the Medieval period. Although his main contributions were in the fields of Optics, he also contributed to Math, Astronomy, Physics and Philosophy. He was a great influence for scientists to come, such as Isaac Newton and Christian Huygens.

Alhazen revolutionized the way Optics was understood, and as a result Physics itself.

Classroom Activity

Let's build up a Camera Obscura

There are many methods of building up a camera obscura and more than one way to use it. Here, the proposal is to build up a tubular one that can be used for observing the Sun- especially during an eclipse- but also for determining the star dimension.

We will need some simple elements as shown in figure 7.
a) One cardboard or plastic pipe (better if recycled!).
It has to be at least 6 cm. wide and long enough to be manageable. Bare in mind that the longer the pipe is the bigger the image will be and easier to measure.
A tube of approximately 1 meter is suitable for this experience (figure 6).
b) A piece of aluminum sheet- you can find it in your kitchen.
c) A piece of tracing paper- the one you use at school.
d) Adhesive tape- plastic transparent tape or paper tape will be fine.
e) A nail.
f) A ruler or a metric tape.

Figure 6. Cardboard made or plastic water pipes.

Figure 7. Necessary elements for a Camera Obscura.

Building up procedures are shown in figure 8, 9 and 10. There you will see how to stick the tracing paper in one extreme of the pipe (figure 8) and the aluminum paper in the other extreme (figure 9) and finally how to open a tiny hole in the aluminum paper with a nail (figure 10).

Figure 8. Tracing paper being placed in one extreme of the pipe.

Figure 9. Aluminum paper being placed in the other extreme of the pipe.

For using the device, first point the extreme with the aluminum paper towards the Sun letting sunlight go through the little hole projecting an image in the opposite extreme on the tracing paper.

Figure 10. The tiny hole through which light goes into the pipe is done with a small nail.

In figure 11 we can see the geometrical relationship between the object (Sun) which has a determined real diameter (D) and is placed at a specific distance from the observer or the camera (dST). Furthermore, the camera has a specific length (l) so in the tracing paper another image is projected wth a different but measurable diameter (di).

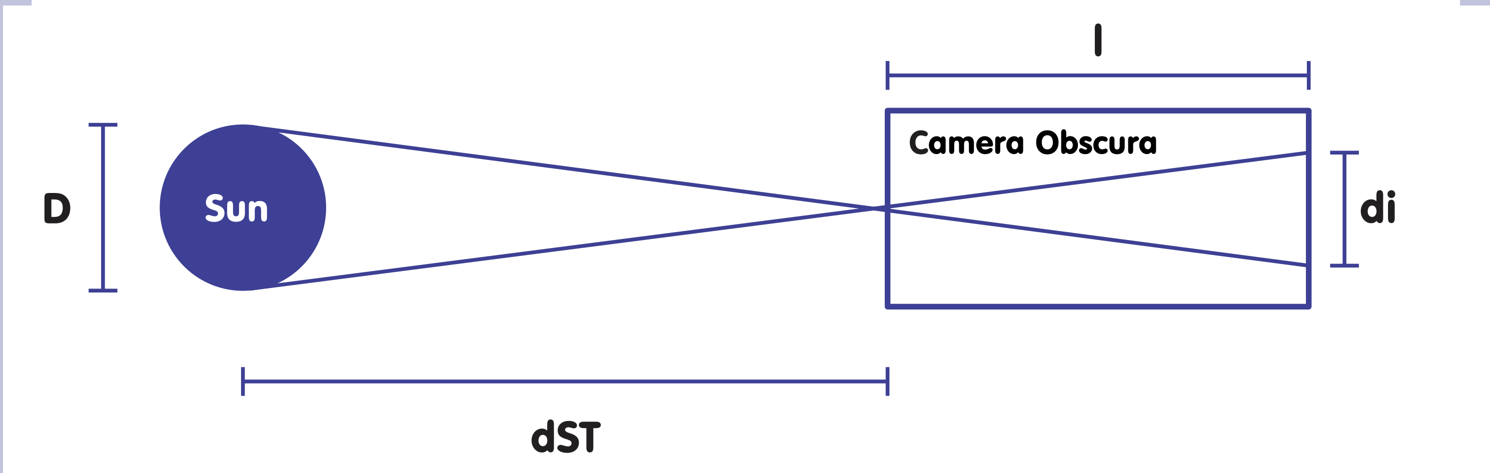

Figure 11. Geometrical explanation for determining diameter of the Sun.

Based on the idea that both triangles are similar but opposite by the vertex, we can calculate the following:

$D/dST = di/l$ (1)

We already know that…

- dST= 150000000 km
- “l” you have to measure from the camera (figure 12).
- “di” you have to measure from the camera (figure 13).

It is possible to calculate (1) which represents the real diameter of the Sun by solving:

$D = dST \times di / l$

Figure 12. Camera Obscura being measured.

Figure 13. Projection of the Sun in the tracing paper being measured.

If we calculated carefully, our measurement will only fail by 10%.

NOTE: our Sun real diameter is 1,391,000 Km.

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