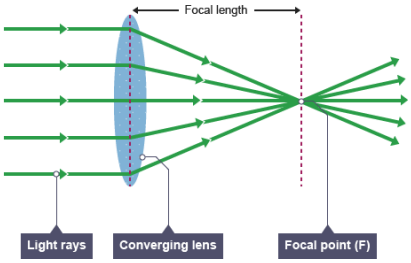
Stories of Science: Refraction and Lenses

The story of how refraction was discovered and described - multiple times!

We use lenses often in modern society; cameras and glasses are two obvious uses. The earliest lens we have found is from the 7th century BC, the Nimrud lens. It is a rock crystal that has been formed into a lens shape, and was used either as a magnifying glass, or to focus the sun's rays to start fires. There also some Egyptian hieroglyphs which people think show lenses being used. Lenses were definitely used in Ancient Greece and the Roman Empire, with references to burning glasses, and the Emperor Nero using an emerald to correct his near-sightedness when watching gladiatorial fights.

Nimrud Lens



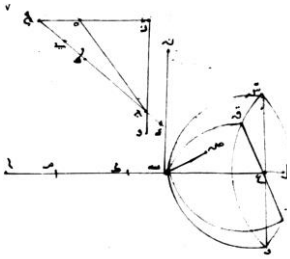
People knew that curved glass caused light to focus on a point, but scientists did not know why, which meant they could only improve lenses by trial and error, rather than designing them in specific ways. We know now that lenses work by refraction. This is an effect that happens because light travels slower in glass than air, so if the light enters as an angle it bends (or refracts). If an object is curved the light can be focused to a single point. The shape of the lens, and the material it's made from, can be altered to make lens which make images bigger or smaller, split light into colours, and many other tasks. Scientists call the study of light and how it behaves 'Optics'.

History of Optics

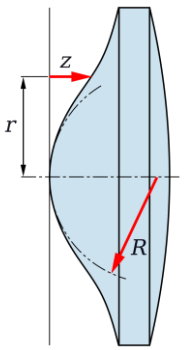
Ptolemy (pronounced with a silent "P") was a Greek scholar who lived in Egypt around AD100-170. He wrote a book called Optics, which did contain a description of refraction, but it was vague, and not useful for designing lenses.

The time between the 8th century and the 14th century is known as the "Islamic Golden Age". During this time much of the Islamic world (the area we call the middle East) was ruled by various caliphates (religious kingdoms), and science and culture were encouraged and rewarded. Scholars of different backgrounds from across the world worked to gather and translate all of the world's knowledge into Arabic. The introduction of paper meant it was easier to spread knowledge, and for the first time in history it was possible to make a living from writing and selling books. Paper was much easier to make than parchment or papyrus. Great steps where made in the development of science, with Ibn al-Haytham sometimes called "the world's first true scientist" for his work on experiments and the scientific method (looking for evidence to prove things). Great developments were made into the effect of medicine, physics, chemistry, biology, astronomy and mathematics.

Ibn Sahl lived over a thousand years ago; we think he was born around 940 and died around the year 1000. He was a Muslim Persian physicist and mathematician, and he lived in or around what is now Baghdad in Iraq. He was the first Muslim scholar known to have studied the work of Ptolemy. He carried out experiments to confirm the laws of refraction, and he is thought to have been the first person to write the law of refraction. He used his knowledge to design biconvex lenses, which focus light like the one above, and then anaclastic lenses, which are a more complex shape to focus light on a precise point than other lenses. He wrote about this in his manuscript 'On Burning Mirrors and Lenses' in 984.



Ibn Sahl's manuscript



Anaclastic lens

Rediscovery

Much work from this time period was lost, and the law of refraction was rediscovered by Thomas Harriot (a British scientist) in 1602. He did not publish this work but wrote to Kepler (a German scientist) about it. Willebrord Snellius (Snell in some languages) discovered the same solution but did not publish it either.

Pierre de Fermat and Rene Descartes (French scientists) separately also discovered the same solution (although in different ways), but credit is generally given to Snell as it is thought they had seen his work. In French Snell's law is called "la loi de Descartes" or "loi de Snell-Descartes". As you can see, scientific discoveries are complex

Comprehension and Reflection Questions

1. How long ago did Ibn Sahl publish his manuscript?

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2. Describe how a lens causes light to focus

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3. Who do you think should get credit for the law of refraction? Why?

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4. Should we name discoveries in science after people?

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5. What should we do in circumstances where credit cannot be clearly attributed to one person?

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Extension Activities

Ideas for things to do next:

Research Chromatic Aberration, and how it can be fixed.

Research the differences and similarities between the lenses used in microscopes and in telescopes..

Further Reading

Ideas for things to read next:

Read more about lenses and their range of uses.
https://en.wikipedia.org/wiki/Lens_(optics)

Read about the other scientific advances made by muslim scientists during the Islamic Golden Age
https://en.wikipedia.org/wiki/Islamic_Golden_Age

Zghal et al 2007. The first steps for learning optics.
https://spie.org/etop/2007/etop07fundamentalsII.pdf