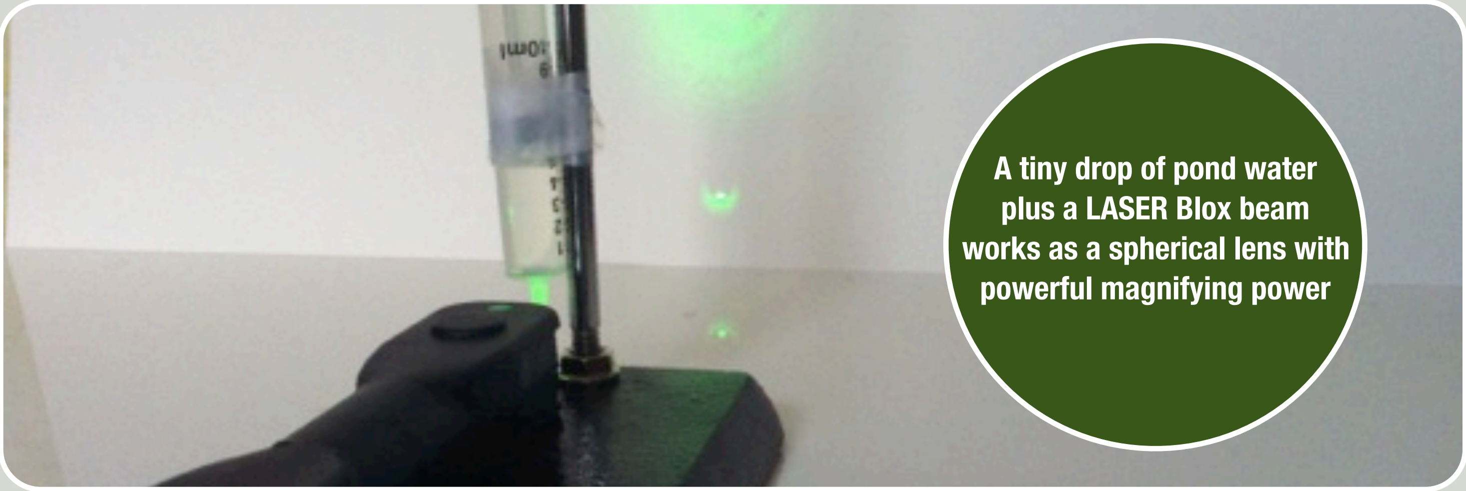
LASER MICROSCOPE

LASER CLASSROOM

www.laserclassroom.com

Adapted from Gorzad Planinsic, Water-Drop Projector
http://www.fmf.uni-lj.si/~planinsic/articles/planin2.pdf



A tiny drop of pond water plus a LASER Blox beam works as a spherical lens with powerful magnifying power

Overview

A simple set up turns a drop of pond water into a spherical lens to make visible the tiny world within. The effect is dramatic and makes an engaging introduction to lenses and geometric optics.

Time: 20-45 minutes
Grades: 3-12 + (depending on math)

Materials

- Green LASER Blox
- Syringe
- Lab Stand
- Tape
- Blank Wall
- Pond, river, lake, stream or ocean water
- A steady hand and a little patience

Antoni van Leeuwenhoek (1632-1723)

Leeuwenhoek created a single lens microscope using a small glass sphere. In this experiment, we will build a single lens microscope using a drop of water rather than a glass lens, and a green LASER Blox beam to view microorganisms and learn the geometric optics that make our home made microscope possible.

HOW IT WORKS

A drop of water hanging from a syringe approximates a spherical lens, so we can apply the thick lens formula to determine the focal length.

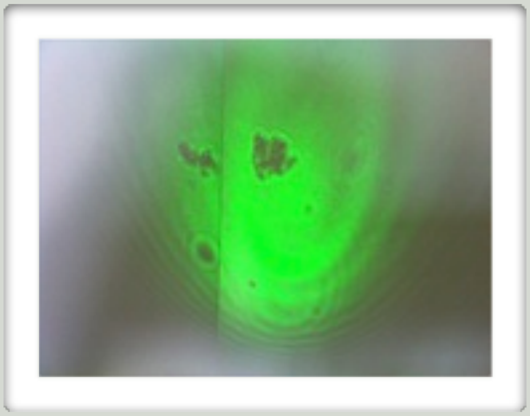
Setting Up

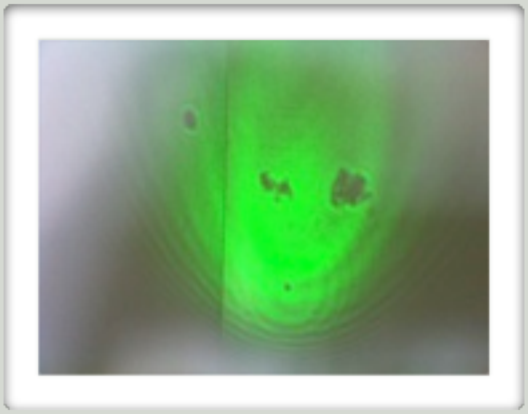
To set up for this simple yet highly engaging demonstration, fill a syringe with water from a pond or river. If you live near a coast, get some sea water. If you are not near a pond or river or ocean, collect water from a puddle or some other standing body of water that is likely to have some tiny (0.2 - 0.5mm) organisms living in it.

Fill a syringe with the collected water. Fix the syringe on a lab stand so that a drop of water hangs from the tip. Position the drop of water to line up with the beam of a green LASER Blox so that the beam passes through the center of the drop, perpendicular to the wall.

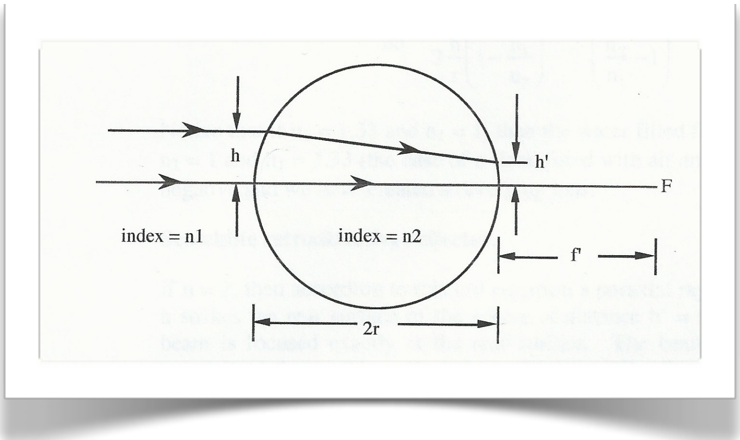
Your set up should be about two meters from a screen or plain white wall where a bright green spot will display an impressive array of single celled animals, larva, fleas floating and swimming.

This is generally engaging enough to interest students in the powerful optics that makes this impressive site possible.





Background and discussion



For a drop of water, suspended from a syringe, as we have here, the figure to the right traces the path into and then out of the lens. The ray through the center does not deviate - all other rays, however, do bend towards the normal as they pass from air, index = n1, to water, index = n2.

For small angels, such as we have here, we use Snell's law - $n_1 \sin\ominus_1 = n_2 \sin\ominus_2$

becomes $n_1\theta_1 = n_2\theta_2$. So, the deviation toward the normal at one surface is given by:

$$\delta = \theta_1 - \theta_2 = \theta_1\left(1 - \frac{\theta_2}{\theta_1}\right) = \theta_1\left(1 - \frac{n_1}{n_2}\right)$$

This is a general equation used for very small angles, and is useful for tracing rays through complicated systems, which, despite our simple set up, is what we have here. For this example, the deviation as the ray passes from the air into our drop (the first surface), is

$$\delta = \frac{h}{r}\left(1 - \frac{n_1}{n_2}\right)$$

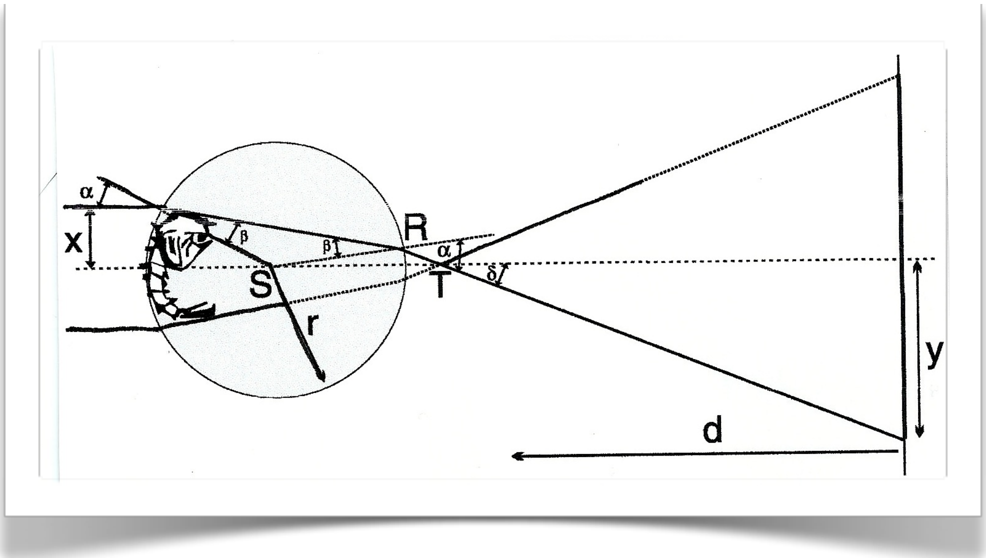
At the rear surface of the drop, the ray is closer to the axis by an amount 2r times the deviation - so it reaches the rear surface at distance h'

$$h' = h - 2r\delta = h - 2h\left(1 - \frac{n_1}{n_2}\right) = h\left(2\frac{n_1}{n_2} - 1\right)$$

The angle of deviation of the ray as it exits the drop is the same as the angle of deviation upon entering the drop. Finally -

$$f' = \frac{h'}{2\delta} = \frac{h\left(2\frac{n_1}{n_2} - 1\right)}{2\frac{h}{r}\left(1 - \frac{n_1}{n_2}\right)} = \frac{r}{2}\frac{\left(2 - \frac{n_2}{n_1}\right)}{\left(\frac{n_2}{n_1} - 1\right)}$$

Now, when you take at how this general phenomenon of light passing through a spherical lens creates the magnificent magnification before you, things get significantly more complicated and may be beyond the scope of high school students. The figure below is a simple ray diagram of the situation.



If you would like to explore the math behind this, please refer to the excellent paper by Gorazd Planinsic referred to at the beginning and end of this lesson.

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