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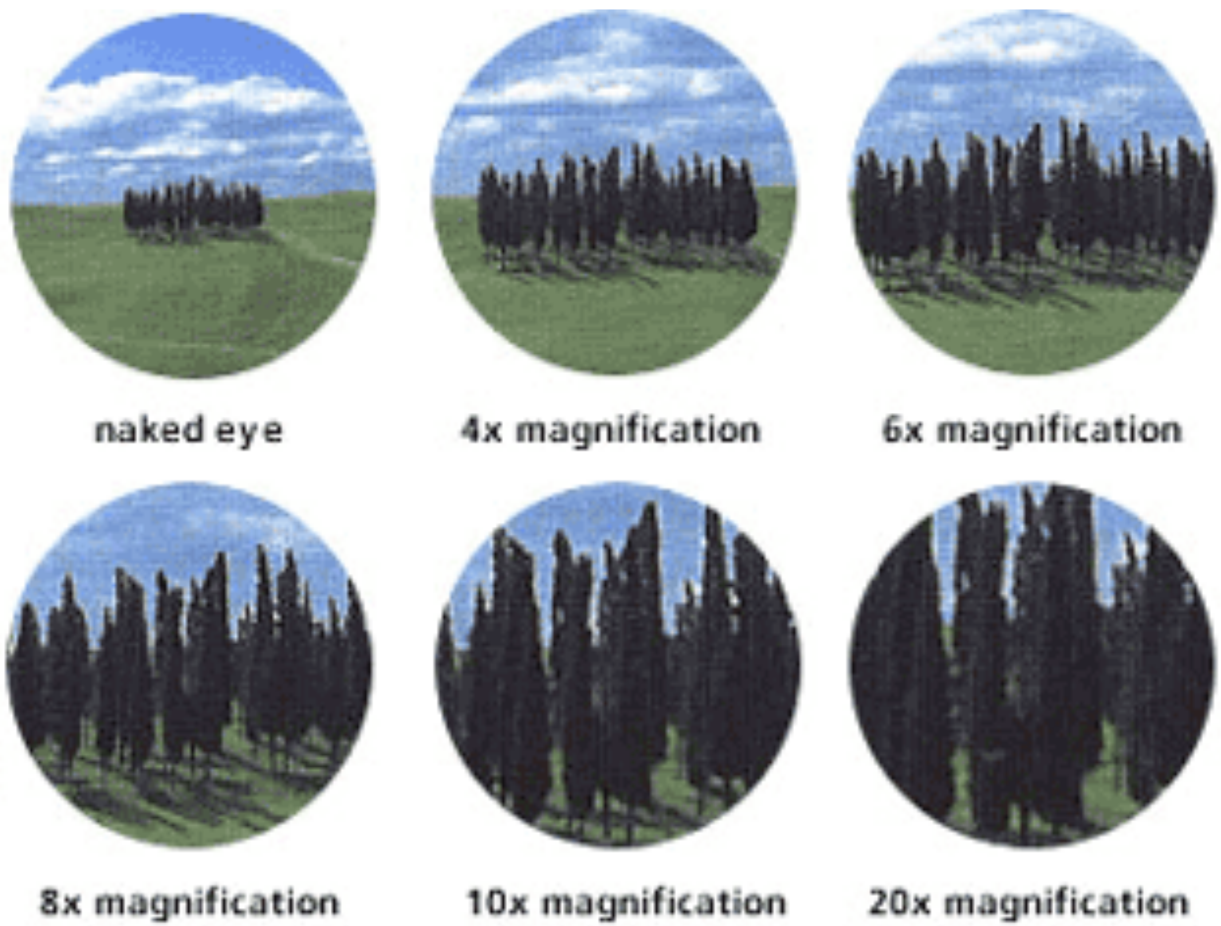
Magnification changes apparent angles



http://personalsecurityzone.com/images/Riflescope_school_Magnification.gif

So what about that sun & moon thing?

Refraction changes the direction of propagation at an interface

Light waves travel more slowly in media such as glass or water

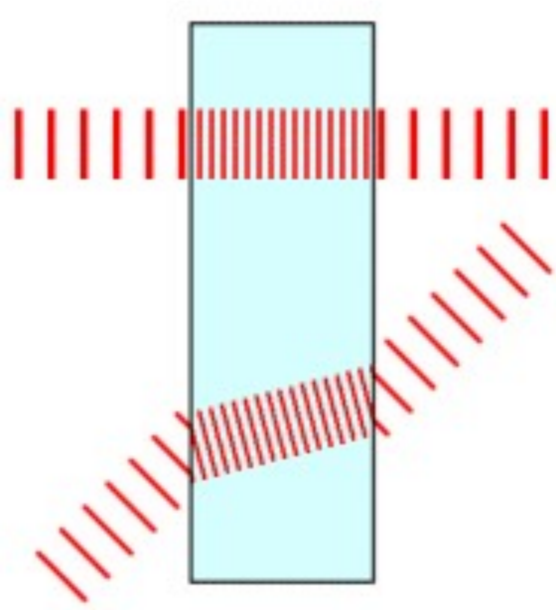
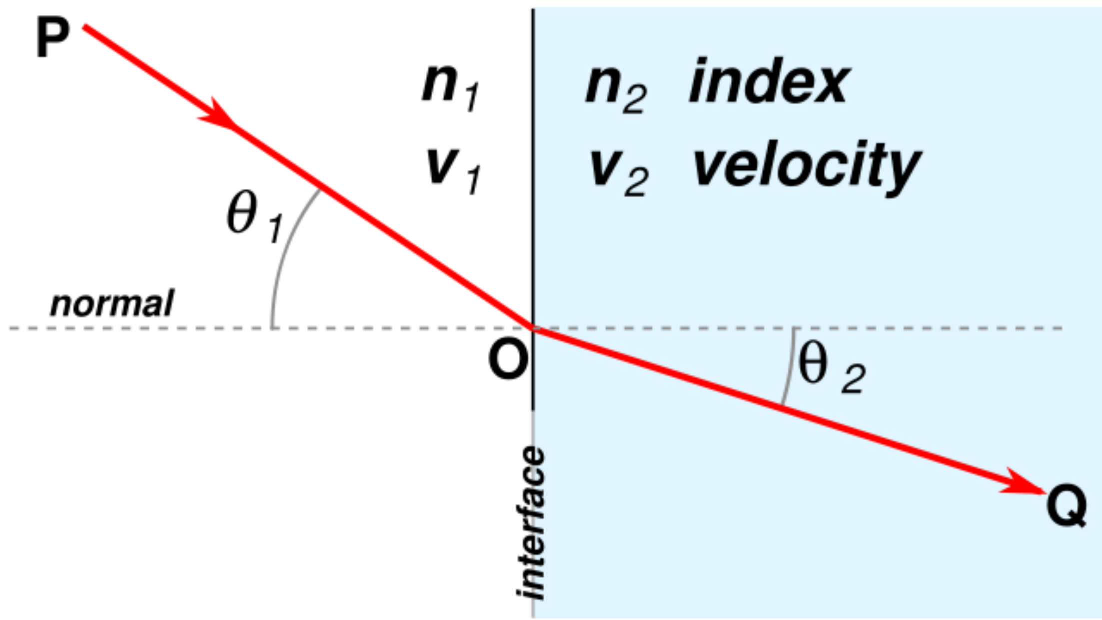


Image from
http://www.williamson-labs.com/optical-body.htm
This website has some nice introductory optics material.

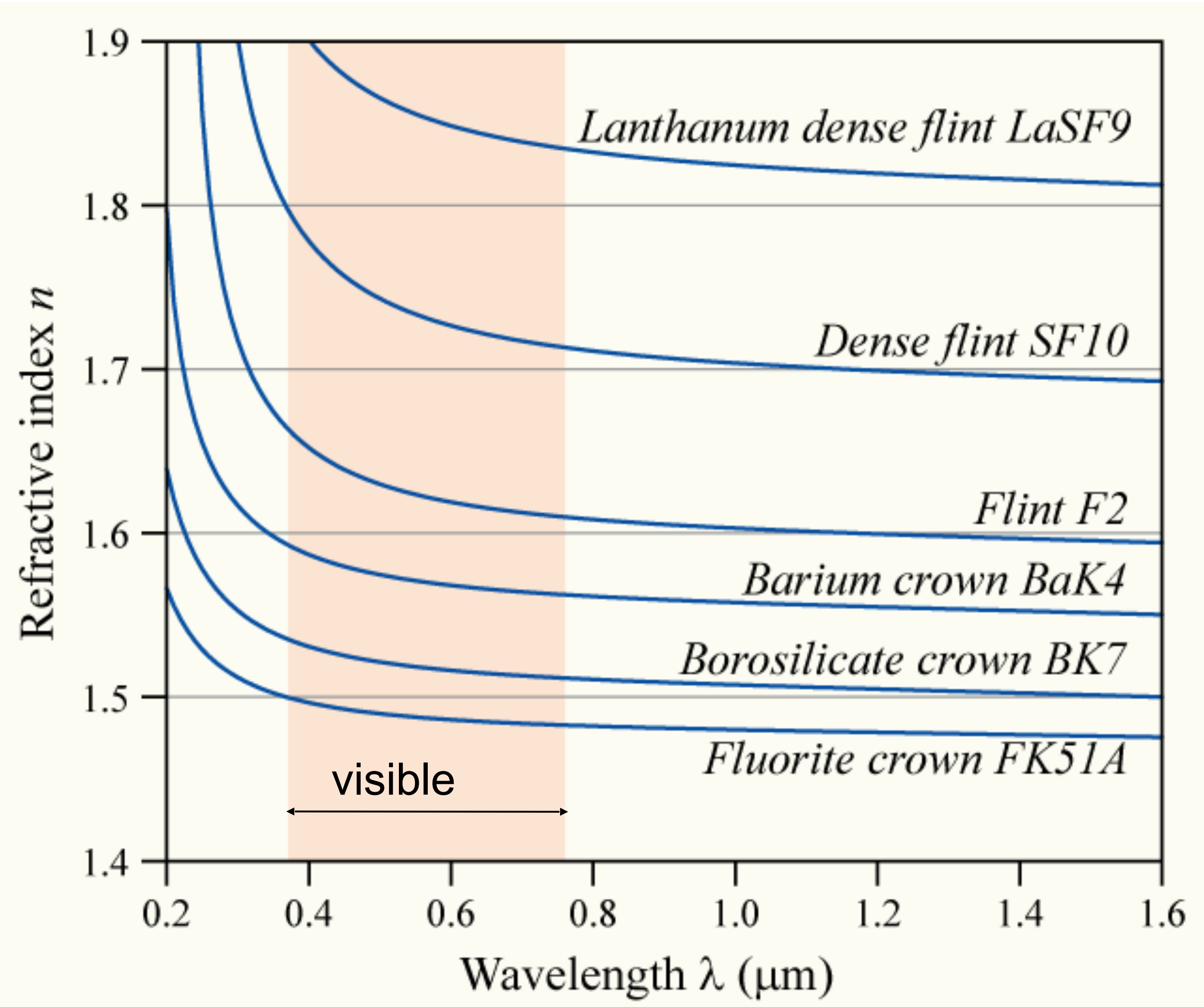
Index of refraction is a measure of resistance to light propagation

Refractive index = speed of light in vacuum / speed of light in material



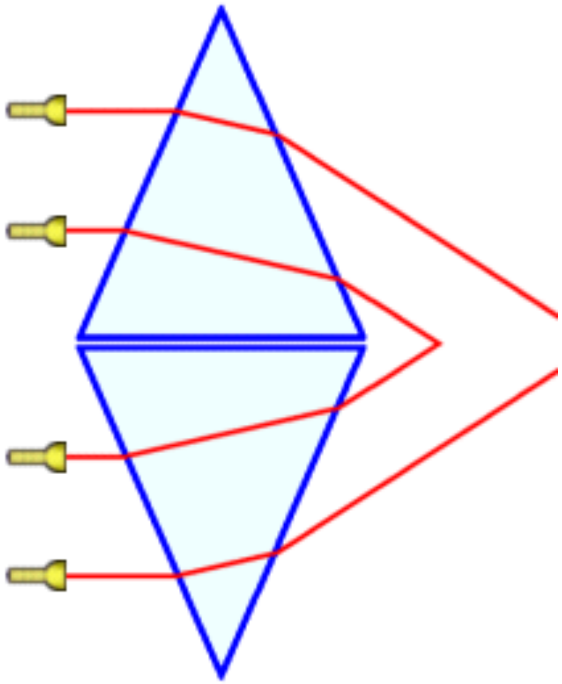
Snell's law: $$\frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2} = \frac{n_2}{n_1} \quad \Rightarrow \quad n_1 \sin\theta_1 = n_2 \sin\theta_2 \ .$$

Index of refraction depends on wavelength, and is different for different materials



Wavelength dependence of refractive index for some glasses. This function is also known as a **dispersion curve**.

Focus is a composite effect of refraction (or of reflection)



http://www.williamson-labs.com

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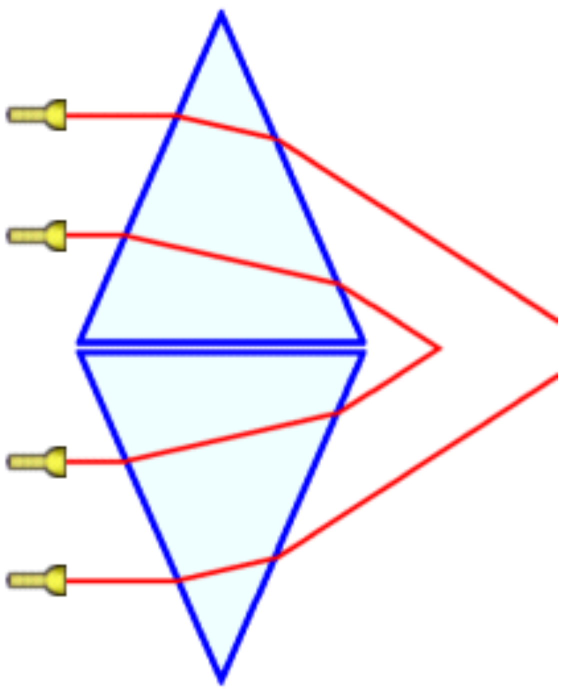


http://www.williamson-labs.com

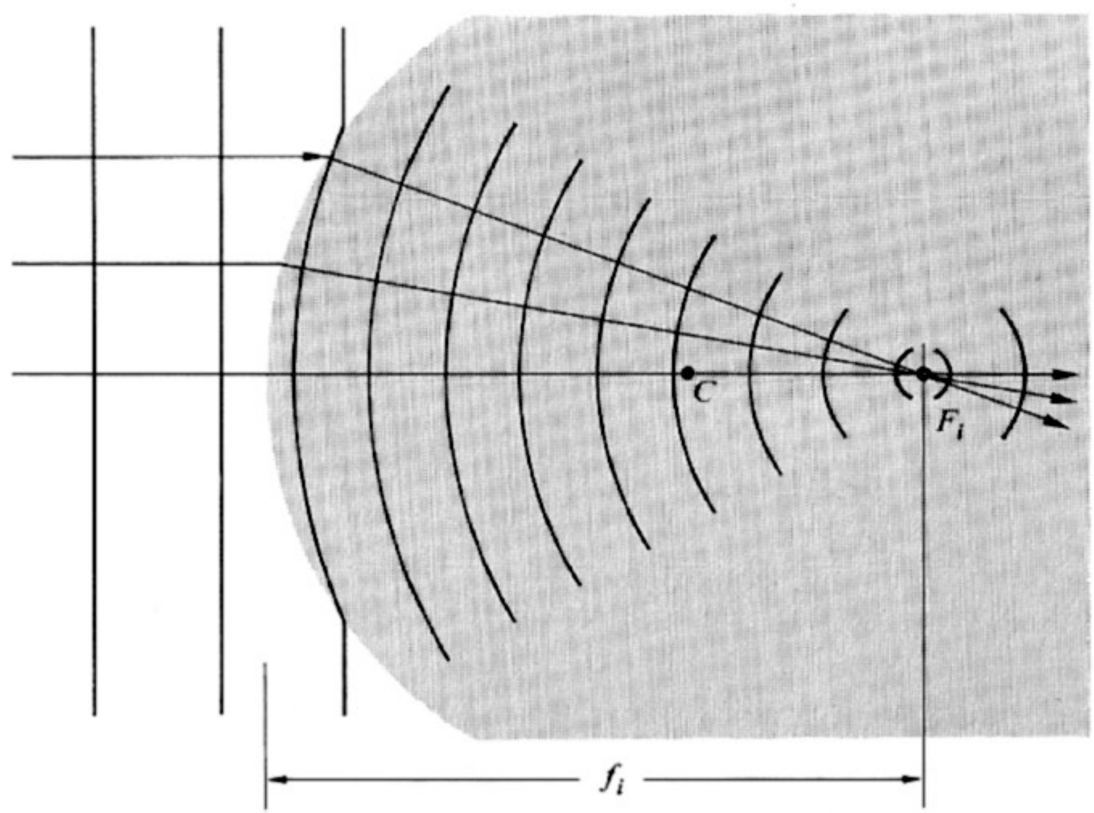
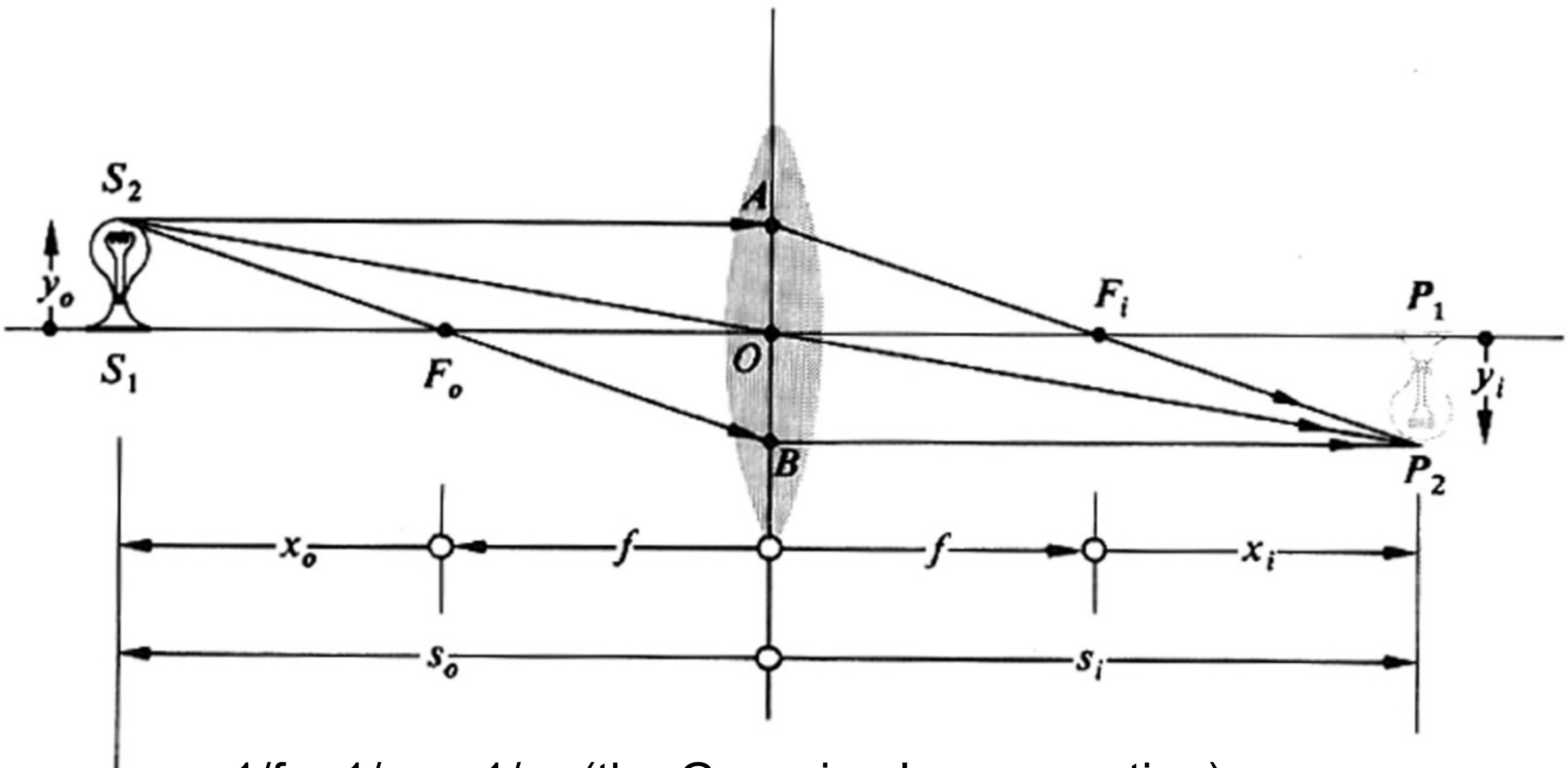


Fig. 5.11 The reshaping of plane into spherical waves at a spherical interface—the image focus.

from Hecht and Zajac, *Optics*

The focusing effect of a lens can reconstruct wavefronts from an object.

This is known as *image formation*.



$1/f = 1/s_o + 1/s_i$ (the Gaussian Lens equation)

An image can also be formed by removing all the unfocused rays.

This is the principle of a pinhole camera.

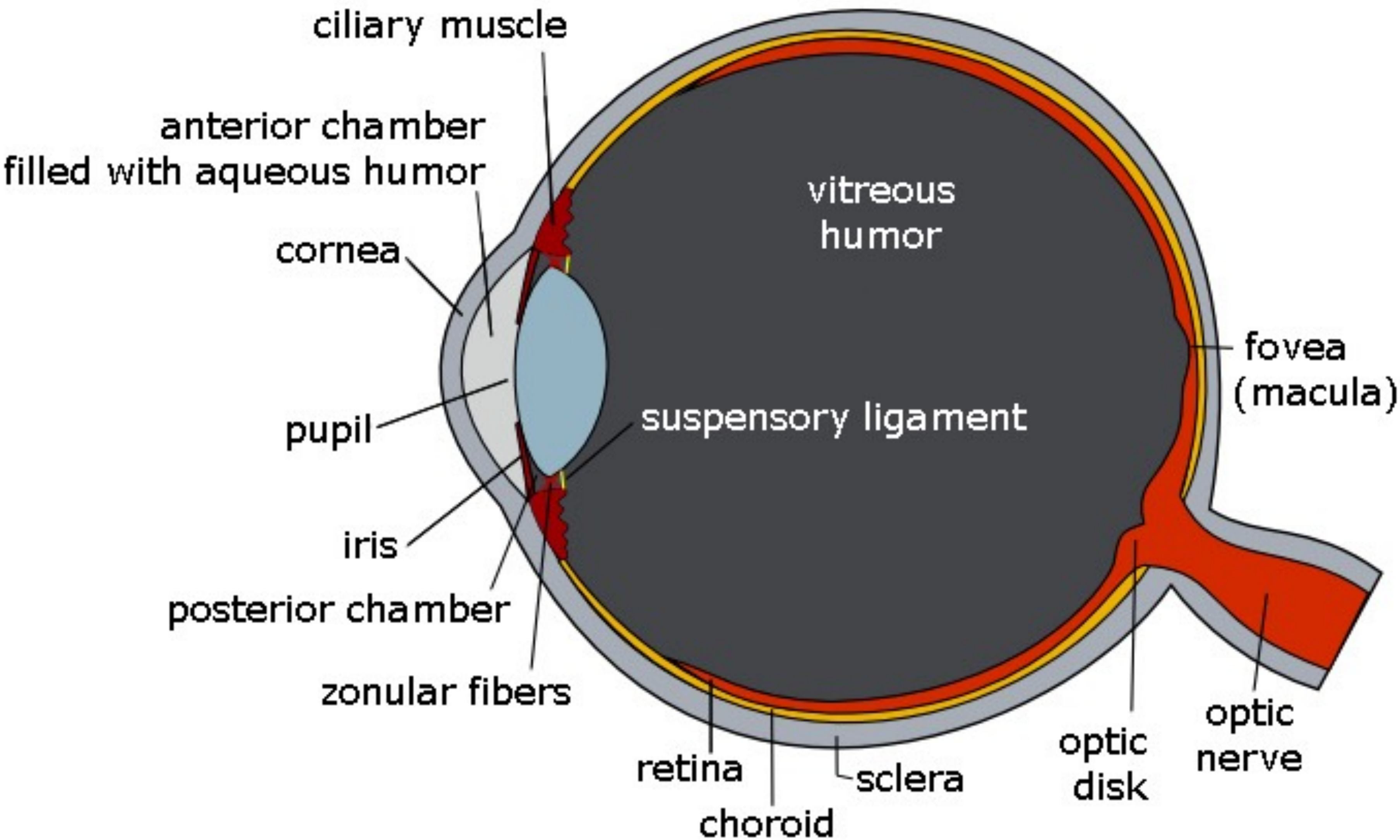
This CCD pinhole camera is only $65 at spygadgets.com

Undesigned lenses can form images

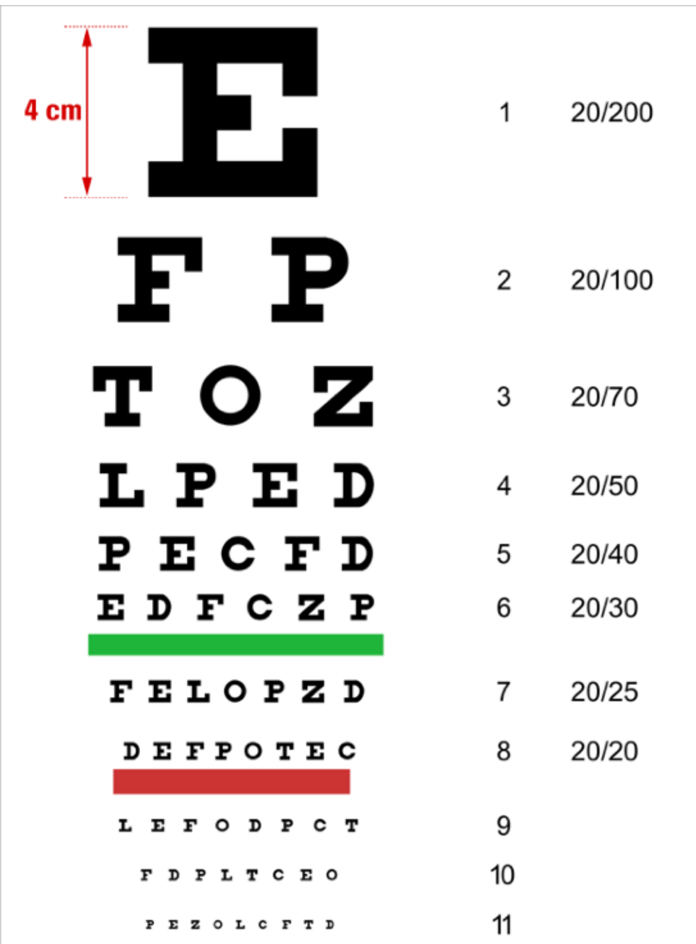
Flower in the background imaged through hanging dew drops
From http://www.flickr.com/groups/macroviewers/discuss/72157594313729574/

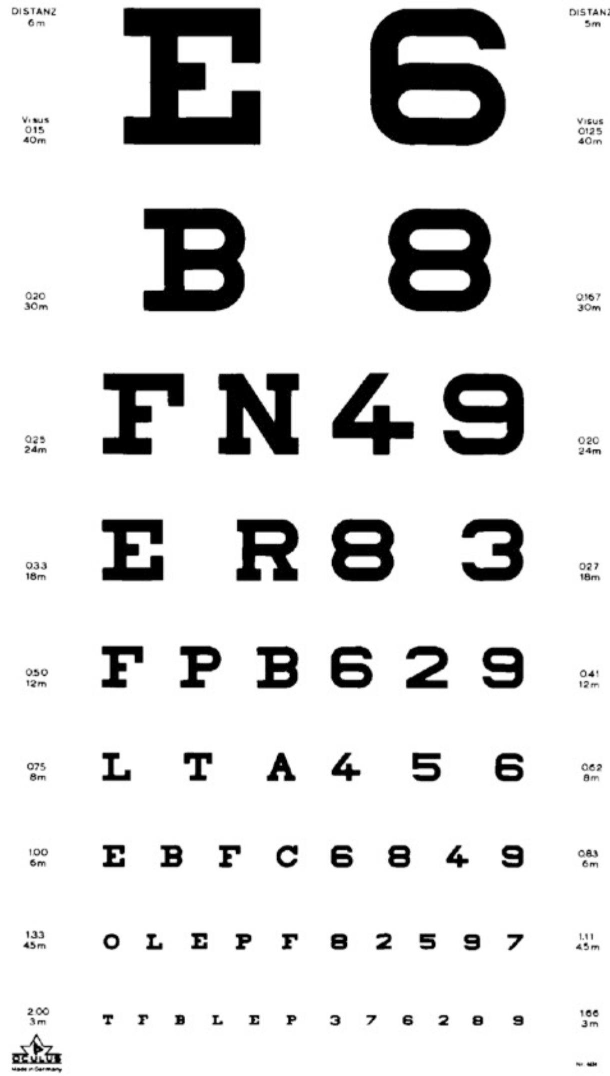
Thus, imperfect eyes can be useful.

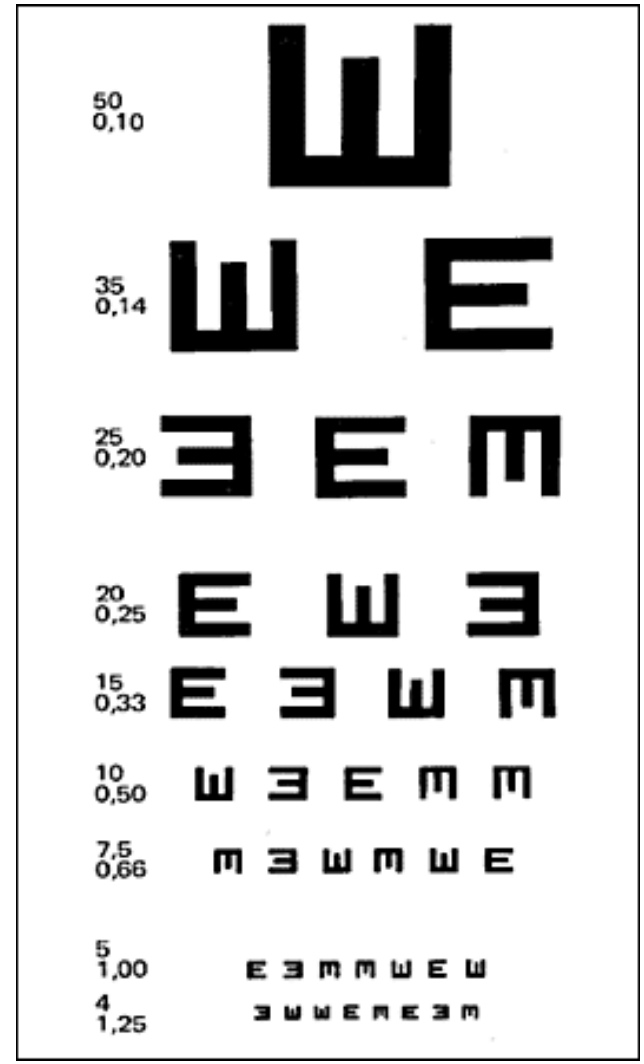
Human eye, horizontal section



"Normal" vision can resolve features of about 1 arc-minute – this is 20/20 or 6/6 or Visus 1.00.







So how can we see something smaller than 1 arc-min?

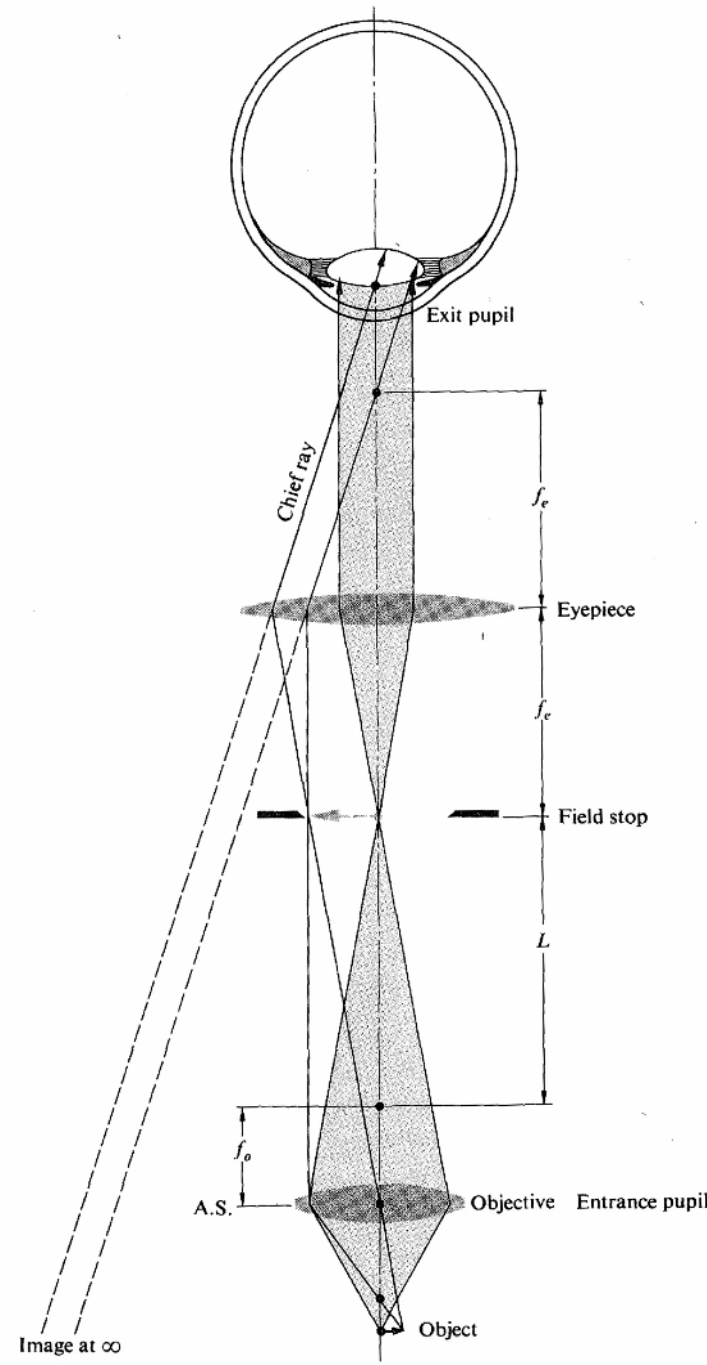
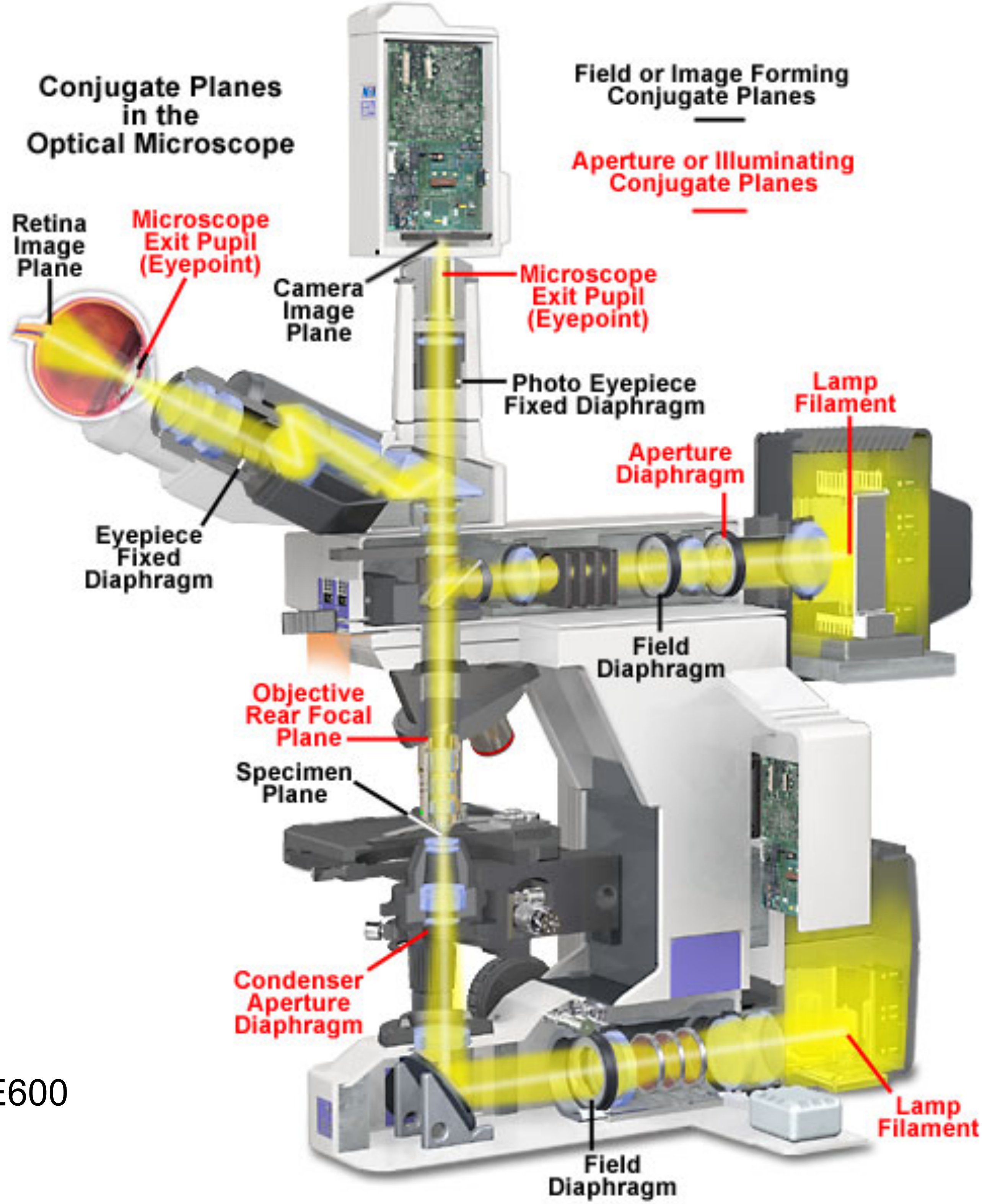


Fig. 5.86 A rudimentary compound microscope.



Nikon Eclipse E600

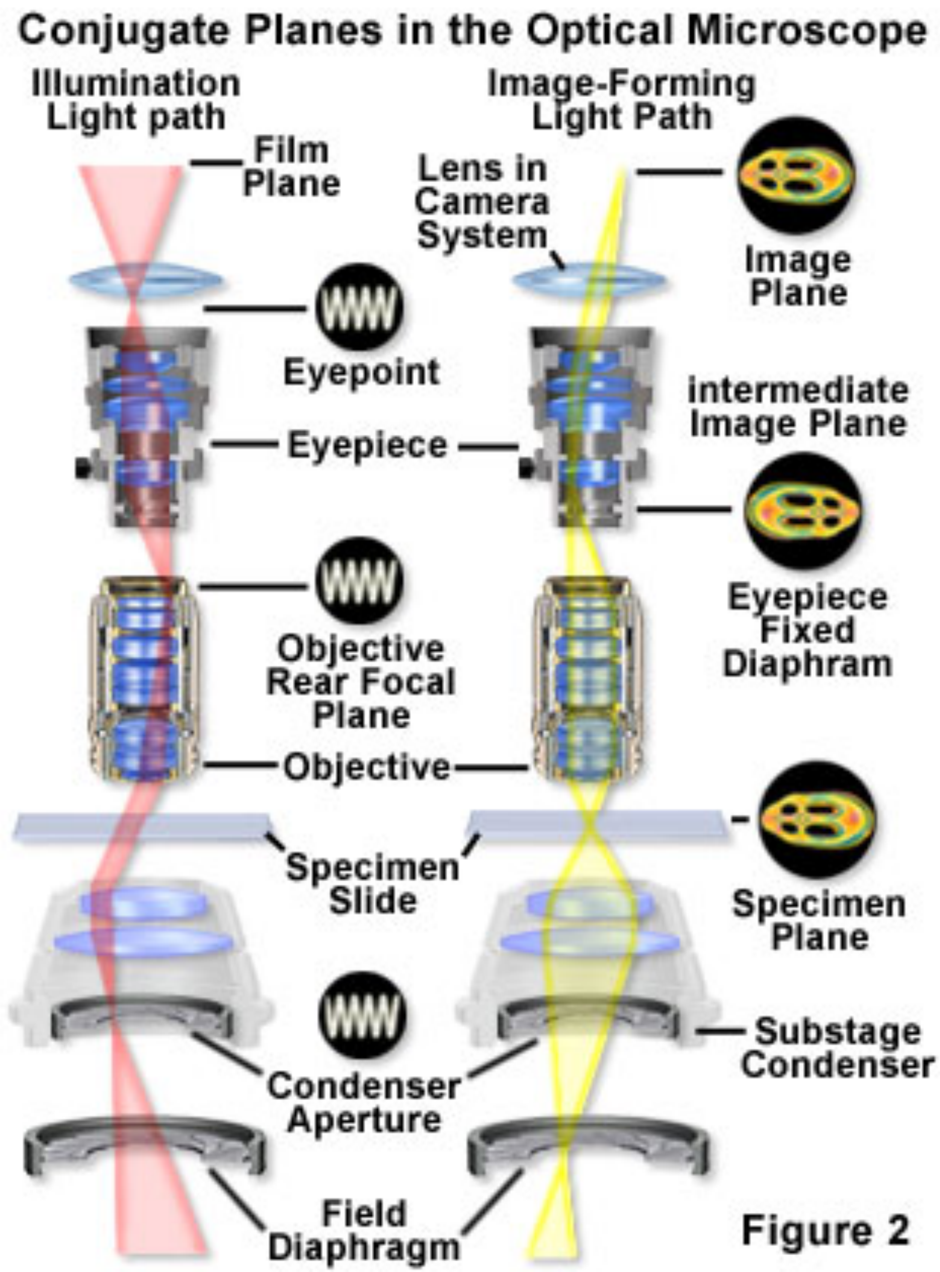

Conjugate Planes in the Optical Microscope
Illumination Light path
Image-Forming Light Path
Film Plane
Lens in Camera System
Image Plane
Eyepoint
intermediate Image Plane
Eyepiece
Eyepiece Fixed Diaphram
Objective Rear Focal Plane
Objective
Specimen Slide
Specimen Plane
Substage Condenser
Condenser Aperture
Field Diaphragm

Figure 2

Higher magnification => smaller field of view

e.g. for a 1k x 1k camera,

4x objective with 5mm fov
=> 5μm pixels

20x objective with 1mm fov
=> 1μm pixels;

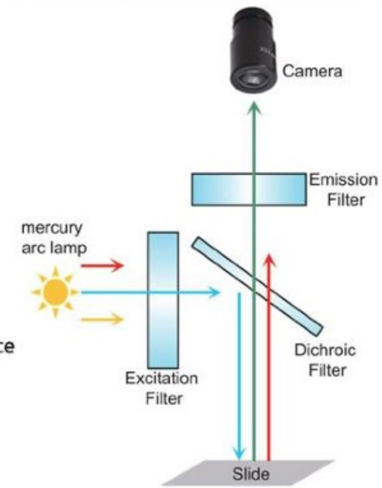
Fluorescence Filters

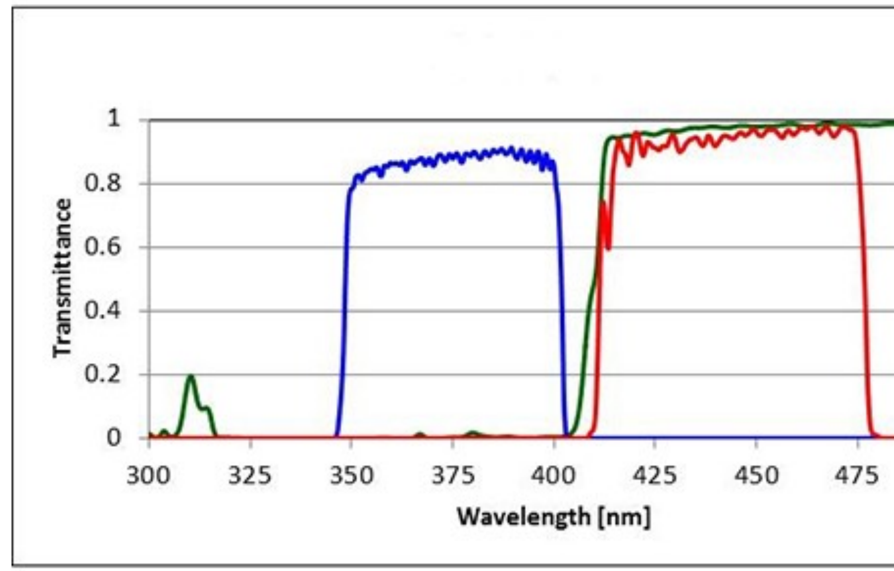
Fluorescence filters include excitation, emission filters and unmounted dichroic mirror. They are the key optical system for each fluorescence microscopes. In market, such filters and sets are very expensive and it must be changed to a new one after using 5 years. Yulong's fluorescence filters are manufactured with high transmittance, deep blocking with sharp contrast, multi-layers hard-coating. It' s durability and stability can reduce the cost and possible accident for our customers. At present, Yulong can provide hundreds of fluorescence imaging filters with mounted or unmounted, single band and multi-band with different thickness.

Excitation filter:
Choose excitation wavelength of light

Emission filter:
Through the fluorescence wavelength

Dichroic mirror:
Cutoff the light, through the fluorescence





From "Fluorescence Microscopy" by Ken Jacobson.

depth of field/focus