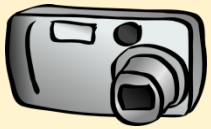
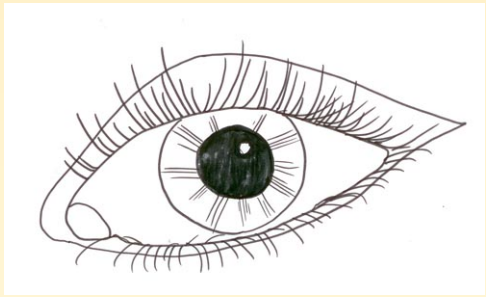
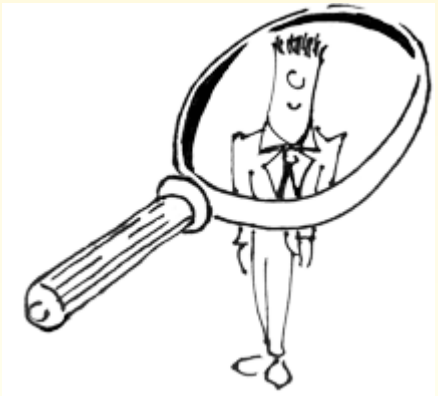
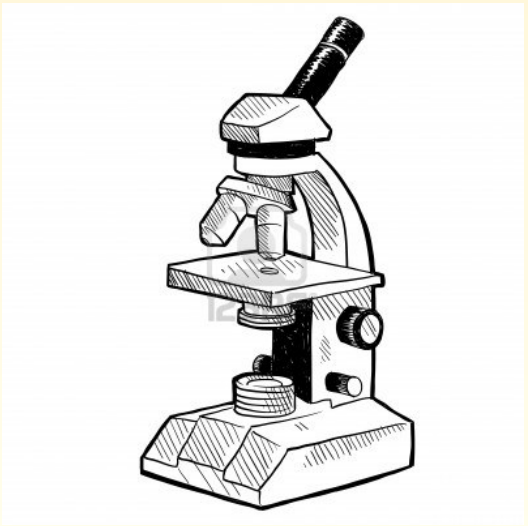
1.2. Lenses



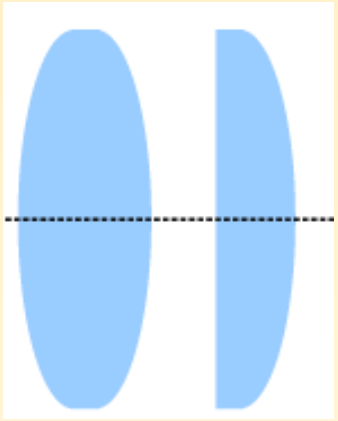






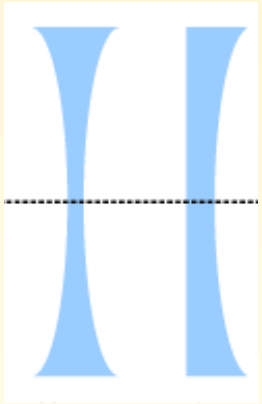
1.2. Lenses – Types

- Collecting lenses - Convex (or positive) lenses
  - thicker in the middle than at the edges
  - **most important lenses of the microscope**



bi-convex plano-convex

- Diverging lenses - Concave (or negative) lenses
  - thicker at the edges than in the middle



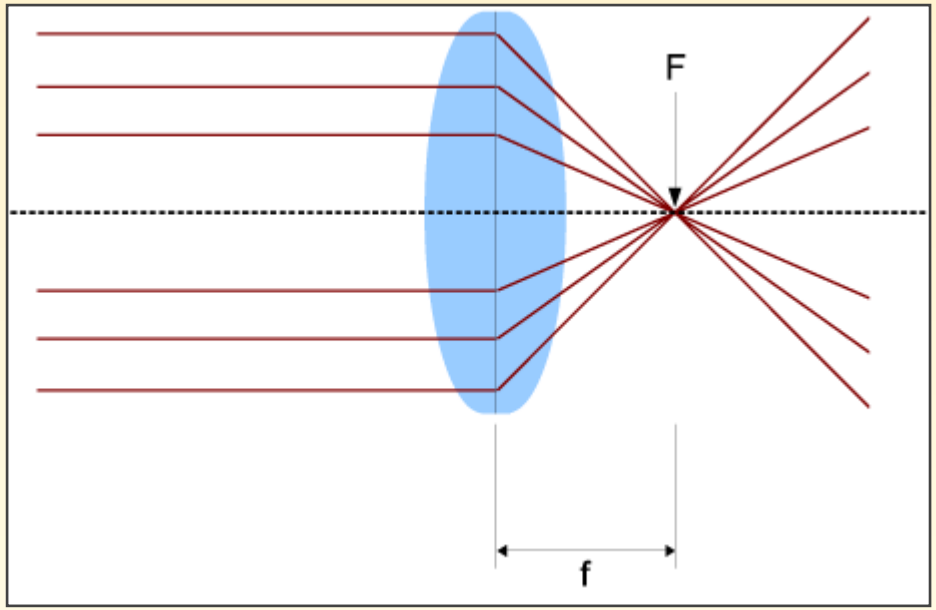
bi-concave plano-concave

- plano means the lens has a flat surface

1.2. Lenses – Focal point and focal length

- Collecting lenses

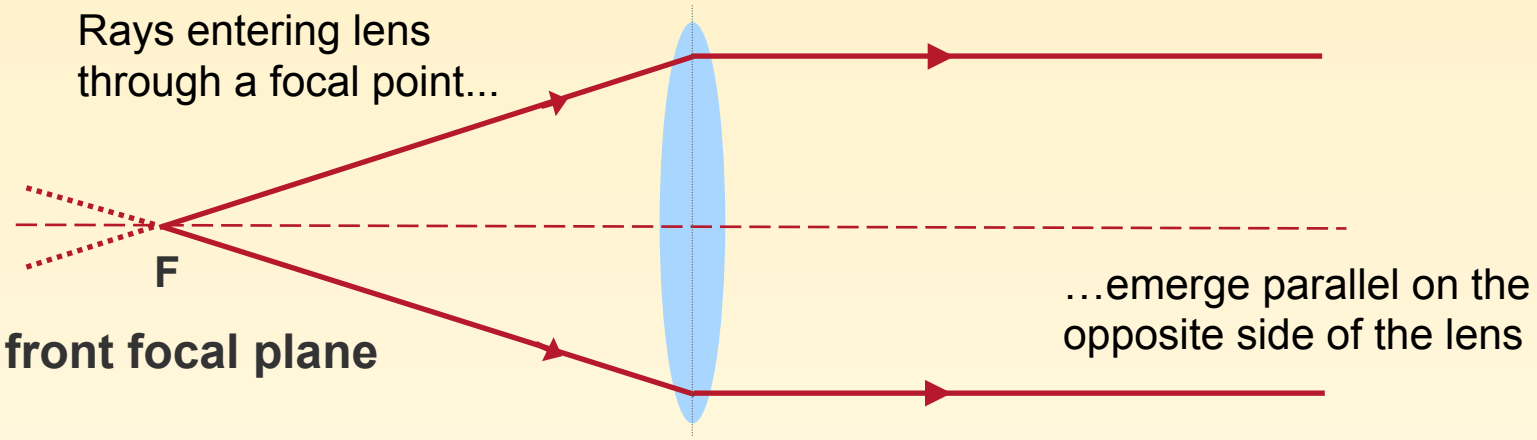
  parallel rays enter→ they are collected in one point = the **focal point F**

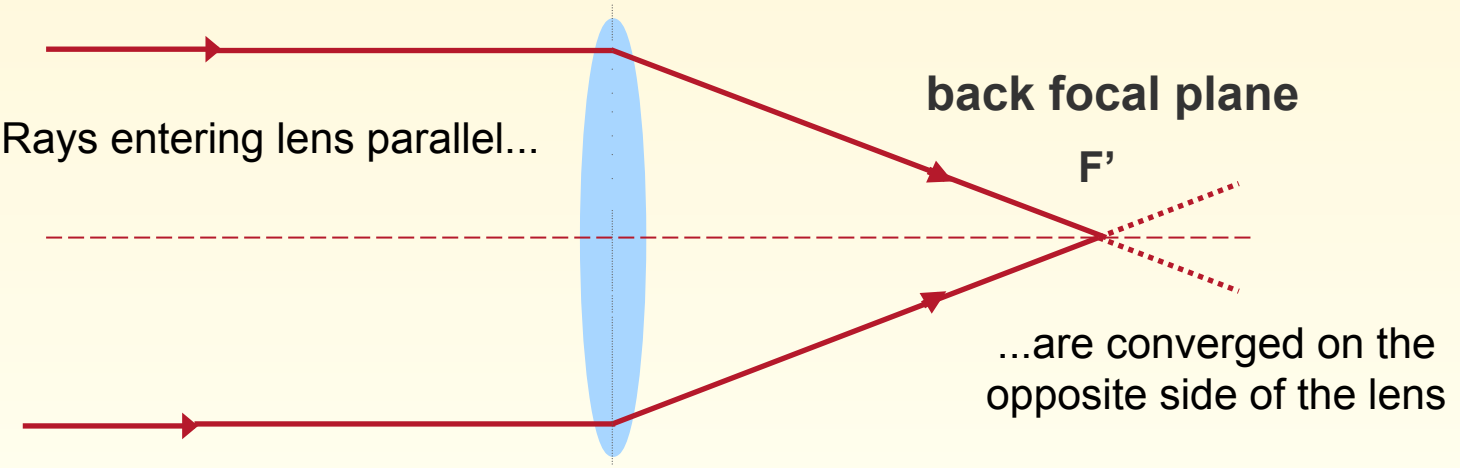


distance between the middle of the lens and the **focal point F** is called the **focal length f**

1.2. Lenses – Focal Planes

- A lens has two focal planes





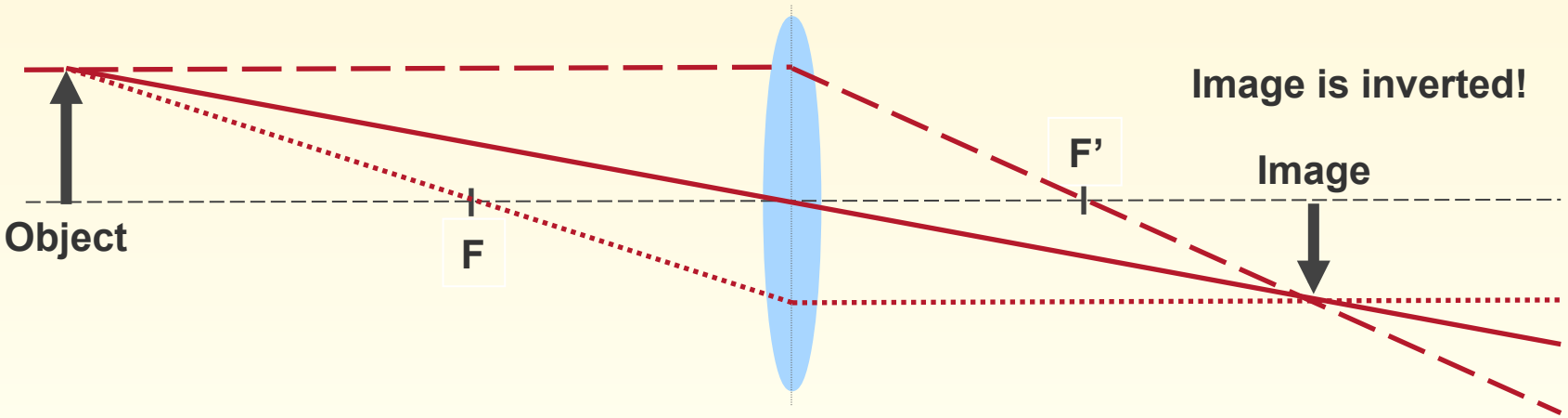
1.2. Lenses – Image Construction

- **Three Rules**

Rays entering lens parallel to axis cross the axis at the focal point on the opposite side of the lens!

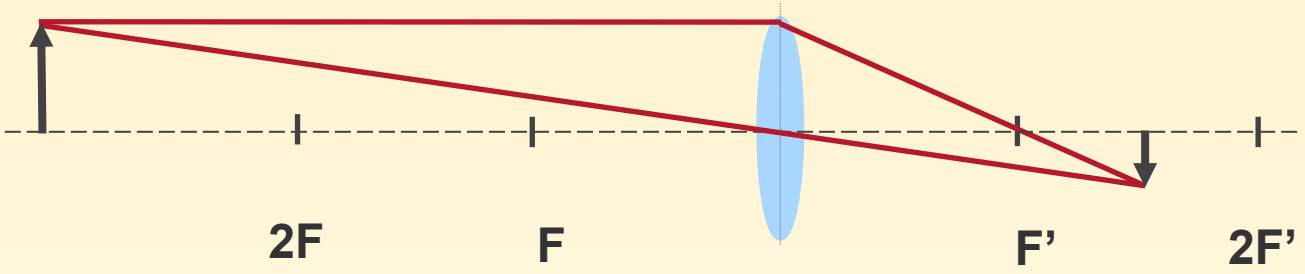
Rays passing through centre of lens are undeviated!

Rays entering lens through focal point leave the lens parallel to axis!

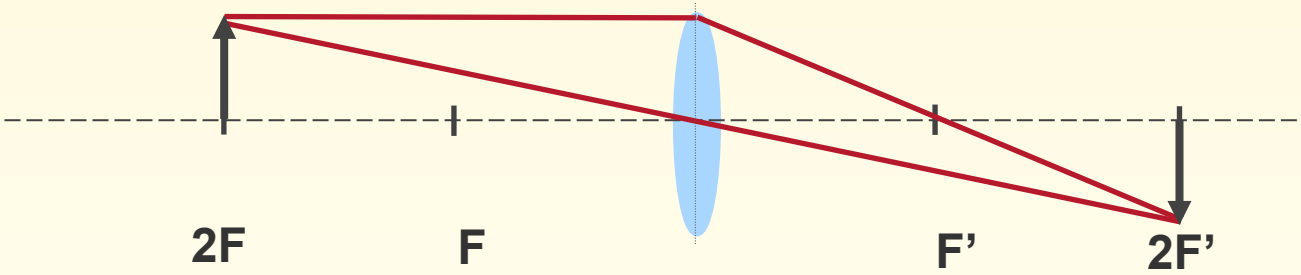


1.2. Lenses - What can lenses do?

- can act in a way similar to those optical devices
  - forming a ***reduced-size***, real image, closer to the lens → like a camera-image



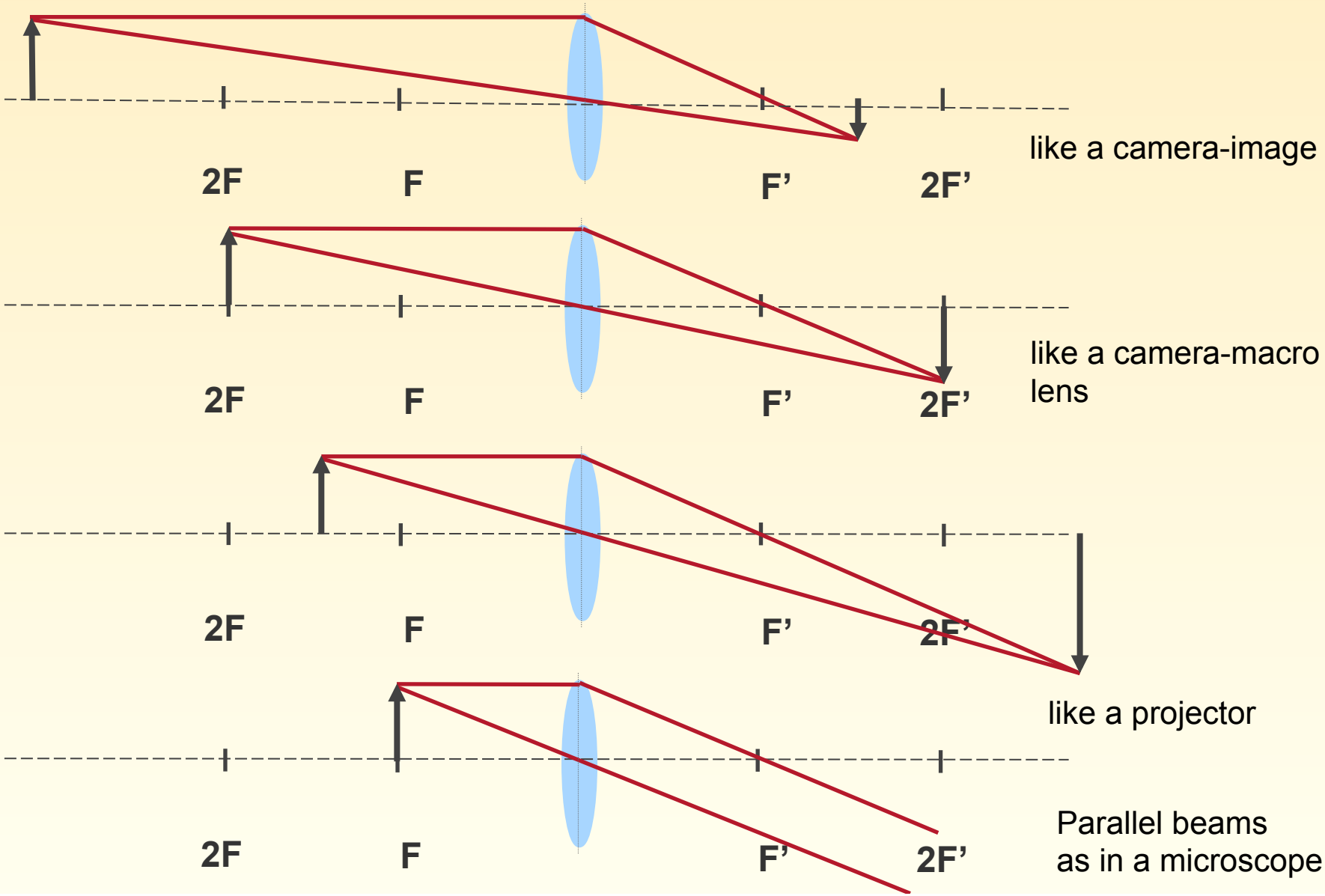
  - forming a ***equal-size***, real image, close to the lens → like a camera-macro lens



1.2. Lenses - What can lenses do?

Lens exercise

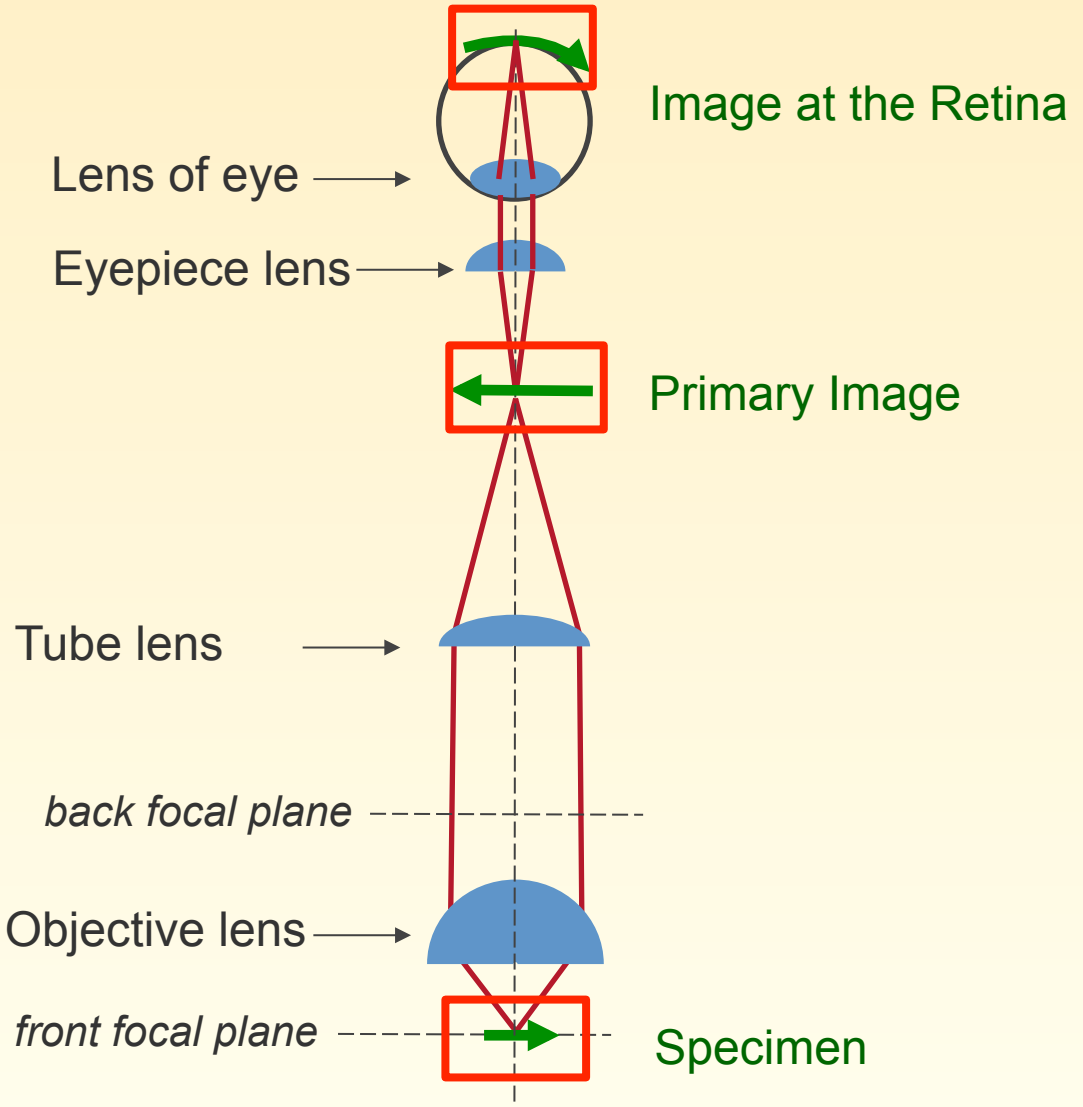
1.2. Lenses - What can lenses do?



1.2. Lenses – Conjugate planes

- An image of the Specimen in the *front focal plane (FFP)* of the objective forms the primary image
- This is transferred to the retina
- The eyepiece acts as a *magnifying glass*

- **These are three conjugate planes** - successive images of one another



… and there are more!

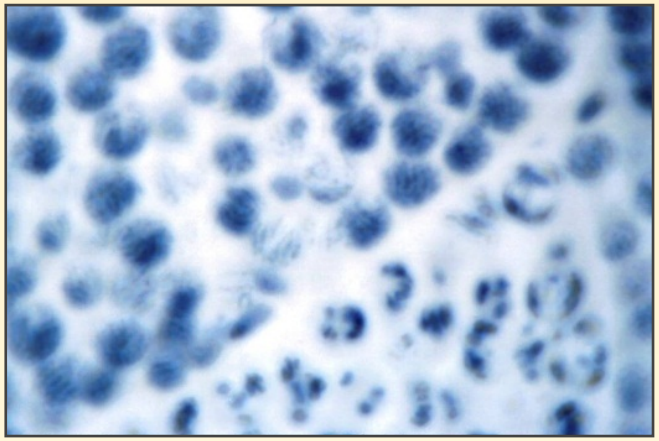
1.2. Lenses – Lens aberrations

Simple single pieces of glass do not act as perfect lenses

They suffer from several *errors,* called *aberrations*

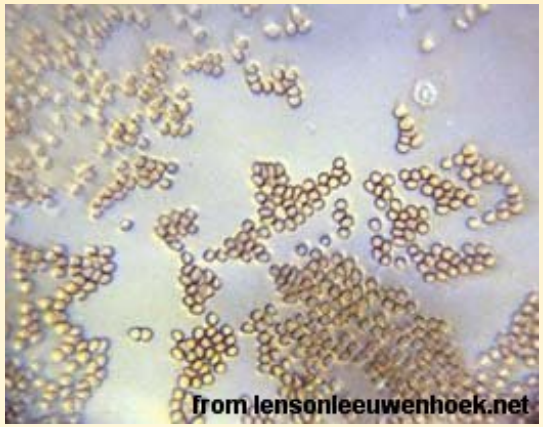
1.2. Lenses – Lens aberrations

- Spherical aberration



- Chromatic aberration

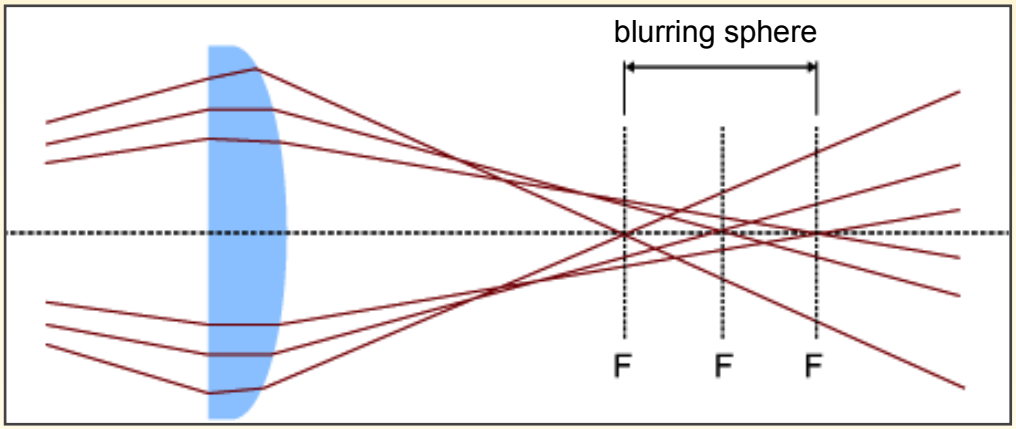
- Curvature of Field

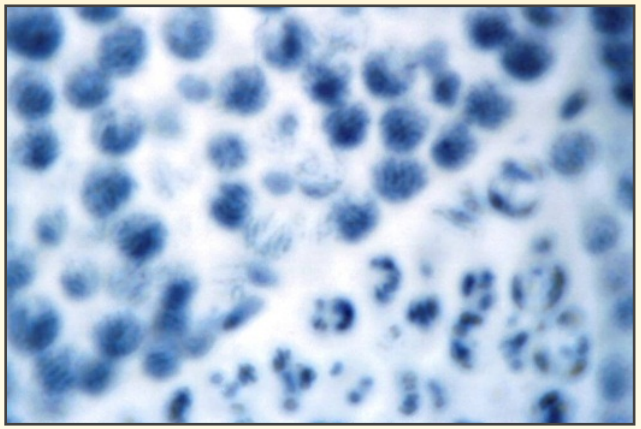


… and there are more!

1.2. Lenses – Lens aberrations

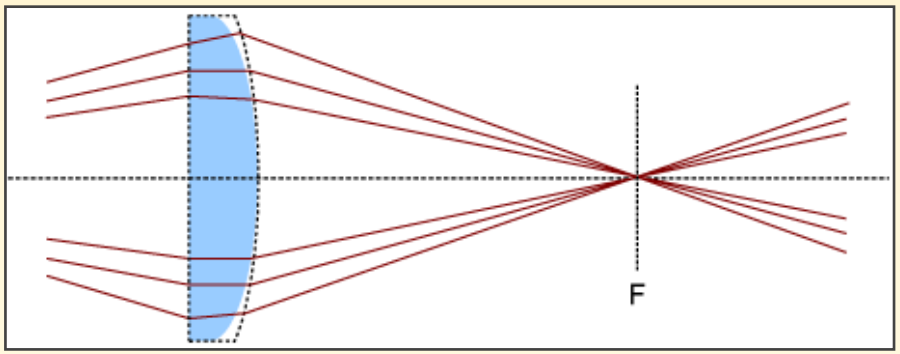
- Spherical aberration
  - occurs in a simple lens with a spherical curvature
  - Beams passing through the peripheral areas of the lens are refracted more
  - their focal point is closer to the lens as focal point of rays which pass through the middle of the lens
  - result is a slightly blurred, fuzzy looking image.





1.2. Lenses – Lens aberrations

- Spherical aberration - Correction



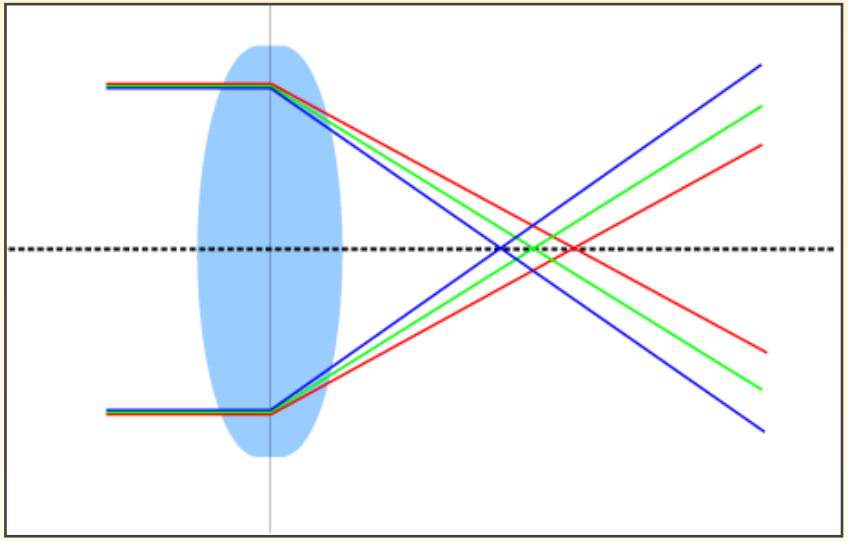
Aspherical lens elements are used: their radius is not constant but increases from the center to the edge.

The best correction of spherical aberration.

But the most expensive!!!

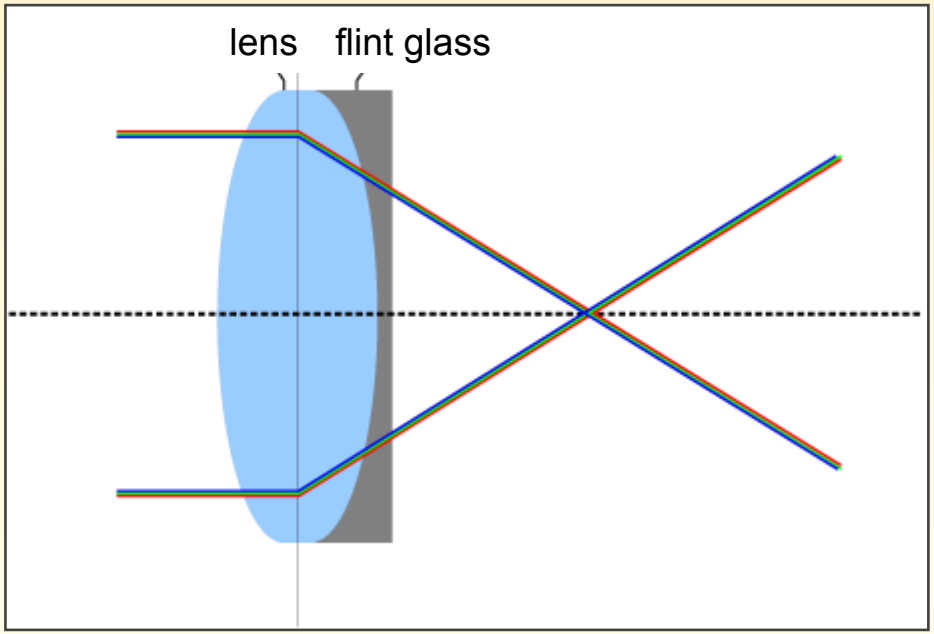
1.2. Lenses – Lens aberrations

- Chromatic aberration
  - light of different wavelengths is refracted differently and split into its spectral components.
  - Similar to the prism
  - the smaller the wavelength the closer the focal point is to the lens
  - color fringing at the edges.



1.2. Lenses – Lens aberrations

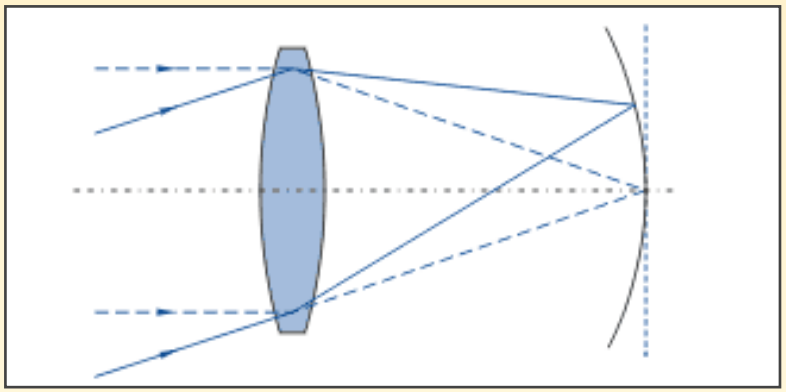
- Chromatic aberration – Correction
  - correction is achieved by a combination of two lenses
  - lenses are chosen that the combination approximately has the same focal length for a certain wavelengths

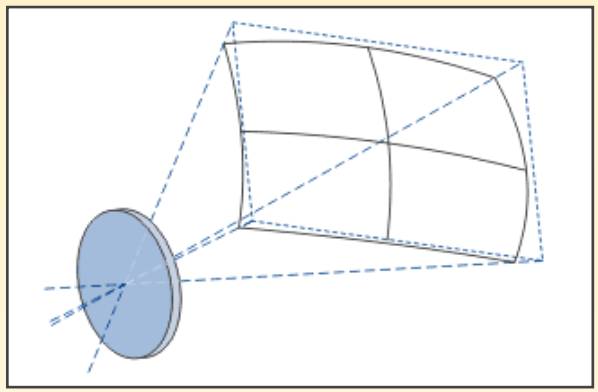


- Depending on the types of glass 2 or 3 wavelength are corrected

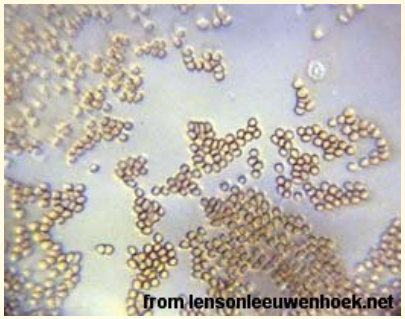
1.2. Lenses – Lens aberrations

- Curvature of Field





  - points at the edge of the lens projected closer to the optical axis then points at the center
  - image isn't displayed just on a surface → it's curved
  - image isn't simultaneously sharp at all points
  - focus on the center → blurred edges
  - focus on the edges → blurred center



In high-quality optics the correction is achieved by the combination of several lenses.