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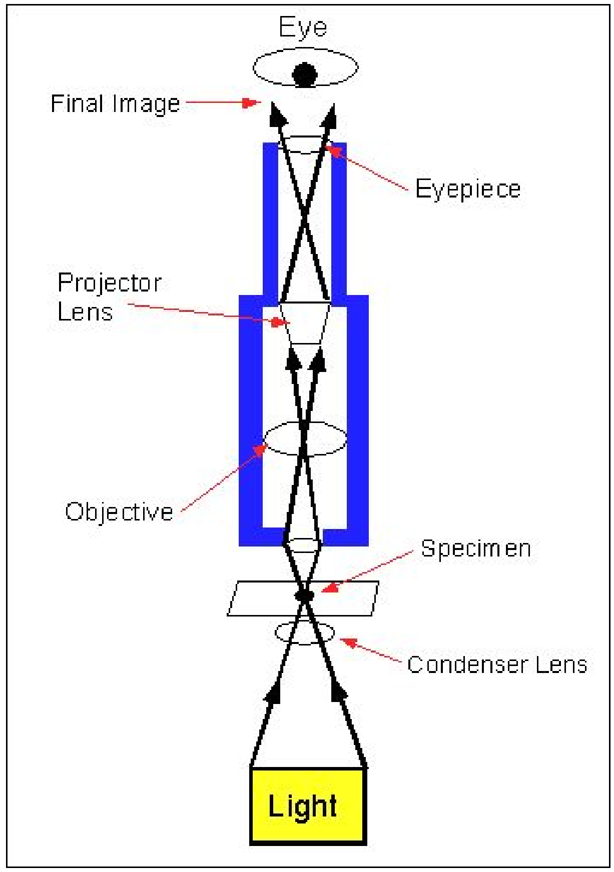
How do the lenses in a microscope work?

Compound Light Microscope:



A compound light microscope uses *light* to transmit an image to your eye. C*ompound* deals with the microscope having more than one lens. *Microscope* is the combination of two words; "micro" meaning small and "scope" meaning view.

Early microscopes, like Leeuwenhoek's, were called simple because they only had one lens. Simple scopes work like magnifying glasses that you have seen and/or used. These early microscopes had limitations to the amount of magnification no matter how they were constructed.

The creation of the compound microscope by the Janssens helped to advance the field of microbiology light years ahead of where it had been only just a few years earlier. The Janssens added a second lens to magnify the image of the primary (or first) lens.

Simple light microscopes of the past could magnify an object to 266X as in the case of Leeuwenhoek's microscope. Modern compound light microscopes, under optimal conditions, can magnify an object from 1000X to 2000X (times) the specimens original diameter.

"The Compound Light Microscope." *The Compound Light Microscope*. Web. 16 Feb. 2017.
http://www.cas.miamioh.edu/mbi-ws/microscopes/compoundscope.html

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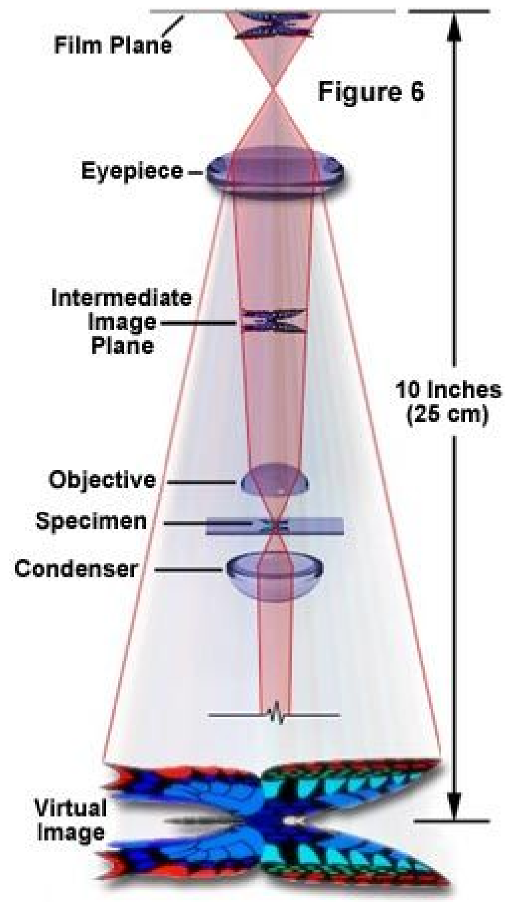
Now we will describe how a microscope works in somewhat more detail. The first lens of a microscope is the one closest to the object being examined and, for this reason, is called the **objective**. Light from either an external or internal (within the microscope body) source is first passed through the **substage condenser**, which forms a well-defined light cone that is concentrated onto the object (**specimen**). Light passes through the specimen and into the objective (similar to the projection lens of the projector described above), which then projects a real, inverted, and magnified image of the specimen to a fixed plane within the microscope that is termed the **intermediate** image plane (illustrated in Figure 6). The objective has several major functions:



- The objective must gather the light coming from each of the various parts or points of the specimen.
- The objective must have the capacity to reconstitute the light coming from the various points of the specimen into the various corresponding points in the image (Sometimes called anti-points).
- The objective must be constructed so that it will be focused close enough to the specimen so that it will project a magnified, real image up into the body tube.

The intermediate image plane is usually located about 10 millimeters below the top of the **microscope body tube** at a specific location within the fixed internal diaphragm of the **eyepiece**. The distance between the back focal plane of the objective and the intermediate image is termed

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the **optical tube length**. Note that this value is different from the **mechanical tube length** of a microscope, which is the distance between the nosepiece (where the objective is mounted) to the top edge of the observation tubes where the eyepieces (oculars) are inserted.

The eyepiece or ocular, which fits into the body tube at the upper end, is the farthest optical component from the specimen. In modern microscopes, the eyepiece is held into place by a shoulder on the top of the microscope observation tube, which keeps it from falling into the tube. The placement of the eyepiece is such that its eye (upper) lens further magnifies the real image projected by the objective. The eye of the observer sees this secondarily magnified image as if it were at a distance of 10 inches (25 centimeters) from the eye; hence this virtual image appears as if it were near the base of the microscope. The distance from the top of the microscope observation tube to the shoulder of the objective (where it fits into the nosepiece) is usually 160 mm in a finite tube length system. This is known as the mechanical tube length as discussed above. The eyepiece has several major functions:

- The eyepiece serves to further magnify the real image projected by the objective.
- In visual observation, the eyepiece produces a secondarily enlarged virtual image.
- In photomicrography, it produces a secondarily enlarged real image projected by the objective. This augmented real image can be projected on the photographic film in a camera or upon a screen held above the eyepiece.
- The eyepiece can be fitted with scales, markers or crosshairs (often referred to as **graticules**, **reticules** or **reticles**) in such a way that the image of these inserts can be superimposed on the image of the specimen.

The factor that determines the amount of image magnification is the objective **magnifying power**, which is predetermined during

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construction of the objective optical elements. Objectives typically have magnifying powers that range from 1:1 (1X) to 100:1 (100X), with the most common powers being 4X (or 5X), 10X, 20X, 40X (or 50X), and 100X. An important feature of microscope objectives is their very short focal lengths that allow increased magnification at a given distance when compared to an ordinary hand lens (illustrated in Figure 1). The primary reason that microscopes are so efficient at magnification is the two-stage enlargement that is achieved over such a short optical path, due to the short focal lengths of the optical components.

Eyepieces, like objectives, are classified in terms of their ability to magnify the intermediate image. Their magnification factors vary between 5X and 30X with the most commonly used eyepieces having a value of 10X-15X. Total **visual magnification** of the microscope is derived by multiplying the magnification values of the objective and the eyepiece. For instance, using a 5X objective with a 10X eyepiece yields a total visual magnification of 50X and likewise, at the top end of the scale, using a 100X objective with a 30X eyepiece gives a visual magnification of 3000X.

"The Concept of Magnification." *Olympus Microscopy Resource Center | Anatomy of the Microscope - The Concept of Magnification*. Web. 16 Feb. 2017. http://www.olympusmicro.com/primer/anatomy/magnification.html

Glossary

magnification: measures how much bigger the image that you see

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appears than the actual object. In compound microscopes, the total magnification is the product of the eyepiece magnification and the objective magnification.

objective: the first lens light passes through after the specimen. The obective collects the light from the specimen and focusses it to a point inside the body tube.

eyepiece: the lens light passes through before getting to your eye. The eyepiece magnifies the image formed by the objective so you can see your sample.

specimen: whatever you are trying to study! Depending on the micrscope, the sample may need to be translucent to allow enough light through it for you to see.

compound microscope: a microscope that uses two or more lenses to form a magnified image.

condenser: a lens placed before the specimen in order to collect and focus light onto the sample in order to help create images.

field of view: the observable area of the sample when looking through the microscope. Higher magnification will increase the detail but decrease the field of view.