You have seen how a converging lens can be used as a magnifier. Typically, the image appears two or three times larger than the object. However, this is insufficient for viewing small objects such as cells. To obtain larger images, two or more lenses are combined to make a simple compound microscope such as the one shown below (a similar process is used in a telescope). The lens closest to the object is called the **objective** lens, and the lens the eye looks into is called the **eyepiece** lens.

Instructions

Follow the steps outlined below to discover how the virtual image you see when you look into a microscope is created. You will need a ruler or straight-edge and a sharp pencil(s). You will also need to be very accurate with your ray diagrams otherwise you will have to redraw them. Remember, when you are drawing your rays, draw them faintly in case you need to erase them.

Part A - The Objective Lens

{5} 1. Use 3 rays to locate the image created by the objective lens. Label this image "objective image".
Note: The objective image should be real, inverted and located between the eyepiece lens and F_e'. If it isn't, you need to redraw your rays.

{5} 2. Taking appropriate and careful measurements, complete the MEASURED column of the OBJECTIVE LENS chart. Record your measurements to 1 decimal place.

{7} 3. Using the appropriate measurements, complete the CALCULATED column of the OBJECTIVE LENS chart. Record your calculations to 1 decimal place.
Note: Perform these calculations on a separate sheet of paper. Be sure to use GRESS!

Part B - The Eyepiece Lens

The objective image from Part A is now the new "object" for the eyepiece lens.

{5} 4. Use 3 rays to locate the image of the new "object" created by the eyepiece lens. Label this image "eyepiece image".
Note: The eyepiece image should be virtual, larger and located somewhere to the left of the eyepiece lens. If it isn't, you need to redraw your rays. The size of the image created will depend on how accurate your ray diagrams are.

{5} 5. Taking appropriate and careful measurements, complete the MEASURED column of the EYEPIECE LENS chart. Record your measurements to 1 decimal place.

{8} 6. Using the appropriate measurements, complete the CALCULATED column of the EYEPIECE LENS chart. Record your calculations to 1 decimal place.
Note: Perform these calculations on a separate sheet of paper. Be sure to use GRESS!
Note: The CALCULATED object height is the same value as the CALCULATED image height from the OBJECTIVE LENS chart.

Part C - Analysis

Answer the following questions on a separate sheet of paper. Be sure to use GRESS for all calculations!

{2} 1. Why must the "object" for the eyepiece be located between the eyepiece lens and F_e'?

{3} 2. Calculate the total magnification of the final image compared to the initial object. (Hint: use the formula $\mathbf{M = h_i/h_o}$)

{6} 3. Use the formula **% difference = 200(measured-calculated)÷(measured+calculated)** to determine the % difference between:
(a) the measured and calculated image height for the objective lens.
(b) the measured and calculated image height for the eyepiece lens.
Note: Record your calculations as a whole number (i.e. no decimal places).

{4} 4. With reference to question 3, explain (a) the two major sources of error in this activity - be specific - and (b) how these errors affect the calculations.

{5} 5. On a bright sunny day arson is reported at an abandoned haystack. Two suspects wearing eyeglasses are detained at the scene. An eyewitness cannot be sure which suspect used their eyeglasses to set the fire. Upon further questioning, the police officer finds out that suspect A has hyperopia and suspect B has myopia. The police officer, having taken physics, immediately knows the identity of the arsonist. Explain how the officer is able to identify the perpetrator.

OBJECTIVE LENS

	MEASURED	CALCULATED
focal length (f)	+ cm	X
object distance (do)	+ cm	X
image distance (di)	+ cm	+ cm
object height (ho)	+ cm	X
image height (hi)	- cm	- cm

EYEPIECE LENS

	MEASURED	CALCULATED
focal length (f)	+ cm	X
object distance (do)	+ cm	X
image distance (di)	- cm	- cm
object height (ho)	- cm	- cm
image height (hi)	- cm	- cm

Remember: measurements made upward or to the right are positive and measurements made downward or to the left are negative!