



Minor White

Who Invented the first microscope?



- Credit for the first microscope is usually given to **Zacharias Jansen**, in Middleburg, Holland, around the year **1595**.




The First Compound Microscope (circa 1595)

Magnification ~ 9x (barely qualifies as a microscope) ₂

Robert Hooke


~1670



Discovered the cell (looking at cork)

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Anton von Leeuwenhoek



Dutch tradesman 1632-1723
-no higher education

Discovered: bacteria, sperm cells, blood cells...

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Anton von Leeuwenhoek



- Single tiny lens

"these little animals were, to my eye, more than ten thousand times smaller than the animalcule which Swammerdam has portrayed, and called by the name of Water-flea, or Water-louse, which you can see alive and moving in water with the bare eyes."

- letter to Royal Society 1678

Magnification ~ 270X

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Anton von Leeuwenhoek



an unbelievably great company of living animalcules, a-swimming more nimbly than any I had ever seen up to this time. The biggest sort . . . bent their body into curves in going forwards. . . Moreover, the other animalcules were in such enormous numbers, that all the water. . . seemed to be alive.

Discovery of bacteria -
In the mouth of old man
who had never brushed his teeth!

Magnification ~ 270X

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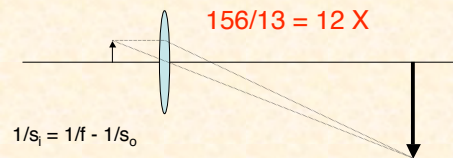
Compound Microscope

- Structure: Made of two lenses, Objective and eyepiece
 - Objective: The object being viewed is placed **just outside** the focal length of the *objective lens*. The intermediate image thus formed is *real, inverted, and enlarged*.

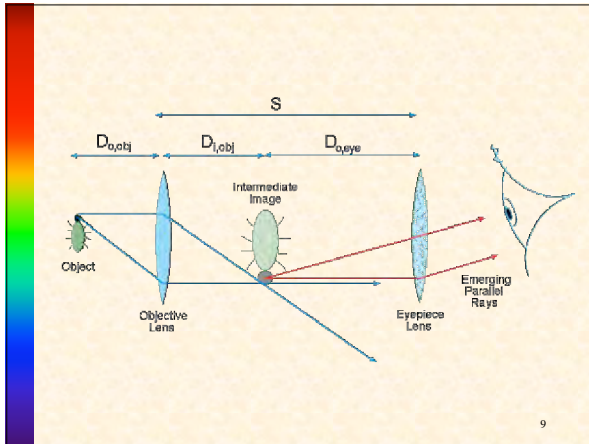
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An example

- Suppose the focal length of the objective is 12mm, and the object is placed at 13mm. The image is then 156mm away from the lens and the magnification is



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– **Eyepiece:** Work as a magnifying glass, used to view the real intermediate image formed by the objective lens.

- To view the image with a relaxed eye (so the light rays entering the eye is parallel), the image must be located at the **focal point of the eyepiece**.
- **Shorter the focal length, larger the magnification.**

Microscope eyepiece

Same principle as magnifying glass

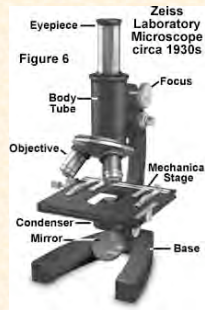
The diagram shows two scenarios for viewing an object. In the first, 'No lens', the object is at the eye's near point, approximately 250 mm away. In the second, 'With lens', an eyepiece lens is placed between the object and the eye. The object is placed at the focal length f of the lens, and the eye is positioned to view the lens. This setup allows the eye to see a larger virtual image.

Magnification = $250/f$ (in mm)

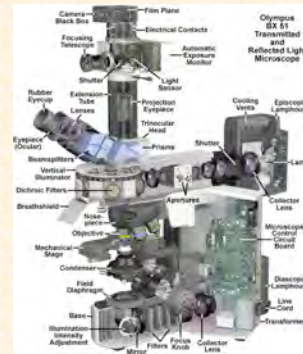
Compound microscope

Total magnification = $M_{obj} \times M_{eyepiece}$
 $= S_o f_{obj} \times 250/f_{eyepiece}$
 $S_o = 160 \text{ mm for standard microscopes}$

Example - $f_{obj} = 1.6 \text{ mm}$, $f_{eyepiece} = 25 \text{ mm}$
 $M = 100 \times 10 = 1000$



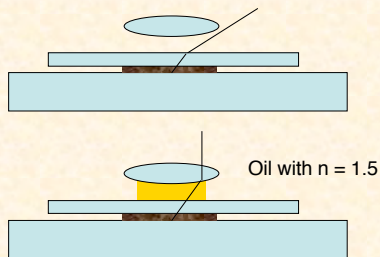
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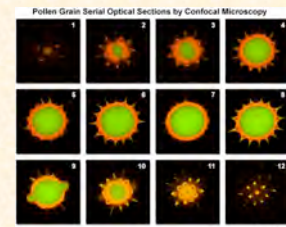
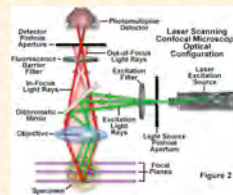
Oil immersion objective

- high magnification -> short focal length - big angles



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Confocal microscopy



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Optical limitation

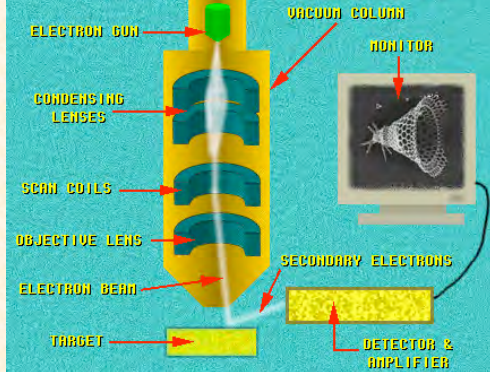
- Light cannot be focused to less than $\sim \lambda$

-due to *diffraction* (coming up later in course)

Solutions - use short wavelength (e.g. x-rays)
- use something other than light

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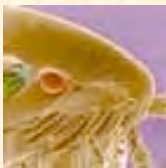
SCANNING ELECTRON MICROSCOPE



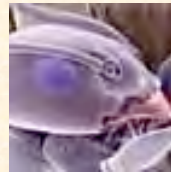
neuron



Fruit fly



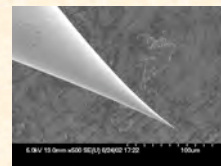
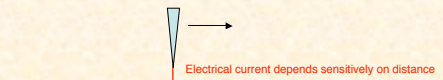
Cat flea



Black ant

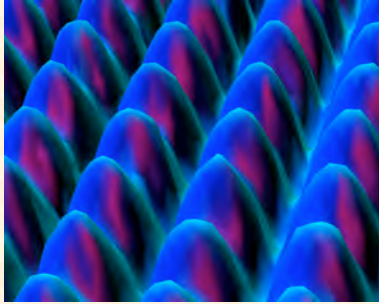
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Scanning Tunneling Microscope



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Scanning tunneling
microscopy (STM)



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