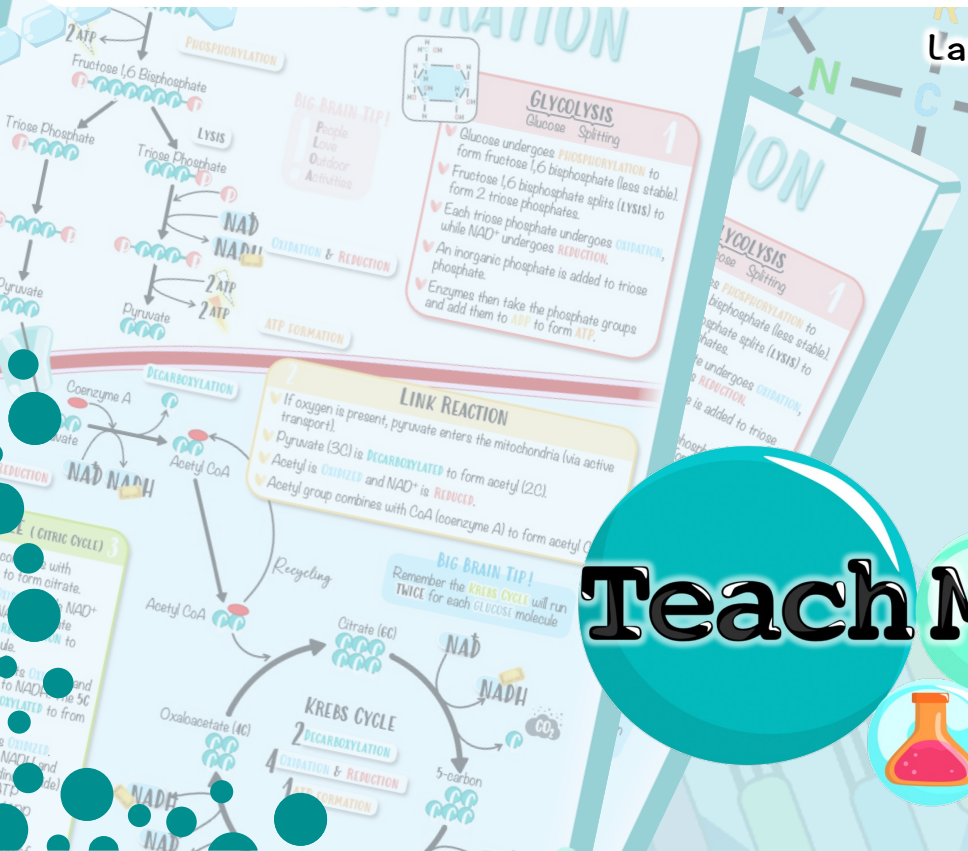
TeachMe

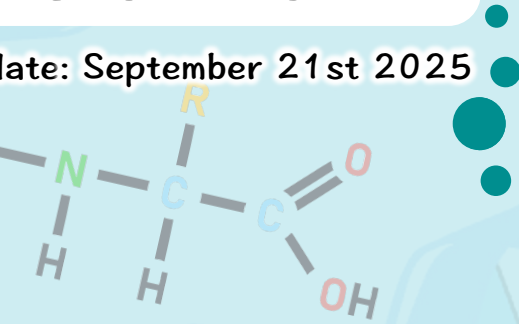
STUDY NOTES

CHAPTER 1 - CELL STRUCTURE

CELL & MICROSCOPE

Last update: September 21st 2025





Teach Me

Cell & Microscope

Why study cells?

Cells are the building blocks of life. Understanding cells helps us explain health, disease, and life itself — from how bacteria cause illness to how our own cells specialize to form tissues.

What is a cell?

Cell – The basic unit of all LIVING organisms.

It is a distinguishing feature between the living and non-living (you and I are both made up of cells, but a rock for example isn't).

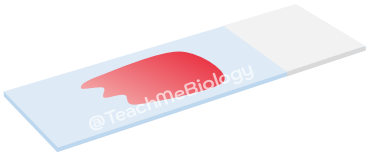
Did you know?

We have over **200** types of cells in our bodies, with a total of approximately **37,000,000,000,000** (37 trillion) cells.

In order to observe those cells, we cannot rely solely on our sight, they are too small. Even a magnifying glass cannot allow us to observe them. Instead we rely on **MICROSCOPES**!

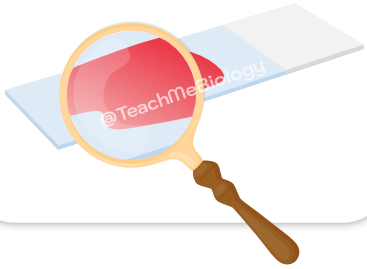
Look with your eyes?

Looking at a blood smear on a slide, we cannot observe the red blood cells it is composed of.



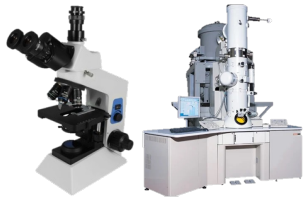
Magnifying glass?

A magnifying glass lets us look closer, but not enough to see cells.

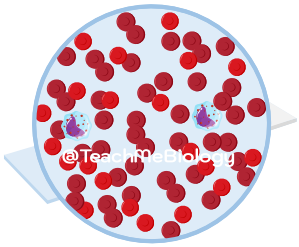


Microscope?

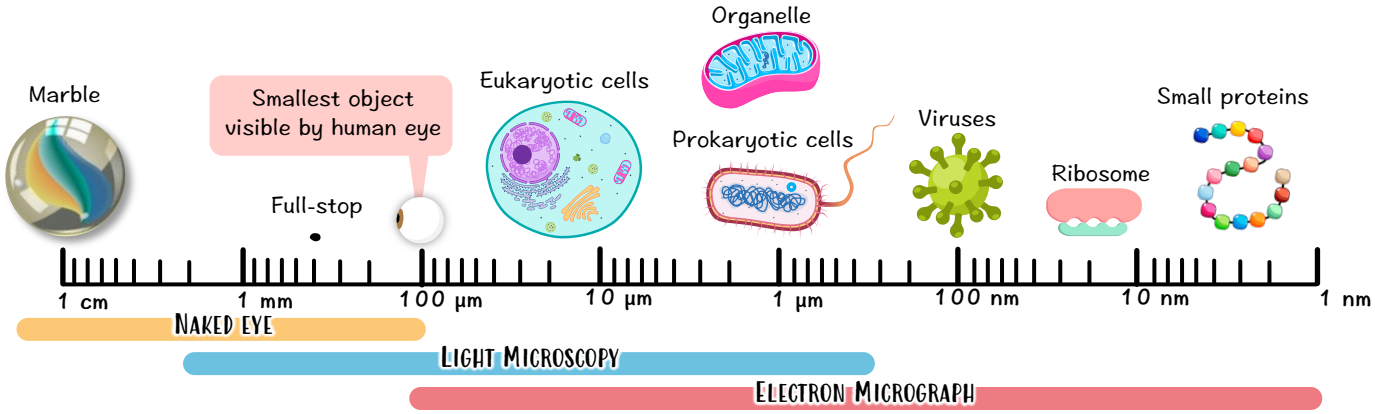
We learn in more detail from page 2 about different types of microscopes.



A microscope is used to observe the small cells within the blood.



So clearly cells are small, but how small are we talking? About 1/10th the size of the smallest object visible by the human eye!

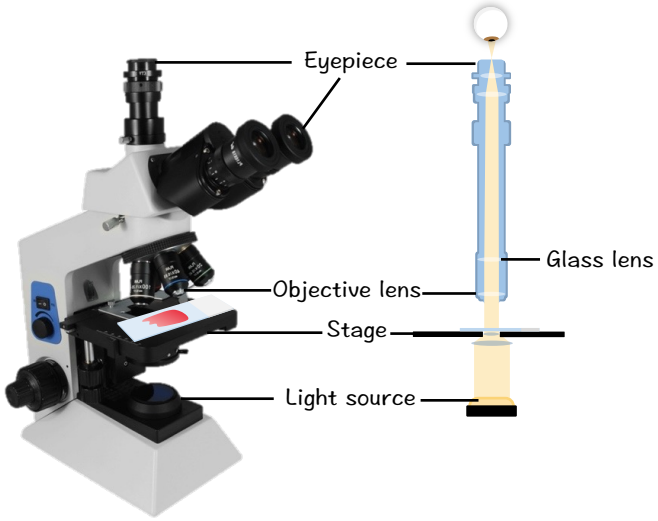


Unit Conversion chart:

*Micrograph: A picture taken with the aid of microscope.

Light Microscope

Mechanism: Uses light (visible to our eyes) shined under the specimen, allowing us to see it.
Can view living and non-living specimens

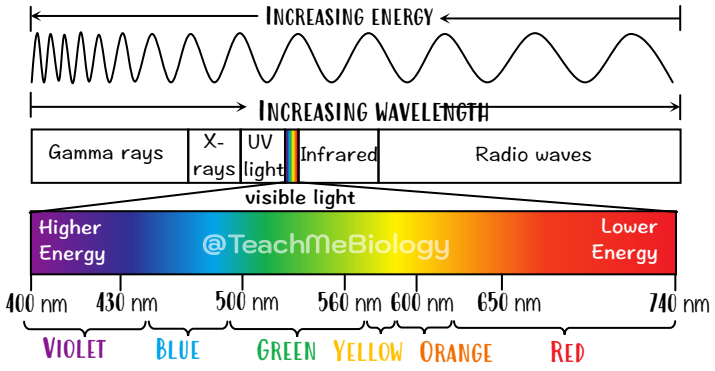


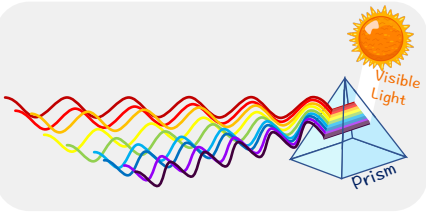
Big Brain Tip!

You do not need to remember how the microscopes look, but it helps you understand their features.

What is the electromagnetic spectrum?

The full range of electromagnetic waves (mostly invisible). The visible light portion contain waves that have wavelengths between 400-700nm (violet to red).



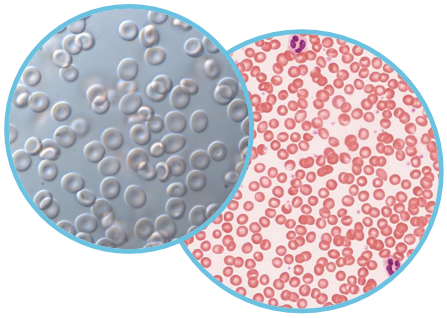


Big Brain Tip!

You need to remember the approximate wavelength (in nm) for each of the colors.

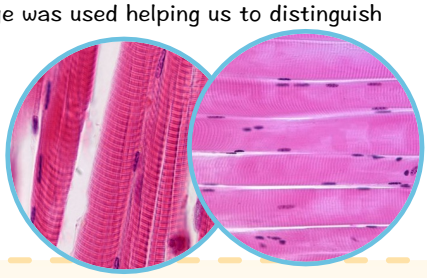
Examples of Photomicrographs

[Images taken with a light microscope are light micrographs* (or photomicrographs)]



Photomicrographs of blood. On the left you can see various red blood cells and a few white blood cells. The first image shows red blood cells without any stain, therefore they look transparent. On the second image, a dye was used helping us to distinguish the red blood cells from the background.

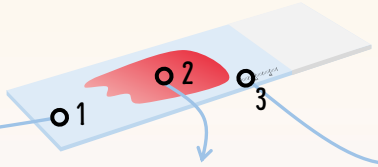
Photomicrographs of Muscle. On the right you can see two different examples of skeletal muscle. Both of these used dye to enhance the structures.



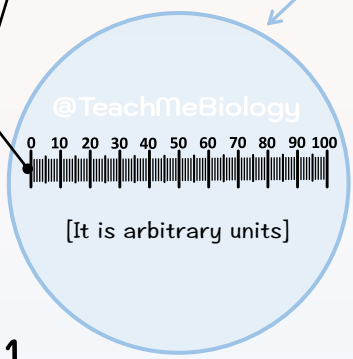
Practical Activity

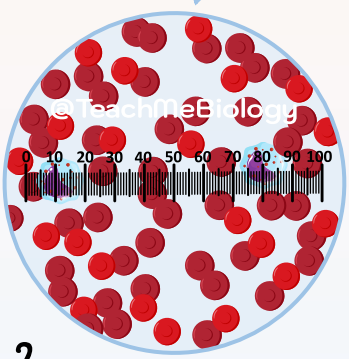
Estimating Size with a Light Microscope

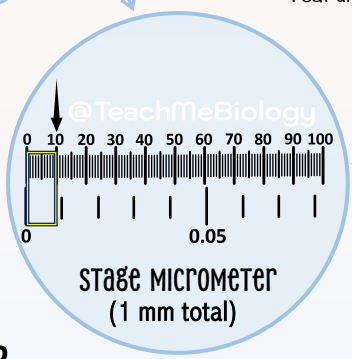
Here we learn how to measure the size of a red blood cell.



Unlike the eyepiece graticule the stage micrometer is a real ruler (a tiny one). it has real units (1mm long)







1. Eyepiece graticule units are arbitrary. We call them eyepiece graticule units (EGU)

2. Here, one red blood cell measures around 10 eyepiece graticule units.

3. With a stage micrometer, you can determine how much 10 EGU are equivalent to (**calibration**). Here: 0.008mm (8um).

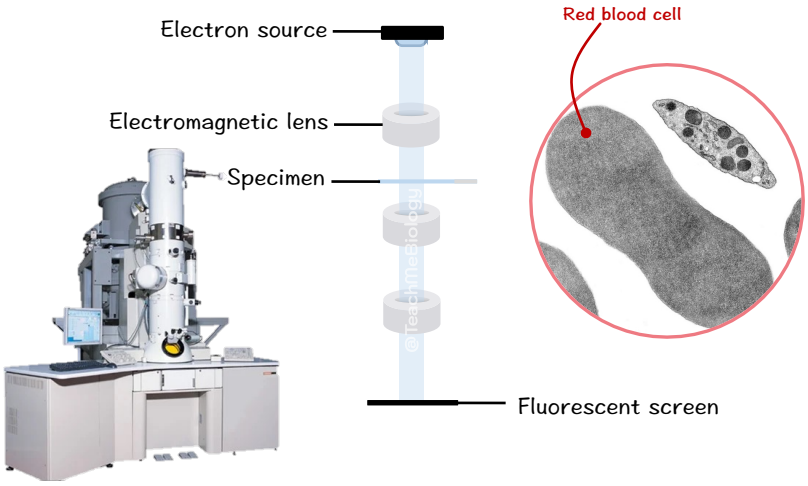
Electron Microscope

Mechanism: Uses electron beams (not visible to our eyes)

Can view only NON-LIVING things as the specimen is in a vacuum (no air)!

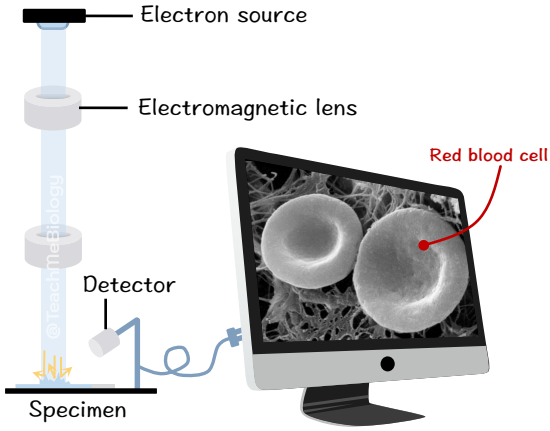
TEM [Transmission electron microscope]

Beam of electrons **pass through** the specimen before being viewed, allowing us to view the inner structures as a 2D image.

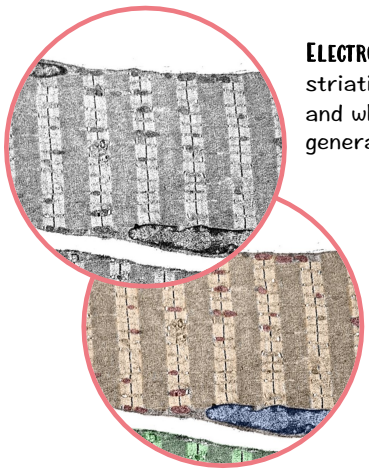


SEM [Scanning electron microscope]

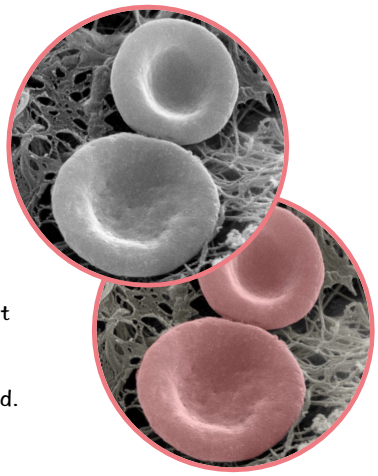
Beam of electrons reflect off specimen surface into detector, allowing us to view the surface structure as a 3D image (has a lower resolution compared to TEM).



Examples of electron micrographs [Images taken with an electron microscope are called electron micrographs]

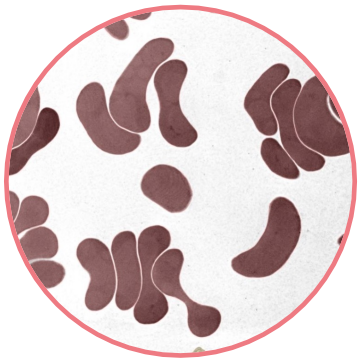


Electron micrograph (TEM) of muscle. You can see in more detail the striations on muscle cells. Notice how the image obtained is in black and white, but we can highlight structures using color (computer generated). We are looking at a cross-section of the muscle.

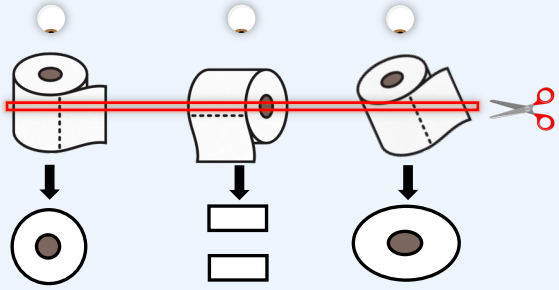


Electron micrograph (SEM) of Red blood cells. You can see the surface structure of two red blood cells, as you can notice they are circular with a concave center. You cannot see the inside of the cell using this microscope. Just like TEM, you can give color to the image to enhance certain details, such as the red blood cells on the grey background.

Electron micrograph (TEM) of Red blood cells. You can see a cross-section of some red blood cells, notice they all have different shapes because of perspective.



It is all about perspective…Lets use toiler paper…



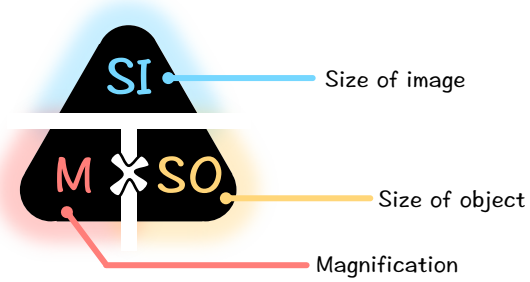
You might have noticed that the electron microscope allows you to see an object in a far larger size in comparison to a light microscope. This is due to its high MAGNIFICATION power (see page 4).

Magnification

The number of times larger an image of an object is than the real size of an object.

Equation:

$$\text{Magnification} = \frac{\text{Size Of Image}}{\text{Size Of Object}}$$



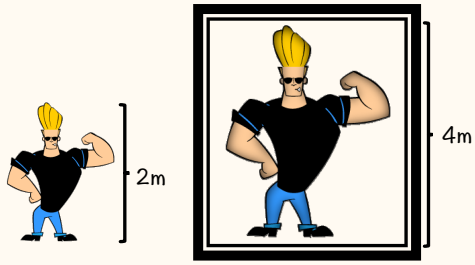
Big Brain Tip!

Hide the variable you want to find, and calculate the value using the two other variables.

SI = M x SO

Example 1

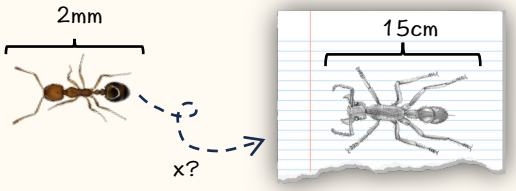
Johnny Bravo gets his picture taken and printed. What is the magnification of the portrait of Johnny Bravo?



$$M = \frac{4m}{2m} = x2$$

Example 2

What is the magnification of the drawn image?

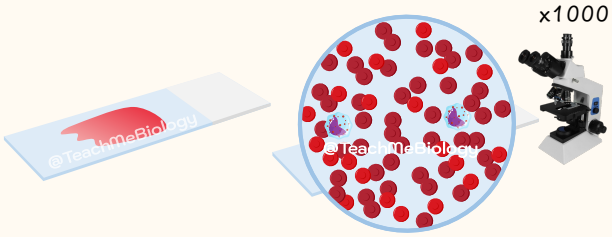


$$M = \frac{15cm}{2mm} = \frac{150mm}{2mm} = x75$$

[Make sure the units of the numerator and denominator MATCH!]

Example 3

A red blood cell is 8um big. What will the size of the magnified image be? Express you answer in millimeters.

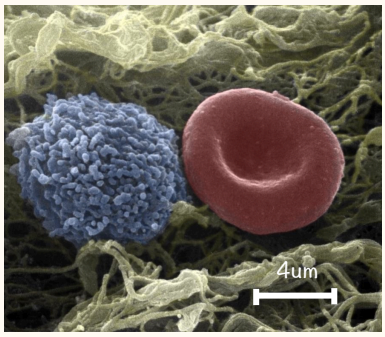


SI = 8um x 1000

SI = 8000um = 8mm

Example 4

What is the diameter of the red blood cell?



RBC diameter = 4um/cm x 2.25cm = 9um

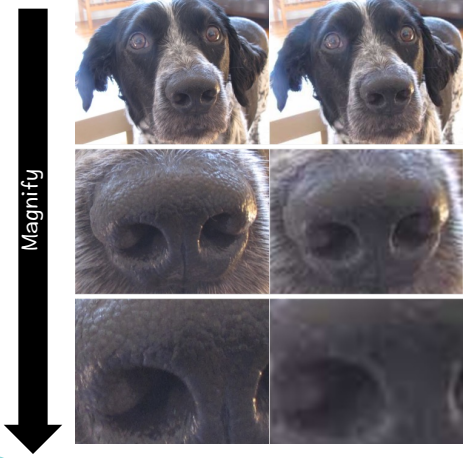
Resolution

The ability of an imaging system to distinguish between two separate points.

If two objects cannot be resolved, they will be seen as one point.

Big Brain Tip!

Resolution: how clear is the image after magnifying it?



Light microscope resolution is 200nm

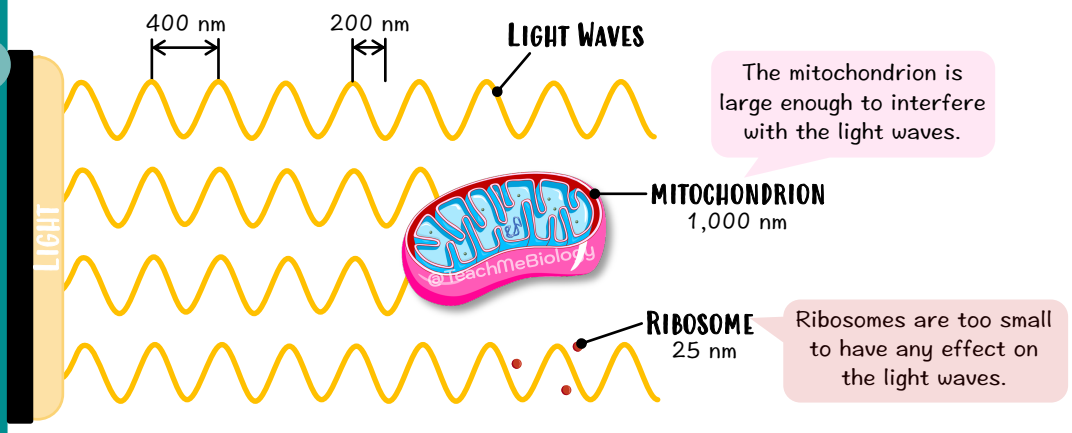
This means if two objects are closer together than 200nm, they cannot be distinguished as separate.

Electron microscope resolution is 0.2nm

This means if two objects are closer together than 0.2nm, they cannot be distinguished as separate.

A microscope has an inherent resolution. It does not change with magnification!

Why does an electron microscope have higher resolution than a light microscope?

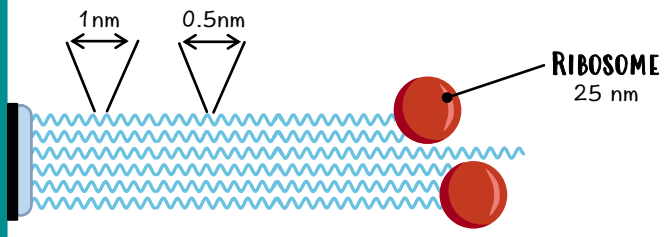


Limit of resolution = ½ the wavelength of the radiation used to view the specimen

Hence, 200nm (400nm is the shortest wavelength of visible light).

If an object is smaller, it cannot be seen separately from nearby objects. Ribosomes are 25nm and can therefor never be seen using a light microscope.

Electron microscope on the other hand, use much shorter wavelength radiation as electron beams (negatively charged particles) are used instead of light waves.



Resolution of 0.5nm can be obtained. 400 times better than light.

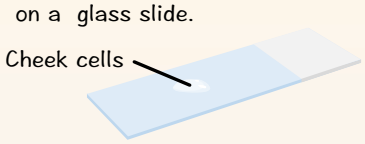
Practical Activity
Preparing Slides

Light Microscope

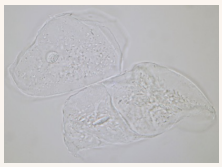
Specimens can be examined **LIVE** or in a **PRESERVED** state – as a **temporary** or **permanent** preparation.

Temporary Preparations (wet mount) Made quickly, easier to prepare – for fresh material containing dead/living cells.

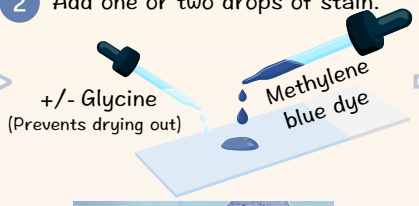
1. Place (mount) biological specimen on a glass slide.

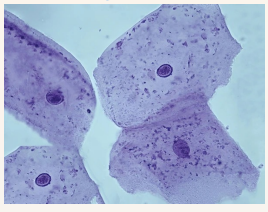


Biological objects may be transparent and therefor need to be stained before they can be seen.

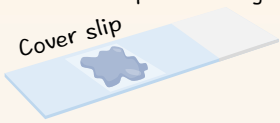


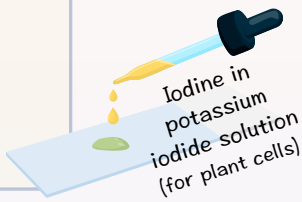
2. Add one or two drops of stain.

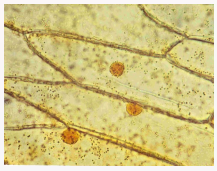




3. Lower a cover over the specimen. Helps to protect the microscope lens and prevent the specimen drying out.







Permanant Preparations Material is killed and preserved in a life-like condition. Complex to prepare - For dead cells

Electron Microscope

Dyes used for electron microscope are not colored.

They contain heavy metals which bind to areas of a specimen. When binding to a certain aspect of a cell it prevents electrons passing. It binds more to dense areas.

Denser areas will appear darker, and vice versa. No color. Color is made with computer software.

Big Brain Tip!

You do not need to know to to prepare electron microscope slides, but do know that they are far more complex to prepare.

Summary Differences Between Light and Electron Microscope

Feature	Light microscope	Electron microscope
Radiation type	Light	Electron
Wavelength	400-700nm	Approx 1nm
Max resolution	Approx 200nm	Approx 0.5nm
Magnification	x2000	x500,000
Cost	Inexpensive	Expensive
Lenses	Glass	Electromagnets
Specimen	Living or non-living (dead)	Non-living (dead)
Stains	Colored dyes	Heavy metal stains (lead)
Image	Colored (naturally or artificially)	Black and white (can be artificially colored)

notes