THE CELL THEORY

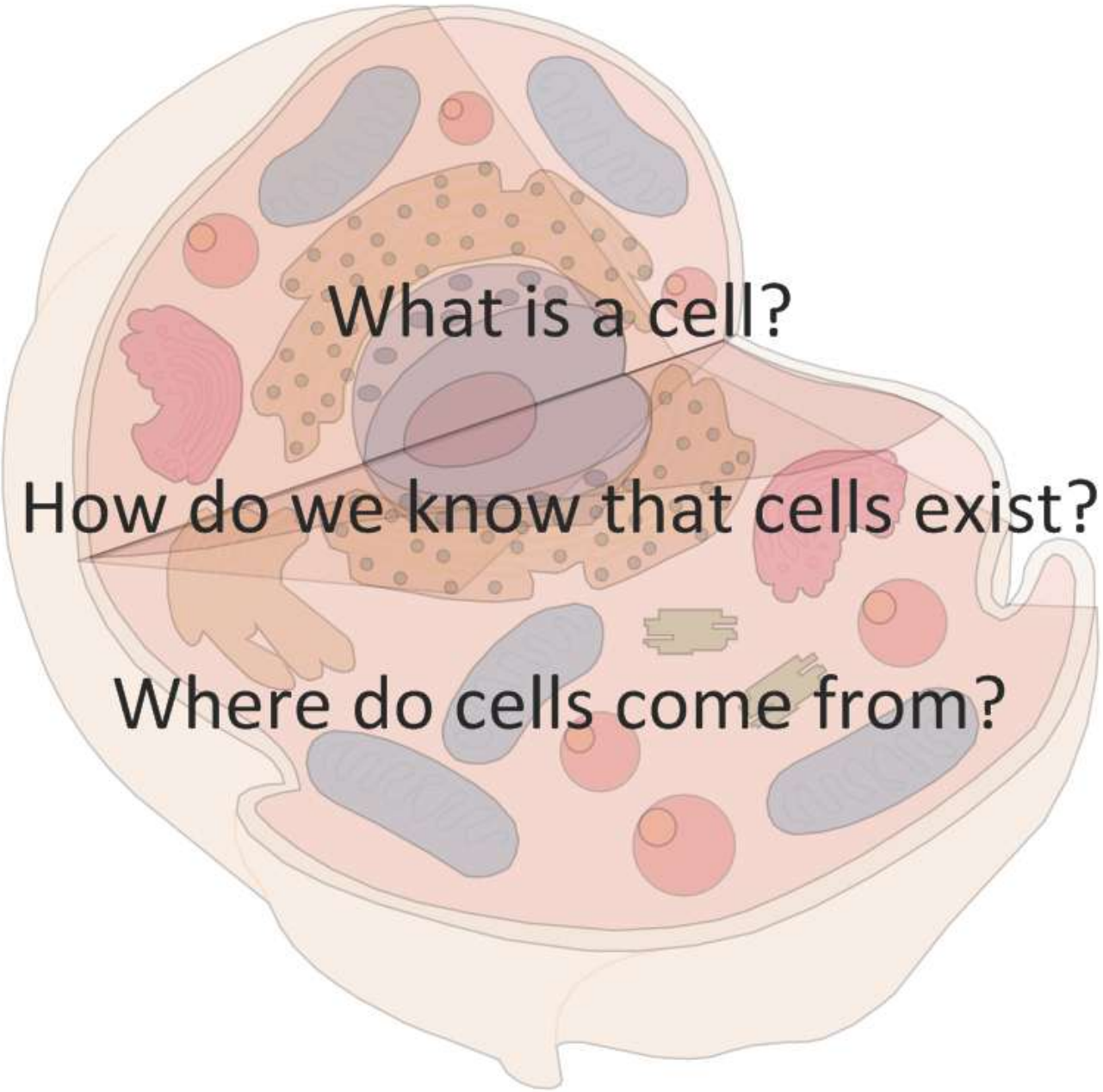
Theory vs Conspiracy Theory

- What is the difference?

  - Alleged plot by a covert or political group
  - A coherent group of facts general propositions commonly regarded as correct used as principals of explanation and prediction

By the end of this class you will begin to. . .

- ***State that unicellular organisms carry out all the functions of life.**
- *Compare the relative sizes of molecules, cell membrane thickness, viruses, bacteria, organelles and cells, using the appropriate SI unit.
- ***Calculate the linear magnification of drawings and the actual size of specimens in images of known magnification.**
- *Explain the importance of the surface area to volume ratio as a factor limiting cell size.
- ***State that multicellular organisms show emergent properties.**
- *Explain that cells in multicellular organisms differentiate to carry out specialized functions by expressing some of their genes but not others.
- ***State that stem cells retain the capacity to divide and have the ability to differentiate along different pathways.**
- *Outline one therapeutic use of stem cells.



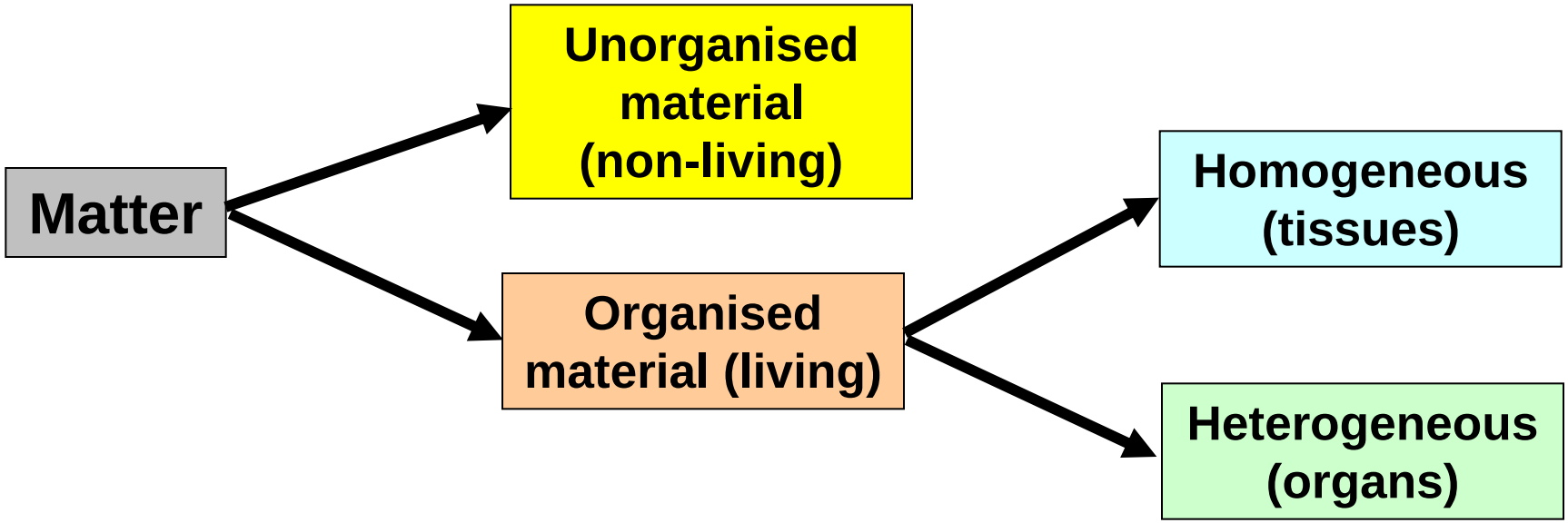
What is a cell?

How do we know that cells exist?

Where do cells come from?

What level of complexity is necessary for life?

- Aristotle (384 – 322BC)



What level of complexity is necessary for life?

17th microscopists discovered tissues were made of **cells** (Hooke 1665 and Leeuwenhoek 1677)

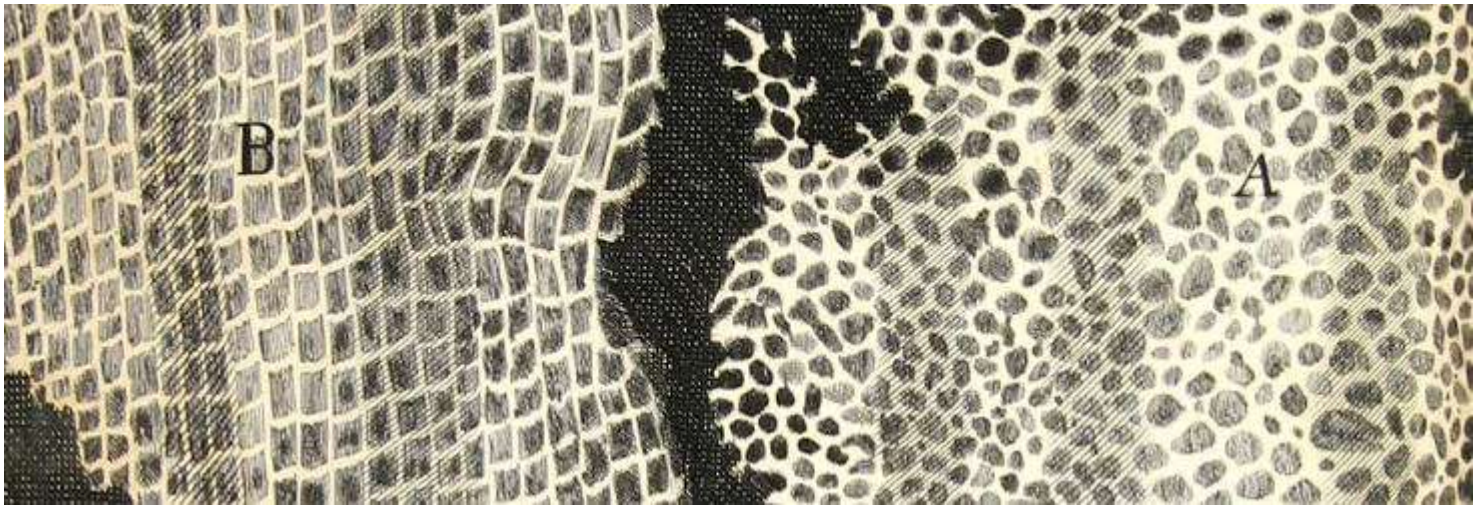


Image Credit Cork cells

Cells

18th and 19th showed that **tissues** were made of **cells**

The cells of a particular tissue had a common structure.

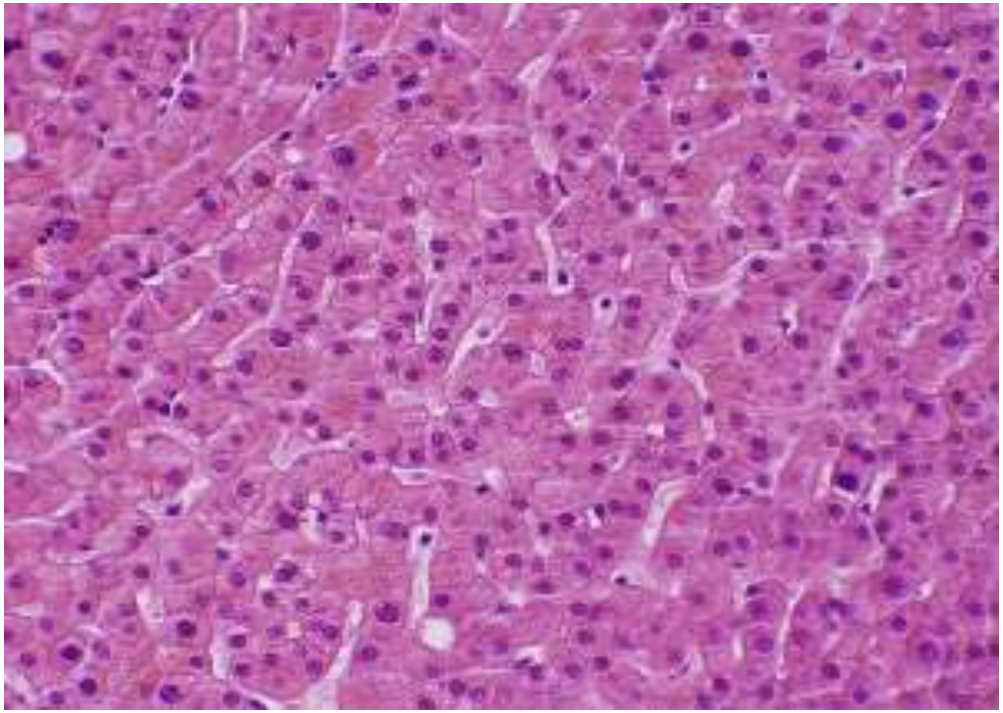
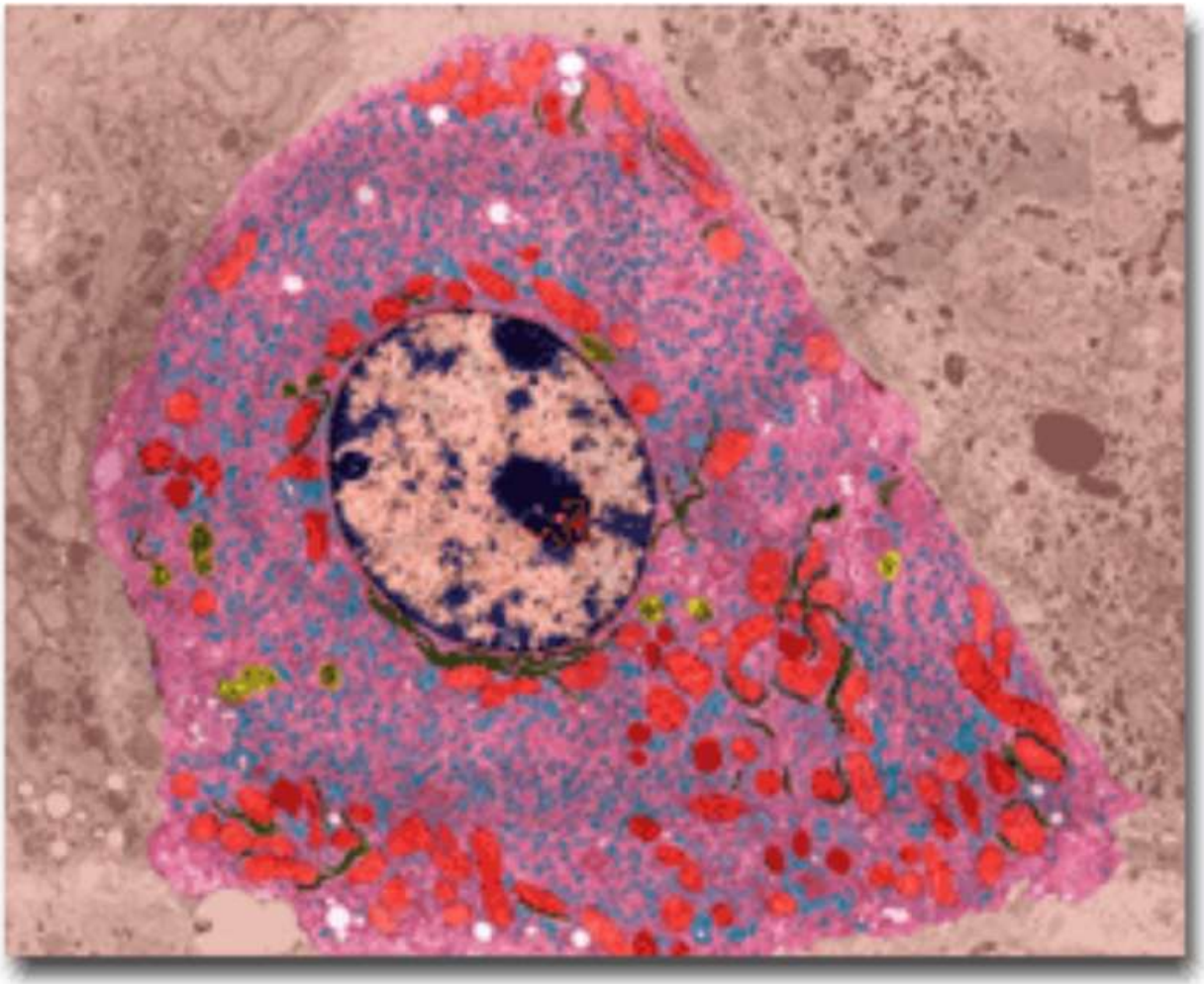


Image Credit Liver cells

What is a cell?

- Taken to its simplest form
- A plasma membrane…
- Surrounding cytoplasm…
- Containing hereditary material.

Cells are the smallest units of life.



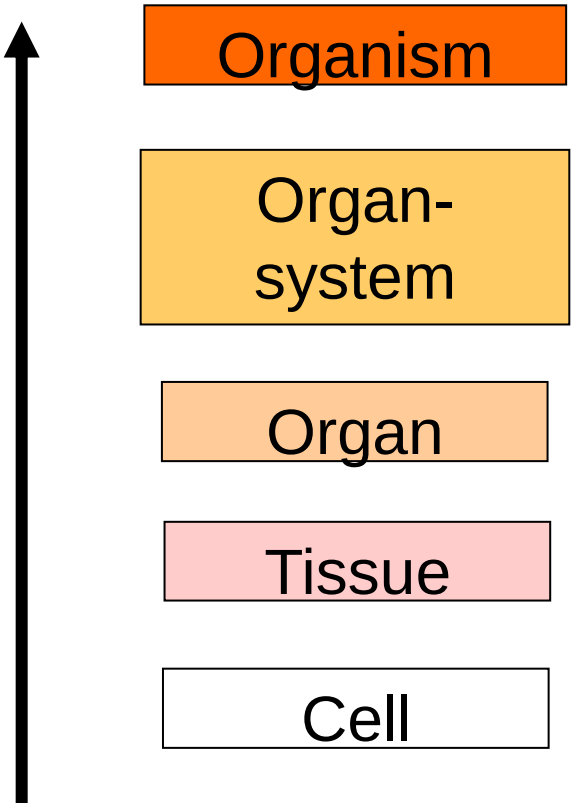
They are made up of a network of ORGANELLES, which each have specific functions.

Organelles cannot 'survive' on their own. Without other organelles' products of metabolism, they cannot perform their own function.

Human liver cell from cellupedia:
http://library.thinkquest.org/C004535/eukaryote_examples.html

What level of complexity is necessary for life?

- Xavier Bichat (1771-1802): An **organ** is composed of different **tissues**
- Several organs can be grouped together as an **organ system** (e.g. the digestive system)
- An idea of hierarchy of structure developed:



What level of complexity is necessary for life?

- Purkinje (1835) Observed a fertilised hen's egg (a single cell) could develop into an embryo (many specialised cells in a compact mass)
- 19th botanists showed that plant tissues consist of many different types of cells.

History & Discovery of Cells

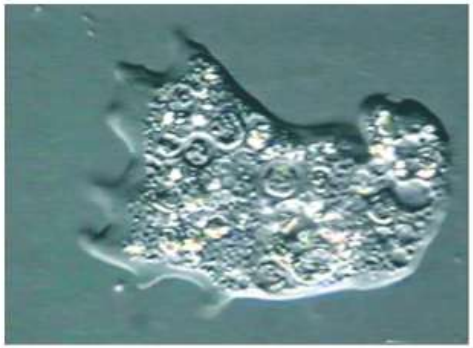
- Anton Van Leeuwenhoek (1600's)
- Robert Hooke (Cork Cells, 1665)
- Robert Brown (Nucleus, 1833)
- Matthias Schleiden (Plant Cells, 1838)
- Theodor Schwann (Animal Cells, 1839)
  - Cell is the basic unit of living tissue
- Rudolf Virchow (All Cells arise from other cells)

Three Main Principles

- All organisms are composed of one or more cells
- Cells are the smallest units of life
- All cells come from pre-existing cells

EXCEPTIONS TO CELL THEORY:

"All living things are made of cells"

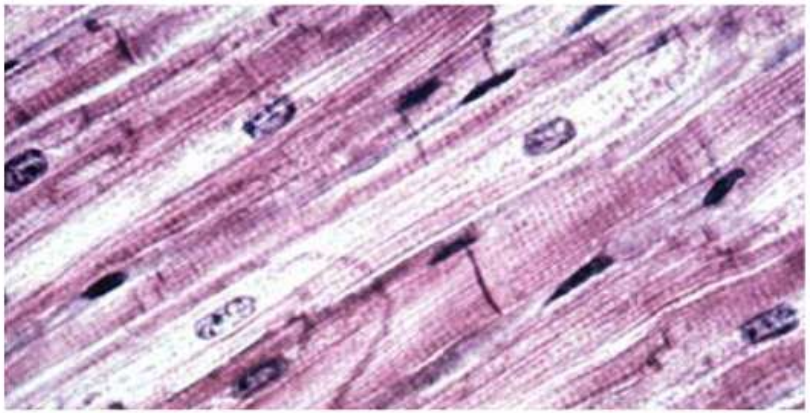


http://www.oberlin.k12.oh.us/talent/isp/reports2002/amoebaproteus/index.htm

Amoebae (protoctista):
- single cell capable of all life processes
- acellular?

Fungal hyphae:
- very large
- multinucleated
- chitin cell wall
- continuous cytoplasm

http://bugs.bio.usyd.edu.au/Mycology/StructureFunction/hyphalStructure.shtml



http://www.meddean.luc.edu/lumen/MedEd/Histo/HistoImages/hl3A-48.jpg

Muscle cells:
- multinucleated
- very long

What about viruses?

Are they alive or not?

Are they cells or not?

HIV virus particle, from:

http://www.healthinitiative.org/HTML/hiv/firstcontact/hivbig.htm

Bone and Tooth Dentine

- Have lots of extracellular material where the actual cell is minute in comparison

Cellulose Cell Wall

- Permeable water travels through easily
- Made up of cellulose molecules arranged into bundles call myofibrils which give it strength

Functions Of Life

Functions of Life

- All organisms are
  - Unicellular
  - Multicellular

Functions of Life

- Include
  - Metabolism
  - Growth
  - Reproduction
  - Response
  - Homeostasis
  - Nutrition

Amoeba

http://www.oberlin.k12.oh.us/talent/isp/reports2002/amoebaproteus/index.htm

http://www.youtube.com/watch?v=I3Jo7moaLdI

CELLS AND SIZES

Cell Size

- Cells are made up of microscopic subunits
- Various types of microscopes are used to view the images
- Stains may also be used to improve viewing

Cell Size

- Cell size order
  - Organelles
  - Bacteria
  - Viruses
  - Membranes
  - Molecules

Cell Size

- Actual sizes can be determined with a microscope and a micrometer
- The size of the specimen are calculated in the field of view
- Important conversions for these calculations

1 millimetre (1 mm) = 1000 micrometre (1000 um)

1 micrometre (1 um) = 1000 nanometres (1000 nm)

Biological Size and Cell Diversity

Human Eye: 1mm - meter+

LM: 1μm – 1mm

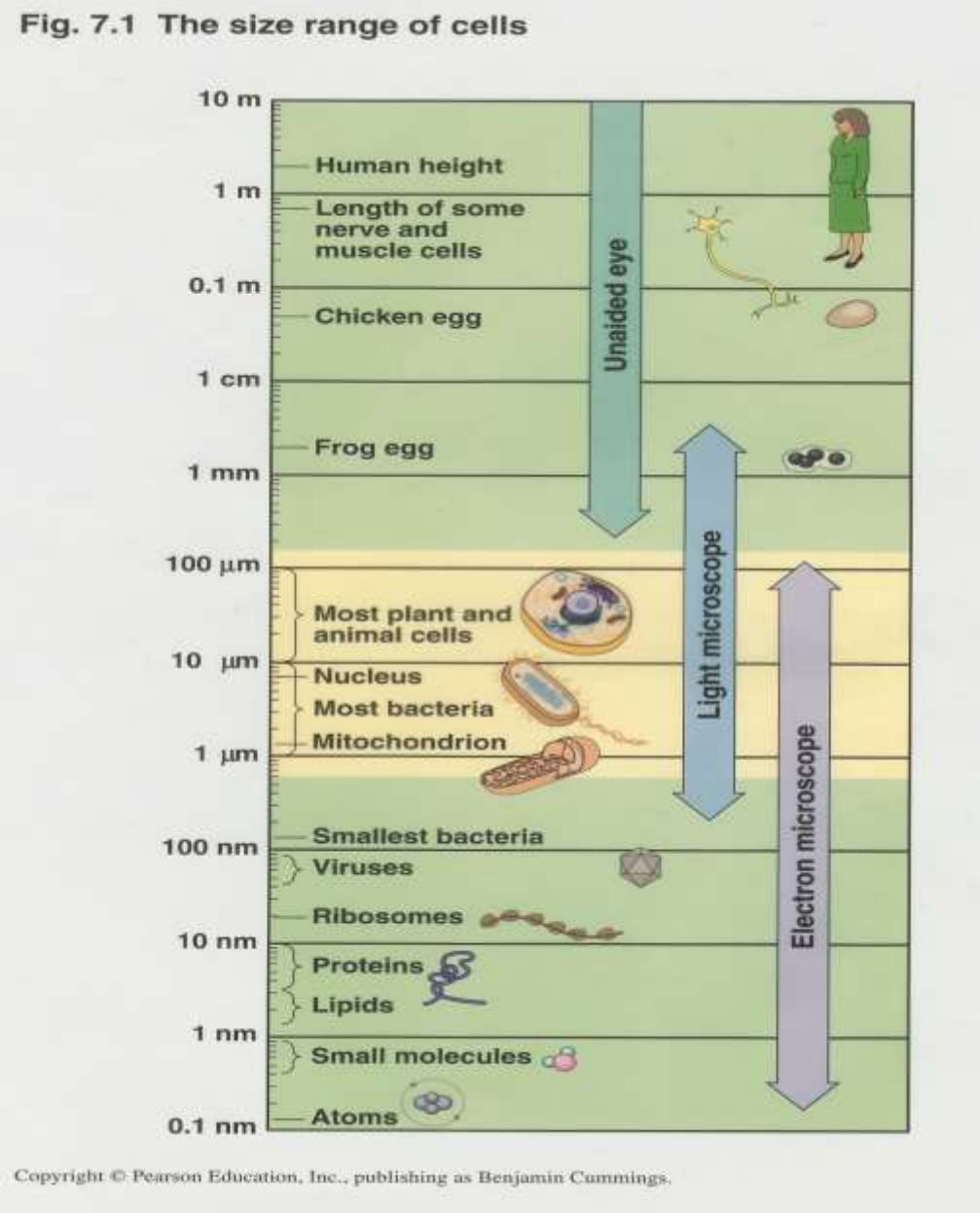
EM: 1nm – 1mm

Chicken Egg (lgst cell)

Mitochondria (1μm)

Ribosomes (20-30 nm)

Viruses (80-100 nm)



Microscopes provide windows to the world of the cell

- The light microscope enables us to see the overall shape and structure of a cell

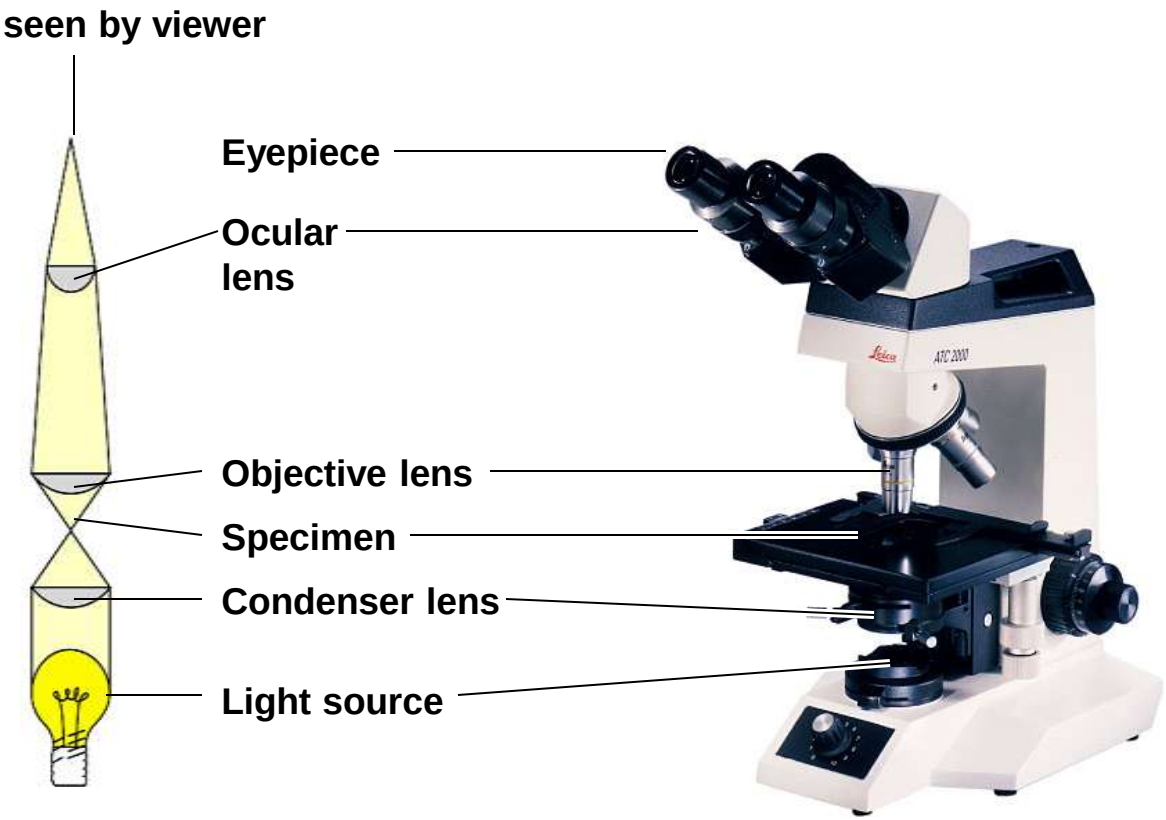


Figure 4.1A

- Scanning electron microscope (SEM)

- Scanning electron micrograph of cilia

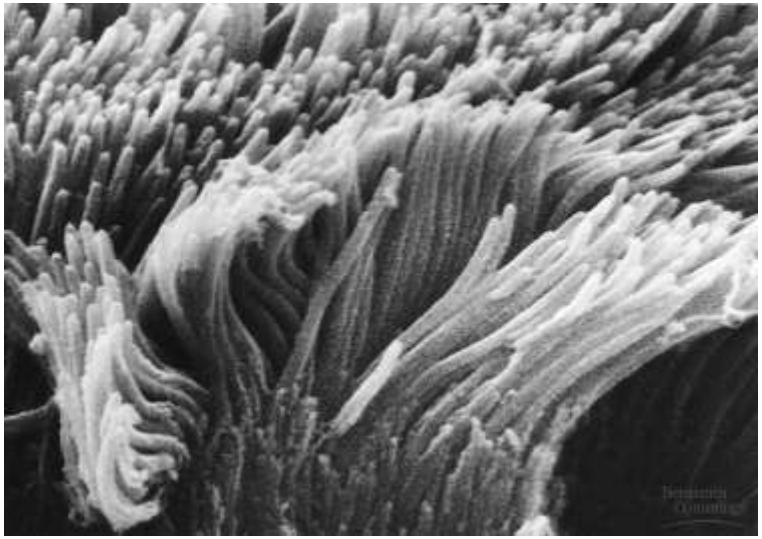


Figure 4.1B

- Transmission electron microscope (TEM)

- Transmission electron micrograph of cilia

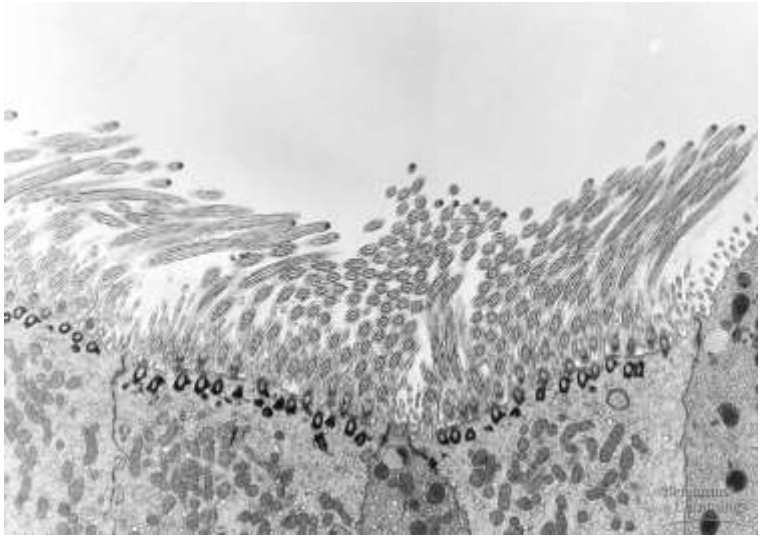


Figure 4.1C

Standard International (SI) units of measurement:

Unit	Abbr.	Metric Equivalent	
kilometer	km	1 000 m	10^3 m
	m	1 m	-
centimeter	cm		10^{-2} m
	mm	0.001 m	10^{-3} m
micrometer	µm	0.000 001 m	
	nm		10^{-9} m

Standard International (SI) units of measurement:

Unit	Abbr.	Metric Equivalent	
kilometer	km	1 000 m	10^3 m
metre	m	1 m	-
centimeter	cm	0.01m	10^{-2} m
millimeter	mm	0.001 m	10^{-3} m
micrometer	µm	0.000 001 m	10^{-6}m
nanometer	nm	0. 000 000 001m	10^{-9} m

Cell Size

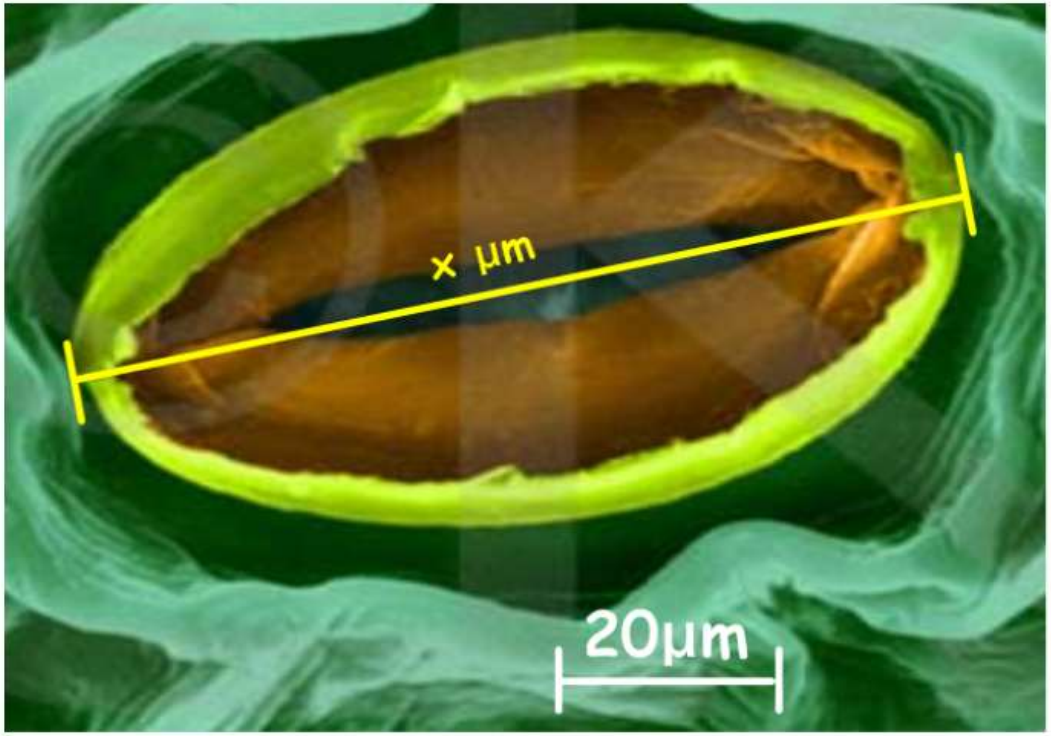
- Most light microscopes have a field of vision at low power of about 1.4 millimetres

Cell Size

- Scale bars are often used with micrographs so actual sizes can be determined

Magnification = size of image / size of specimen

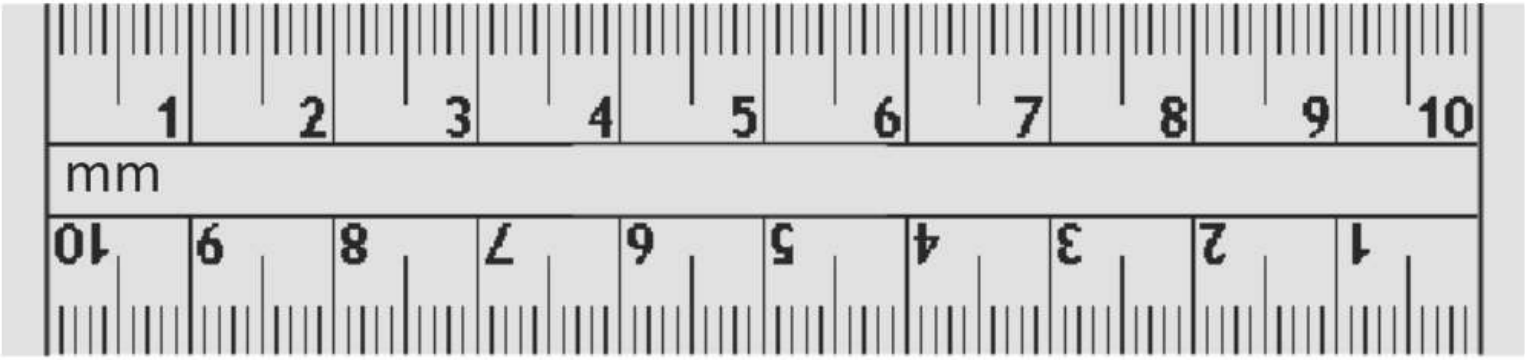
USING SCALE BARS



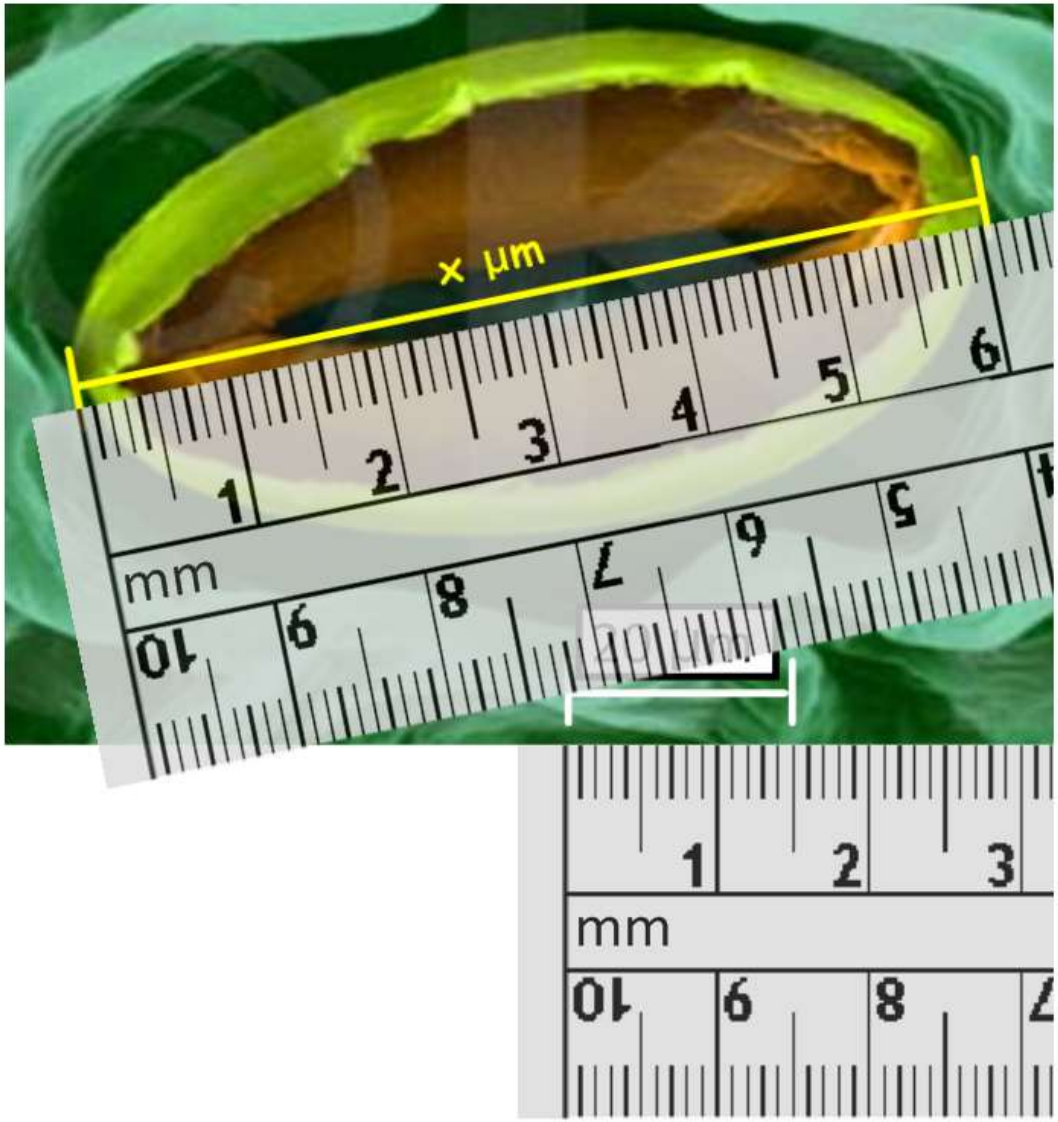
When asked to find the length of an object, look for the longest dimension.

Here the length of the stoma has been marked as xµm.

Our scale bar shows us 20µm in real life - so we can use a ruler or micrometer eyepiece to determine the actual size of the stoma.



USING SCALE BARS



First calculate the scale on the scale bar:

$$\frac{\text{scale length}}{\text{ruler length}} = \frac{20\ \mu m}{15mm}$$

= 1.33 µm per mm

(real life) (image)

Then measure the image with the ruler:

x µm is 60mm on the image.

Now calculate the true length:

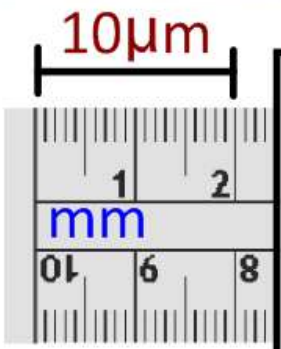
1.33 x 60 = 80 µm

(scale) (image length)

CALCULATING MAGNIFICATION

We might want to know how many times an image has been magnified.

The scale bar represents the 'real' size of the sample in the image, so we only need to work with the scale bar.



First convert your units so that they are all the same:

scale bar = µm, so convert ruler to µm

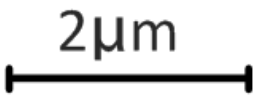
1 mm = 1,000 µm so 20mm = 20,000µm

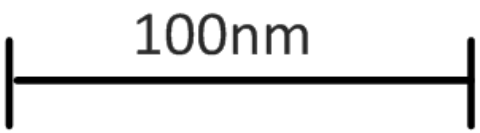
Now we can calculate the magnification:

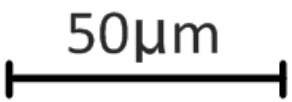
$$\frac{\text{scale bar measurement (we just measured)}}{\text{scale bar label ('real life' of sample)}} = \frac{20{,}000\ \mu m}{10\ \mu m}$$

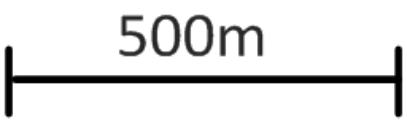
magnification = 2,000 times

Now calculate the magnification of these scale bars:

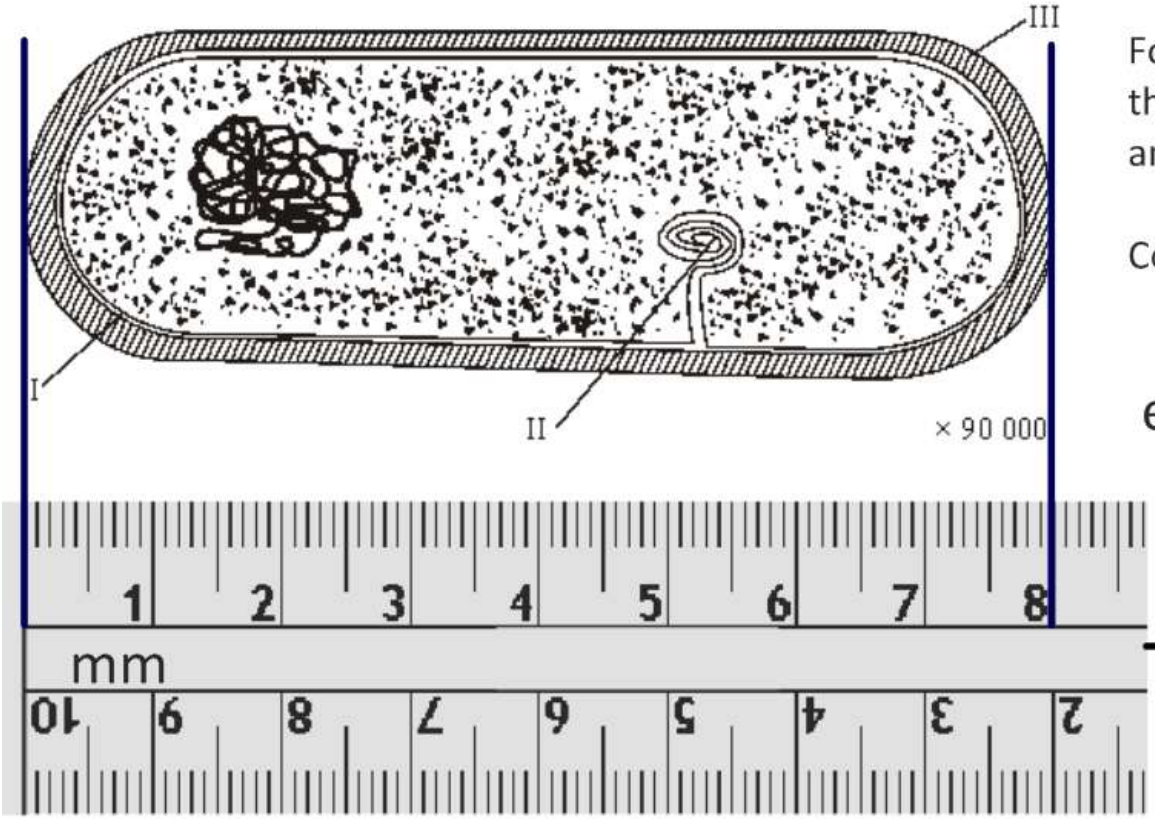








CALCULATING ACTUAL SIZE (NO SCALE BAR)



For this type of question, simply measure the part of the image you are instructed to and divide it by the magnification.

Convert to the most appropriate units.

e.g. $\frac{\text{measured length}}{\text{magnification}}$

$\frac{80\text{mm}}{90{,}000} = 8.9 \times 10^{-4}\text{mm}$

or 0.00089mm

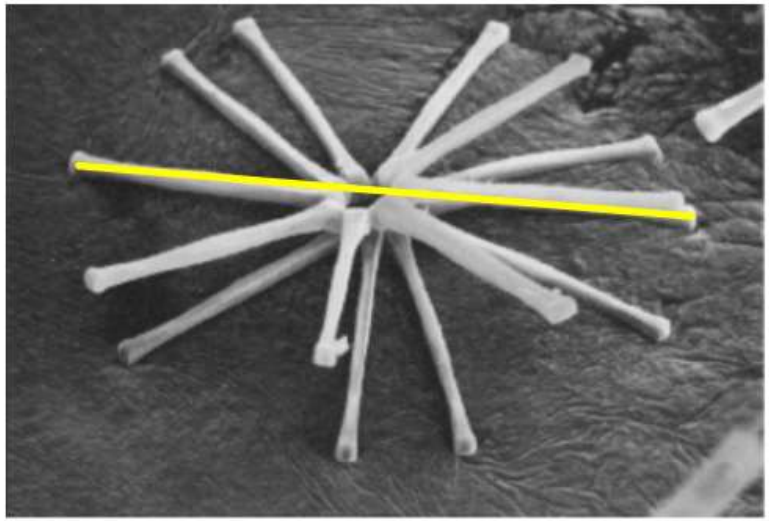
converts to: 0.89µm

should have an integer on this side of the point

this is best - gives us clear whole numbers

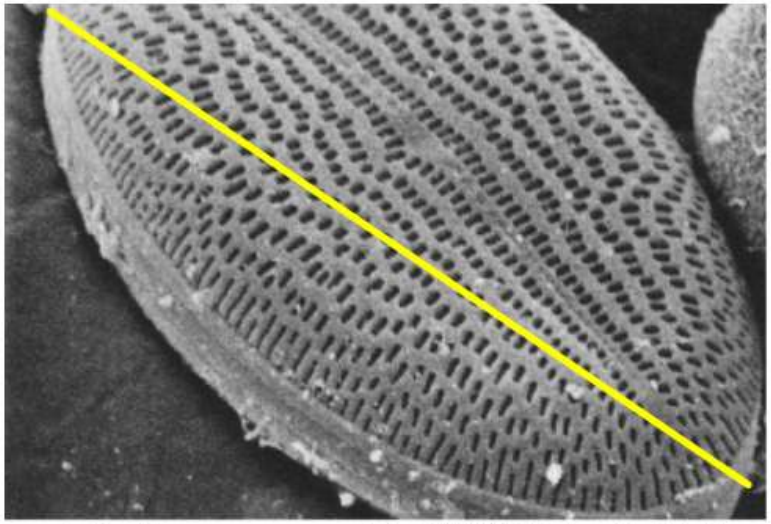
or 890nm

Diatom x 1,000



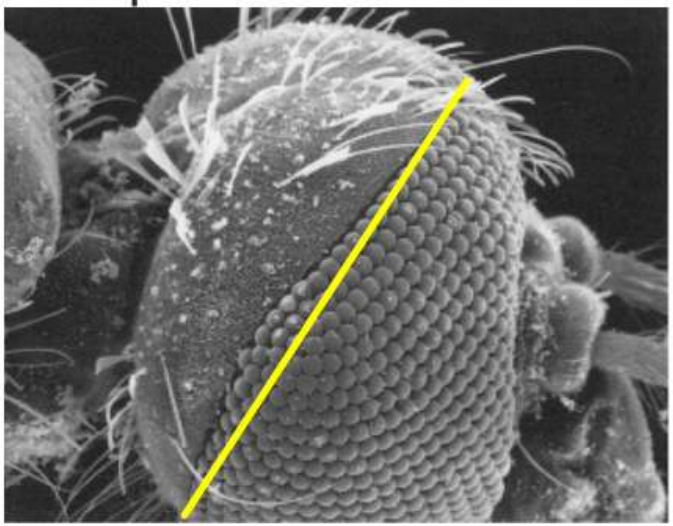
http://www.mos.org/sln/SEM/diatom.html

Diatom x 5,000



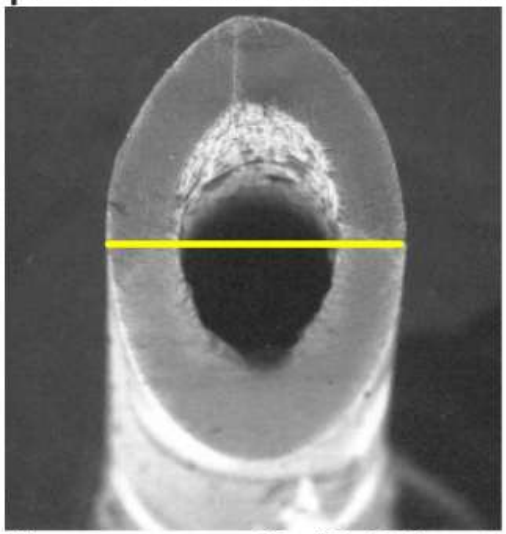
http://www.mos.org/sln/SEM/diatomb.html

Mosquito head x 200



http://www.mos.org/sln/SEM/mhead.html

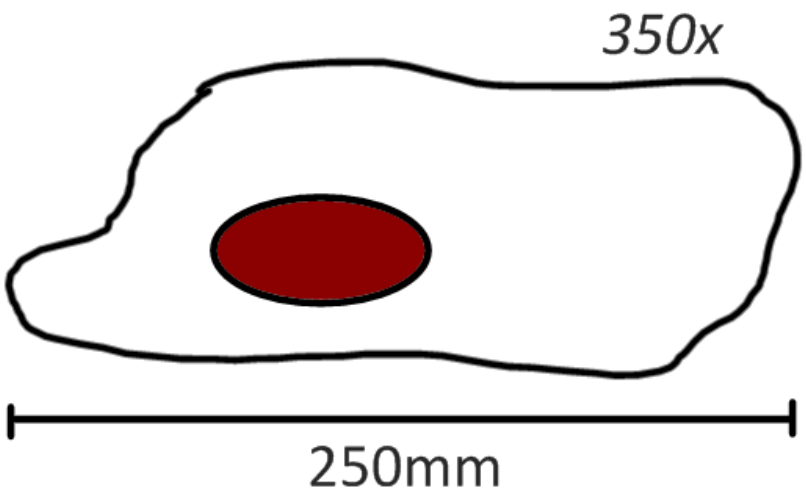
Hypodermic needle x100



http://www.mos.org/sln/SEM/needle.html

1. A student views an image of a cell magnified 350 times. The image is 250mm long. What is the actual length of the sample in the image?

If you're stuck, draw it out...



$$\text{Actual length} = \frac{\text{image length}}{\text{magnification}}$$

$$= 250\text{mm}/350$$

$$= 0.71\text{mm}^*$$

(or 710 μm)

* isn't that a bit big for a cell?
More on size of cells later...

2. A sperm cell has a tail 50µm long. A student draws it 75mm long. What is the magnification?

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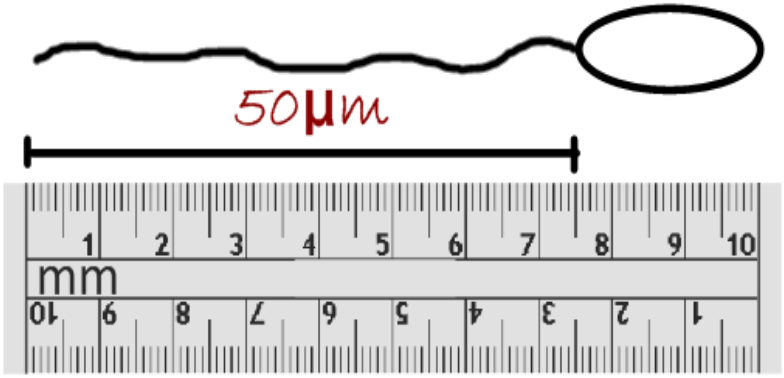

1. Convert mm to µm:

75mm = 75,000um

2. $\frac{\text{drawing length}}{\text{scale bar label}}$

= 75000/50

= 1500x magnification