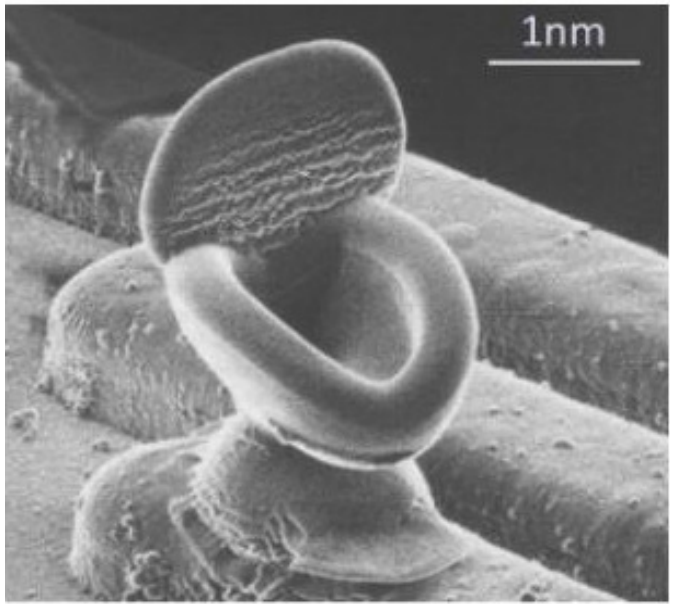
2.1 Cell Theory



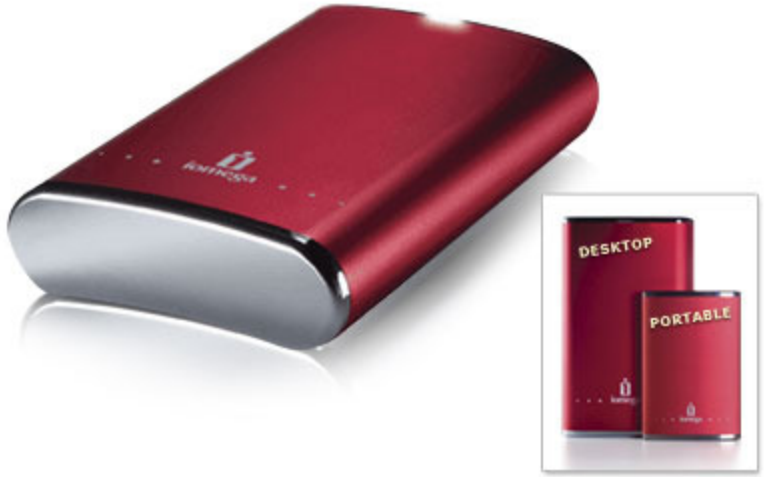
Part 1: Size in Biology

Metric Prefix Review

•	Tera	T	$1x10^{12}$	1,000,000,000,000
•	Giga	G	$1x10^{9}$	1,000,000,000
•	Mega	M	$1x10^{6}$	1,000,000
•	Kilo	K	$1x10^{3}$	1,000
•	Hecto	h	$1x10^{2}$	100
•	Deka	da	$1x10^{1}$	10
•	(Base Unit)	(m,L,g,s)	$1x10^{0}$	1
•	Deci	d	$1x10^{-1}$	.1
•	Centi	c	$1x10^{-2}$	.01
•	Milli	m	$1x10^{-3}$	.001
•	Micro	u	$1x10^{-6}$	.000001
•	Nano	n	$1x10^{-9}$	.000000001
•	Pico	p	$1x10^{-12}$	.000000000001
•	Femto	f	$1x10^{-15}$	.000000000000001

116 kb

1Tb



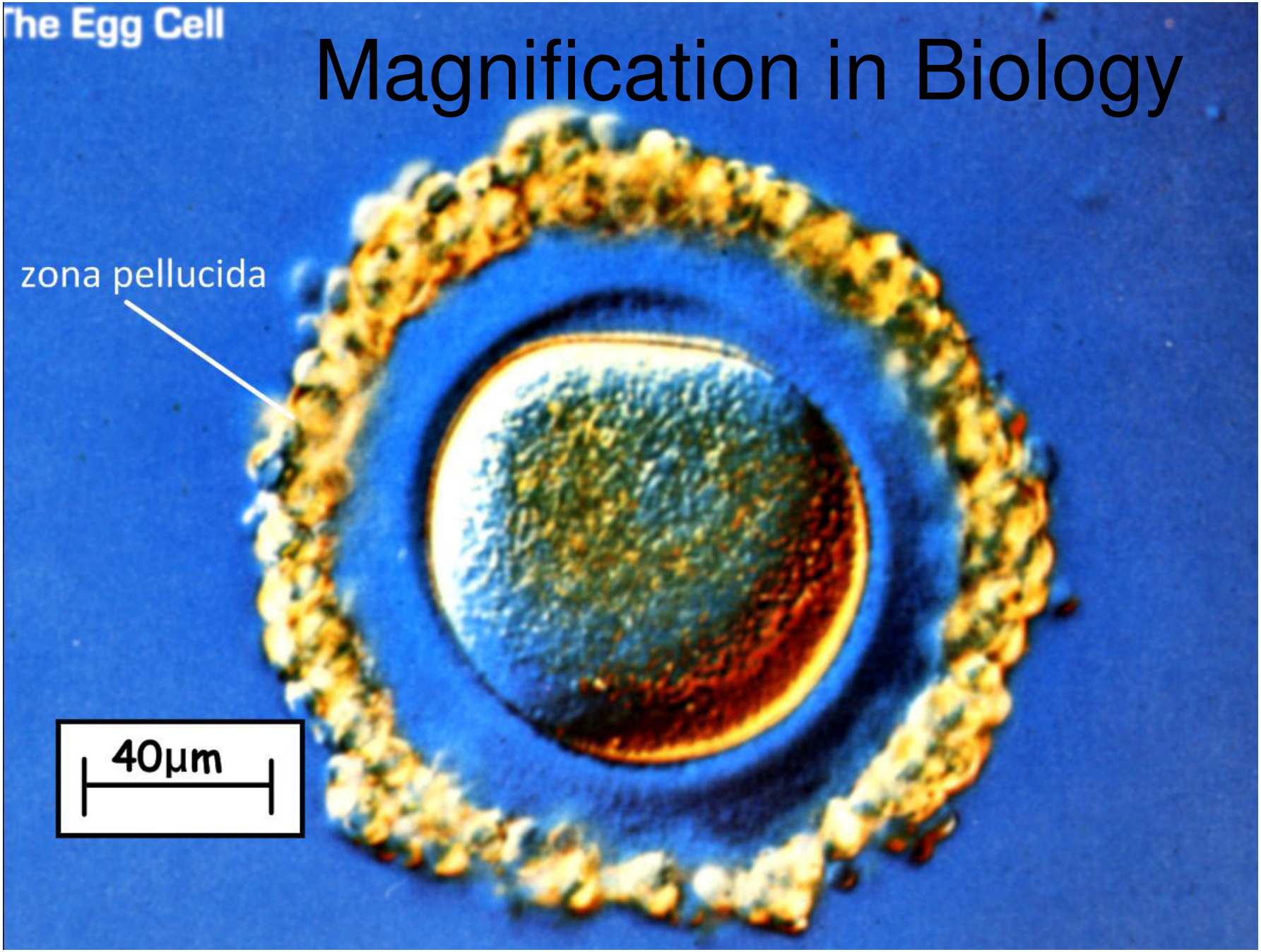
Size in Biology

"MTV BOC"

	Approx. Size
• Molecule of DNA (Double Helix)	$1x10^{-9}$ (nm)
• Thickness of Membrane	$1x10^{-8}$
• Viruses	$1x10^{-7}$
• Bacteria	$1x10^{-6}$ (um)
• Organelles	$1x10^{-5}$
• Eukaryotic Cell	$1x10^{-4}$
(Protists	$1x10^{-3}$)

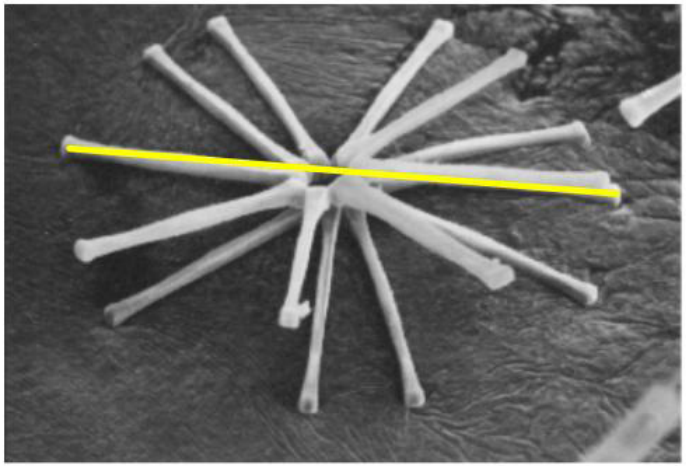
(Please keep in mind sizes are approximate and do vary with organism)

Magnification in Biology



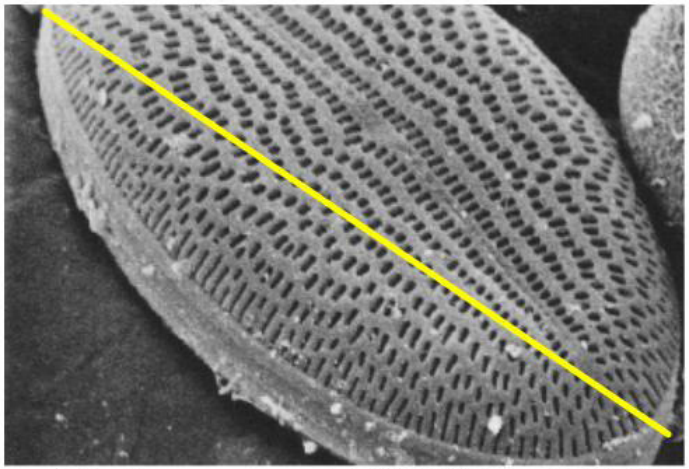
How big? Could you draw an appropriate scale bar?

Diatom x 1,000



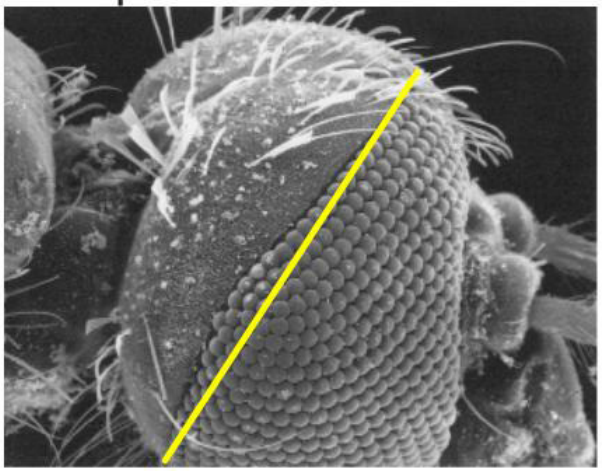
http://www.mos.org/sln/SEM/diatom.html

Diatom x 5,000



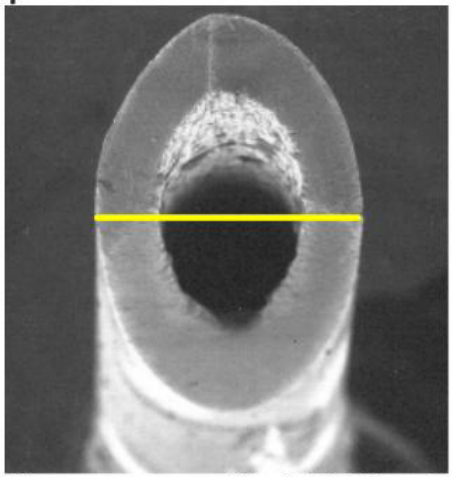
http://www.mos.org/sln/SEM/diatomb.html

Mosquito head x 200



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

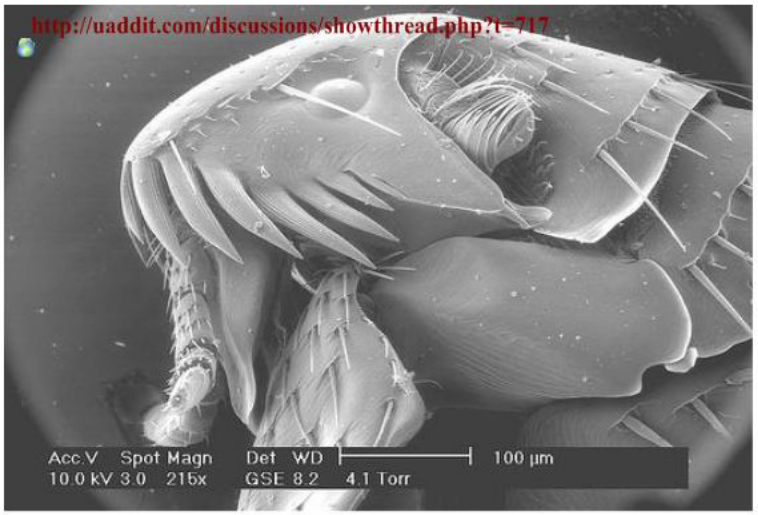
Hypodermic needle x100

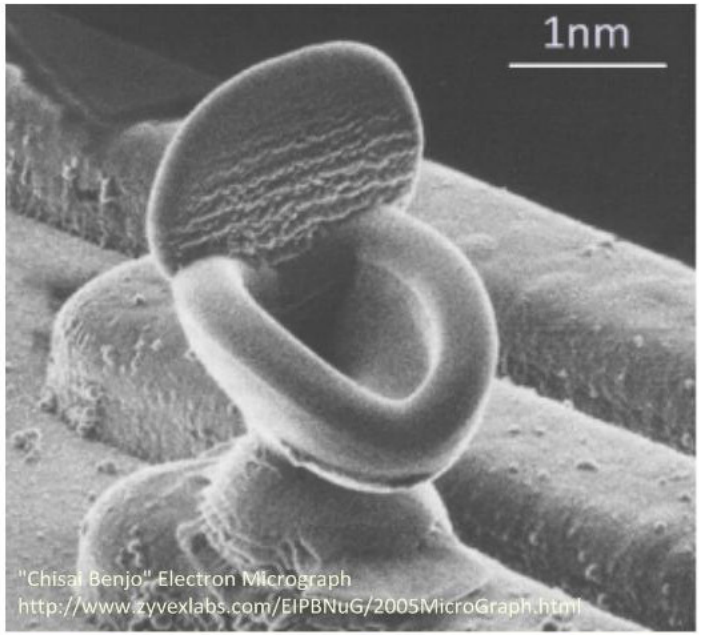


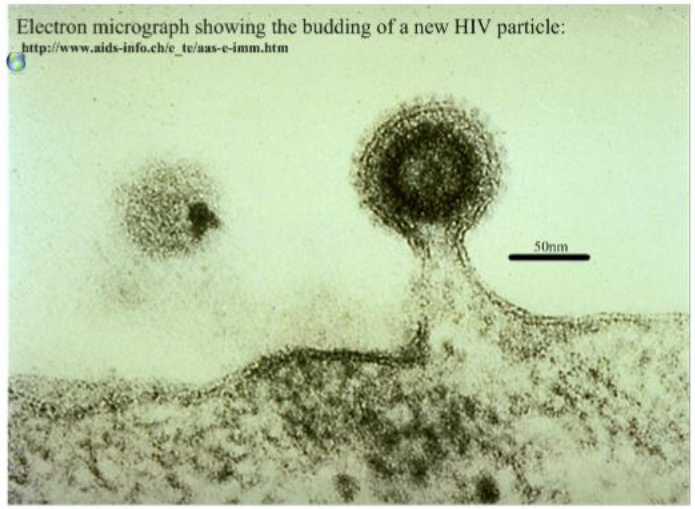
http://www.mos.org/sln/SEM/needle.html

How big? What is the magnification of these images?

Some more practice:



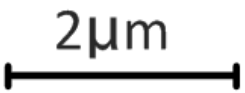


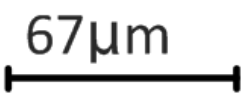


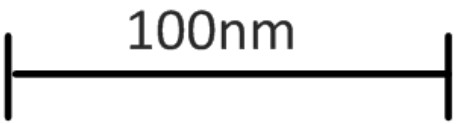
A student views an image of a cell magnified 350 times. The image is 250mm long. What is the actual length of the sample in the image?

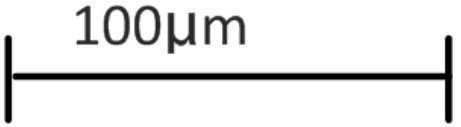
.A sperm cell has a tail 50µm long. A student draws it 75mm long. What is the magnification?

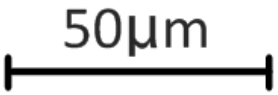
Print this and calculate the magnification of these scale bars:

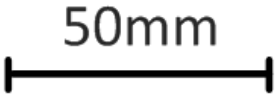


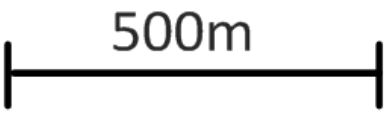




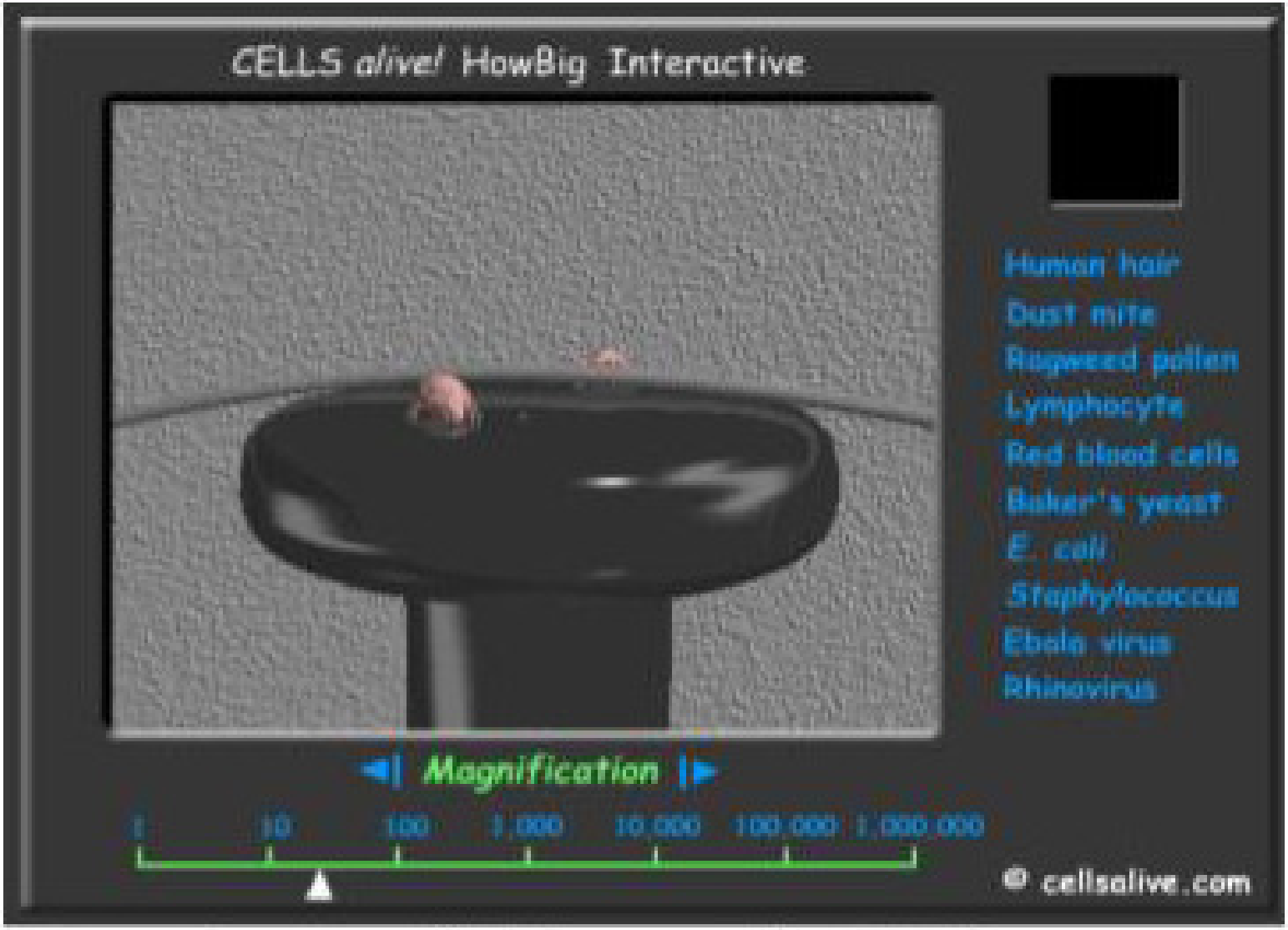






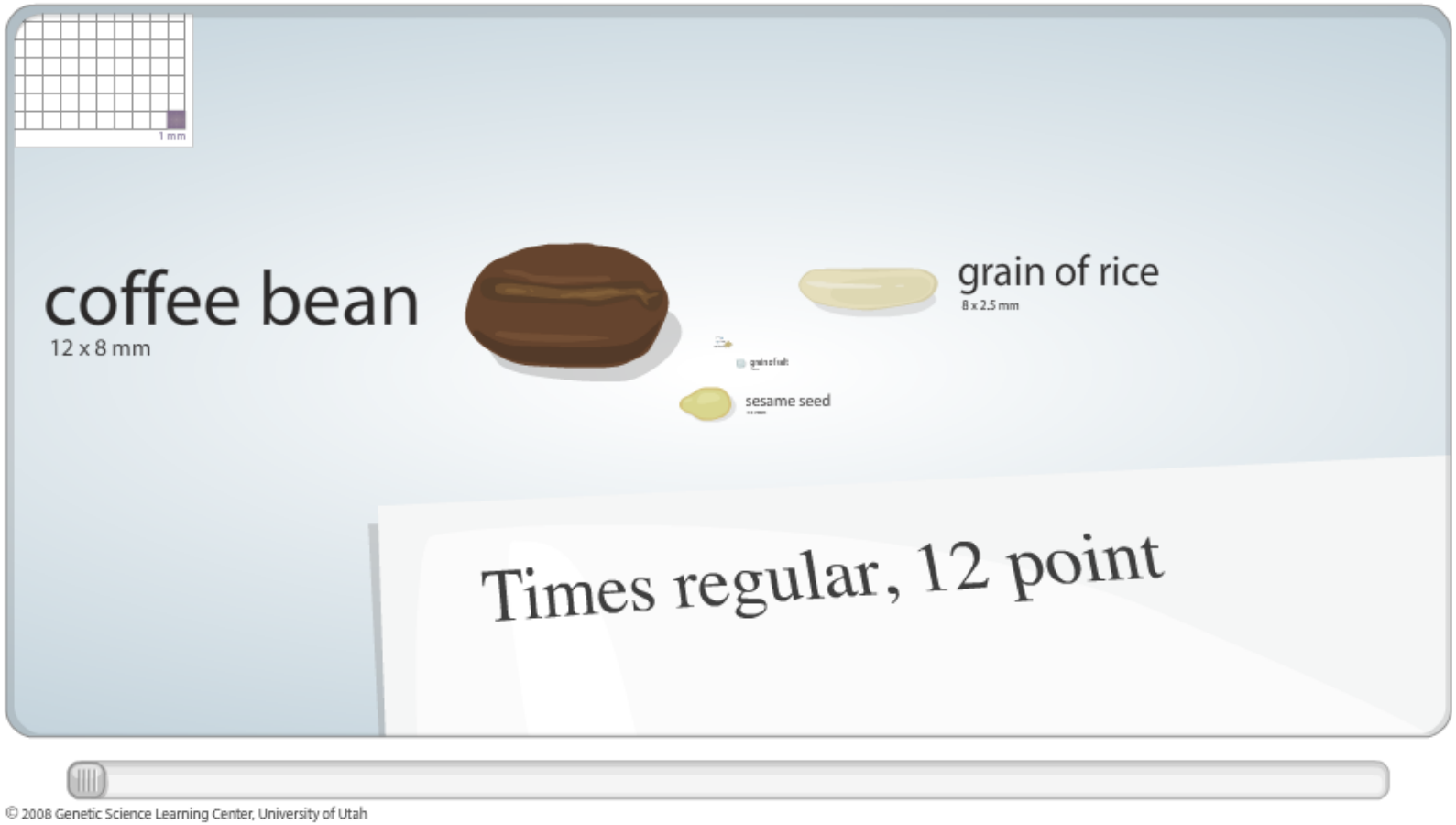


Remember - for '*calculate the magnification*' questions, the image is irrelevant as long as you have a scale bar.



http://www.cellsalive.com/howbig.htm

CELL SIZE AND SCALE



© 2008 Genetic Science Learning Center, University of Utah

http://learn.genetics.utah.edu/content/begin/cells/scale/

Part 2: Cell Theory

Biology: "The Study of Life"

- The scope of Biology ranges from submicroscopic molecules to the global distribution of biological ecosystems
- It encompasses life over huge spans of time from contemporary organisms to ancestral life forms

Cell Theory

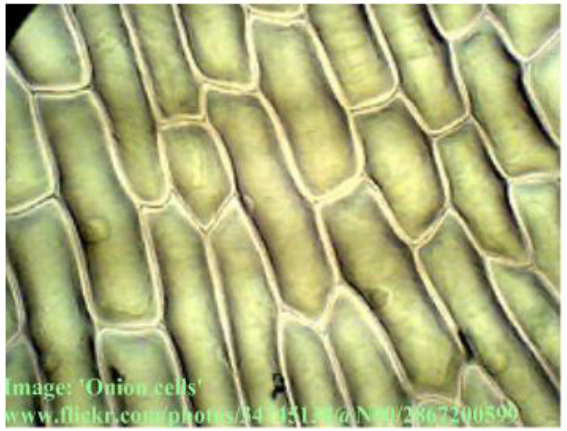
The knowledge of cells is nearly universal now, why not 2 centuries ago?

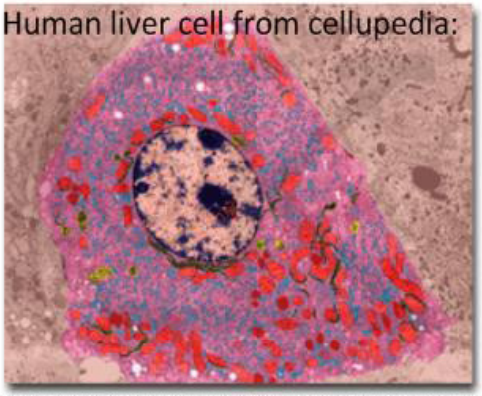
- Cell: The basic unit of structure and function in living organisms

Cell theory has three basic principles:

All living things are made of cells.

- Multicellular organisms have specialised cells to carry out various functions.
- Are unicellular organisms 'made of cells'?



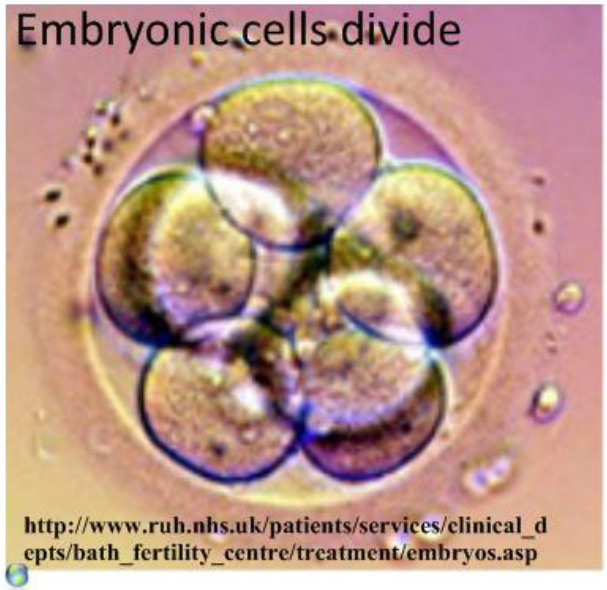


Cells are the smallest units of life.

- Organelles carry out various metabolic functions in the cell
- Cell components cannot survive alone

Cells come only from other cells.

- Louis Pasteur refuted the idea of spontaneous generation with his experiments
- Cells multiply by division
  - Mitosis and meiosis in eukaryotes
  - Binary fission in prokaryotes
- All cells descended from simpler common ancestors



Cell Theory Expanded?

- Cells contain inherited information
  - DNA carries instructions for growth and development

- Cells may exist singly or as subunits of multicellular organisms

Timeline & Key Players

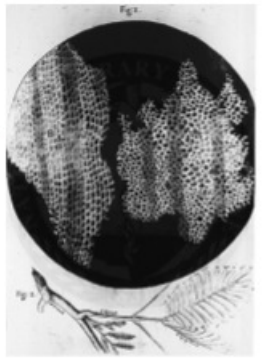
- Antonie Van Leeuwenhok
- Robert Hooke
- Theodor Schwann
- Matthais Schleiden
- Francesco Redi
- Lazzaro Spallanzani
- Louis Pasteur
- Rudolf Virchow "*Omnis cellula e cellula*"

(TOK connections… more than just the "cell" story)

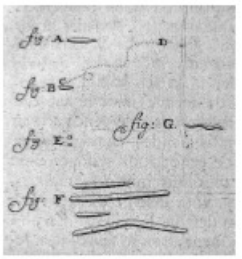
Cell theory is a great example of the scientific process

Observation

Hooke's observed cork cells



van Leeuwenhoek's bacteria



Hypothesis

"Cytoblasts build cells"
"Living things are made of cells"
"Cells are the smallest units of life"
"Cells come only from other cells"
"Vital energy is the source of life"
"Life generates spontaneously"

try again

Test

Refute

"Vital energy is the source of life"
"Cytoblasts build cells"
"Life generates spontaneously"

Corroborate

"Living things are made of cells"
"Cells are the smallest units of life"
"Cells come only from other cells"

Evidence

Microscope observations:
- light microscopes
- TEM and SEM (modern)

Culture growth

Pasteur's experiments

Remak's discovery of cell division

repeat

Theory

Evidence for cell theory: "*All living things are made of cells*"

http://www.nndb.com/people/356/000087095/

Robert Hooke
(1635-1703)

Robert Hooke (1635 - 1703)

Pioneering microscopist, optics enthusiast and coiner of the term "Cell" following his drawings of cork sections under a microscope (1655).

Antonie van Leeuwenhoek (1632 - 1723)

"*The Father of Microbiology*"

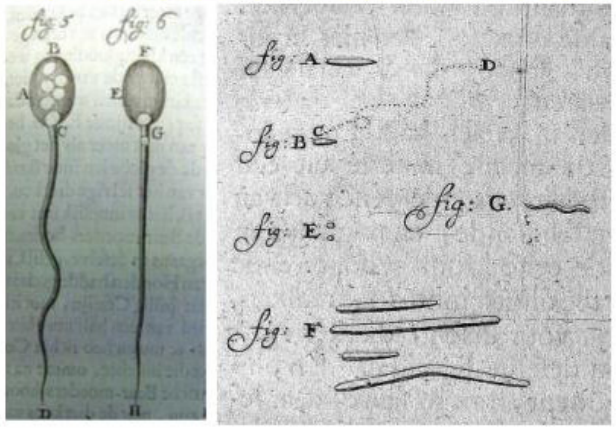
Master lens-maker - used them to analyse quality of the cloth made in his factory. He discovered 'animalcules' in water, wrote his findings to the Royal Society and eventually became known as the discoverer of cells.

Hooke's cork cells:

Hooke and van Leeuwenhoek:

http://www.youtube.com/watch?v=Q2ezDdKyRUc

First images of sperm and bacteria:



http://www.euronet.nl/users/warnar/leeuwenhoek.html

van Leeuwenhoek

“Abiogenesis”

Evidence for cell theory: "*Cells come only from other cells*"

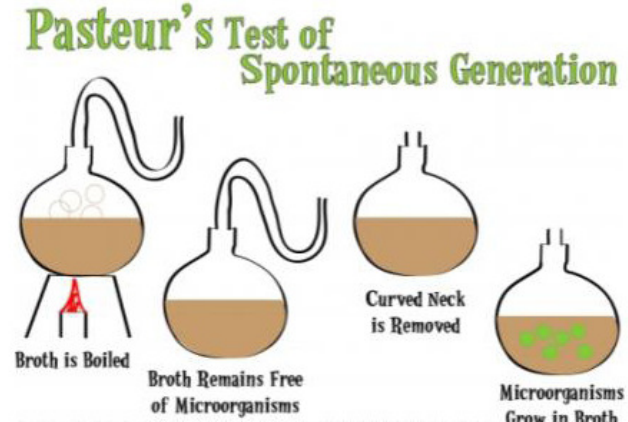
Pasteur's experiments:

Debunking spontaneous generation

http://www.youtube.com/watch?v=FWVIG1NFIDY

Throughout the 1700's and 1800's, the idea of spontaneous generation of life (rats from sweaty grain, maggots from meat, etc) persisted - until Louis Pasteur disproved the idea in 1864.

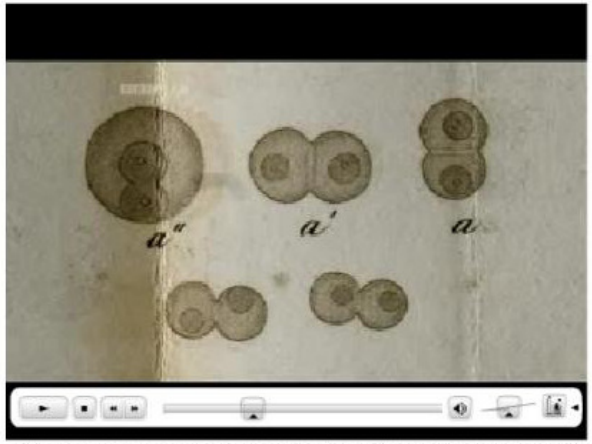
By preventing entry of airborne particles to a nutrient broth, he stopped growth of the culture. Leaving it open allowed microbes to grow. It seems obvious to us, but was a huge step forward for cell biology.



http://amoebamike.wordpress.com/2009/10/06/spontaneous-generation-a-brief-history-of-disproving-it/

Remak's experiments:

Cells come only from other cells:



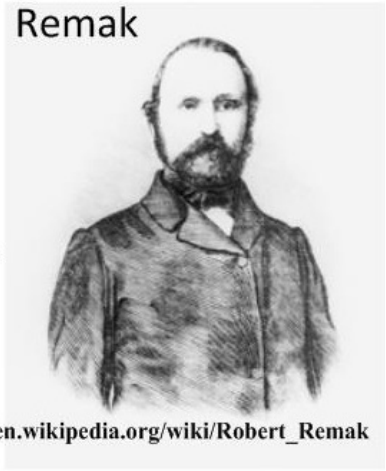
http://www.youtube.com/watch?v=jYCHsEUO-3U

In studying chicken embryos, Jewish scientist Robert Remak discovered cell division under the microscope. In 1858, after many years of doubt, his ideas were plagiarised and made popular by his German colleague, Rudolf Virchow.

"*Omnis cellula e cellula*"

("Cells come only from other cells")

Remak



http://en.wikipedia.org/wiki/Robert_Remak

Limitations and exceptions to cell theory

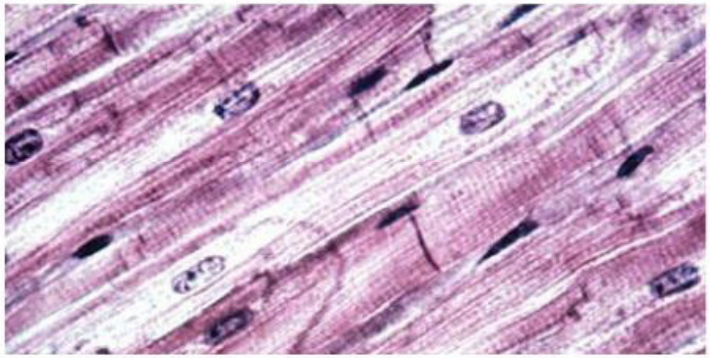
http://www.oberlin.k12.oh.us/talent/isp/reports2002/amoebaproteus/index.htm

Amoebae (protoctista):
- single cell capable of all life processes
- if there is only one cell, can we say 'made of cells'?

Fungal hyphae:
- very large
- multi-nucleated
- chitin cell wall (not cellulose)
- continuous cytoplasm

(HL read ahead: plant science!)

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

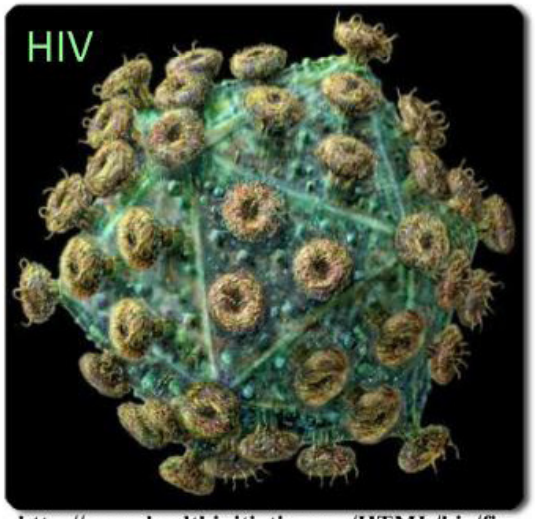


http://www.meddean.luc.edu/lumen/MedEd/Histo/HistoImages/hl3A-48.jpg

Muscle cells:
- multi-nucleated
- very long

Viruses:
- living or not?
- cells or not?

Can only reproduce when in control of a host cell.



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

Reading:
Sputnik - the virus of viruses

If viruses can be infected by other viruses, does that provide evidence that they are living?

http://scienceblogs.com/notrocketscience/2008/08/the_virophage_a_virus_that_infects_other_viruses.php

Emergent Properties

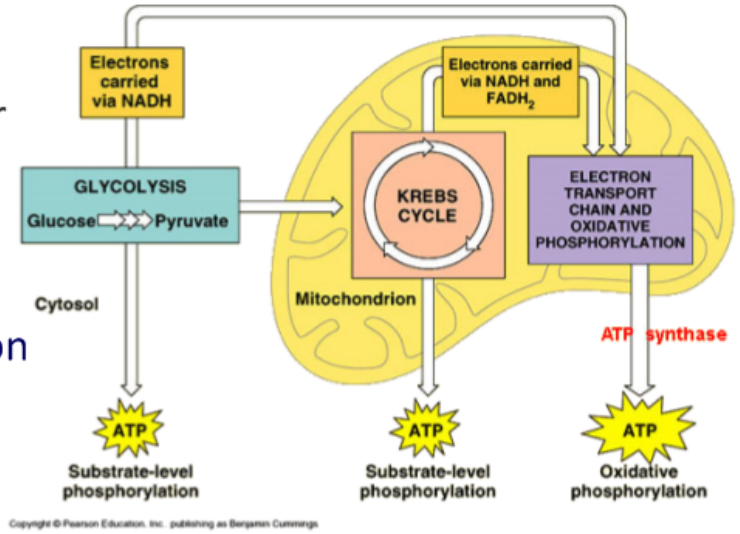
- A property that emerges as a result of interactions between components

- When we break something complex into its component pieces, they appear to be simple. Combined they can perform a whole new function.

The discipline of Systems Biology looks at the way different parts of a whole organism interact with each other to give emergent properties.

This is a relatively new field, where science has been traditionally reductionist - breaking things down into their component parts. By looking at the whole system, we can see that an organism is more than the sum of its parts.

In this diagram, we see that when this specific combination of molecules and pathways are combined, the ability to carry out aerobic respiration emerges.



http://fig.cox.miami.edu/~cmallery/150/makeatp/c9x6cell-respiration.jpg

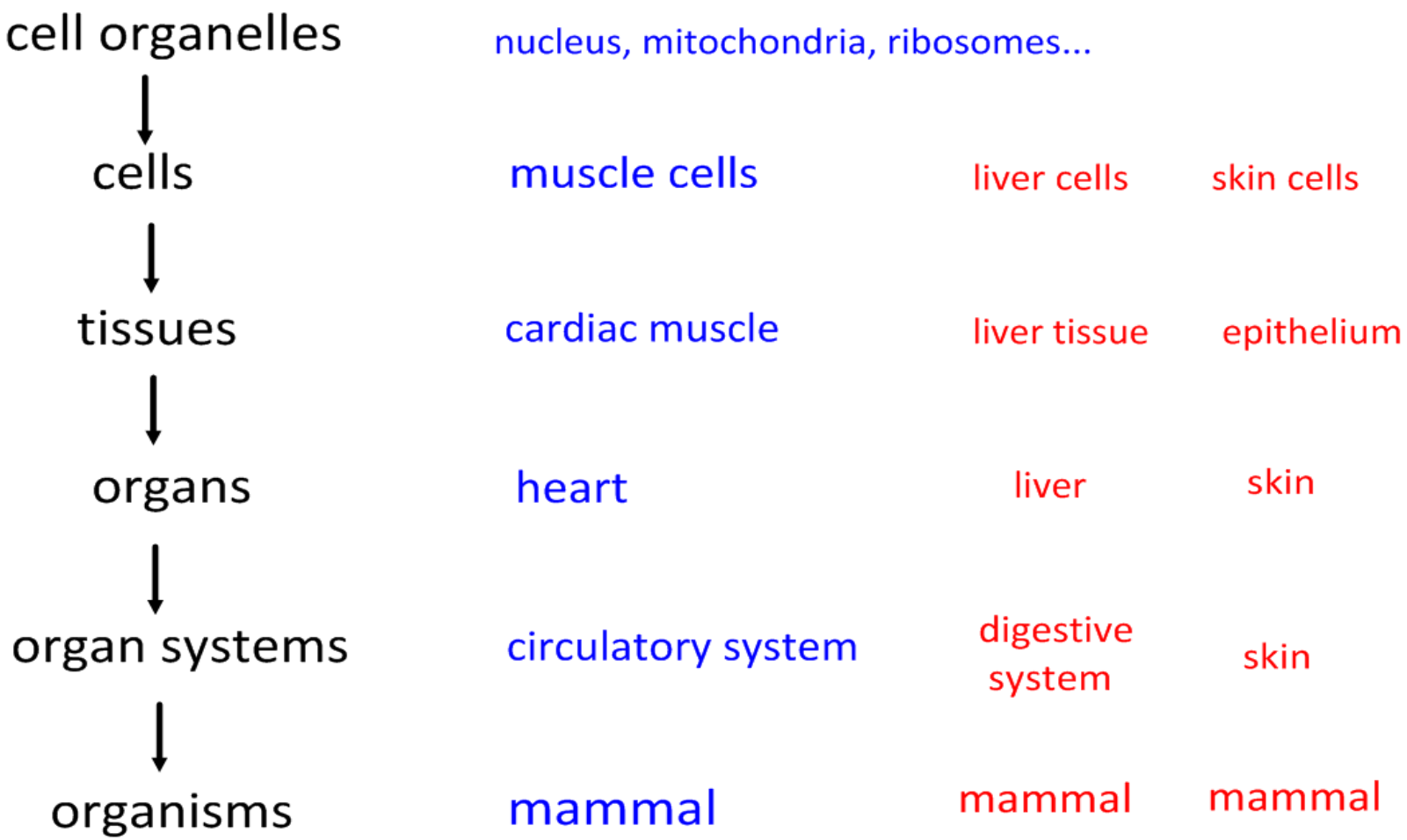
Emergent properties are seen at every level of increasing complexity, from the atom to the molecule, to the cell, to the organism to the biosphere.

TOK: How does the failure of one or multiple systems bring about the death of an organism?

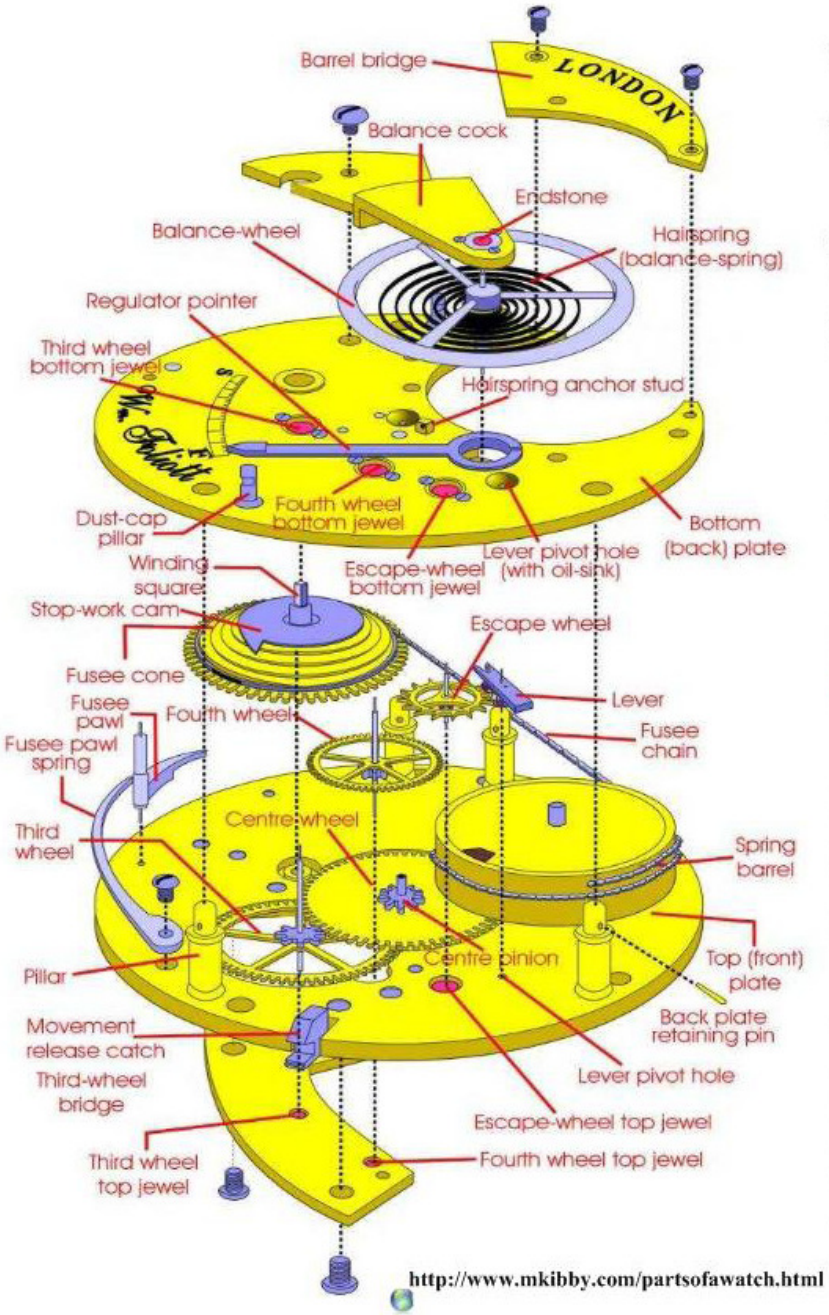
One of the main hurdles to AI is the issue of emergent properties: in biosystems, they 'appear' and if they are not detrimental are selected through evolution. Swarm technology is an example of how scientists are trying to generate software that mimics this process.

http://www.scribd.com/doc/2405989/Emmeche-aLife-Organism-and-Body-The-Semiotic-of-Emergent-Properties

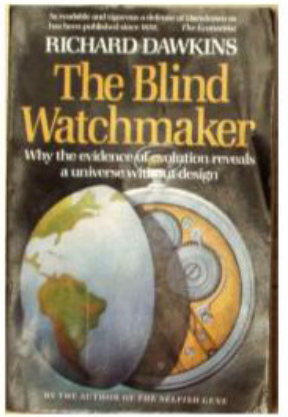
Life's Hierarchical Order



Evolution: The Blind Watchmaker



http://www.mkibby.com/partsofawatch.html



What do the components of the watch do individually?

What do they do when they are put together in the right way?

This is an example of emergent properties: *the whole is more than the sum of its parts*.

One analogy used for evolution is that of the blind watchmaker*.

Given millions of years and infinite mutations and combinations, it is inevitable that even complex structures will emerge.

There is no purpose or design to evolution - beneficial mutations in a particular environment will allow the organism to survive and reproduce.

Emergent Properties →Characteristics of Life

All living organisms carry out the functions of life

Nutrition Reproduction Movement Excretion

Growth Response to stimulus Homeostasis

Unicellular organisms, such as amoebae, are capable of all of these functions.

Multicellular organisms have specialised cells to carry out some of the functions and not others - but as a whole, all functions are covered.

There is some debate on the classification of viruses, as they cannot carry out all of the functions independently - they must invade a host and use the host cell's apparatus to survive. They can be considered acellular.

Amoeba

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

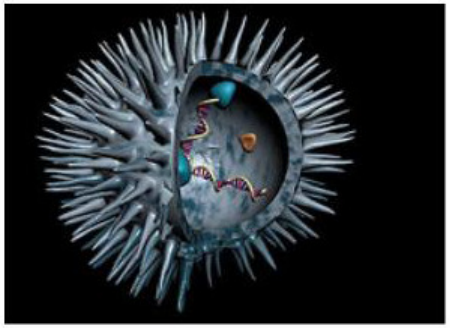


Image: 'virus'
www.flickr.com/photos/81561937@N00/145103594

A few more details…

BBC's "The Cell"

Part 3: Microscopy

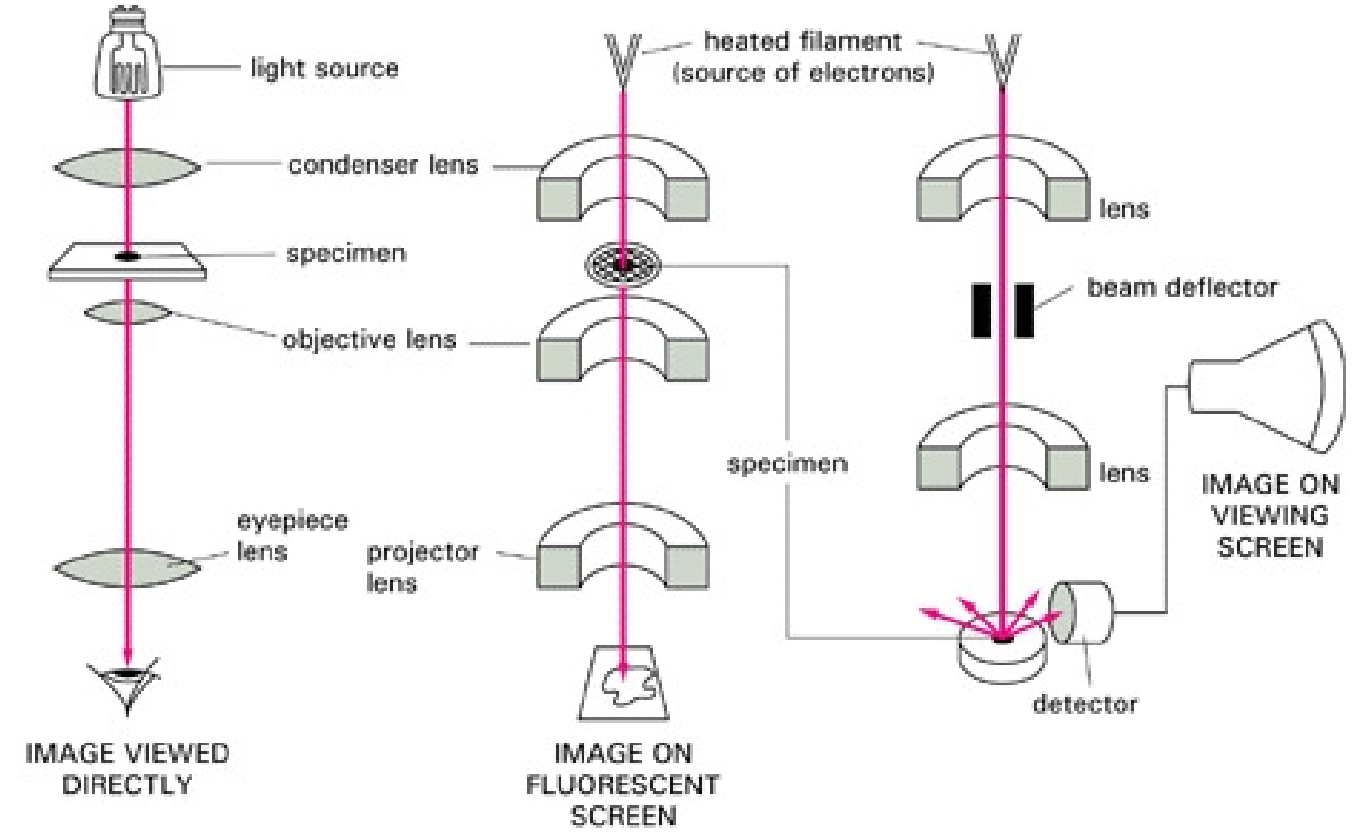
Three Microscope Types

Compound Light Microscope

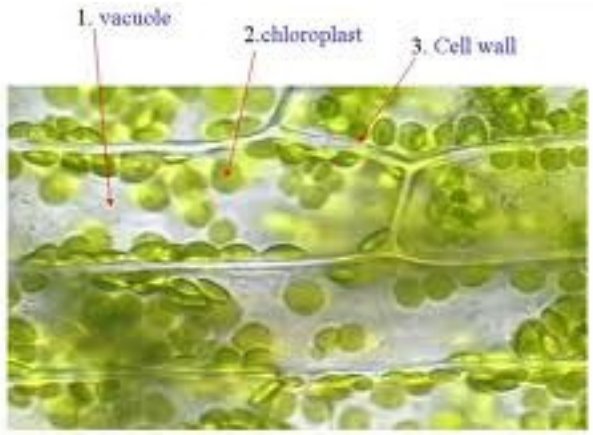
Transmission Electron Microscope

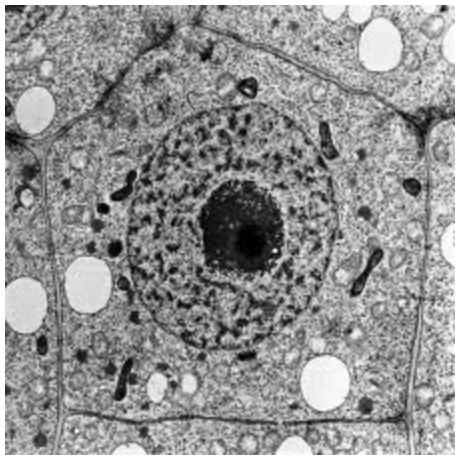
Scanning Electron Microscope

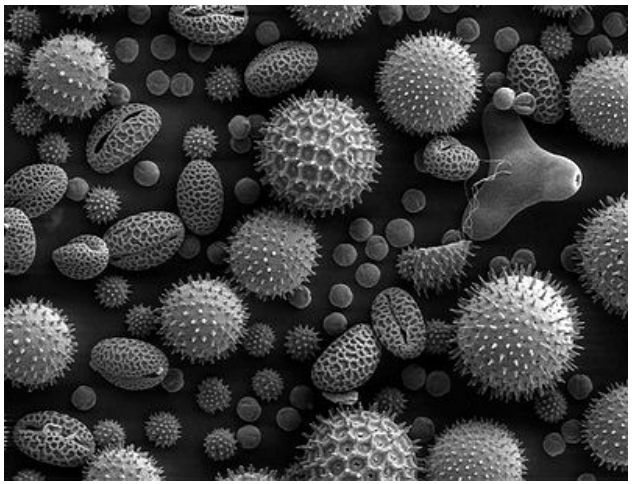
Three Microscope Types



Images from Three Microscope Types







Compound Light Microscope

Transmission Electron Microscope

Scanning Electron Microscope

Three Microscope Types

- Light Microscopes:
  - Visible light is passed through the specimen and then through the glass lenses
  - The lenses refract the light in such a way that the image in formed
  - Living specimen in color
- Electron Microscopes:
  - Beams of electrons instead of light are used to form the image
  - Non-living, “fixed” specimen, no true color

Three Microscope Types

- Transmission Electron Microscope:
  - Beams of electrons are passed through a very thin section of material
  - Internal structures can be seen
- Scanning Electron Microscope:
  - A narrow beam of electrons is scanned across the surface of an object producing a detailed image of the surface of the specimen
  - Gives 3D-like image

What is the magnification of the image when we view it down the compound microscope?

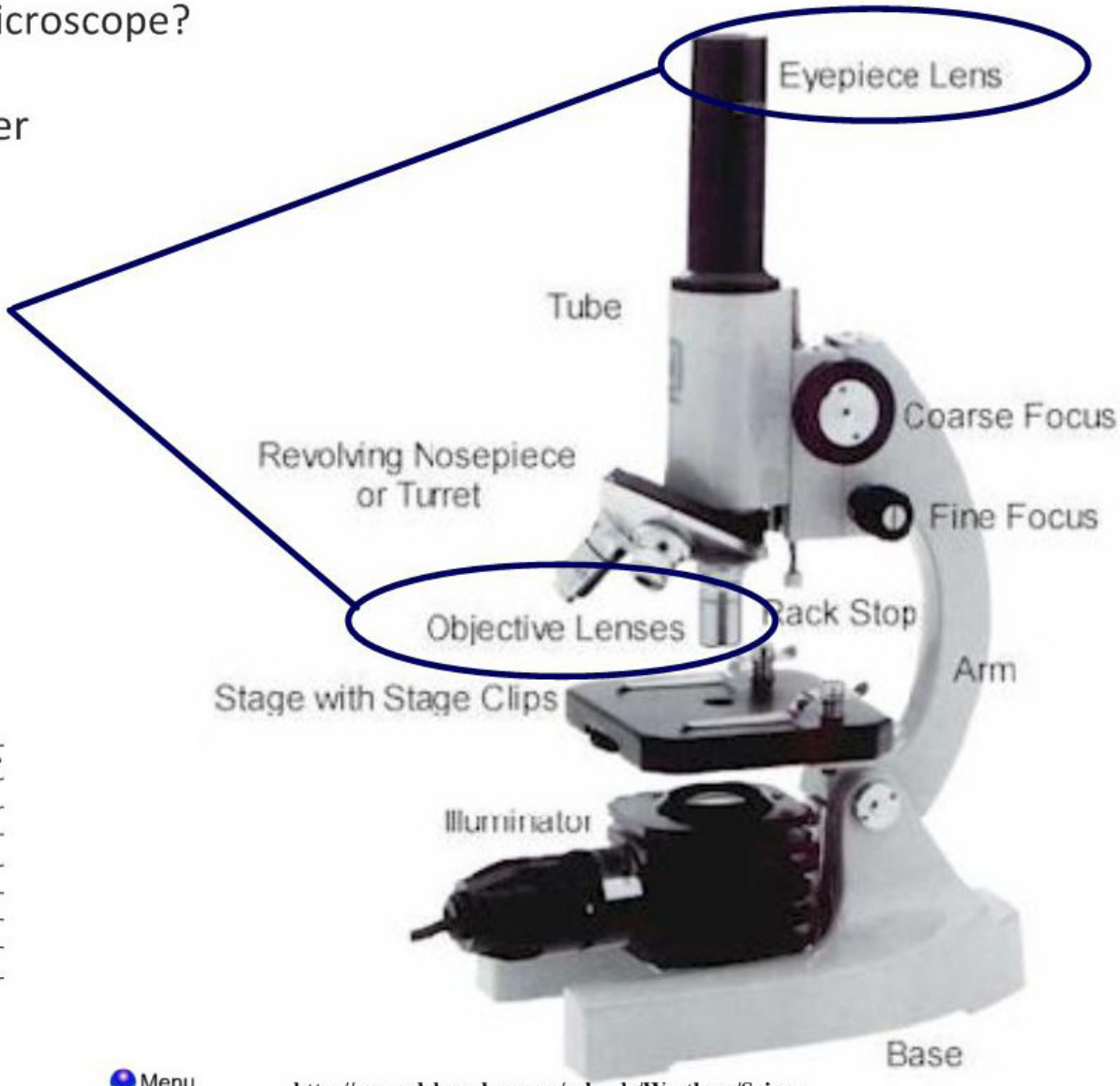
Multiply these values together

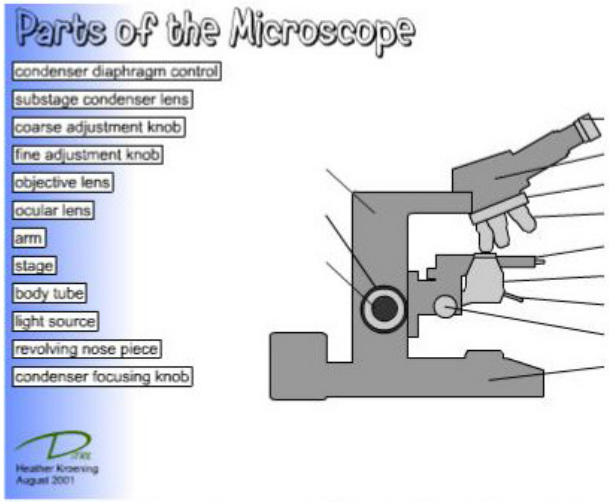
e.g.

eyepiece x objective

10 x 40

= 400x magnification



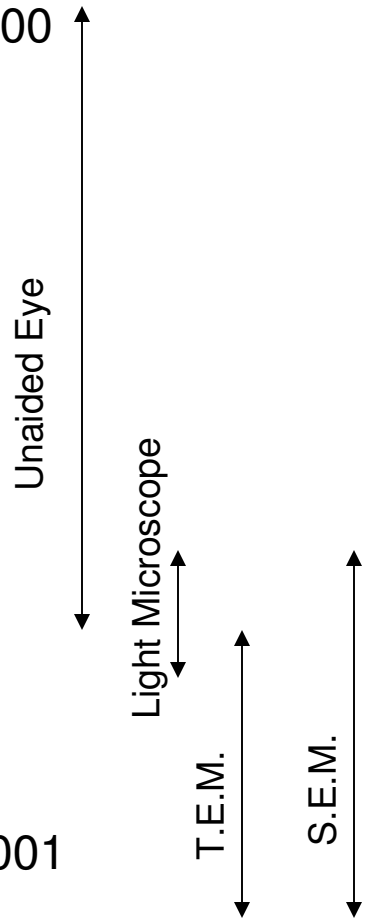


http://www.biology.ualberta.ca/facilities/multimedia/uploads/alberta/microscope.swf

http://www.dsbn.edu.on.ca/schools/Westlane/Science/simon/SBI3C1/Grade%2011%20Biology.htm

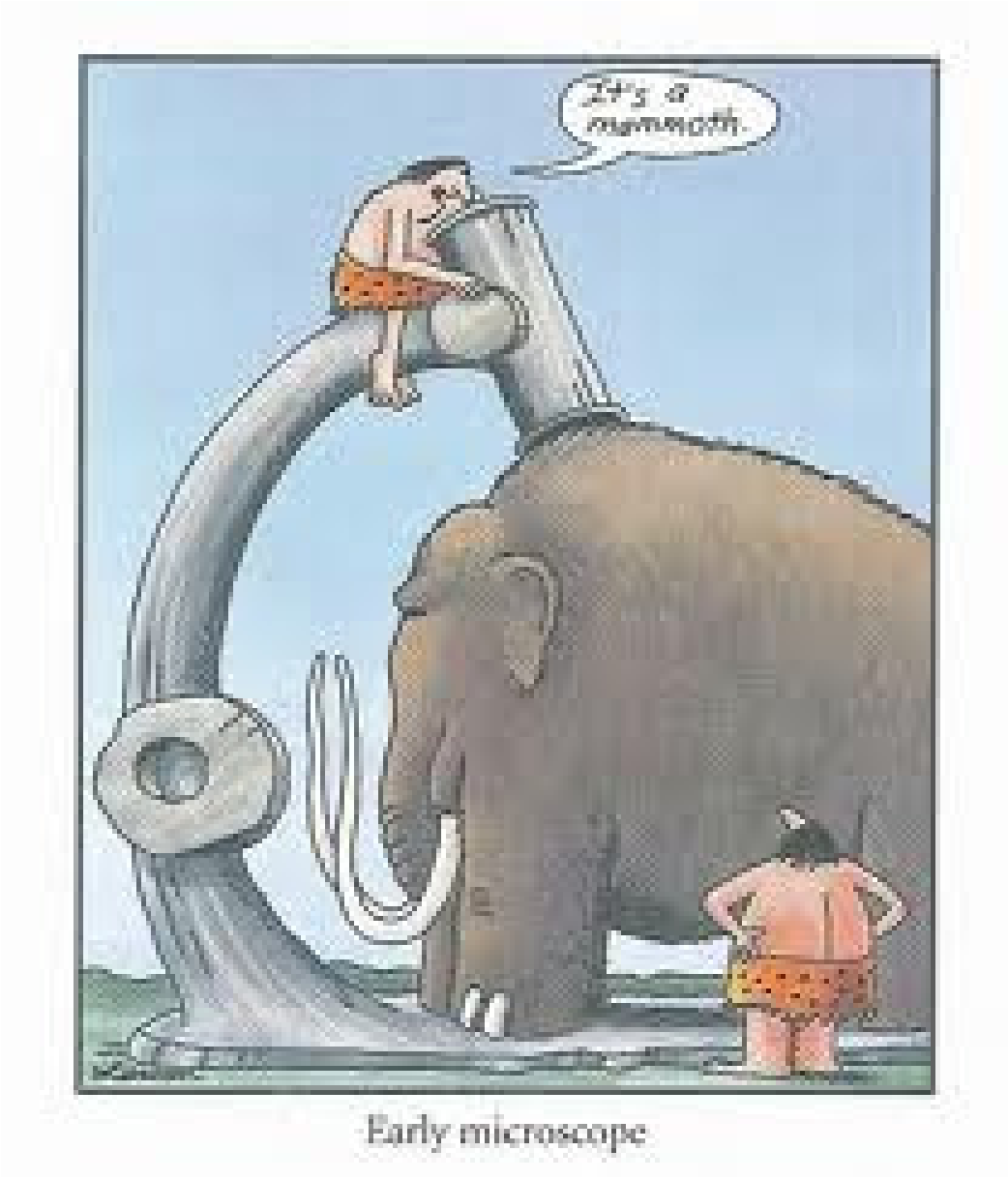
Resolving Power

• Tera	T	$1x10^{12}$	1,000,000,000,000
• Giga	G	$1x10^{9}$	1,000,000,000
• Mega	M	$1x10^{6}$	1,000,000
• Kilo	K	$1x10^{3}$	1,000
• Hecto	h	$1x10^{2}$	100
• Deka	da	$1x10^{1}$	10
• (Base Unit)	(m,L,g,s)	$1x10^{0}$	1
• Deci	d	$1x10^{-1}$	.1
• Centi	c	$1x10^{-2}$	.01
• Milli	m	$1x10^{-3}$	.001
• Micro	u	$1x10^{-6}$	.000001
• Nano	n	$1x10^{-9}$	.000000001
• Pico	p	$1x10^{-12}$	.000000000001
• Femto	f	$1x10^{-15}$	.000000000000001



Resolving Power of Light Microscope: ~0.3 um / Electron Microscope ~0.5 nm

Hmmm……



Early microscope