MCB 150

The Molecular and Cellular Basis of Life

Lecture 2: Technology Intro; Domains of Life

Today's Learning Catalytics Session ID is

32489498

If/when you can, go ahead and log into Canvas, click on Learning Catalytics, and enter this Session ID

Announcements

- Discussion Assignment due at 11:59 PM tonight
- Lecture 3 pre-lecture assignment due 1:00 PM Monday
- Remember to go through Canvas to get to everything
- Please take other devices off the wireless network when doing Learning Catalytics questions

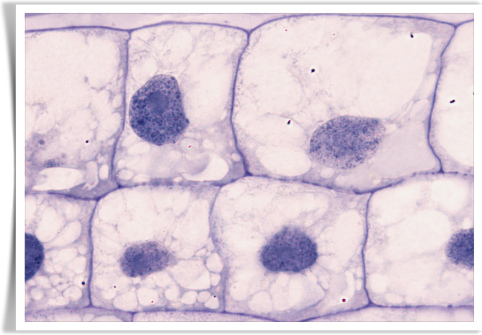
The Linnaen system of classification originated in the 1700's, and was based on physical characteristics

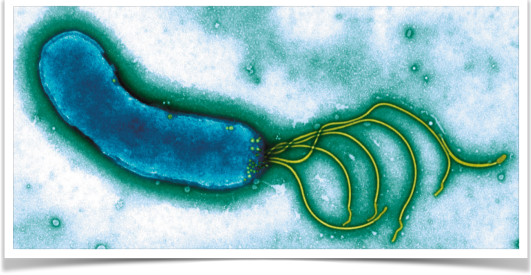
- Does it make its own food? Does it move?

Genus:species scheme is still used, but 2 kingdoms (animals & plants) wasn't enough to explain fungi, microbes, etc.

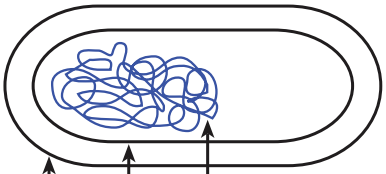
Technology eventually advanced to the point where we could examine the contents of individual cells

- Two basic types of cells were seen:
  - those with a "kernel" (=karyon =nucleus; eukaryotes)
  - those without a "kernel" (prokaryotes)





A typical PROKARYOTIC cell

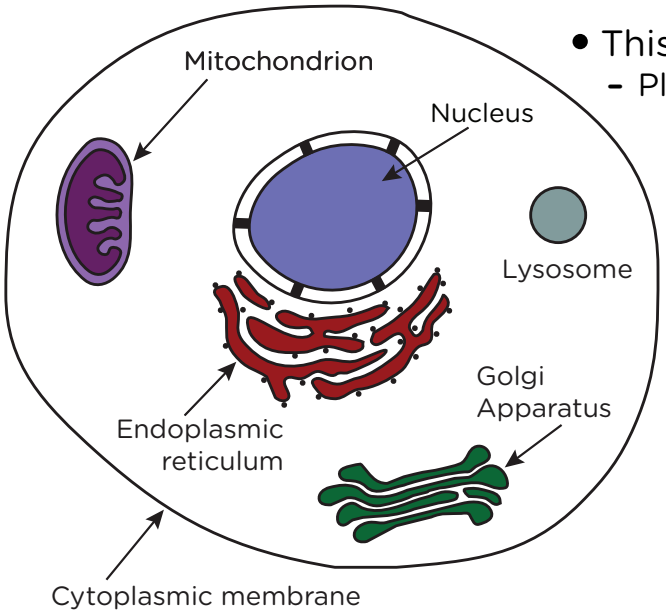


Nucleoid (usually a single chromosome)
– not surrounded by a membrane

Cytoplasmic membrane
– serves role of cytoplasmic membrane and other internal membranes in eukaryotes

Cell wall (usually but not always present)

A typical EUKARYOTIC cell



- This is an ANIMAL cell
  - Plants have cell walls and chloroplasts
- Inside of cell separated into distinct compartments called ORGANELLES (note: this list is representative, not exhaustive)

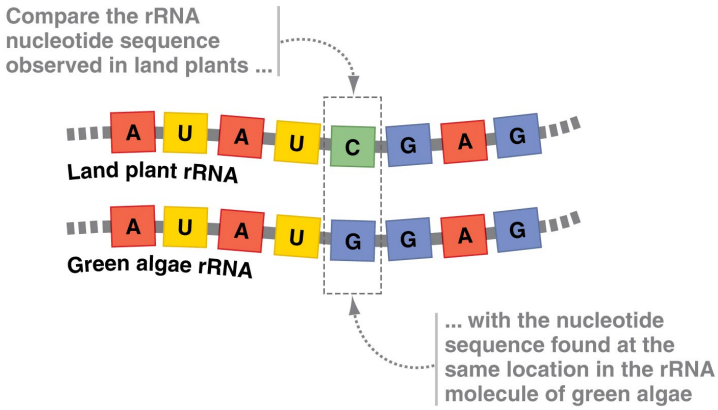
Until ~1977, organisms were thought to fall into 2 "superkingdoms"

- Prokaryotes, without a nuclear membrane and membrane-bound organelles
- Eukaryotes, with a nuclear membrane and membrane-bound organelles

Physical /structural characteristics are useful for crude classifications, but to understand true evolutionary relationships among organisms (to make a true "tree of life" and find a common ancestor), it's necessary to look at their genomes and biochemical systems

Then, in 1977, something important happened...

- Carl Woese and co-workers here at Illinois compared the sequences in different species of molecules (small subunit ribosomal RNAs) which are an essential component of every cell's machinery for synthesizing proteins

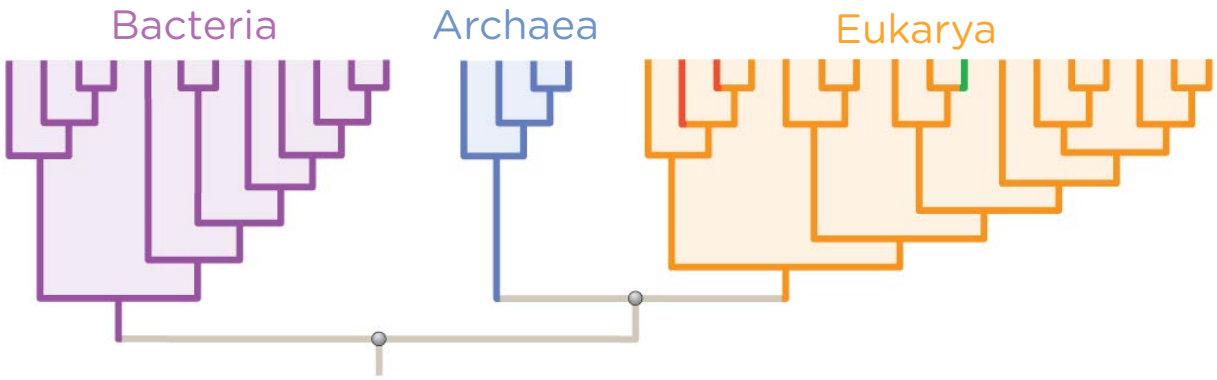


Conclusion: "prokaryotes" are actually two distinct groups of organisms

- (EU)BACTERIA: true bacteria like *E. coli*; found everywhere
- ARCHAEA: "ancient" prokaryotes; frequently found in extreme habitats that resemble early Earth
  - extreme heat, pressure, acids, salts, gases, etc.

That conclusion was based on the observation that archaeal rRNA sequences are more closely related to eukaryotic rRNA sequences than to bacterial rRNA sequences

Revised "Tree of Life" was created with 3 DOMAINS rather than 2 superkingdoms



- Despite physically resembling bacteria (they are both prokaryotes), in most molecular processes archaea are more similar to humans than they are to *E. coli*...

Comparison of Bacteria, Archaea, and Eukarya

	Bacteria	**Archaea**	**Eukarya**
Nuclear membrane	No	No	Yes
Membrane-bound organelles	No*	No	Yes
Typical size (microns)	1-10	1-10	10-100
Typical number of chromosomes	1	1	>1
Shape of chromosomes	mostly circular	mostly circular	mostly linear (in the nucleus)
Examples	*E. coli* *H. influenza*	Methanogens Thermophiles	Yeast Plants Animals

No two species are identical structurally and biochemically, but they are all made of one or more cells. Why?

Life requires a structural compartment separate from the external environment in which molecules can perform unique functions in a relatively constant internal environment

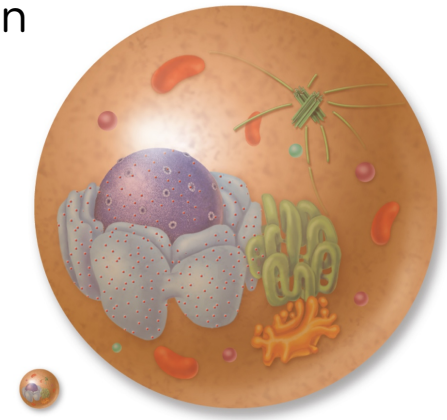
- This "living compartment" is a ***cell***

Basic tenets of the CELL THEORY:

- Cells are the fundamental units of life.
- All organisms are composed of (one or more) cells.
- All cells come from preexisting cells.

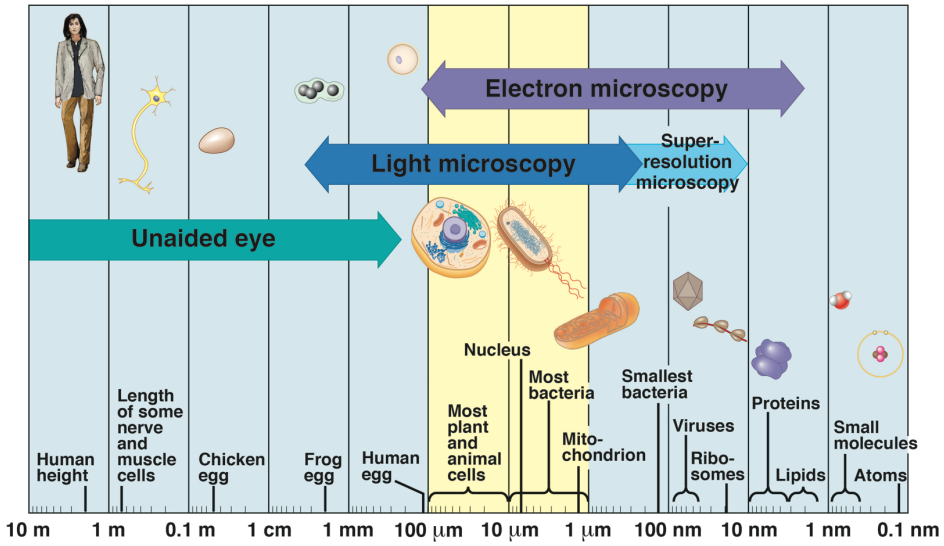
Why are cells so small, and found in such a narrow size range?

- As the size increases, the surface area-to-volume ratio decreases.



Cell radius (r)	1 unit	10 unit
Surface area ($4\pi r^2$)	12.57 unit^2	1257 unit^2
Volume ($\frac{4}{3}\pi r^3$)	4.189 unit^3	4189 unit^3
Surface Area / Volume	3	0.3

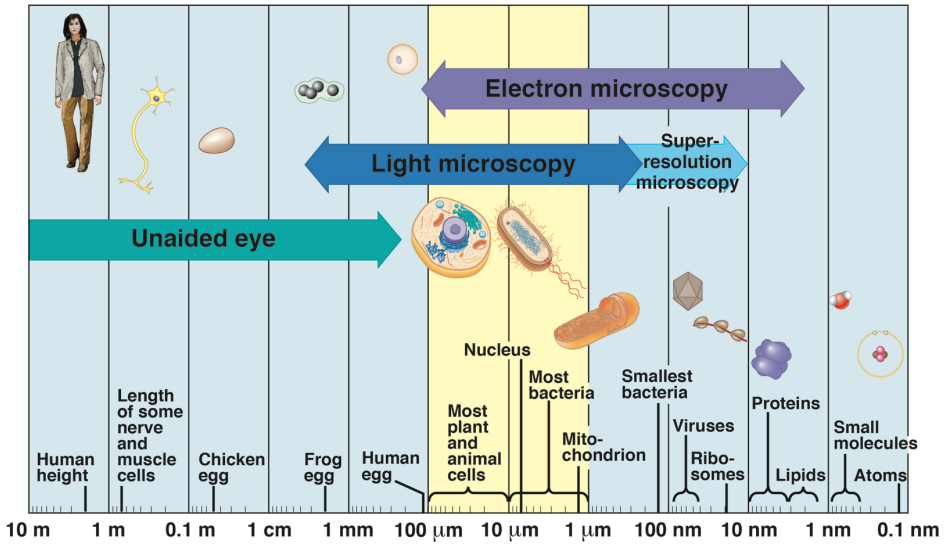
Relative Size, Scale, and Resolution



Resolution: the ability to identify the separation of two objects that are close to each other

- Resolving power of light microscopes is ~0.2 microns (μm; 10^{-6} m)

Relative Size, Scale, and Resolution



What if we want to visualize sub-cellular objects?

- Electron microscopy has resolution of ~0.5 nm (10^{-9} m)
- Denser material absorbs more electrons and appears darker