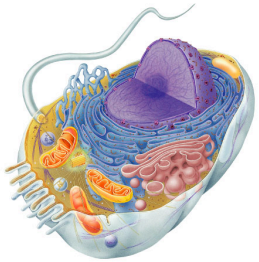
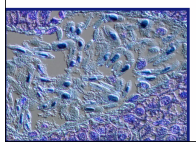
Chapter 6: Part I

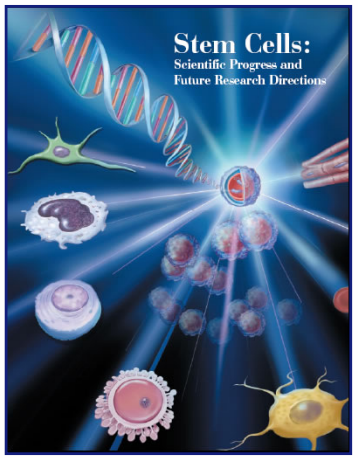
Studying Cells



Biological diversity & unity

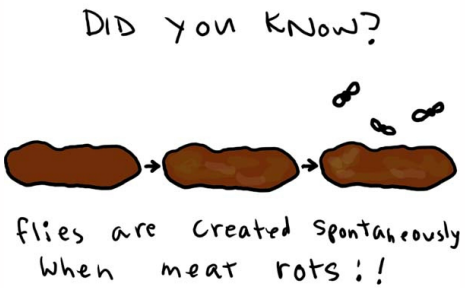
- Underlying the diversity of life is a striking unity
  - DNA is universal genetic language
  - Cells are the basic units of structure & function
    - lowest level of structure capable of performing all activities of life





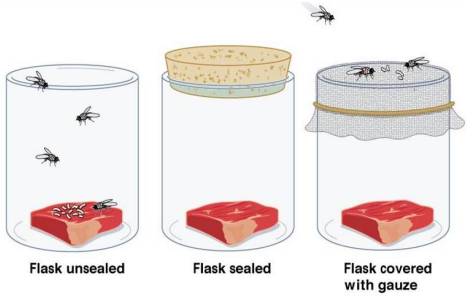
Where do cells come from?

- Spontaneous generation
  - Idea coherently synthesized by thinkers like Aristotle
    - Certain forms such as fleas could arise from inanimate matter such as dust and that maggots could arise from dead flesh.



Where do cells come from?

- Francisco Redi (1626-1697)
  - Kept meat in three jars.
    - One of the jars was uncovered, and two of the jars were covered, one with cork and the other one with gauze.
      - Flies could only enter the uncovered jar, and in this, maggots appeared. In the jar that was covered with gauze, maggots appeared on the gauze but did not survive.
- Ultimately, the ideas of spontaneous generation were displaced by advances in germ theory and cell theory.

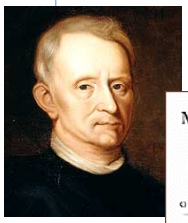


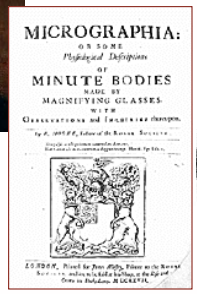
Activities of life

- Most everything you think of a whole organism needing to do, must be done at the cellular level…
  - Reproduction
  - Growth & development
  - Energy processing
  - Response to the environment
  - Homeostasis
  - Maintaining order and structure

How do we study cells?

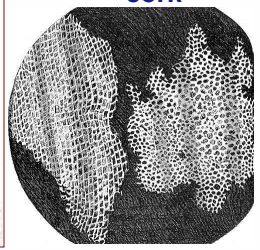
- Microscopes opened up the world of cells
  - Robert Hooke (1665)
    - the 1st cytologist
    - The 1st to see a cell
      - Viewed dead cells from bark & cork



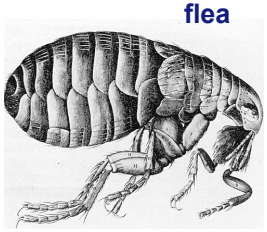


Drawings by Hooke

cork



flea

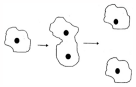


Making Scientific Generalizations

- Three scientists are generally credited with the formulation of the 'Cell Theory' of life (1839)

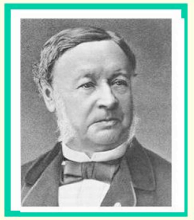
1. 1838: Matthias Jakob Schleiden, a German botanist, concluded that all plant tissues are composed of cells and that an embryonic plant arose from a single cell.
   - *He declared that the cell is the basic building block of all plant matter.*
   - *This statement was the first generalizations concerning cells.*

2. 1839: Theodor Schwann, a German biologist, reached the same conclusion as Schleiden about animal tissue being composed of cells, ending speculations that plants and animals were fundamentally different in structure.
3. Anthropologist Rudolf Virchow (1950s) was the first to demonstrate that the cell theory applies to diseased tissue as well as to healthy tissue-that is, that diseased cells derive from the healthy cells of normal tissue.
   - *He did not accept Louis Pasteur's Germ Theory of Disease, which stated that many diseases are caused by microorganisms, too small to see without magnification, that invade living hosts and cause disease when they grow and reproduce within their hosts.*



Main Founders of the Cell Theory

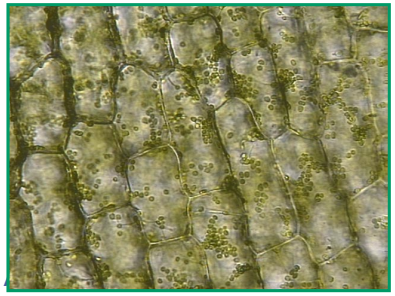
Cell Theory

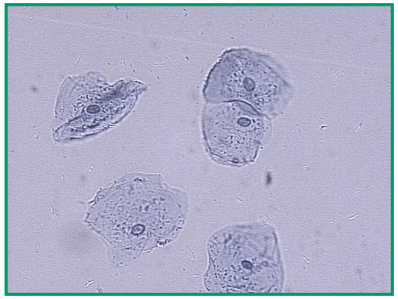
Matthias Schleiden	Theodore Schwann	Rudolf Virchow
		
all plants are made of cells	all animals are made of cells	all cells came from pre-existing cells

Cell Theory

Tenants of Modern Cell Theory

1. **All organisms are made up of one or more cells**
2. The cell is the basic *living* unit of organization for all organisms
3. All cells come from pre-existing, living cells

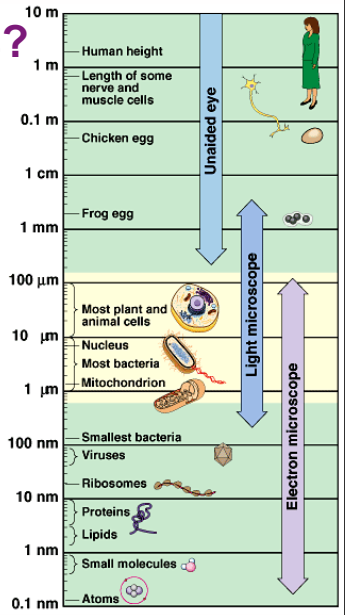




How do we study cells?

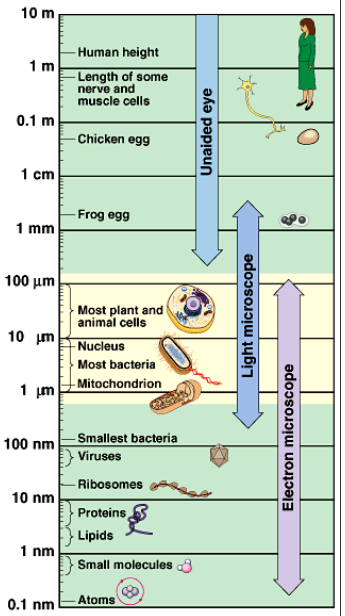
- **Microscopes today…**
  1. light microscopes
  2. electron microscope
  3. transmission electron microscopes (TEM)
  4. scanning electron microscopes (SEM)

Technology advances science..



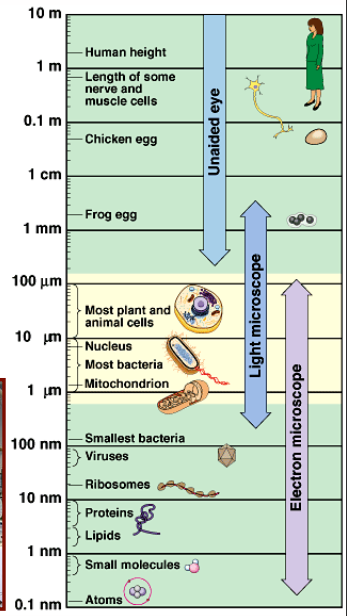
Light microscopes

- Visible light is passed through specimen and glass lenses which bend the light so the image is magnified as it is projected
  - Minimum 0.2 µm (200nm) resolution
  - Magnify about 1000x
  - Can see animal and plant cells and smaller cells like some bacterium
    - Most organelles too small to be visualized
  - can be used to study LIVE cells



Electron microscope

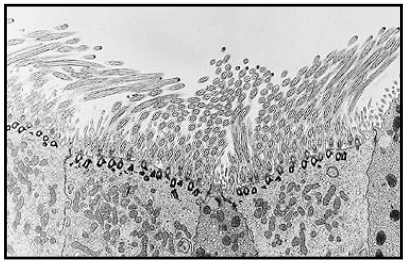
- Designed in the 1950s…
- Beam of electrons is focused through or onto the surface of a specimen.
- 2.0 nm resolution
- 100x to 1000x better resolution than the light microscope *(for a total magnification of 100,000x to 1,000,000x)*
- reveals organelles *(membrane-enclosed compartments)* and large macromolecules
  - but can only be used on DEAD cells



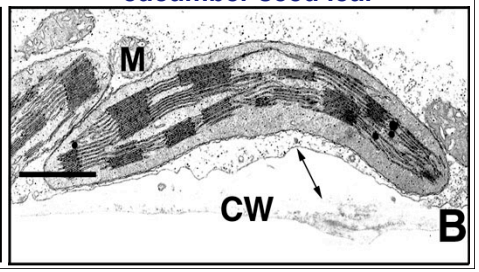
Transmission electron microscopes

- TEM
  - used mainly to study internal structure of cells
    - aims an electron beam, focused by magnets, through a thin section (slice) of specimen or tissue
      - a detector then converts the refracted or reflected beams of electrons into a black and white image.
        - Reveals much more detail than light microscopes

rabbit trachea



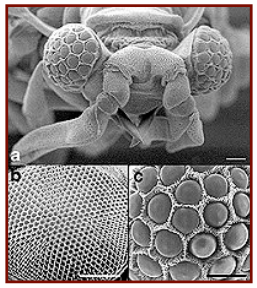
cucumber seed leaf



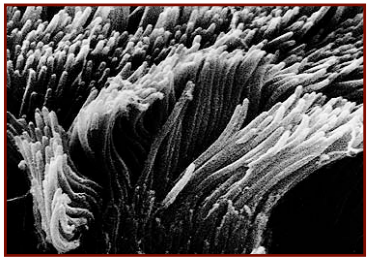
Scanning electron microscopes

- SEM
  - studying surface structures
    - sample surface covered with thin film of gold
      - Electron beams bounce off the surface and are directed at a screen, where they create a 3D picture.
        - Great depth of field revealed through an image that highlights the three-dimensional surface of biological structures

compound eye of an insect



rabbit trachea



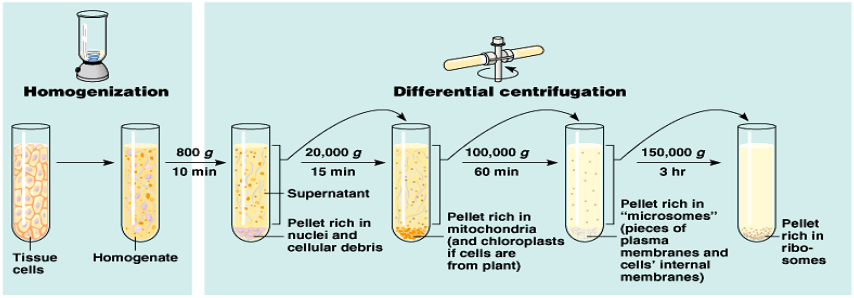
AP Biology

Isolating organelles

What organelle would be heaviest?

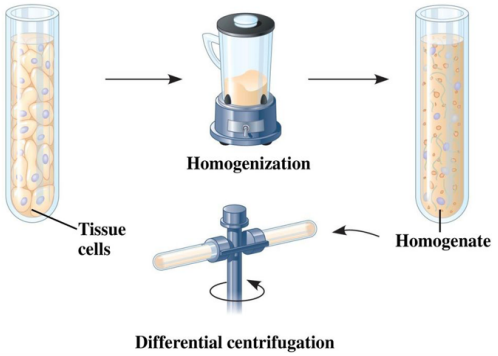
What structure would be lightest?

- Cell fractionation *(Using "artificial" gravity)*
  - Separate organelles from cell by using the fact that organelles have different sizes and weights.
    - Uses an ultracentrifuge *(and the creation of gravitational forces)* to separate parts of cells based on their mass.
      - Ultracentrifuge = instrument that spins test tubes holding mixtures of disrupted cells at various speeds.



Cell fractionation

- To begin fractioning a cell, once must first convert the tissue into a homogenate.

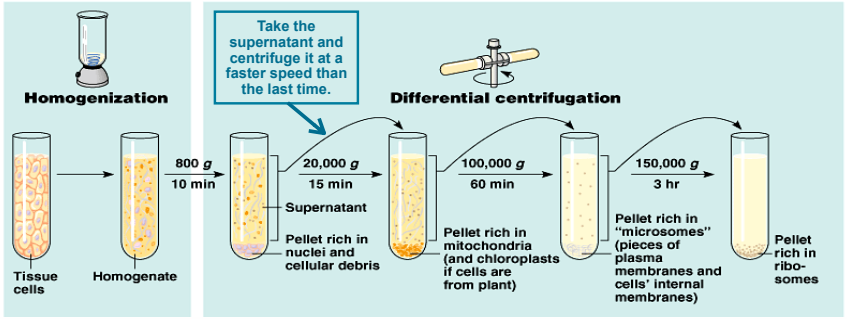


- A tissue homogenate is a suspension of cell fragments and cell constituents (parts) obtained when tissue cells (and their plasma membranes) are mechanically disrupted.

Cell fractionation

Nucleus (large organelle) is separated early. Lighter particles like ribosomes are removed from the supernatant last only after very high *g* forces pull them to the base of the test tube

- Pellet: Cell components that settle at the bottom of the tube
- Supernatant: the solution left behind on top of the pellet
  - At lower speeds, the pellet consists of larger components
  - At higher speeds, the pellet also consists of smaller components
    - Centrifuging, using increasing speeds of rotation (rpm's) allows you to separate specific cell components in bulk for studying



Ultracentrifuge

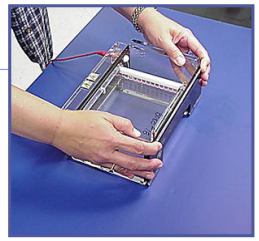
- spins up to 130,000 rpm
  - forces = 1 million times the force of gravity (1,000,000*g's*)

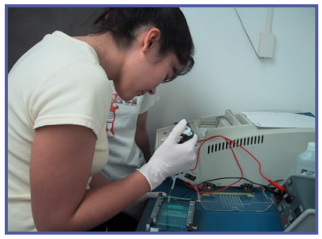
Why is it in a BIG thick lead-lined housing?

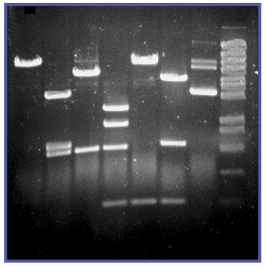
Safety - In case any part breaks loose

Microcentrifuge - spins at lower rpm's

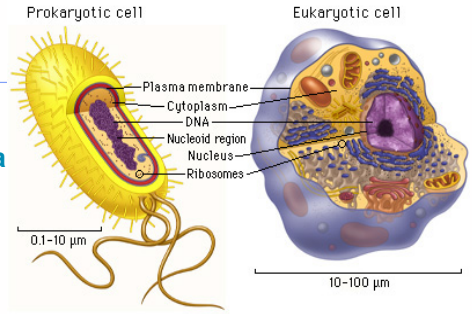
- Used a lot in Biotechnology research
  - To study cells at protein & genetic (DNA) levels



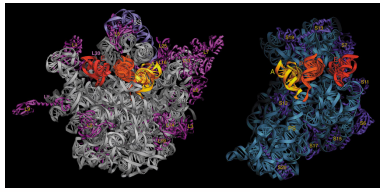




Cell characteristics



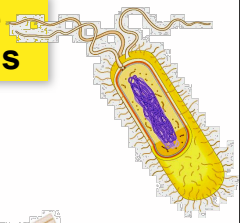
- All cells:
  - Are surrounded by a "selective barrier" called the plasma membrane
  - Have cytosol
    - semi-fluid substance within the membrane
    - cytoplasm = cytosol + solutes (for ex: organelles)
    - contain chromosomes which have genes in the form of DNA

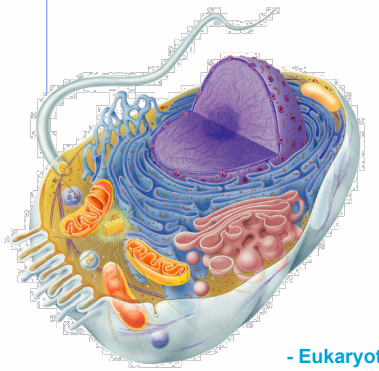


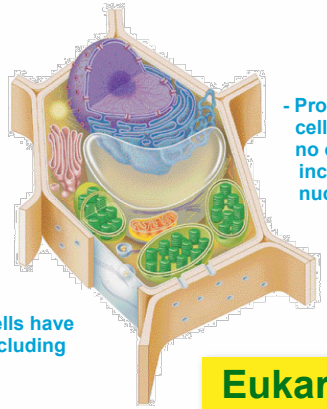
- Have ribosomes
  - tiny complexes that make proteins using instructions contained in genes
  - Ribosomes are NOT organelles since they are not membrane-bound, but are complexes of proteins and RNA

Types of cells

Prokaryote bacteria cells







- Prokaryotic cells contain no organelles including no nucleus

- Eukaryotic cells have organelles including a nucleus

Eukaryote animal cells

Eukaryote plant cells

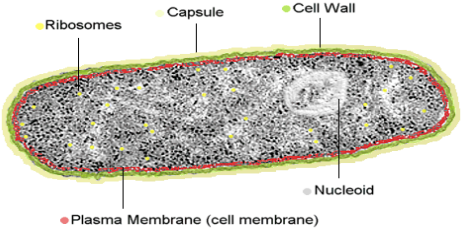
Types of cells

- Prokaryotic vs. eukaryotic cells
  - Difference: # of chromosomes, location of chromosomes, & presence of organelles

Prokaryotic cell

(Greek pro = before & karyon = kernel)

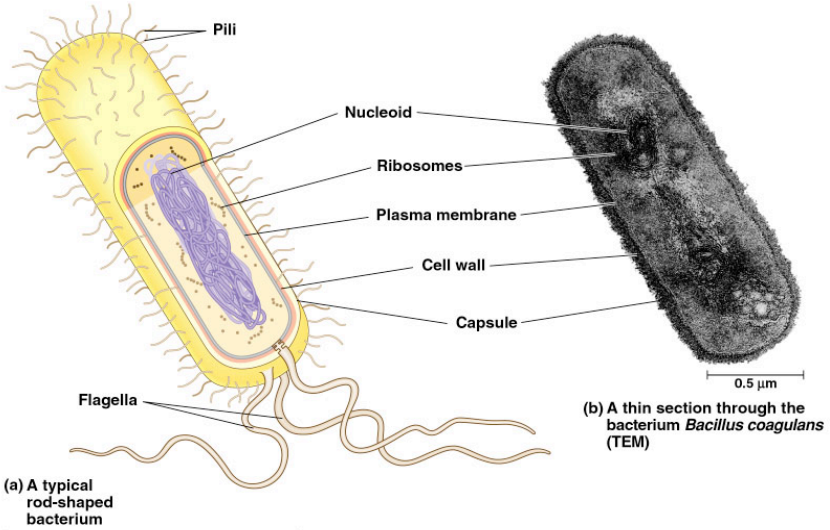
- DNA in nucleoid region, without a membrane separating it from rest of cell



Eukaryotic cell

(Greek eu = true & karyon = kernel)

- chromosomes in nucleus, double membrane-enclosed organelle

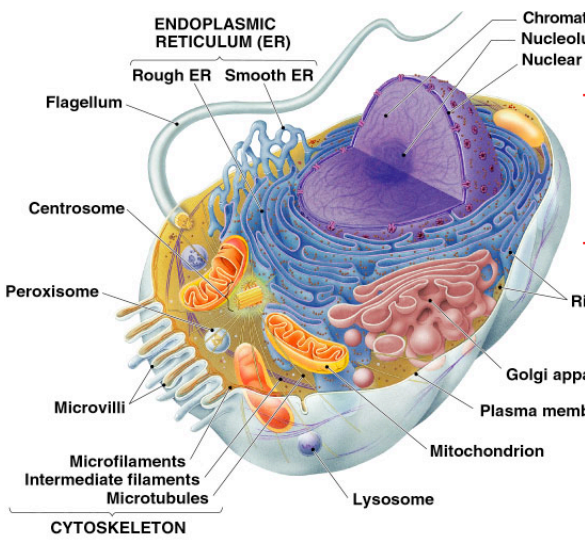


The prokaryotic cell is much simpler in structure, lacking a nucleus and the other membrane-enclosed organelles of the eukaryotic cell. *[Pili (aka fimbriae), capsule, & flagella are not found on all prokaryotes]*

Eukaryotic cells

- Eukaryotic cells are more complex than prokaryotes
  - within cytoplasm are a variety of membrane-bounded organelles
    - specialized compartments with special structures that enable cells to divide and conquer!
    - sequester chemical processes and do various incompatible activities simultaneously
  - Even plasma and organelle membranes participate directly in cell's metabolism since many enzymes are built right into these membranes
    - Each double layer phospholipid membrane does have a unique composition of lipids and proteins that help with its function
- Eukaryotic cells are generally bigger than prokaryotic cells

Generalized Animal Cell



- some structures vary in quantity depending on the cell's function and needs.

For ex: The number of mitochondria or amount of ER or the shape of the cytoskeleton may vary.

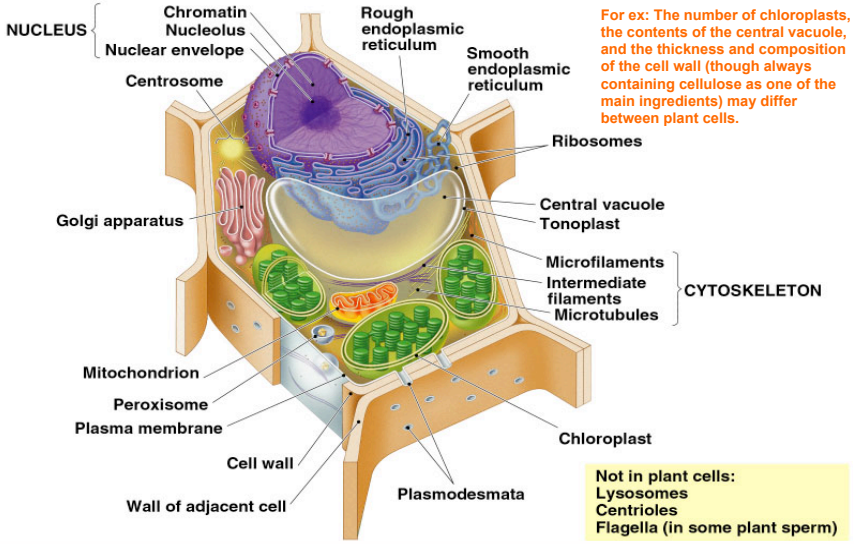
- not all animal cells have flagella or microvilli.

Not in animal cells:
Chloroplasts
Central vacuole and tonoplast
Cell wall
Plasmodesmata

Generalized Plant Cell

- some structures vary in quantity depending on the cell's function and needs.

For ex: The number of chloroplasts, the contents of the central vacuole, and the thickness and composition of the cell wall (though always containing cellulose as one of the main ingredients) may differ between plant cells.



Not in plant cells:
Lysosomes
Centrioles
Flagella (in some plant sperm)