Introduction to Cell

BMSC1101
BMSN1601

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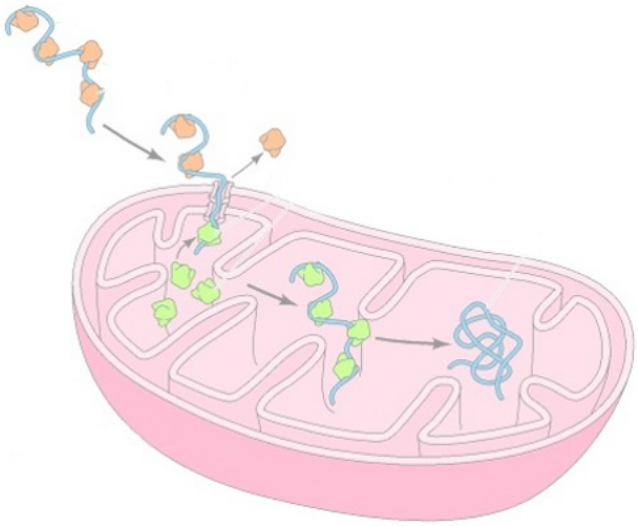


Learning Objectives

01 Summarize the cell theory

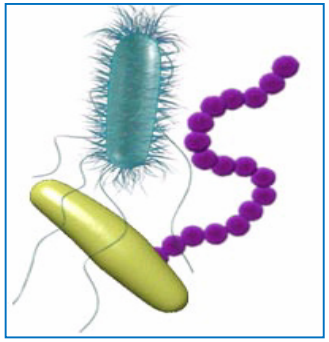
02 Compare and contrast prokaryotic and eukaryotic cells

03 Describe the structures and functions of major organelles of animal cells

References
Molecular Biology of the Cell by Alberts B, Johnson A, Lewis J, et al.
Molecular Cell Biology by Lodish H, Berk A, Zipursky L, et al.
The Cell: A Molecular Approach by Cooper GM.

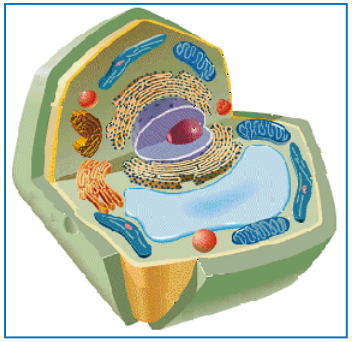
Cells

- Smallest living unit - basic unit of life
- Cytology - study of cells
- Three basic types of cells:



Bacterial cell

Animal cell



Plant cell

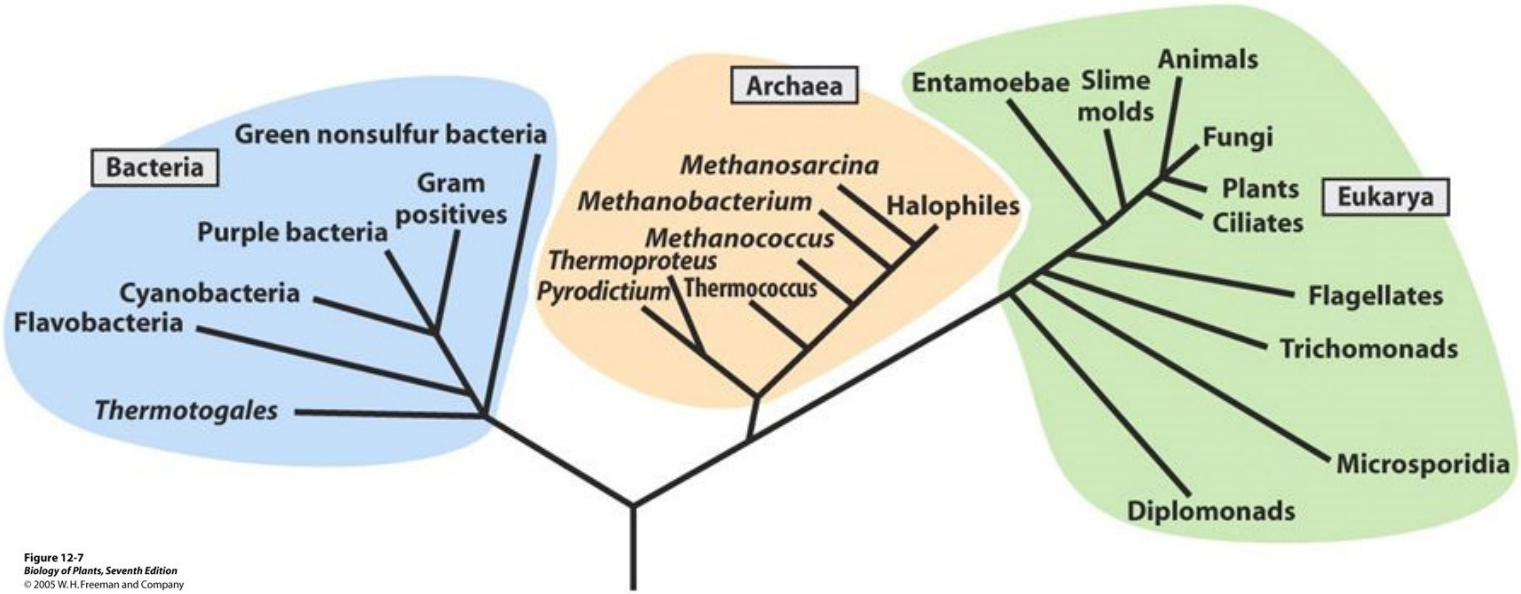
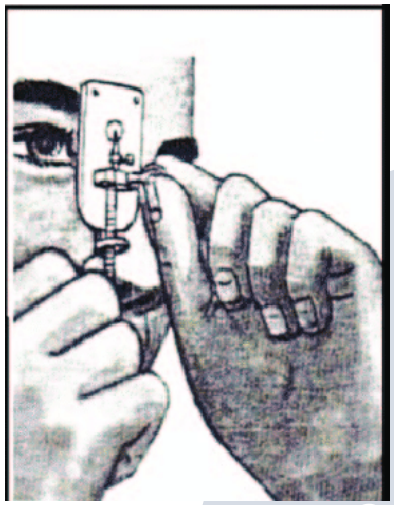


Figure 12-7
Biology of Plants, Seventh Edition

Discovery of cells



- What invention is necessary to observe cells?

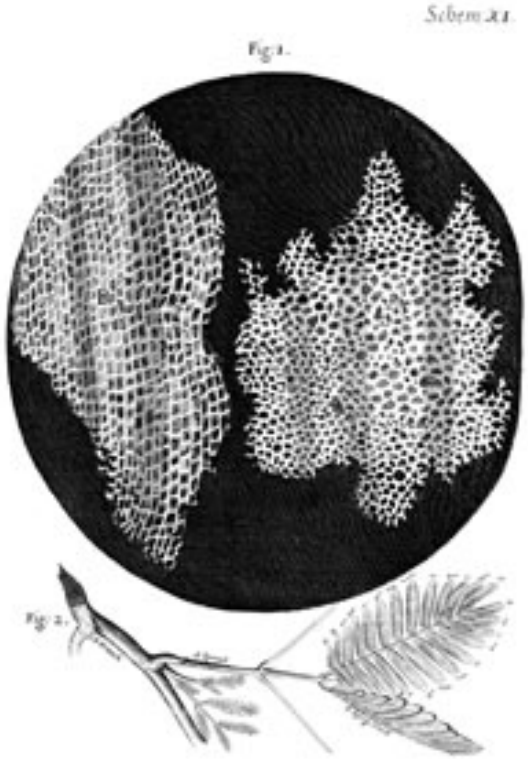
- What was the first cell type discovered?

Discovery of cells

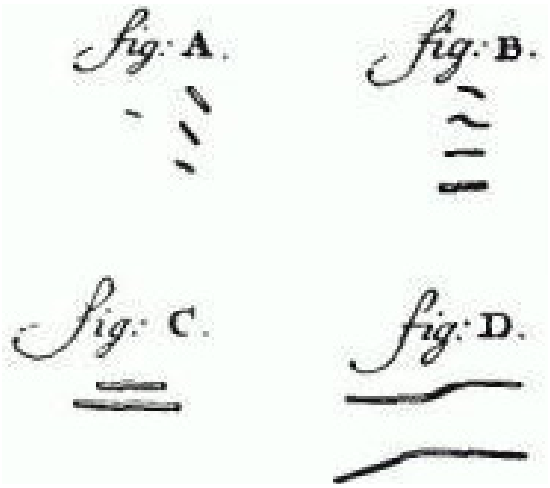
- The first to view cells

  Robert Hooke (1665): observed a thin slice of cork (dead plant cell wall)

  The structure looked like the small rooms that monks lived in (called cells).



- Anton van Leeuwenhoek (1675): the first to describe living cells.
  He examined pond water & scrapings from his teeth.



The cell theory

Who developed the cell theory?

- Matthias Schleiden (1838): concluded that all plants are composed of cells.
- Theodor Schwann (1839): concluded that all animals are composed of cells.
- Rudolph Virchow (1855): observed cells dividing under the microscope.

Principles of cell theory:

1. All living things are composed of one or more cells.
2. Cells are the basic unit of structure and function in an organism.
3. Cells come only from other pre-existing cells (cell division).

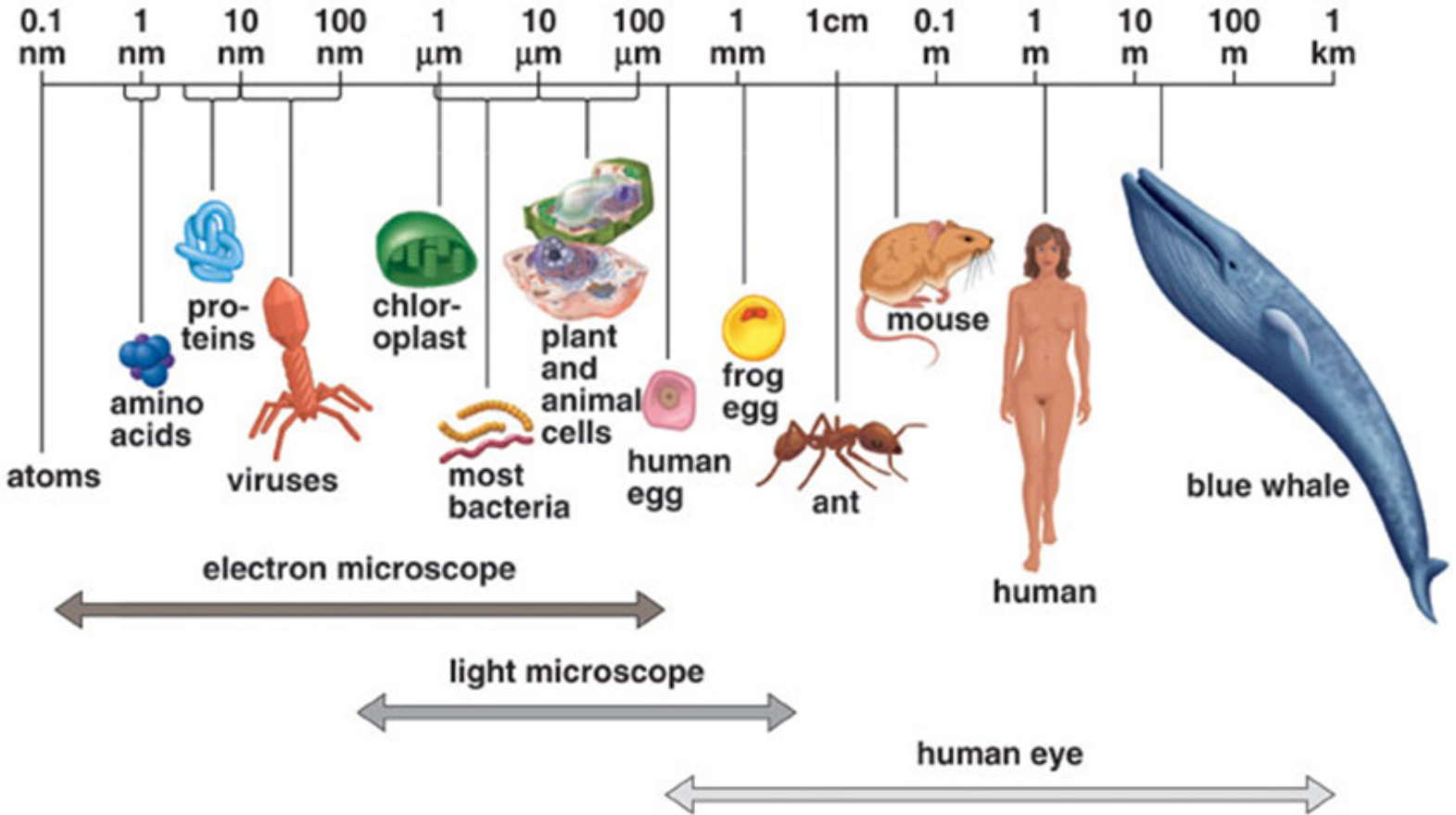
Cell diversity

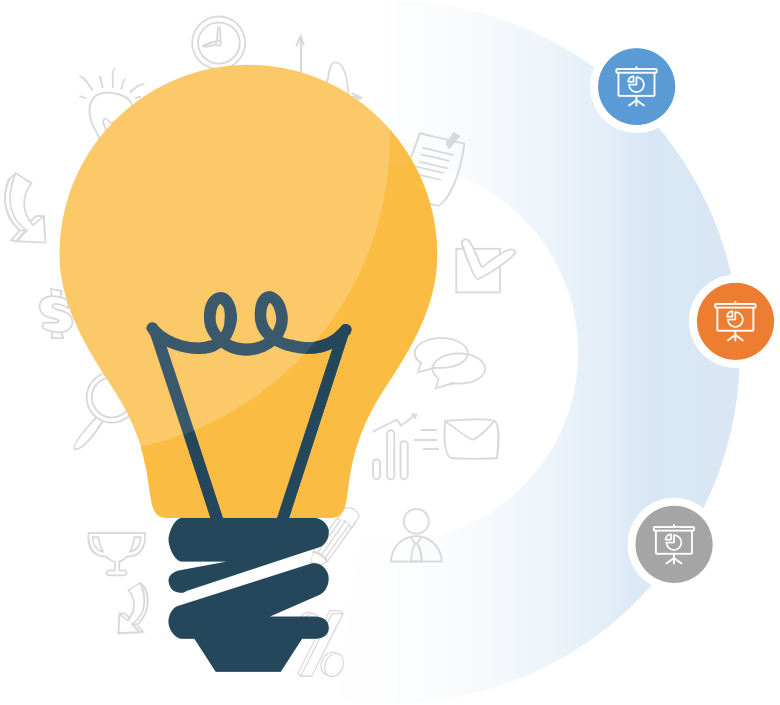
- Size
- Shape
- Cellular organization

Cell size

Most cells are visible only with a microscope.

Bacteria: 1-10µm, smallest cells
Typical animal cells: 10-50µm
Typical plant cells: 10-100µm
Chicken egg (the yolk): 3cm

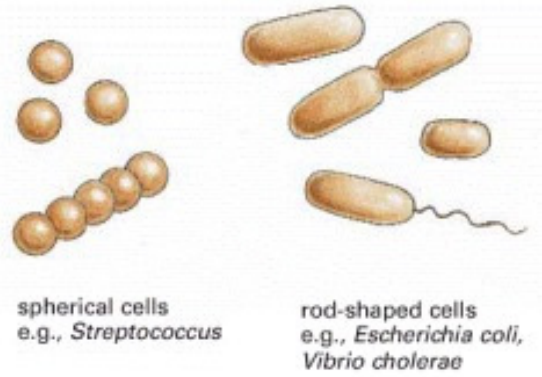




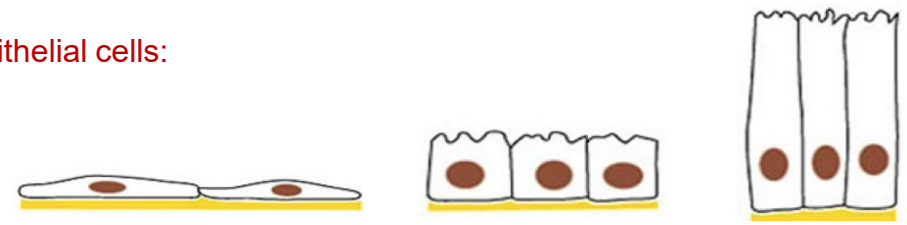
Are the cells in an elephant bigger, smaller, or about the same size as those in a mouse?

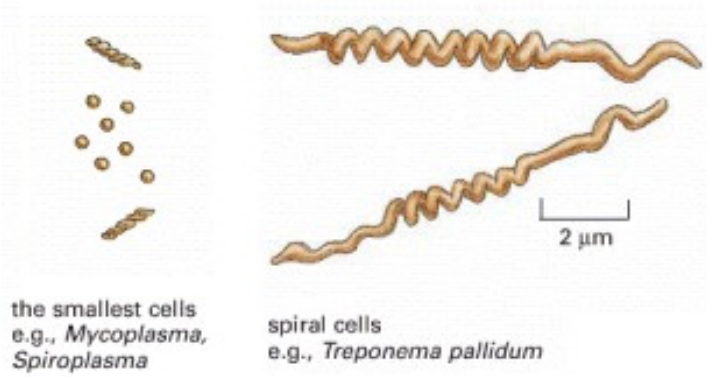
Cell shape

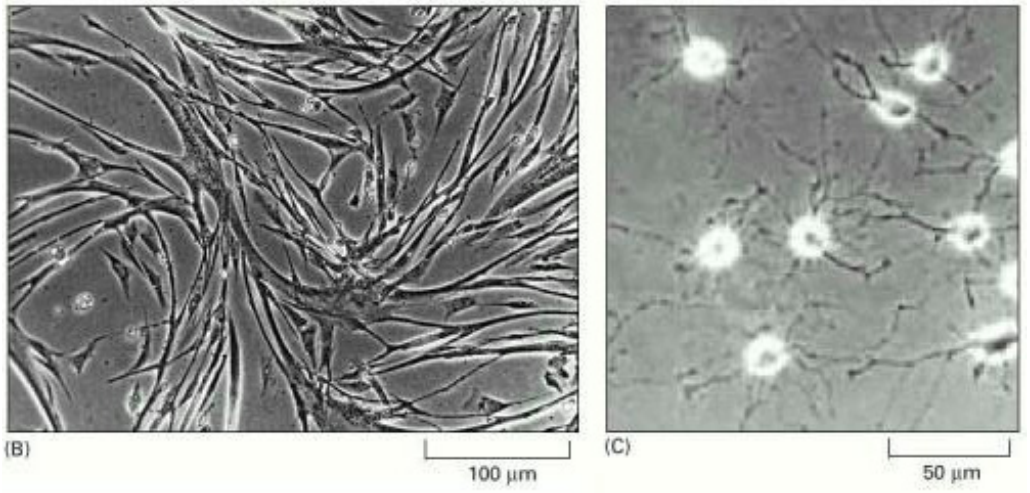
- Cells differ widely in shape.
- Different shapes reflect a diversity of functions.



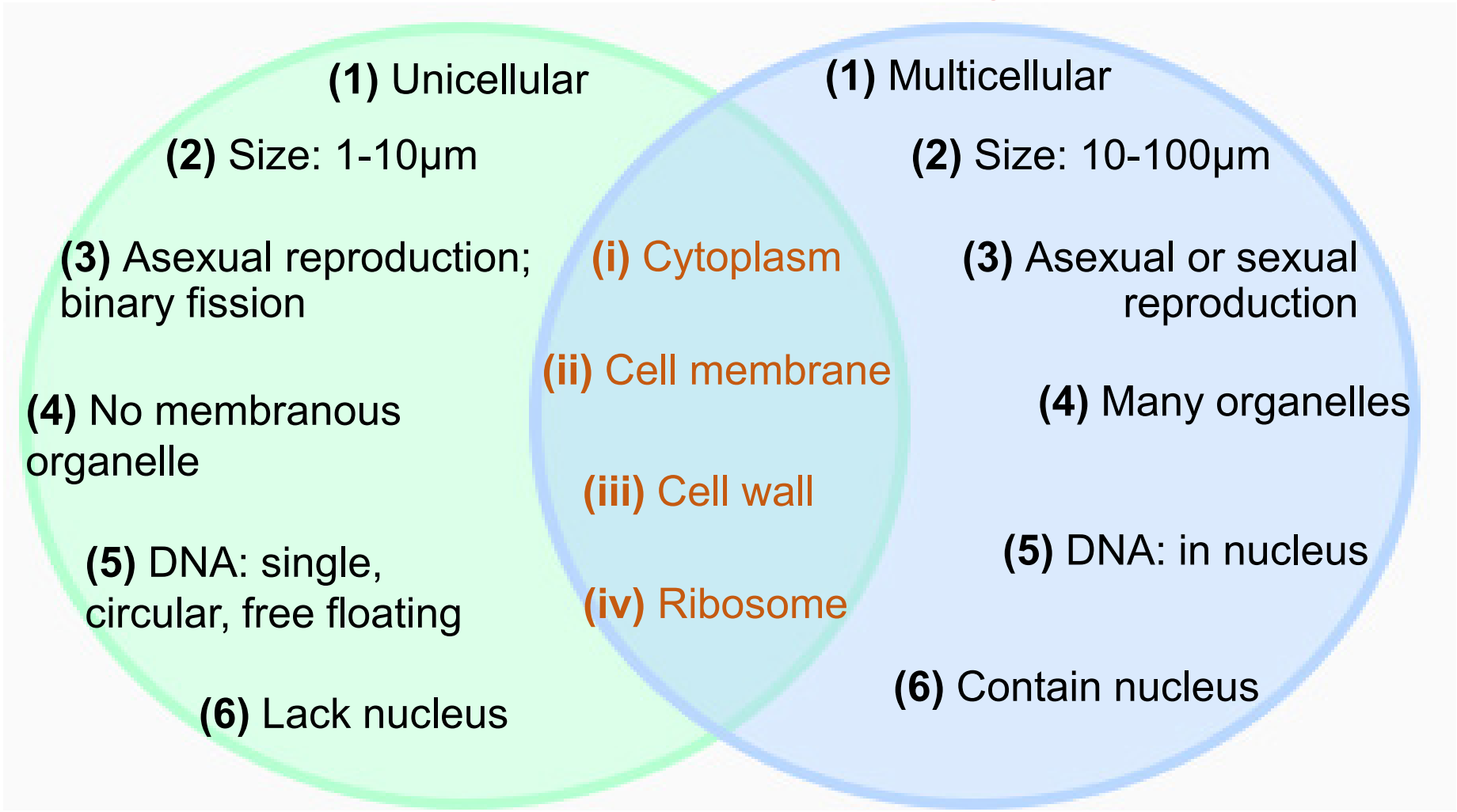
Epithelial cells:







Cellular organization



Examples: bacteria, archaea

Examples: animals, plants, fungi

*Animal cells do not contain chloroplast/cell wall.

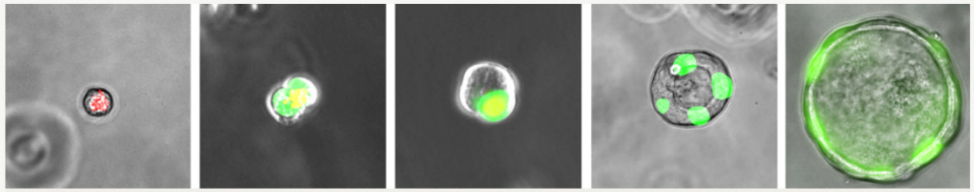
>200 cell types in human

Penn Researchers Discover New Cell Type in Human Lung with Regenerative Properties

Findings shine light on underpinnings of COPD, pave new direction for future research on treatments

April 01, 2022

2022



Human ES cell derived RASC (respiratory airway secretory cell) transitioning to an Alveolar type 2 cell over time in culture

PHILADELPHIA— A new type of cell that resides deep within human lungs and may play a key role in human lung diseases has been discovered by researchers at the Perelman School of Medicine at the University of Pennsylvania.

The researchers, who report their findings today in *Nature*, analyzed human lung tissue to identify the new cells, which they call respiratory airway secretory cells (RASCs). The cells line tiny airway branches, deep in the lungs, near the alveoli

New Type Of Stem Cell Discovered

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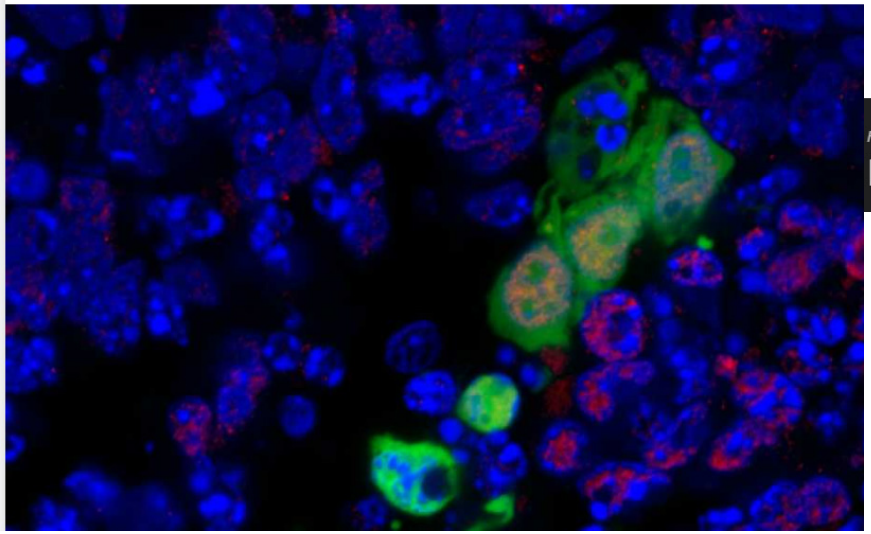
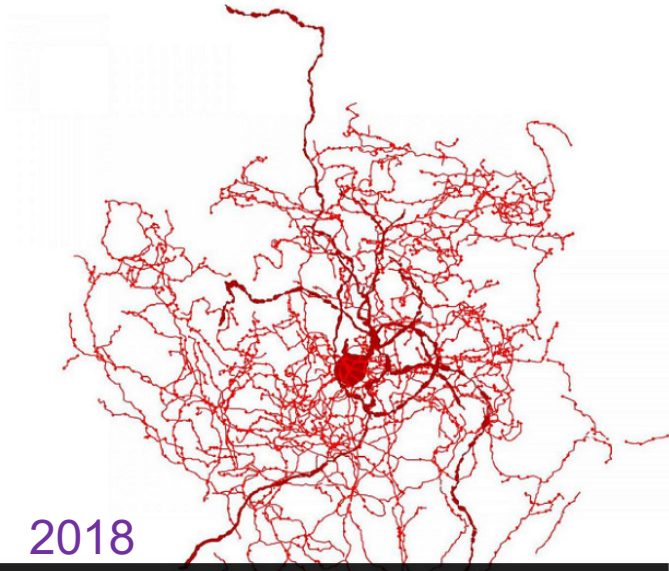
2015





2018

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New Cell Type Discovered in Human Brains

Eukaryotic cell

All cells take in food, get rid of waste and reproduce.

Basic cell structures:

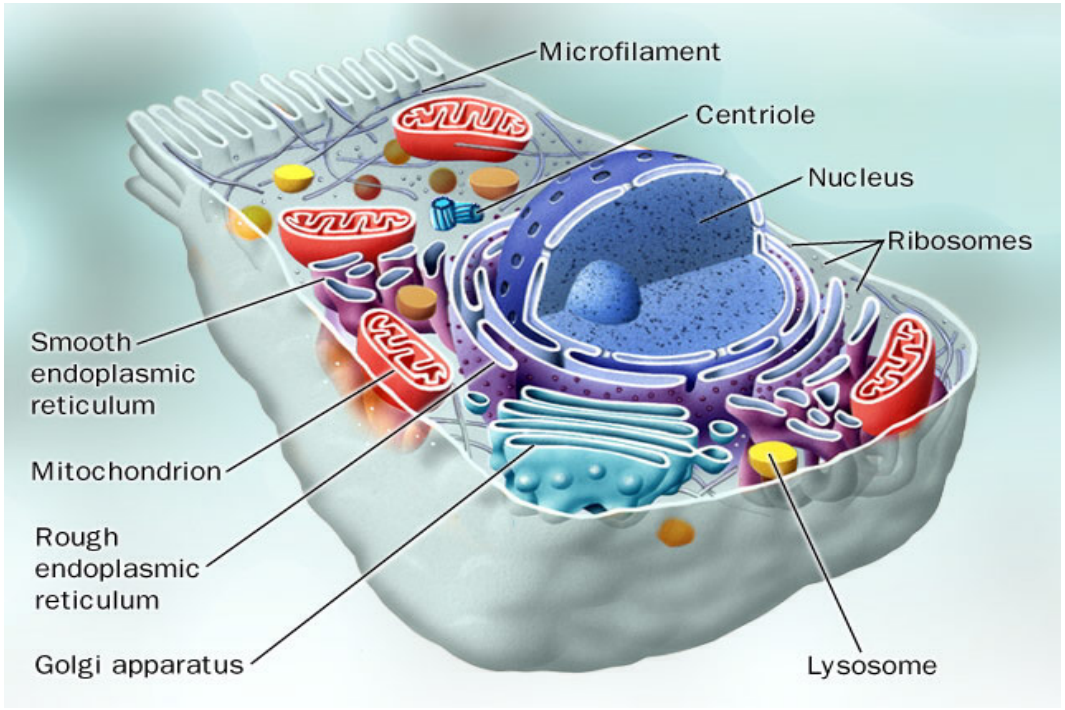
(1) Cell Membrane

(2) Cytoplasm

(3) Nucleus

(4) Organelles

- in cytoplasm
- most are membrane-bound
- cellular machinery



Plasma membrane

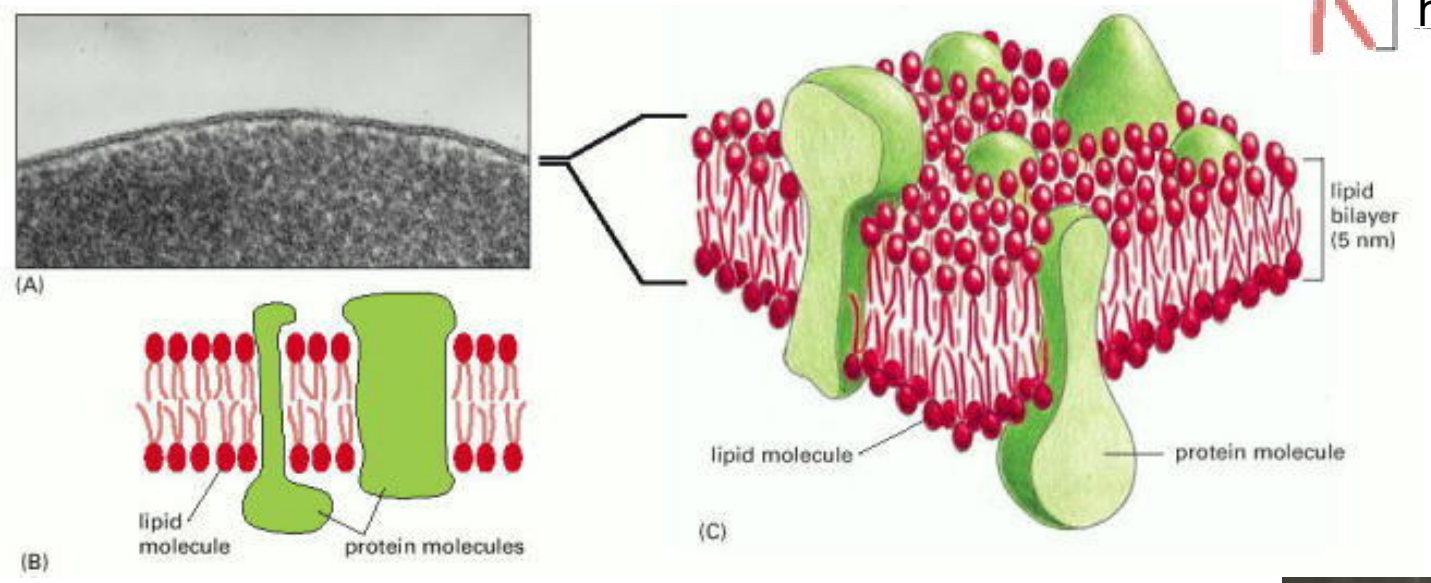
- Structure: phospholipid bilayer with proteins

- Semipermeable

- Molecules within cell membranes are highly mobile.

hydrophilic head

hydrophobic tails

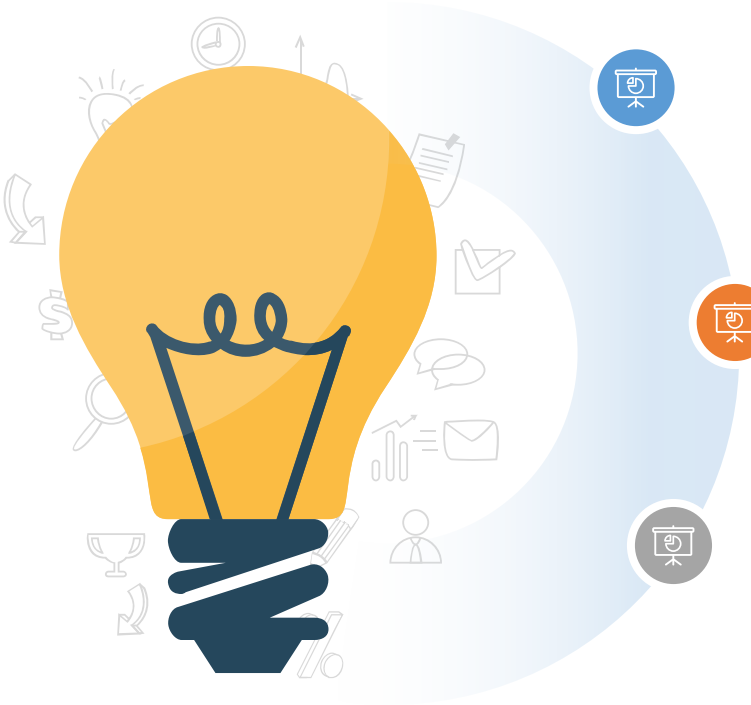


- Functions:

  (1) Separates the cell interior from the environment

  (2) Controls molecules that enter or exit the cells

Which of the following can pass through the cell membrane by simple diffusion?



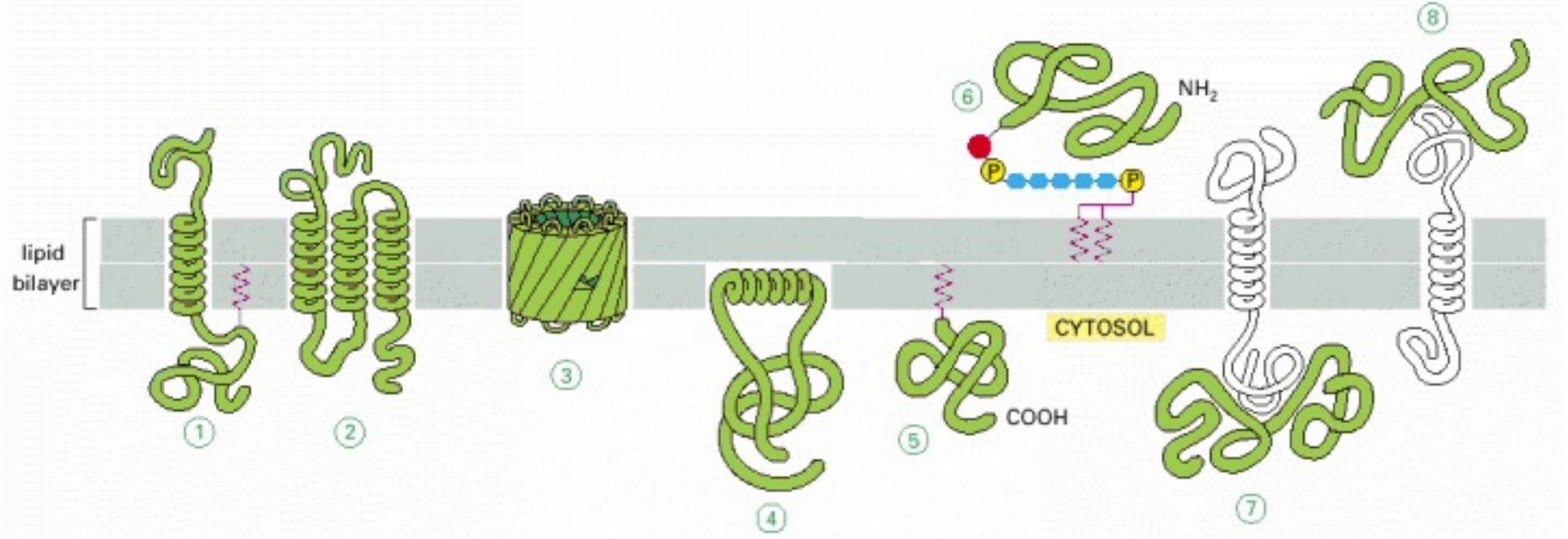
A. Carbon dioxide/oxygen

B. Steroid hormones

C. DNA

Membrane proteins

1. Receptors
   - Recognize and interact with ligands to mediate downstream signaling
2. Glycoproteins
   - Identify cell type, act as markers for cell recognition
3. Channels or transporters
   - Move molecules across the membrane
4. Enzymes
   - Catalytic reactions (intracellular)



Cytoplasm

- Structure: viscous fluid that lies inside the cell

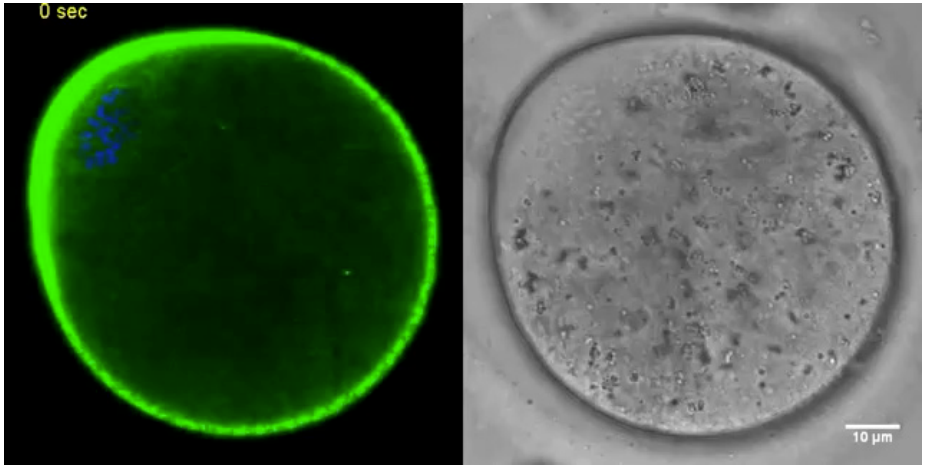
- Constitutes >50% of the total volume of the cell

- Functions:

  (1) Holds organelles to perform specific roles

  (2) Provides a medium for chemical reactions

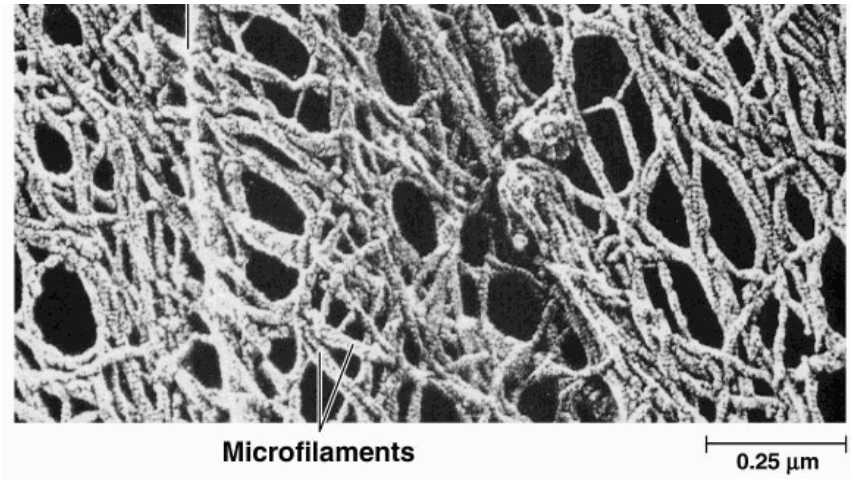
Cytoplasmic streaming

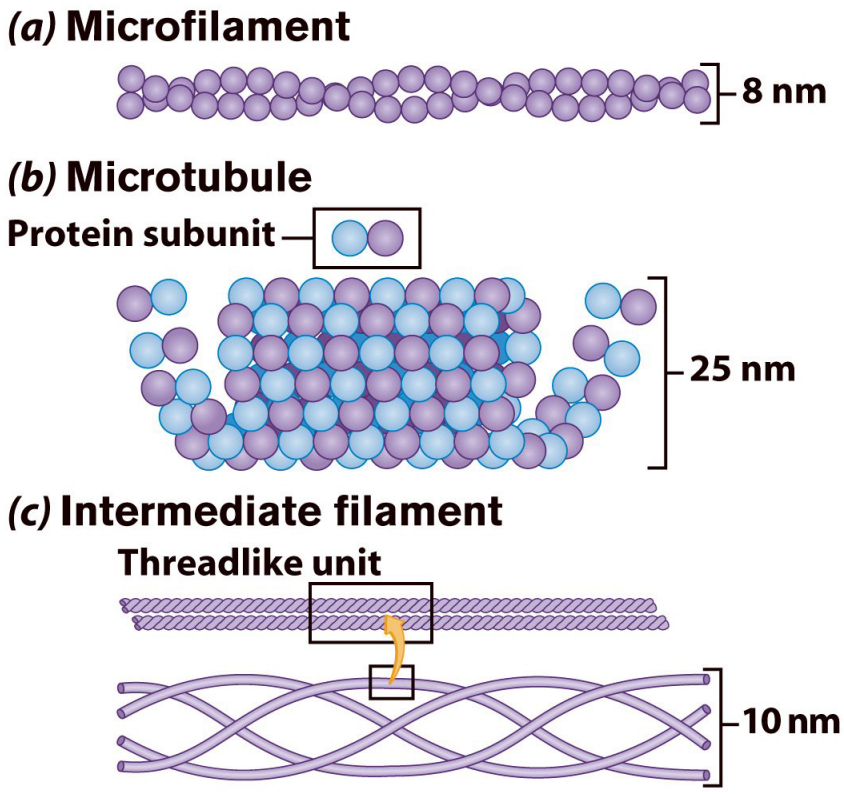


Cytoskeleton

- Structure: network of protein filaments extending throughout the cytoplasm

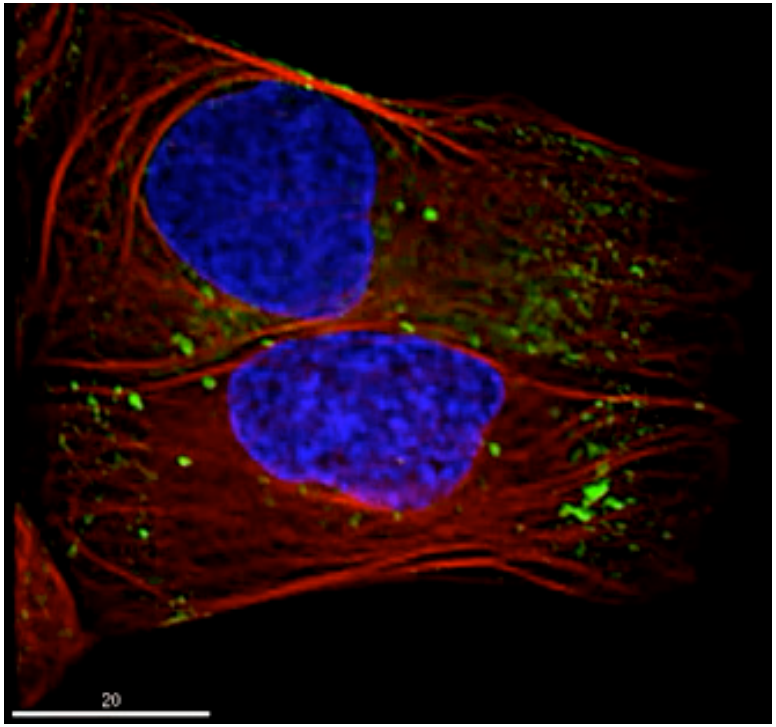
- Made of 3 types of fibers:
  - (1) Microfilaments
  - (2) Microtubules
  - (3) Intermediate filaments

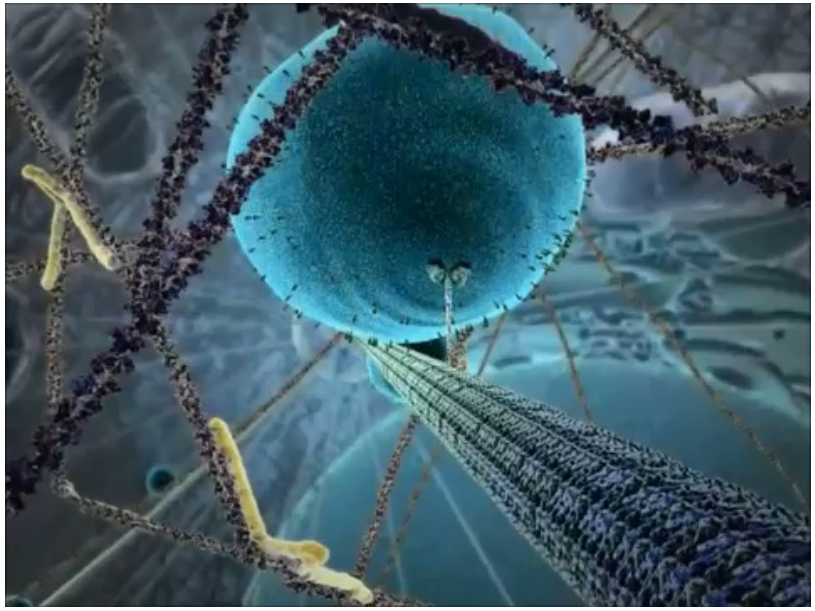




Cytoskeleton

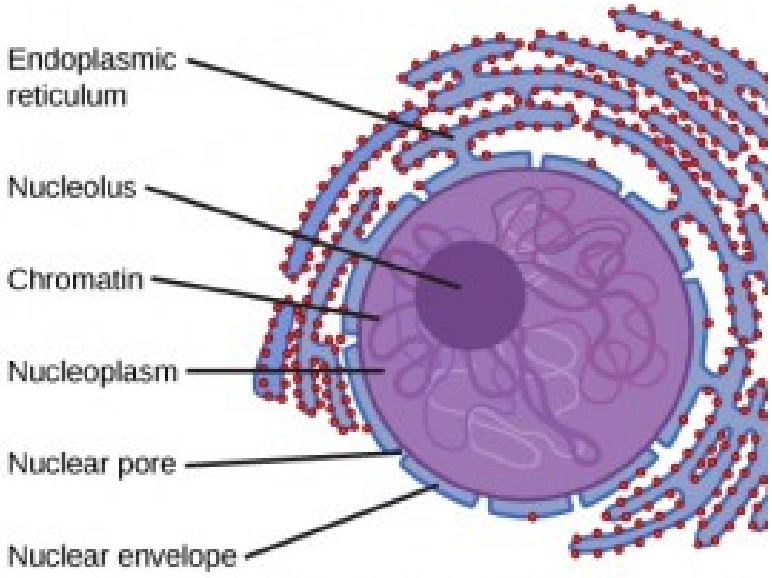
- Functions:
  (1) Provides a structural framework for the cell (maintain cell shape)
  (2) Movements of the entire cell
  (3) Intracellular transport



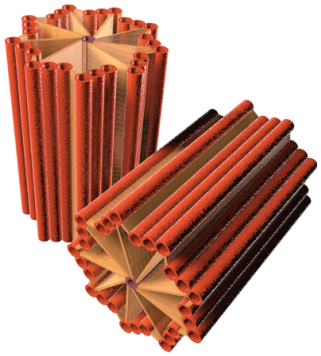


Nucleus

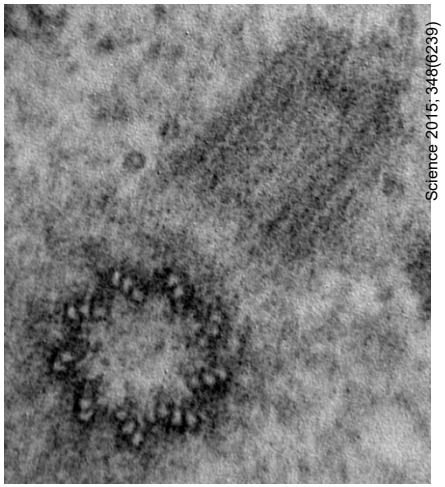
- Brain of cell (the “control” organelle)
- Structure:
  - Bounded by nuclear envelope
    - 2 phospholipid bilayers
    - Outer nuclear membrane is continuous with endoplasmic reticulum
    - Contains nuclear pores for material entry and exit
  - Contains nucleolus
    - A cell may have 1 to 3 nucleoli
    - Produces ribosomal RNA (rRNA) which makes ribosomes
- Functions:
  (1) Storage center of DNA
  (2) Ribosome production

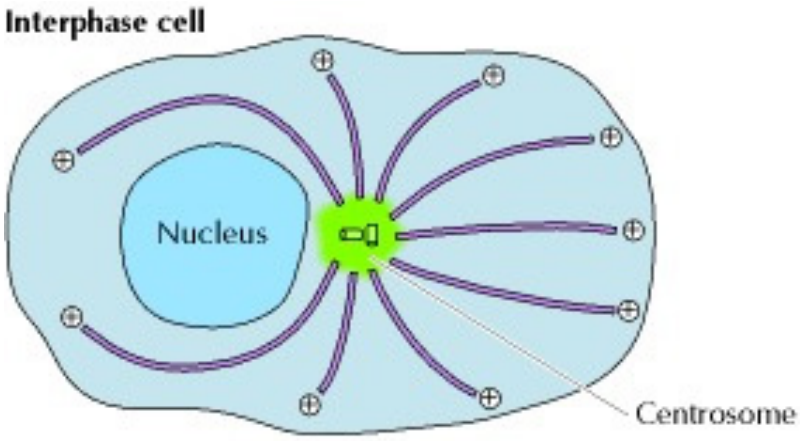


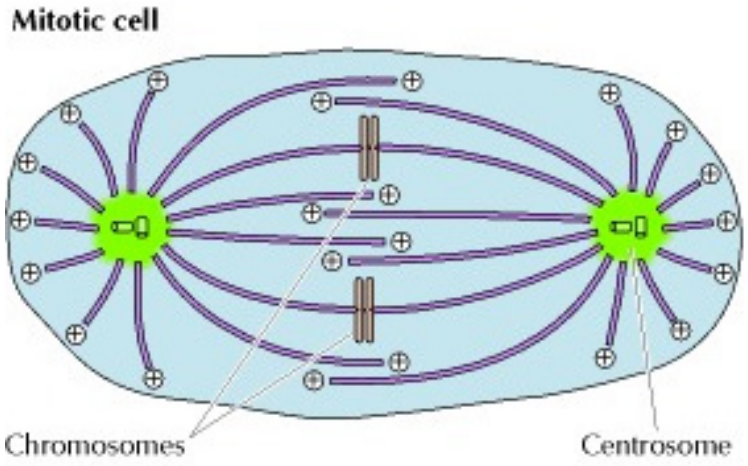
Centriole



- Only in animal cells
- Locates near nucleus
- Structure: nine sets of triplet microtubules arranged in a ring
  - Exist in pair, at right angles to each other
- Function: Helps pulling the duplicated chromosomes to opposite ends of the dividing cell

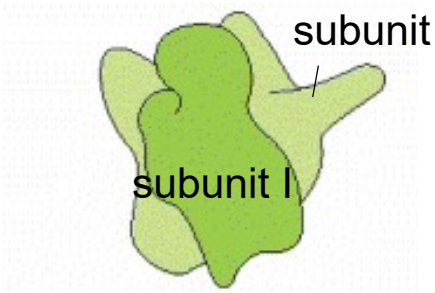






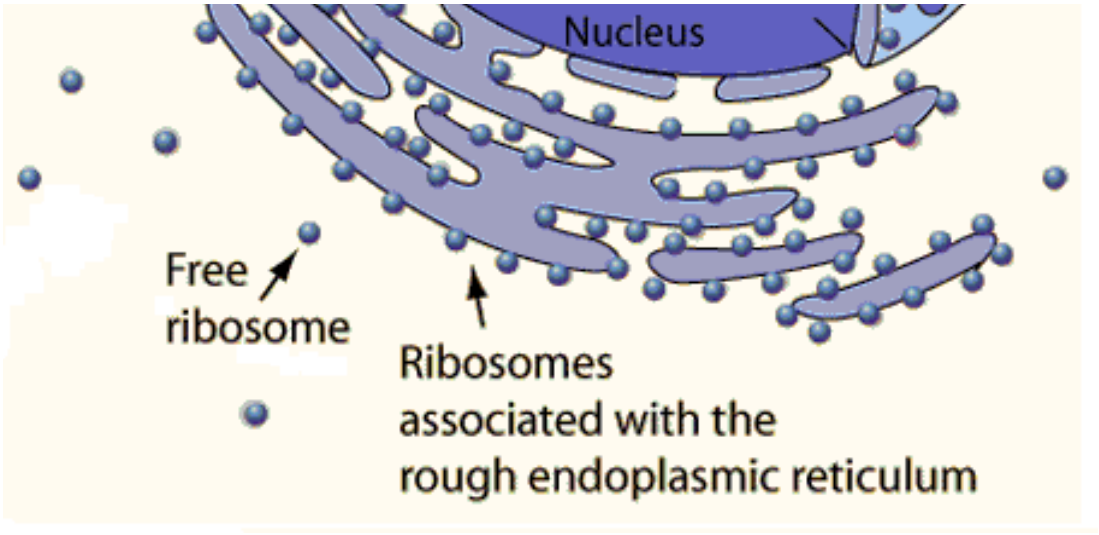
Ribosome

- Structure:
  - Consist of two subunits, each comprised of both proteins and rRNA
  - Assembled at nucleolus



- Function:

  Protein synthesis



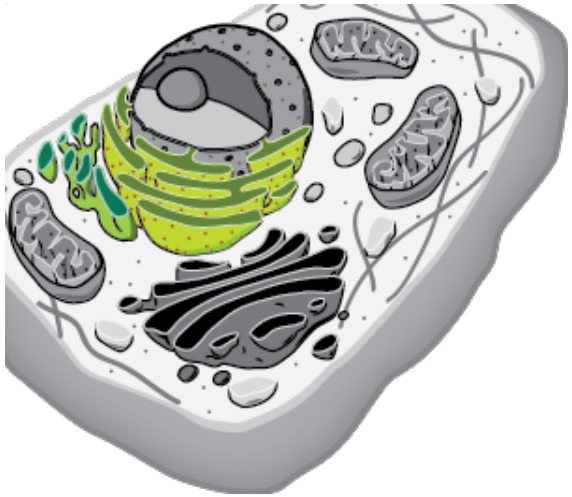
- An active proliferating mammalian cell may contain ~10 million ribosomes

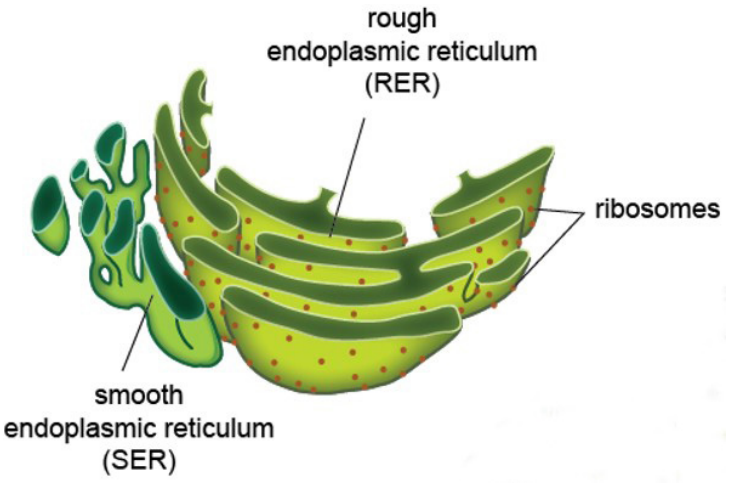
Endoplasmic reticulum - ER

- Structure: a network of interconnected membranous tubules and sacs extending throughout the cytosol

- Accounts for ~half of all cell membranes

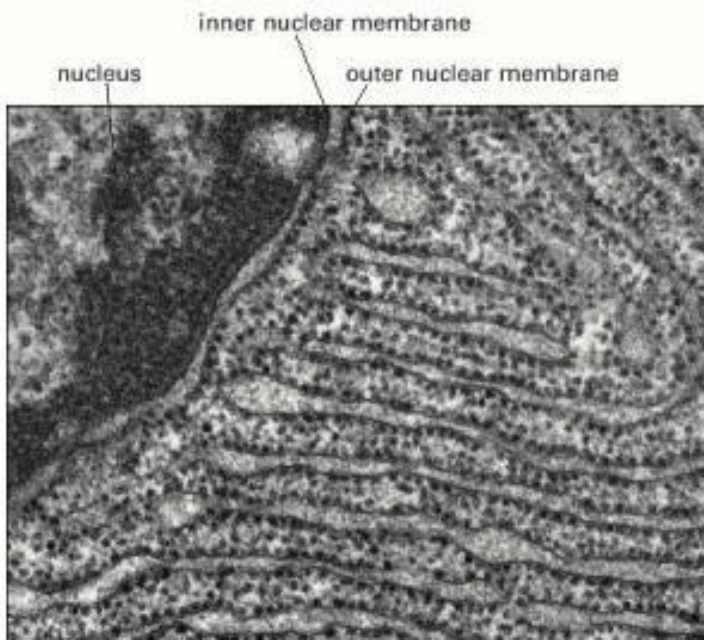
- Two types:
  - Rough endoplasmic reticulum
  - Smooth endoplasmic reticulum





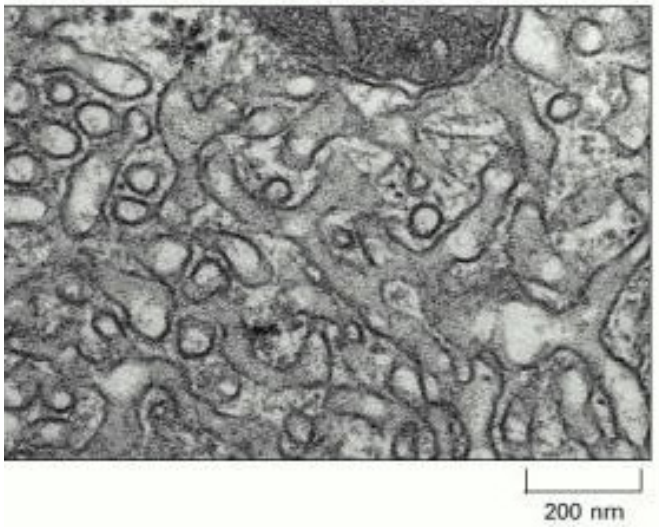
Rough endoplasmic reticulum

- Connects to nuclear envelope
- Has ribosomes on surface
- Mainly functions in protein processing
- Abundant in cells that make lots of proteins



Smooth endoplasmic reticulum

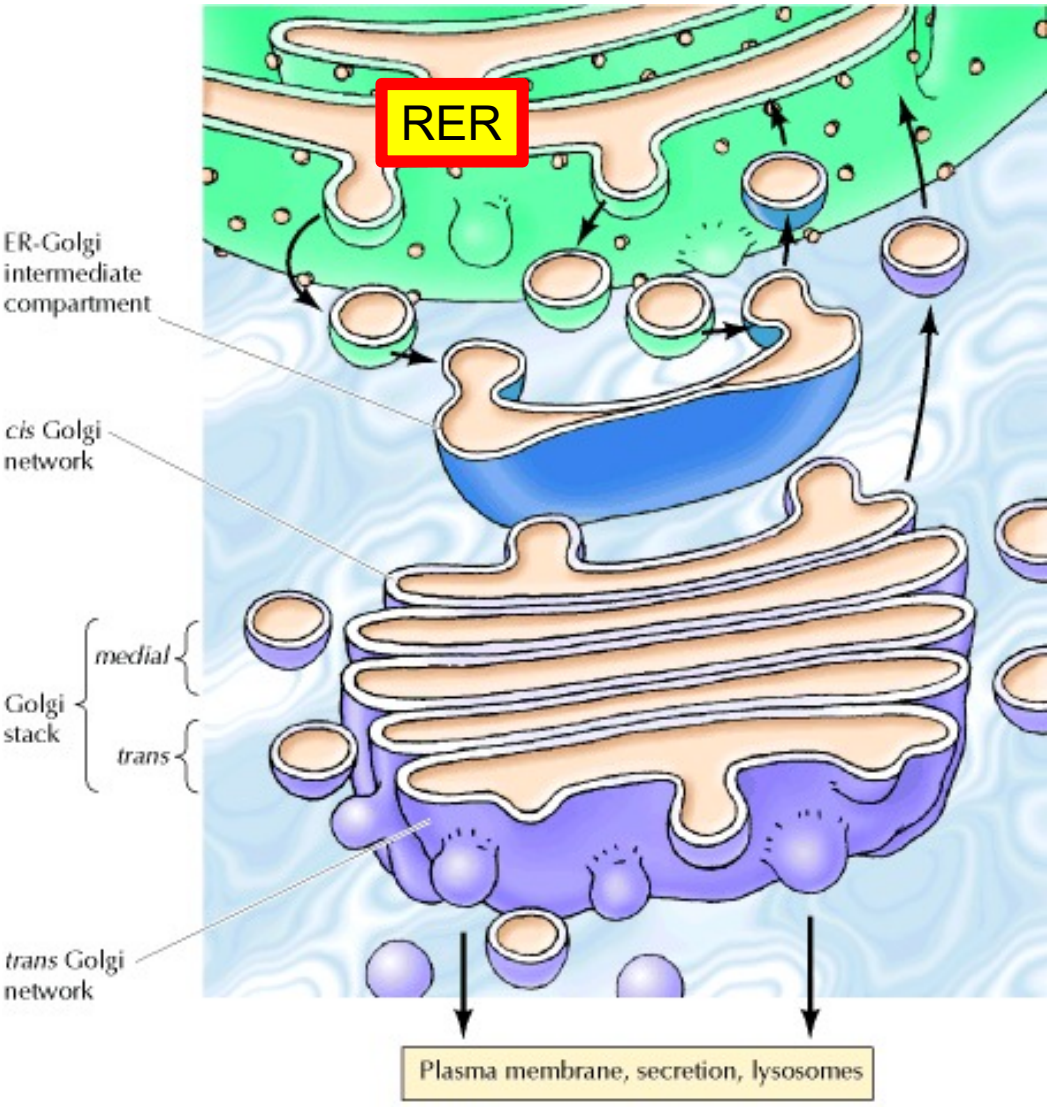
- Ribosome-free
- Lipid synthesis, regulate calcium storage, breakdown of toxic substances

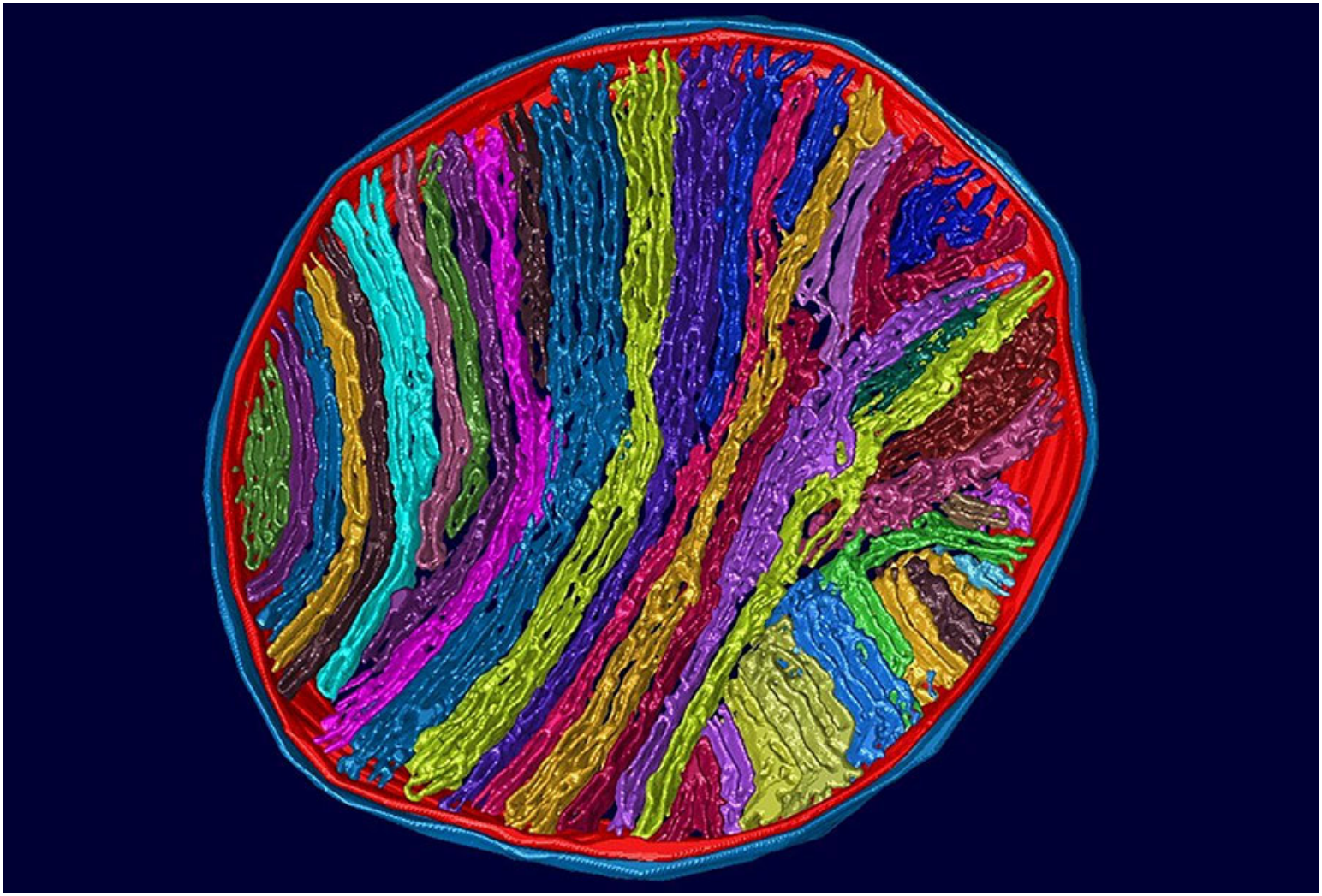


Golgi apparatus

- Structure: stacks of flattened membrane vesicles or sacs
- Function:
  - Receives proteins from RER → modify, sort, package, and ship (to other organelles or export out of the cell)

- The Golgi sacs have 3 defined faces:
  (1) the *cis* - receiving side
  (2) the *medial* - processing
  (3) the *trans* - shipping side





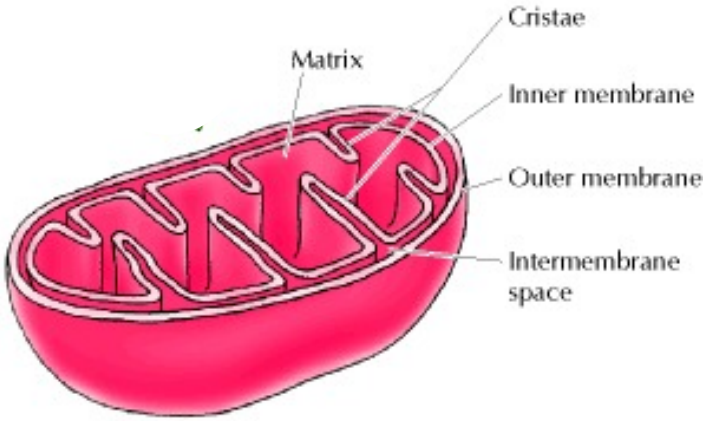
Electron microscopic tomography

Photo credit: Adams RA et al
Krasnow Institute for Advanced Study and School of Systems Biology, George Mason University

Mitochondrion

Plural = mitochondria

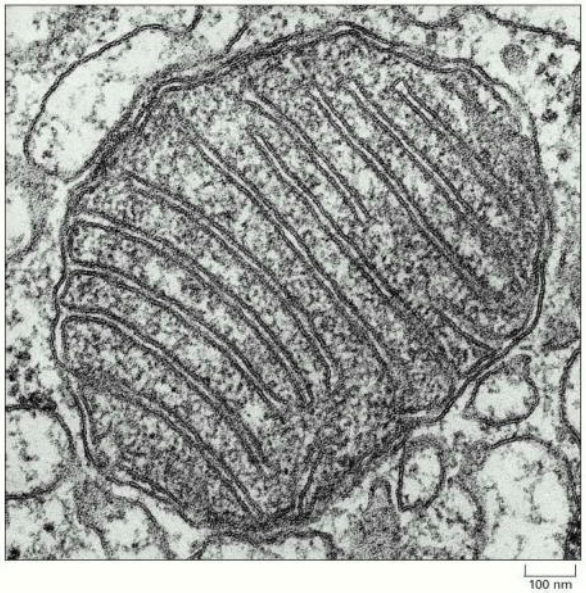
- “Powerhouse” of the cell
- Structure:
  - Double membrane
    - Folded inner membrane called cristae (increases surface area for chemical reactions)



- Function:

  Cellular respiration
    - Converts energy in food into usable cellular energy (ATP)

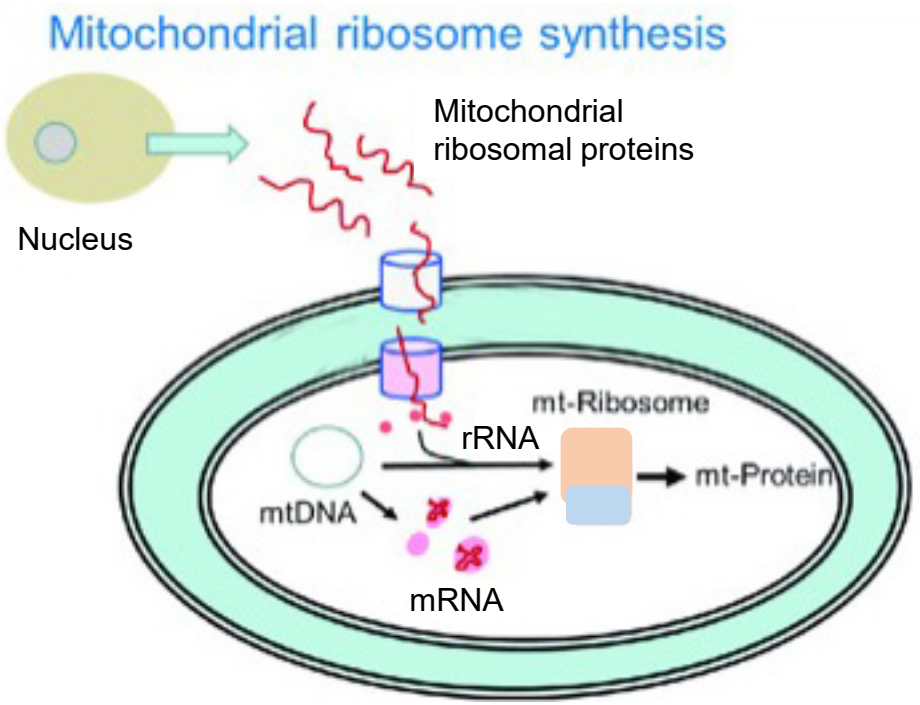
- Active cells (e.g. muscle cells) have more mitochondria.



Contains its own DNA (mDNA or mtDNA)

- Inherit from mother

Contains mitochondrial ribosomes

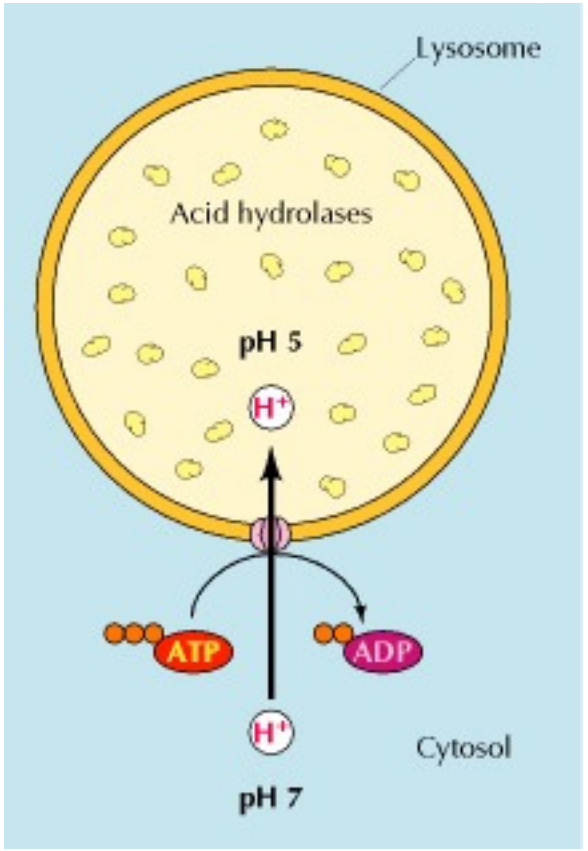


Lysosome

- “Recycling” center
  - Recycle cellular debris
- Structure: single membrane-enclosed

- Function: contain enzymes, digests all types of biological polymers (proteins, nucleic acids, carbohydrates, and lipids)

- All enzymes are acid hydrolases (effective only in acidic environment). WHY?

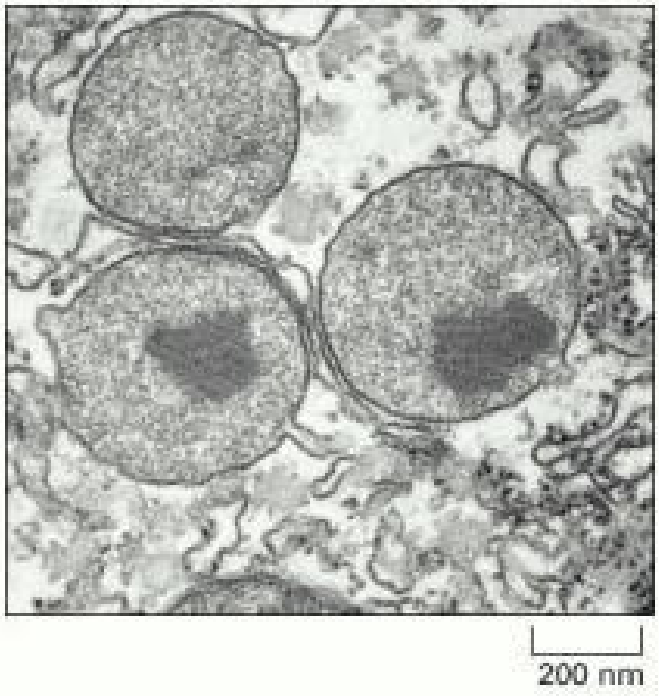


Peroxisome

- Structure: spherical organelles with single membrane

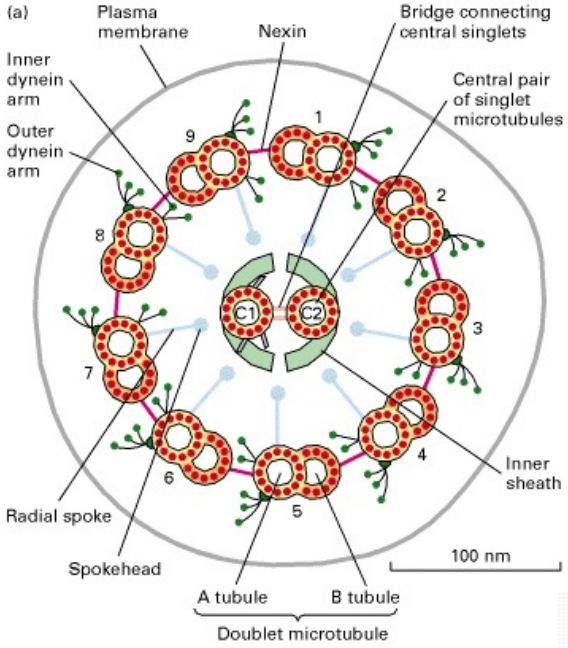
- Function:

contains enzymes to break down fatty acid, uric acid, amino acid, hydrogen peroxide (toxic)



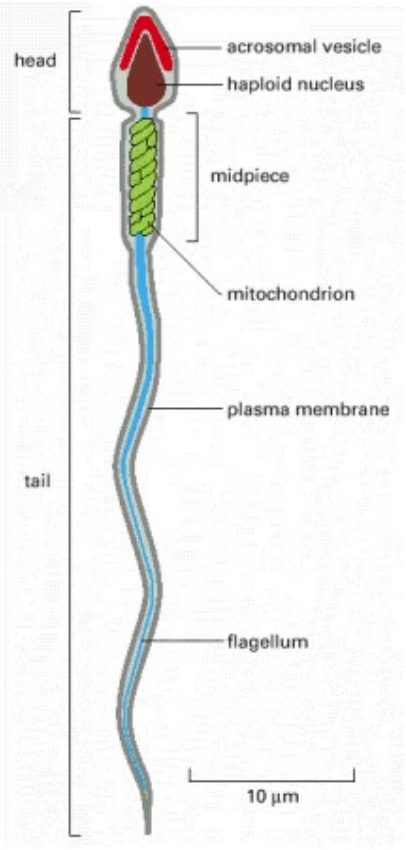
Cilium and Flagellum

- Structure: hair-like organelles on cell surface
  - Both organelles are composed of 9 pairs of microtubules arranged around a central pair (9+2 arrangment).



- Flagellum:

  Plural = flagella
  - Long
  - Usually one flagellum or a few flagella on one cell
  - Used to move an entire cell
  - Example: sperm



Cilium:

Plural = cilia

- Short
- Numerous in number
- Along the entire surface of plasma membrane
- Move substances along the outer surface of the cell
- Example: >10^7/mm^2 cilia lining the cells of respiratory passages