

Chapter 2

The Cell: the Basic Unit of Life



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Cells

2

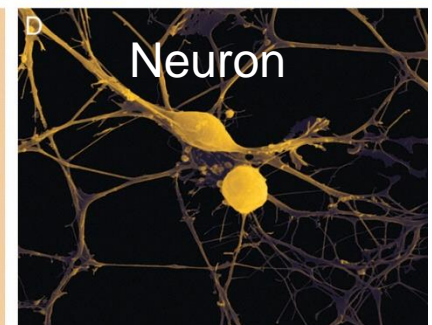
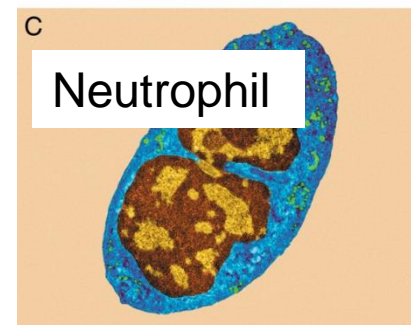
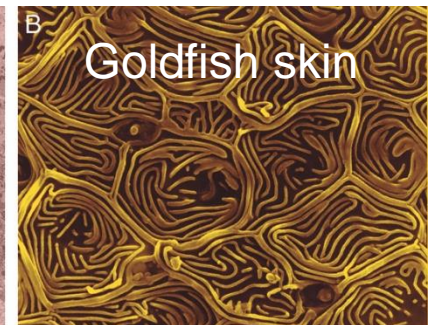
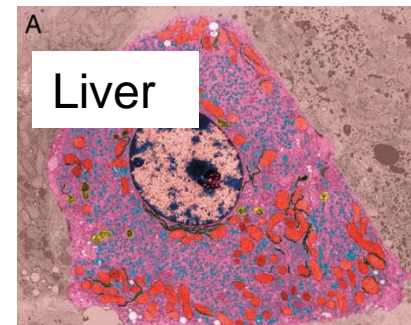
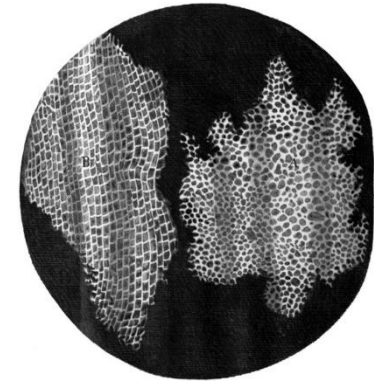
Cell Organization

3

Two Fundamental Cell
Types

Cells

- Basic unit of living organism
- First named by Robert Hook in the 17th century
- Different types but the same essential properties
- Same building blocks: proteins, carbohydrates, fats, and nucleic acids

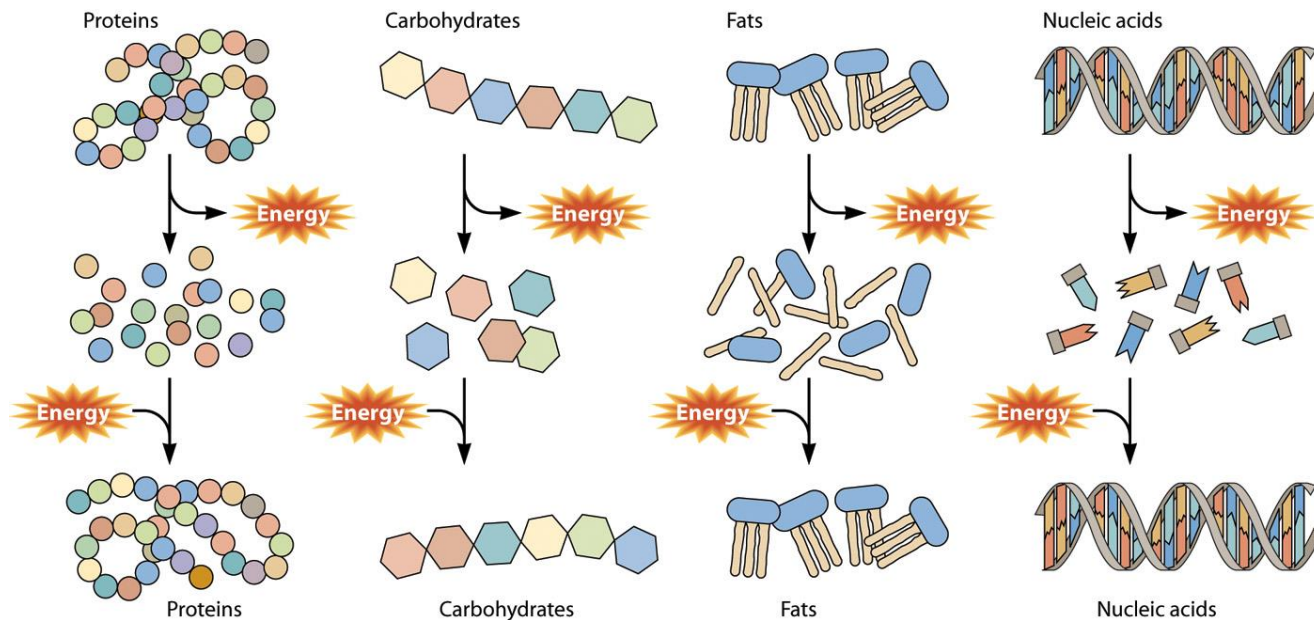


Essential Functions of Living Cells 1

■ Growth

■ Metabolism

- Catabolism: breaking down large molecules to generate building blocks and energy
- Anabolism: Generation of large molecules using building blocks and energy

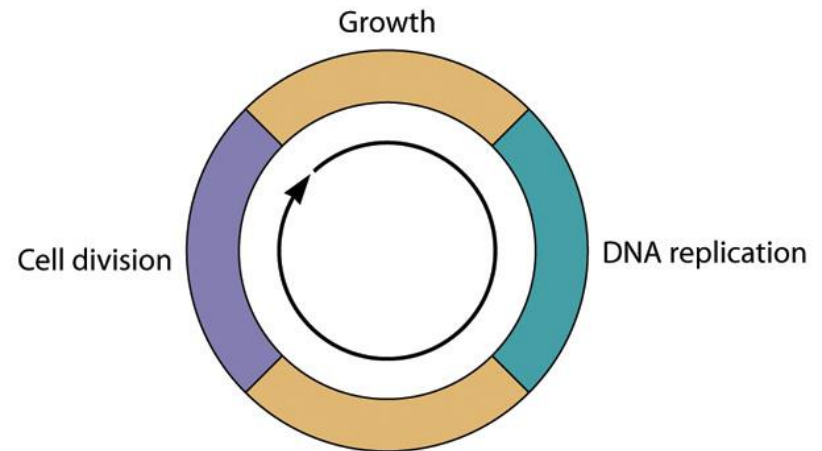
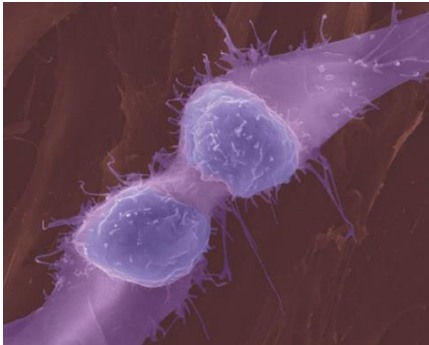


Essential Functions of Living Cells 2

■ Reproduction

■ Cell cycle

- Cyclical process of cell growth and division
- Daughter cell must receive a correct copy of genetic material
→ DNA replication before cell division



Cell cycle

Essential Functions of Living Cells 3

- Maintenance of internal environments
 - Use energy to maintain the internal environments
 - Unique molecules
 - Specific proteins, DNA etc.
 - Some same molecules as outside but with different concentrations
 - Water, salts, sugar etc.



Amoeba

Essential Functions of Living Cells 4

- Response to external environments
 - Sense a change in their environment
 - Respond
 - Maintaining osmotic homeostasis
 - Bacterial chemotaxis
 - Release of digestive enzymes from stomach cells
 -

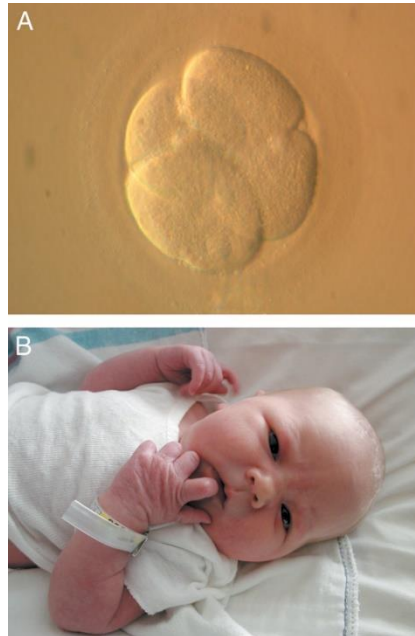


Essential Functions of Living Cells 5

- Communication with each other
 - Between cells in an organism
 - e.g. Nerve cell and muscle
 - Between single cell organisms
 - e.g. Mating of yeast cells, quorum sensing of bacteria

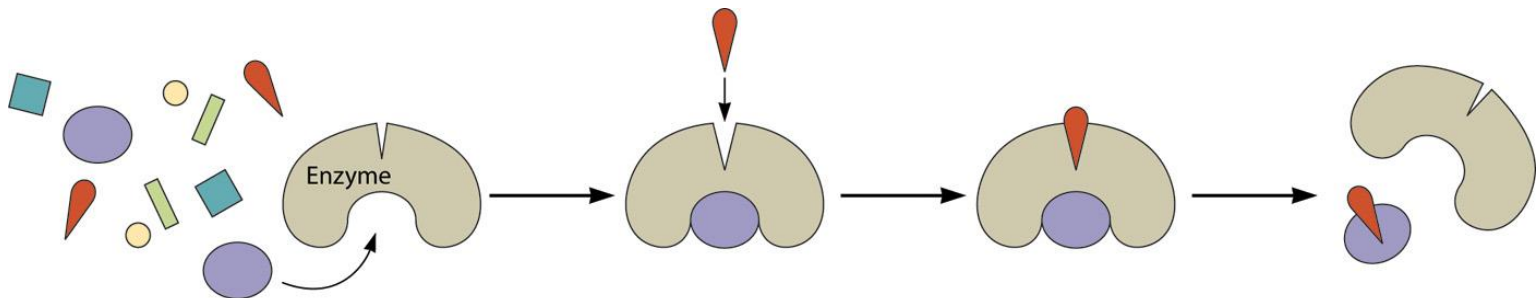
Essential Functions of Living Cells 6

- Differentiation in multicellular organisms
 - Cells differentiate to cells with specific functions
 - Specific cells organize into different tissues and organs



Common Cellular Processes

- Constant supply of energy
 - Need energy for all the cellular activities
 - Energy source
 - Sun: photosynthetic plant or bacteria
 - Food and Chemicals
- Chemical reactions
 - Enzymes: protein catalyst accelerating chemical reactions

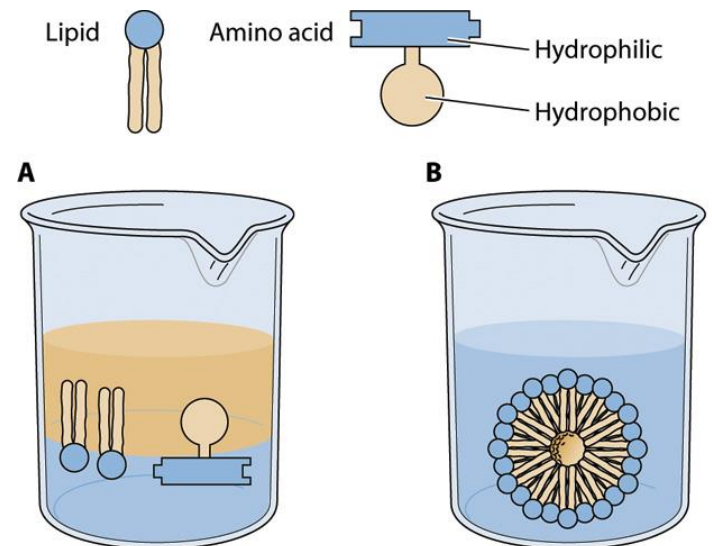


Common Cellular Processes

- Cell processes occur in a series of small steps
 - Pathway: a process consisting of a series of steps
- Regulation of processes
 - Regulation of various processes by regulation of protein-protein and protein-DNA interactions
 - Cell cycle, blood sugar levels, blood pressure, body water balance etc.

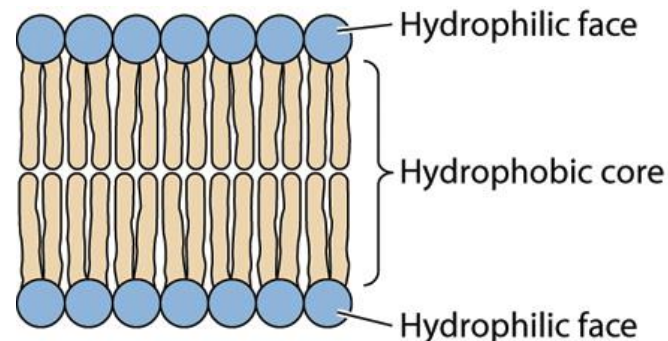
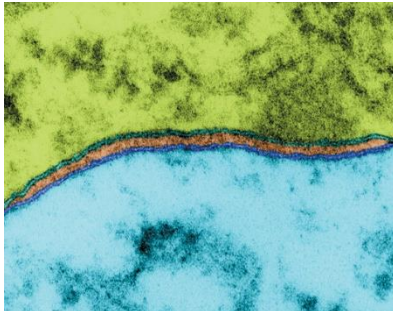
Cell Organization

- Interaction of molecules with water
 - Important factor for determining the molecular organization within a cell
 - Hydrophilic (water soluble) or Hydrophobic (water insoluble)
 - Congregation of hydrophilic parts with other hydrophilic parts
 - Congregation of hydrophobic parts with other hydrophobic parts
- Binding of molecules
 - Specificity of molecular bindings determines cellular processes
 - Binding: fitting between molecules
 - Depends on shape and chemical properties (charge)



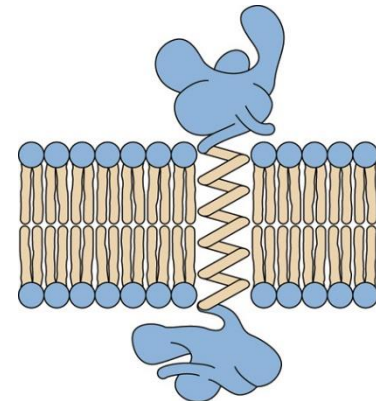
Cellular Membranes I

- Provide structural organization
 - Lipid bilayer with hydrophobic core and hydrophilic face
 - Plasma (cell) membrane: Hydrophobic barrier between inside (cytoplasm) and outside of the cell
 - Internal membranes
 - Nucleus
 - Endoplasmic reticulum, Golgi apparatus
 - Mitochondria
 - Chloroplast



Cellular Membranes II

- Control molecular transport across the membrane
 - Free diffusion
 - Small, electrically neutral or slightly charged molecules (CO_2 , O_2 , water)
 - Transport through membrane-bound channels and transporters



Two Fundamental Cell Types

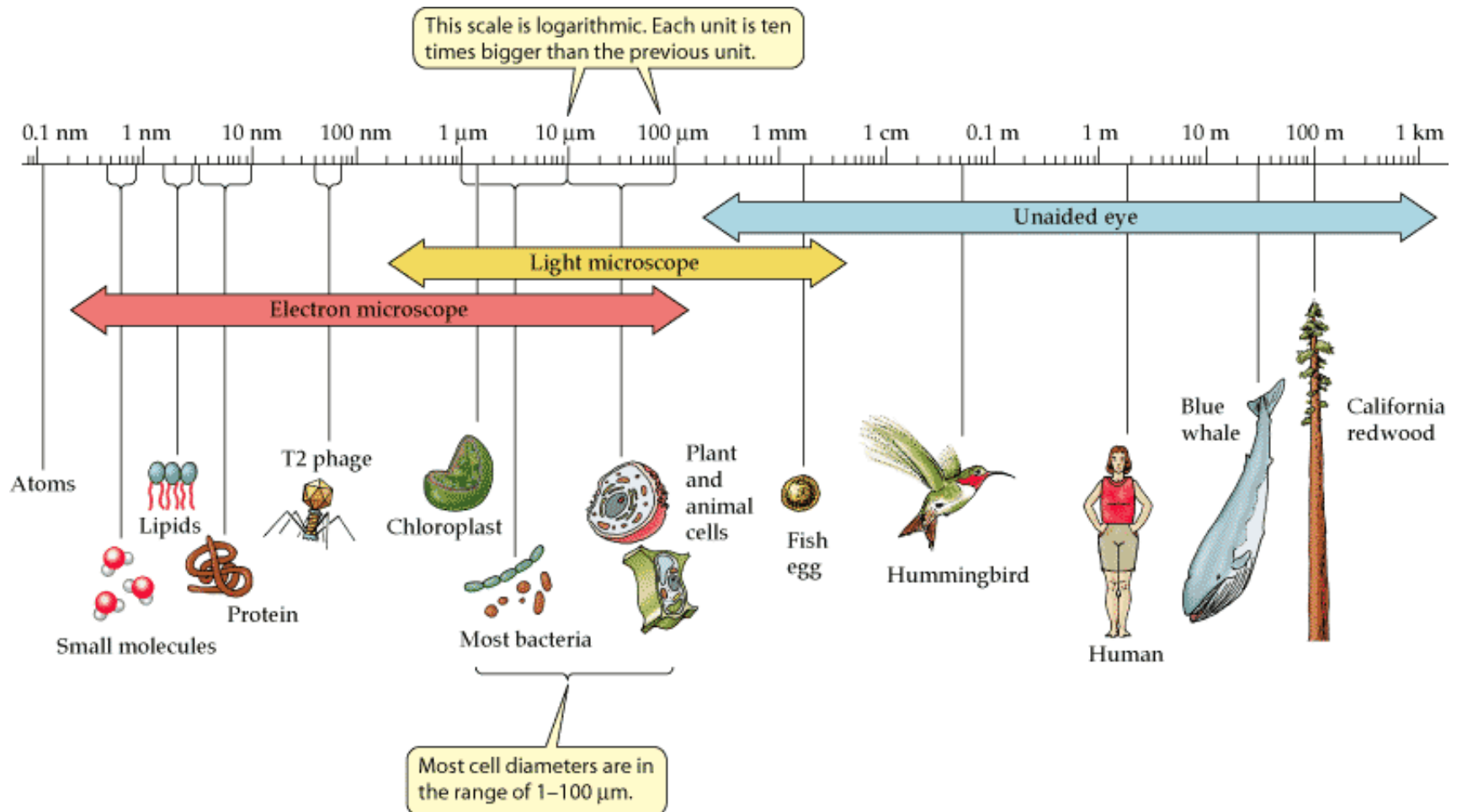
■ Prokaryotic cells

- Prokaryote (pro; before, karyon: kernel or nucleus)
- No nuclear membrane
- Small (0.2-2 μm), mostly single-celled organisms
 - Eubacteria : common bacteria, e.g. *E. coli*, blue-green algae
 - Archaea (Archaeobacteria)

■ Eukaryotic cells

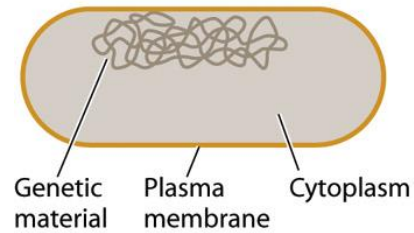
- Eukaryote (well-formed nucleus)
- Nuclear and internal membranes \rightarrow organelles
- Larger than prokaryotes (10-100 μm)
 - Single-celled: yeast, green algae, amoebae
 - Multicellular: fungi, plant, animal

The Scale of Life

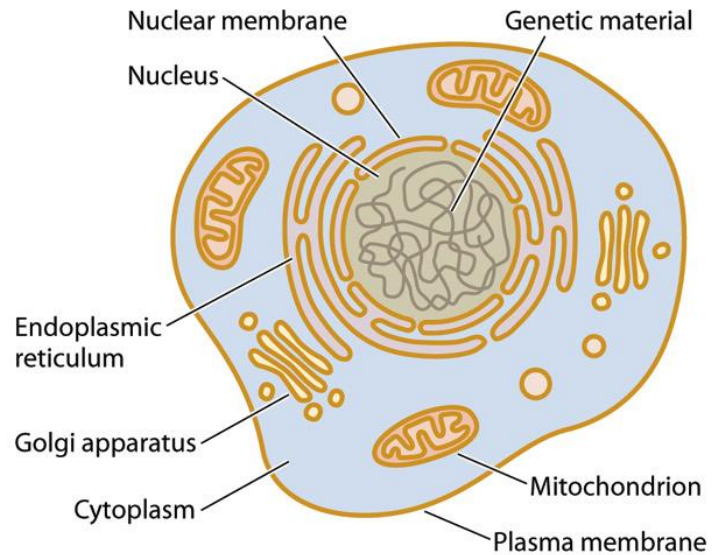


Two Fundamental Cell Types

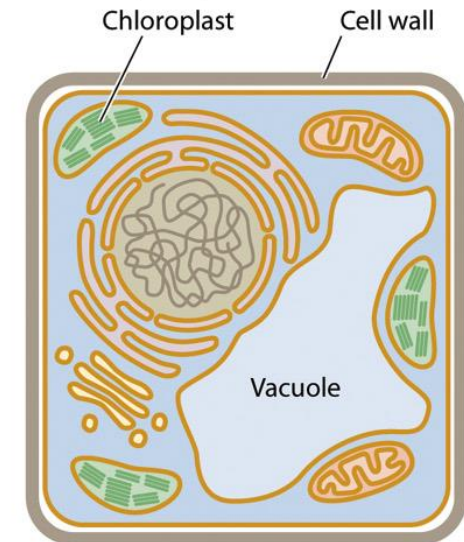
A. Prokaryotic cell

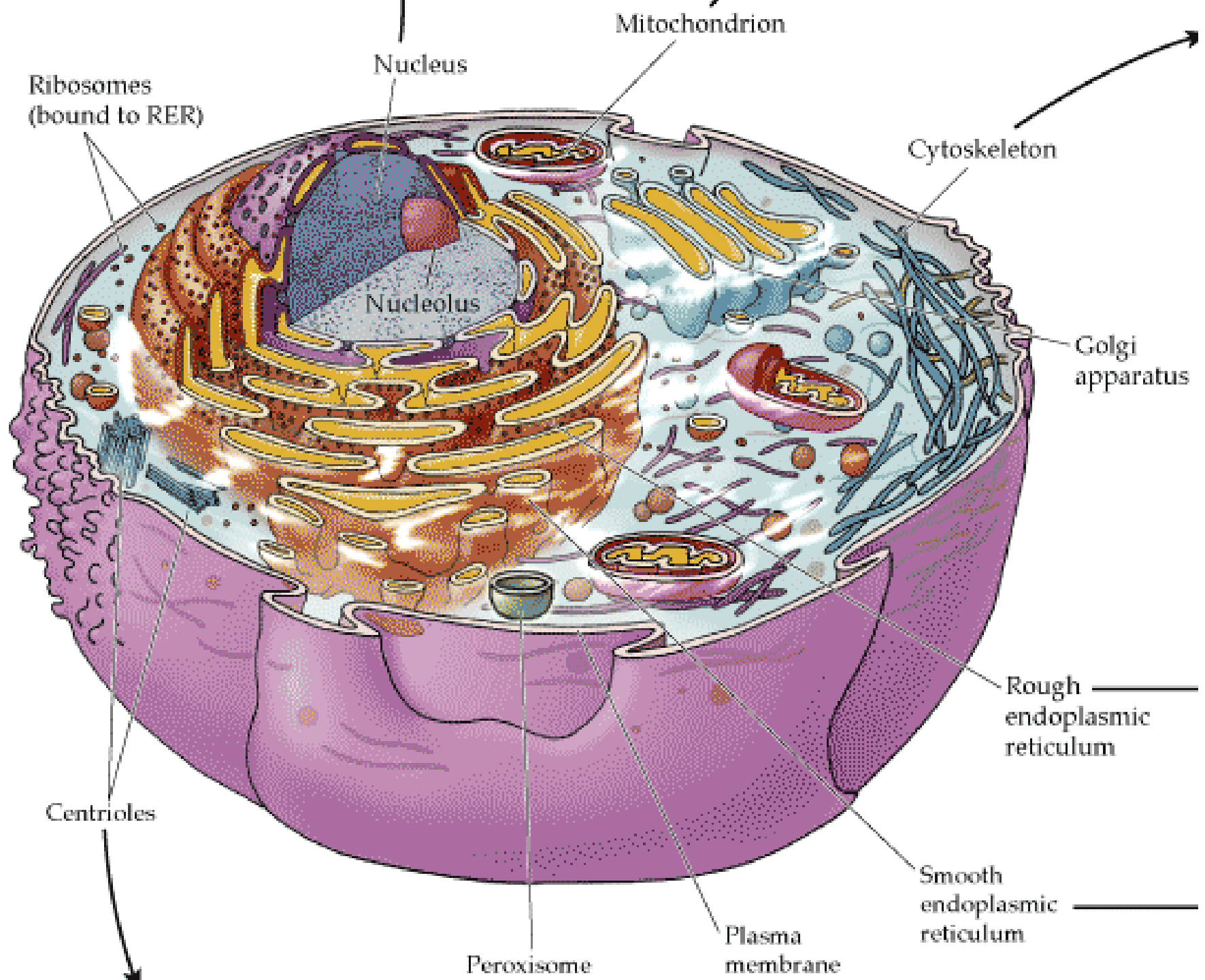


B. Eukaryotic animal cell



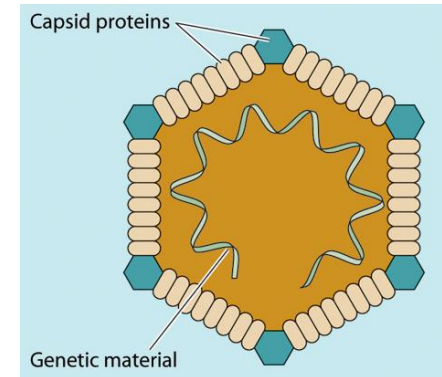
C. Eukaryotic plant cell

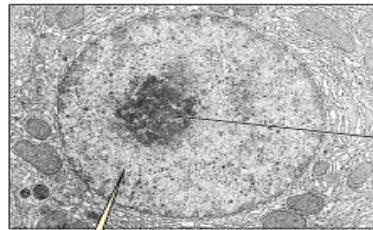




Viruses

- Not cells
- No independent reproduction (not alive by itself)
 - Genetic material (DNA or RNA)
 - Proteins (Capsid)
- “Viruses are in the semantic fog between life and non-life.”
(Campbell and Reece, *Biology*, 6e, p 339.)
- Are viruses living beings?
“The answer to that question is ‘no’, inasmuch as viruses are incapable of independent life.” (de Duve, *Life Evolving*, p.313)
- Conclusion:
Viruses do not fit the basic definition of cellular life.
 - Require host for all cellular activities
 - No metabolic capability of their own

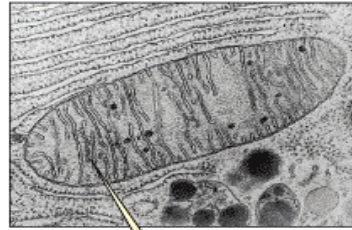




Nucleolus

1.5 μm

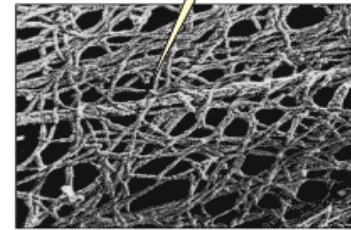
The **nucleus** is the site of most cellular DNA which, with associated proteins, comprises chromatin.



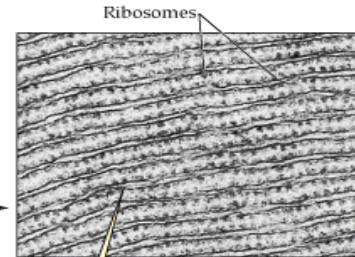
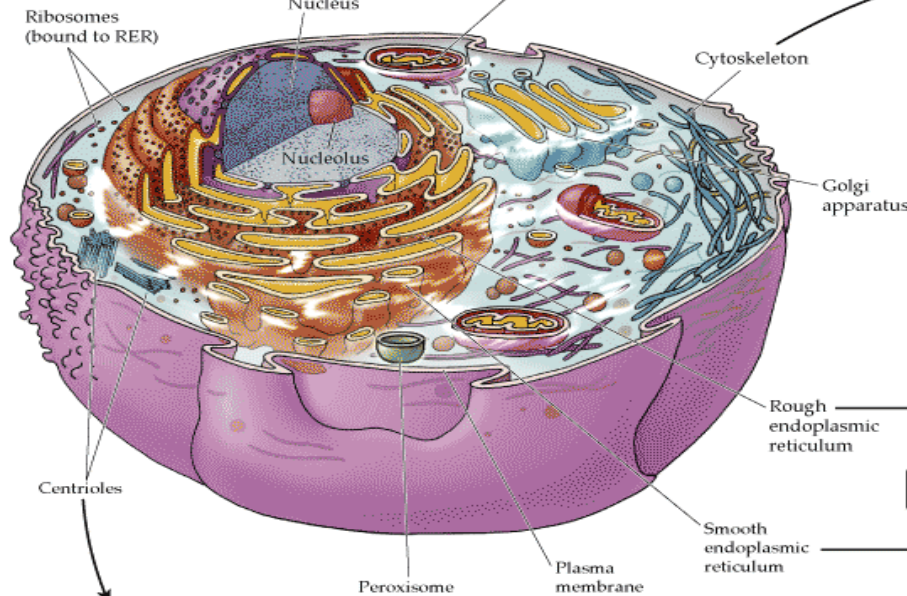
Mitochondria are the cell's power plants.

0.8 μm

A **cytoskeleton** composed of microtubules and microfilaments supports the cell and is involved in cell and organelle movement.



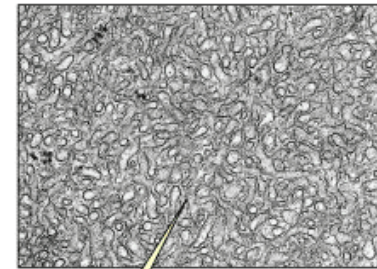
25 nm



Ribosomes

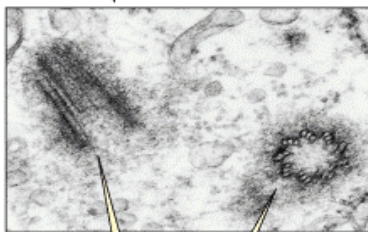
0.5 μm

The **rough endoplasmic reticulum** is the site of much protein synthesis.



0.5 μm

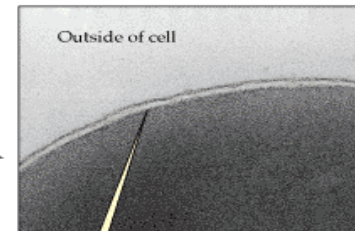
Proteins and other molecules are chemically modified in the **smooth endoplasmic reticulum**.



Centrioles are associated with nuclear division.

0.1 μm

AN ANIMAL CELL

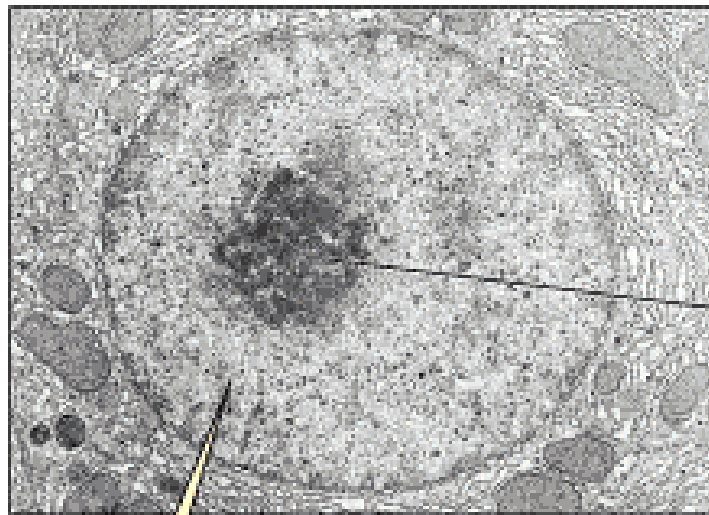


Outside of cell

30 nm

The **plasma membrane** separates the cell from its environment and regulates traffic of materials into and out of the cell.

Nucleus and Mitochondria



Nucleolus

1.5 μm

The **nucleus** is the site of most cellular DNA which, with associated proteins, comprises chromatin.

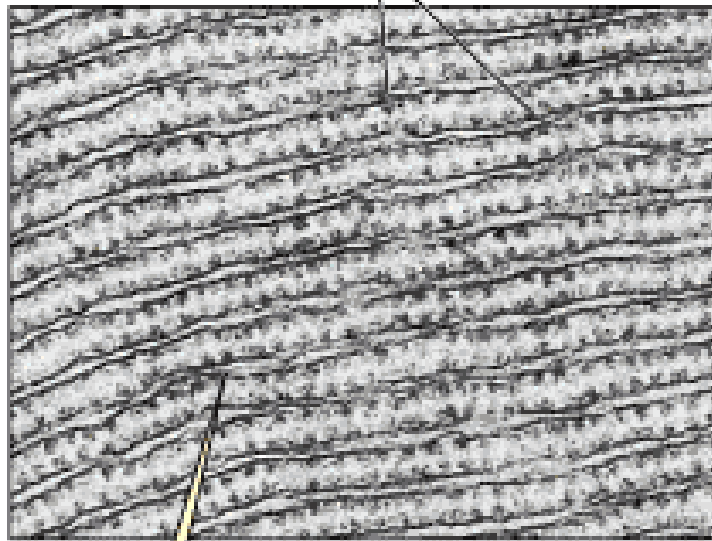


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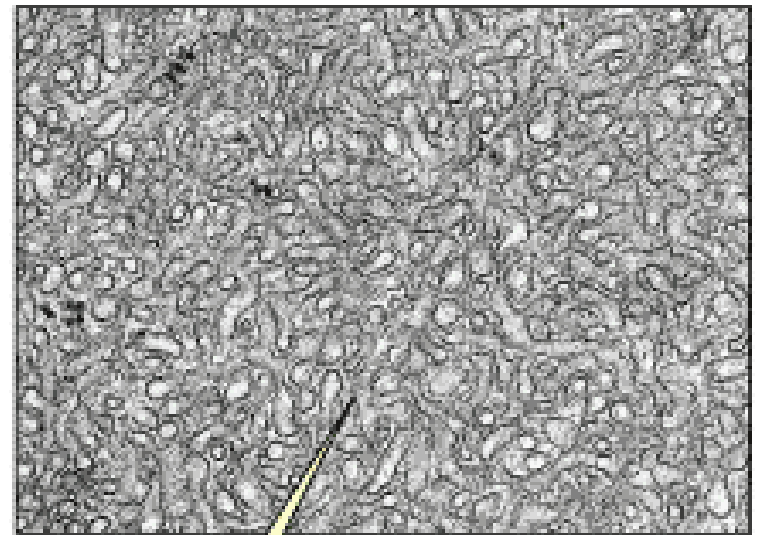
Endoplasmic Reticulum

Ribosomes



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0.5 μm

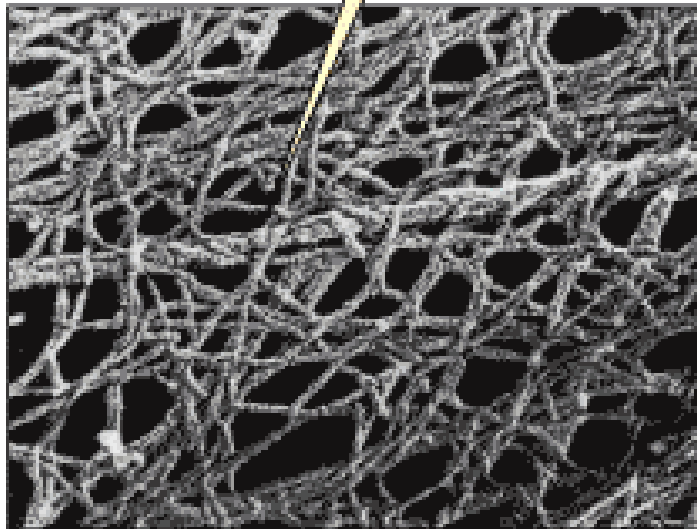


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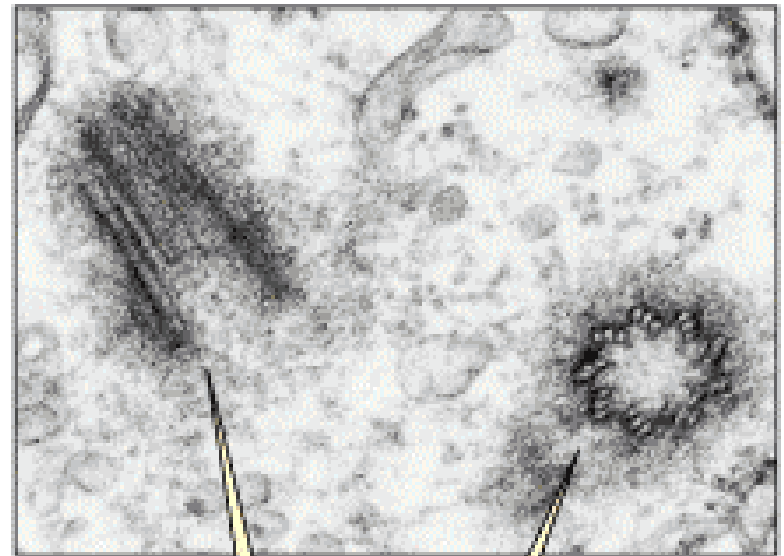
0.5 μm

Cytoskeleton and Centrioles

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25 nm



Centrioles are associated with nuclear division.

0.1 μm