Cell Structure and Function

Eukaryotic Cell: Neuron
Cell Structure and Function

Eukaryotic Cells: Blood Cells
Cell Structure and Function

Prokaryotic Cells: Bacteria
Cell Structure and Function

- All living organisms are made of cells. A cell is a small, membrane enclosed structure filled with an aqueous solution where organelles and other subcellular structures are found.
- Cells are of different size and shape
- The cell’s size and shape can be related to its specific function.
From Prokaryotes to Eukaryotes

- It is thought that all organisms living now on Earth are derived from a single cell born 3,500 millions of years (my) ago.
- This primordial cell was defined by an outer membrane— one of the crucial events leading to the establishment of life on Earth.
- Simple organic molecules are likely to have been produced in the conditions that existed on the Earth in its infant state (approximately during its first billion years).
Unicellular vs. Multicellular Organisms

• Why unicellular?

• Why multicellular?
Can we see cells?

1. Yes
2. No

50%

Yes
No
Can We See Cells?
Structural Features of Cells: Outside Covers

• All cells have a *plasma or cell membrane*, which contains the cell

• Plant cells and most bacteria have an outermost additional layer, the *plant cell wall* and the *bacterial cell wall* respectively
Outside Covers: The Plant Cell Wall

- The plant cell wall is the outermost layer of plant cells
- It provides extra protection to the plant and cohesiveness among neighbor plant cells. Why do plants need these extra features?
- Cell walls of adjacent plant cells are in close communication through plasmodesmata
Structural Features of Cells: Inner Structures of Prokaryotic Cells

No nucleus or membrane-enclosed organelles in prokaryotic cells. Ribosomes present.
Structural Features of Cells: Inner Structures of Prokaryotic Cells

Electron Micrograph of Bacteria (Cross and Longitudinal Sections)
Which one of these would not be found in a prokaryotic cell?

1. ribosomes
2. cell membrane
3. nucleus
4. DNA
cellulose: plasmodesmata: protection and cohesiveness: outermost cell cover

1. animal cell membrane
2. prokaryotic cell membrane
3. plant cell membrane
Structural Features of Cells: Inner Structures of Eukaryotic Cells

Pancreatic Cell: In Eukaryotic Cells, Nucleus, Cytoplasm, and Membrane-bounded Organelles Are Present
Inner Structures of Eukaryotic Cells: The Nucleus

- The nucleus of eukaryotic cells is contained by the *nuclear envelope*, which is made of two membranes (inner and outer) decorated with *pore complexes*
- Inside the nucleus, chromatin (DNA + DNA associated proteins) and a *nucleolus* are present
- The *nuclear lamina* (made of *intermediate filaments*) covers the inner nuclear membrane, helping in the maintenance of nuclear shape
- The nucleus hosts the genetic material (DNA and RNA)
Ribosomes are present in the outer nuclear membrane
Inner Structures of Eukaryotic Cells: The Nucleus

Transmission Electron Micrograph (TEM) of Hemocyte Nucleus

Freeze Fracture Replica of a Nucleus: Outer Membrane and Pore Complexes
Some Eukaryotic Cells Lose Their Nucleus as They Mature

TEM of Human Enucleated Erythrocytes (Er)
“Nuclear envelope” refers to:

1. outer nuclear membrane
2. nuclear pore complexes
3. outer and inner nuclear membrane and pore complexes
4. none of the above

25% 25% 25% 25%
Inner Structures of Eukaryotic Cells: Cytoplasmic Membrane-bounded Organelles

Animal Cell

Plant Cell
Different Cytoplasmic Organelles Perform Distinct Cell Functions

- Production, circulation, storage, and delivery of substances produced or taken by the cell (those organelles constitute the endomembrane system)
- Production of energy
- Movement and maintenance of the cell’s shape

Chloroplasts in Plant Cells
Different Cytoplasmic Organelles Perform Distinct Cell Functions

Organelles of Animal Cells
Different Cytoplasmic Organelles Perform Distinct Cell Functions

Organelles of Plant Cells
Organelles of the Endomembrane System
Organelles of the Endomembrane System: Endoplasmic Reticulum (ER)

The ER is constituted of smooth (SER) and rough (RER) regions. Both animal and plant cells have SER and RER.
Organelles of the Endomembrane System: Endoplasmic Reticulum (ER)

- The ER is a membrane bounded organelle. The smooth and rough regions of the ER are interconnected.
- **Smooth ER** lacks ribosomes. It is a network of pipe-like interconnected tubes. Functions of the SER include synthesis of lipids, processing of sugars, and detoxification of drugs and poisons.
- **Rough ER** has bound ribosomes attached to the outside. The RER is in fact an extension of the outer nuclear membrane. Functions of the RER include anchorage of newly synthesize proteins, and the finishing of proteins.
Organelles of the Endomembrane System: Endoplasmic Reticulum (ER)

Pancreatic Cell: In Eukaryotic Cells, Nucleus, Cytoplasm, and Organelles Are Present. ER, Endoplasmic Reticulum
The Golgi Apparatus is a single membrane-bounded organelle constituted of piled sac-like cisternae. Both animal and plant cells have Golgi Apparatus
Organelles of the Endomembrane System: Golgi Apparatus

- The Golgi Apparatus receives, packs, and ships vesicles coming from the ER, or from other parts of the cell back to the ER.
- Vesicles arriving from the ER (on *cis* side) coalesce in the Golgi apparatus, where they mature and form new vesicles that would be shipped (from *trans* side) to other cell locations.
Organelles of the Endomembrane System: Golgi Apparatus

Golgi Apparatus in Neuron
Organelles of the Endomembrane System: Vesicles and Lysosomes

*Transport and Secretory Vesicles (single membrane-bounded organelles). Both animal and plant cells have transport vesicles*
Organelles of the Endomembrane System: Vesicles

Pancreatic Secretory Cell: Basal and Apical Parts
Organelles of the Endomembrane System: Vesicles and Lysosomes

Lysosomes are typical of animal cells; lysosomes are vesicles that contain hydrolytic enzymes. Tay-Sachs is an autosomal recessive disease caused by mutations in lysosomal enzymes.
How Do Vesicles, Lysosomes, and Vacuoles Move?

Cytoskeletal elements and motor proteins interact with the vesicle’s surface receptor proteins. Such interaction leads to vesicle movement.
Organelles of the Endomembrane System: Central Vacuole

- Mature plants generally contain a large *central vacuole* that may occupy 50-90% of the cell’s interior.
- The central vacuole is a single membrane-bounded organelle. Such cell membrane is termed *tonoplast*.
- The central vacuole stores a variety of organic and inorganic compounds.
Organelles of the Endomembrane System

• Plasma Membrane and Nuclear Envelope
• Endoplasmic Reticulum (SER, RER)
• Golgi Apparatus
• Transport, Secretory Vesicles, and Vacuoles
• Lysosomes (only in animal cells)
• Central Vacuole (only in plant cells)
Organelles of the endomembrane system control production, circulation, storage, and delivery of substances produced or taken by the cell.

1. True
2. False
trans side: sorting of vesicles: secretion of vesicles

1. SER
2. RER
3. Golgi apparatus
4. central vacuole
cell storage: tonoplast
: endomembrane system

1. SER
2. RER
3. Golgi apparatus
4. central vacuole
Energy- Producing Organelles
Mitochondria are double membrane-bounded organelles present in nearly all eukaryotic cells (plant, animals, fungi, etc.). Mitochondria process macromolecules to obtain energy through a process termed aerobic respiration. Mitochondria have their own DNA (mitochondrial DNA, mDNA) and ribosomes in their matrix.
Energy-Producing Organelles: Mitochondria

Mitochondria in Neurons
Energy- Producing Organelles: Chloroplasts

- Chloroplast are *plastids* that contain the green pigment chlorophyll along with other photosynthetic pigments. Chloroplasts perform photosynthesis.
- Chloroplasts are double membrane-bounded organelles present in plant cells.
- In the *stroma*, chloroplast DNA and ribosomes can be found.
Energy-Producing Organelles: Chloroplasts
If a cell did not have mitochondria, it would be unable to:

1. move
2. produce energy
3. synthetize lipids and move vesicles
4. all of the above
Select the choice that indicates organelles bounded by a double membrane

1. Golgi apparatus & vesicles
2. SER & RER
3. mitochondria & chloroplasts
4. all of the above
Energy- Producing Organelles: Chloroplasts
Shape Maintenance and Movement- Producing Organelles
Movement - Producing Organelles and Cytoskeleton

(a) Motion of flagella

(b) Motion of cilia

Motion produced by cilia or flagella

Motion of vesicles provided by cytoskeleton

Amoeboidal movement provided by cytoskeleton
Movement - Producing Organelles and Cytoskeleton

Skeletal Muscle and Cardiac Muscle
# Shape Maintenance and Movement - Producing Organelles and Cytoskeleton: The Cytoskeleton

## Table 6.1 The Structure and Function of the Cytoskeleton

<table>
<thead>
<tr>
<th>Property</th>
<th>Microtubules (Tubulin Polymers)</th>
<th>Microfilaments (Actin Filaments)</th>
<th>Intermediate Filaments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Structure</strong></td>
<td>Hollow tubes, wall consists of 13 columns of tubulin molecules</td>
<td>Two intertwined strands of actin, each a polymer of actin subunits</td>
<td>Fibrous proteins supercoiled into thicker cables</td>
</tr>
<tr>
<td><strong>Diameter</strong></td>
<td>25 nm with 15-nm lumen</td>
<td>7 nm</td>
<td>8–12 nm</td>
</tr>
<tr>
<td><strong>Protein subunits</strong></td>
<td>Tubulin, consisting of α-tubulin and β-tubulin</td>
<td>Actin</td>
<td>One of several different proteins of the keratin family, depending on cell type</td>
</tr>
<tr>
<td><strong>Main functions</strong></td>
<td>Maintenance of cell shape (compression-resisting &quot;girders&quot;)</td>
<td>Maintenance of cell shape (tension-bearing elements)</td>
<td>Maintenance of cell shape (tension-bearing elements)</td>
</tr>
<tr>
<td></td>
<td>Cell mobility (as in cilia or flagella)</td>
<td>Changes in cell shape</td>
<td>Anchorage of nucleus and certain other organelles</td>
</tr>
<tr>
<td></td>
<td>Chromosome movements in cell division</td>
<td>Muscle contraction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Organelle movements</td>
<td>Cytoplasmic streaming</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cell mobility (as in pseudopodia)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cell division (cleavage furrow formation)</td>
<td></td>
</tr>
</tbody>
</table>

Micrographs of fibroblasts, a favorite cell type for cell biology studies. Each has been experimentally treated to fluorescently tag the structure of interest.

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**Column of tubulin dimers**

- **Tubulin dimer**
- **Actin subunit**
- **Protein subunits (keratins)**
- **Fibrous subunits**
Movement- Producing Organelles and Cytoskeleton: The Cytoskeleton

• Microtubules grow out from a *centrosome*, a microtubule-organizing region. In animal cells, the centrosome contains a pair of *centrioles*

• Centrioles are made of nine triplets of microtubules
Cilia and flagella are extensions of the plasma membrane that contain an array of nine pairs of peripheral microtubules and a central one (9+2 array). Cilia and flagella are rooted on the basal body, constituted of nine peripheral triplets of microtubules. Cilia are shorter than flagella.
Movement- Producing Organelles and Cytoskeleton: Flagella

- Flagella propel the cell (*flagellated* cell) in a whip-like motion
- Sperm cells of animals, plants, and algae are flagellated
Movement- Producing Organelles and Cytoskeleton: Cilia

• Cilia provide movement to free-swimming eukaryotic unicellular organisms (i.e. Paramecium)

• In multicellular organisms, they generally constitute ciliated epithelia (i.e. trachea and oviducts). What is the function of these ciliated epithelia?
This organelle belongs to the endomembrane system. Do you agree?

1. Yes
2. No

50% 50%
This organelle belongs to the endomembrane system. Do you agree?

1. Yes
2. No
This organelle belongs to the endomembrane system. Do you agree?

1. Yes
2. No