Cell physiology
Structure and Function
Introduction to the cell biology

What is a Cell?

- Cells: are the microscopic fundamental units of all living things.
- Every living thing has cells: bacteria, protozoans, fungi, plants, and animals are the main groups (Kingdoms) of living things.
- Some organisms are made up of just one cell (e.g. bacteria and protozoans).
- But animals, including human beings, are multicellular.
- An adult human body is composed of about 100 trillion cells! Each cell has basic requirements to sustain it. and the body's organ systems are largely built around providing the many trillions of cells with those basic needs (such as oxygen, food, and waste removal).
Introduction to the cell biology

- About **200** different types of *specialized cells* carry out a multitude of functions that help each system contribute to the homeostasis of the entire body.

- At the same time, all cells share key structures and functions that support their intense activity.

- For ease of study, we divide the cell into **three** main parts:

1. plasma membrane
2. cytoplasm
3. nucleus
Human Cell, Structure and Functions:

- **The cell:** is the basic functional in a human meaning that it is a self-contained and fully operational living entity.

  Humans are *multicellular* organisms with various different types of cells that work together to sustain life.

Other *non-cellular* components in the body include *water*, *macronutrients* (carbohydrates, proteins, lipids), *micronutrients* (vitamins, minerals) and *electrolytes*.

A collection of cells that function together to perform the same activity is known as *tissue*. Masses of tissue work collectively to form an *organ* that performs specific functions in the body. Despite this structural organization, all activity boils down to the cell – a complex unit that makes life possible.
The cell contains various structural components to allow it to maintain life which are known as organelles. All the organelles are suspended within a gelatinous matrix, the cytoplasm, which is contained within the cell membrane. One of the few cells in the human body that lacks almost all organelles are the red blood cells. The main organelles are as follows:

- Nucleus
- Cell membrane
- Endoplasmic reticulum
- Golgi apparatus
- Lysosomes
- Peroxisomes
- Mitochondria
- Microfilaments and microtubules.
The nucleus: is the master control of the cell. It contains genes, collections of DNA, which determines every aspect of human anatomy and physiology. The DNA which is arranged into chromosomes also contains the blueprint specific for each type of cell which allows for replication of the cell. Within the nucleus is an area known as the nucleolus. It is not enclosed by a membrane but is just an accumulation of RNA and proteins within the nucleus. The nucleolus is the site where the ribosomal RNA is transcribed from DNA and assembled.
Cell Membrane:
The cell membrane is the outer coating of the cell and contains the cytoplasm, substances within it and the organelle. It is a double-layered membrane composed of proteins and lipids. The lipid molecules on the outer and inner part (lipid bilayer) allow it to selectively transport substances in and out of the cell.

Endoplasmic Reticulum:
The endoplasmic reticulum (ER) is a membranous structure that contains a network of tubules and vesicles. Its structure is such that substances can move through it and be kept in isolation from the rest of the cell until the manufacturing processes conducted within are completed. There are two types of endoplasmic reticulum – rough (granular) and smooth (a granular).
The cytoplasm:

- consists of all the cellular contents between the plasma membrane and the nucleus.
- This compartment has two components: cytosol and organelles.

1. Cytosol: means the fluid portion of cytoplasm.
   - Contains: (water, dissolved solutes, and suspended particles). Surrounded by cytosol are several different types of organelles (little organs).
   - Each type of organelle has a characteristic shape and specific functions. Examples include:
     - (the cytoskeleton, ribosomes, endoplasmic reticulum, Golgi complex, lysosomes, peroxisomes, and mitochondria)
Golgi Apparatus

The Golgi apparatus is a stacked collection of flat vesicles. It is closely associated with the endoplasmic reticulum in that substances produced in the ER are transported as vesicles and fuses with the Golgi apparatus. In this way, the products from the ER are stored in the Golgi apparatus and converted into different substances that are necessary for the cell’s various functions.
Lysosomes: are vesicles that break off from the Golgi apparatus. It varies in size and function depending on the type of cell. Lysosomes contain enzymes that help with the digestion of nutrients in the cell and break down any cellular debris or invading microorganisms like bacteria.

A structure that is similar to a lysosome is the secretory vesicle. It contains enzymes that are not used within the cell but emptied outside of the cell, for example the secretory vesicles of the pancreatic lacunar cell release digestive enzymes which help with the digestion of nutrients in the gut.
These organelles are very similar to the lysosomes and contain enzymes that act together in the form of hydrogen peroxide to neutralize substances that may be toxic to the cell. **Peroxisomes** are formed directly from the endoplasmic reticulum rather than from the Golgi apparatus like lysosomes.
These are the powerhouses of the cell and break down nutrients to yield energy. Apart from producing its own energy, it also produces a high-energy compound called ATP (adenosine triphosphate) which can be used as a simple energy source elsewhere. Mitochondria are composed of two membranous layers – an outer membrane that surrounds the structure and an inner membrane that provides the physical sites of energy production. The inner membrane has many in folding that form shelves where enzymes attach and oxidize nutrients. The mitochondria also contain DNA which allows it to replicate where and when necessary.
Mitochondria
Microfilaments and microtubules are rigid protein substances that form the internal skeleton of the cell known as the cytoskeleton. Some of these microtubules also make up the centrioles and mitotic spindles within the cell which are responsible for the division of the cytoplasm when the cell divides. The microtubules are the central component of cilia, small hair-like projections that protrude from the surface of certain cells. It is also the central component of specialized cilia like the tail of the sperm cells which beats in a manner to allow the cell to move in a fluid medium.
The functions of the human cell varies based on the type of cell and its location in the human body. All the organelles work together to keep the cell alive and allow it to carry out its specific function. Sometimes these organelles are highly specialized and can vary in (size, shape and number). The organelles are the most basic functional units but it cannot exist and operate without the cell as a whole. Its functions include intake of nutrients and other substances, processing of these compounds, production of new substances, cell replication and energy production. In specialized cells that need to be motile, like sperm cells, tail-like projections allow for cellular locomotion.
The function of each organelle has already been discussed but is worth considering in summary:

The **cell membrane** allows substances to **enter** and **leave** the cell.

While certain **substance** like **oxygen** can easily **diffuse** through the cell membrane, others have to **actively** transported through the process of **endocytosis**. **Small particles** are transported by the process of **pinocytosis** while **larger** particles are moved by the process of **phagocytosis**. These functions can become highly specialized to allow cells to perform specific activities, like the **macrophages** that **phagocytosis** invading bacteria to neutralize it.

**Small and large** substances that **do not dissolve** in the cytoplasm are **contained** within **vesicles**. Lysosomes attach to the vesicles and digest this material.

The **endoplasmic reticulum (ER)** and **Golgi apparatus** **synthesize** different substances like **protein** and **fats** as required by the cell or designated according to its specific function. It **utilizes** basic **nutrient** molecules that are either **dissolved** in the cytoplasm or **specific substances contained within vesicles**.
Endocytosis

Endocytosis (endo = internal, cytosis = transport mechanism) is a general term for the various types of active transport that move particles into a cell by enclosing them in a vesicle made out of plasma membrane.

There are variations of endocytosis, but all follow the same basic process. First, the plasma membrane of the cell invaginates (folds inward), forming a pocket around the target particle or particles. The pocket then pinches off with the help of specialized proteins, leaving the particle trapped in a newly created vesicle or vacuole inside the cell.

Endocytosis can be further subdivided into the following categories: phagocytosis, pinocytosis, and receptor-m

1. Phagocytosis

Phagocytosis (literally, “cell eating”) is a form of endocytosis in which large particles, such as cells or cellular debris, are transported into the cell. We’ve already seen one example of phagocytosis, because this is the type of endocytosis used by the macrophage in the article opener to engulf a pathogen.
Phagocytosis

- Outside cell
  - Large particle
- Plasma membrane
- Cytoplasm
- Food vacuole
2- Pinocytosis:

Pinocytosis (literally, “cell drinking”) is a form of endocytosis in which a cell takes in small amounts of extracellular fluid. Pinocytosis occurs in many cell types and takes place continuously, with the cell sampling and re-sampling the surrounding fluid to get whatever nutrients and other molecules happen to be present. Pinocytosed material is held in small vesicles, much smaller than the large food vacuole produced by phagocytosis.
Different types of membrane transport:

- **Simple Diffusion**: Molecules to be transported move across the membrane from an area of high concentration to an area of low concentration without the use of energy.

- **Facilitated Diffusion**: Similar to simple diffusion, but requires specific transport proteins in the membrane to facilitate the passage of molecules.

- **Active Transport**: Requires energy (ATP) to pump molecules against their concentration gradient, from an area of low concentration to an area of high concentration.

**Hydrophilic (polar) head of phospholipid**

**Hydrophobic (nonpolar) fatty acid tail of phospholipid**

**Extracellular surface**

**Cell membrane**

**Intracellular surface**

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Exocytosis

Cells must take in certain molecules, such as nutrients, but they also need to release other molecules, such as signaling proteins and waste products, to the outside environment.

Exocytosis (exo = external, cytosis = transport mechanism) is a form of bulk transport in which materials are transported from the inside to the outside of the cell in membrane-bound vesicles that fuse with the plasma membrane.
EXOCYTOSIS

outside cell

cytoplasm

vesicle
### Cell Parts Chart

<table>
<thead>
<tr>
<th>Name</th>
<th>What does it do?</th>
<th>Picture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nucleus</td>
<td>Directs all the activities of the cell</td>
<td><img src="image" alt="Nucleus" /></td>
</tr>
<tr>
<td>Cell Membrane</td>
<td>Protects the cell and allows nutrients to come into the cell.</td>
<td><img src="image" alt="Cell Membrane" /></td>
</tr>
<tr>
<td>Cytoplasm</td>
<td>The gel-like fluid that holds the organelles.</td>
<td><img src="image" alt="Cytoplasm" /></td>
</tr>
<tr>
<td>Ribosomes</td>
<td>Produces proteins that helps the cell grow.</td>
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<tr>
<td>Endoplasmic Reticulum</td>
<td>Passages that transports materials.</td>
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<tr>
<td>Mitochondria</td>
<td>Produces energy</td>
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</tr>
<tr>
<td>Golgi bodies</td>
<td>Packages materials to be sent or received.</td>
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<tr>
<td>Lysosomes</td>
<td>Breaks down food and waste materials.</td>
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<tr>
<td>Vacuoles</td>
<td>Stores food, water, and nutrients.</td>
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<tr>
<td>Cell Wall</td>
<td>Provides shape for plant cells.</td>
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<tr>
<td>Chloroplasts</td>
<td>Uses sunlight energy to make food (glucose).</td>
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THANK YOU FOR LISTENING