

I. The History of Cells

A. The Discovery of Cells

1. All living things are made of cells.
2. A cell is the smallest unit that can carry on the processes of life.
3. Robert Hooke
 - a. Discovered cells in a slice of cork.
4. Leeuwenhoek
 - a. First to observe living cells.

5. Cell Theory

- a. All living things are made of cells.
- b. Cells are the basic unit of structure and function.
- c. Cells come only from preexisting cells.
- d. Developed by Schwann, Schleiden and Virchow.

B. Cellular Basis of Life

1. All living things are made of organized parts, obtain energy from their surroundings, perform chemical reactions, change with time, respond to their environment, and reproduce.
 - a. These are the characteristics of life.

II. Introduction to Cells

A. Cell Diversity

1. Cells Shape
 - a. A cell's shape reflects its function.

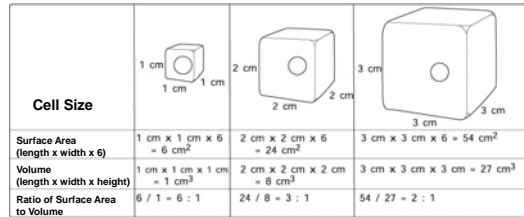
2. Cell Size

- a. Cell size is limited by a cell's surface area-to-volume ratio.



| Side length | Surface area | Volume | Surface area/volume ratio |
|-------------|--------------------|--------------------|---------------------------|
| 1 mm | 6 mm ² | 1 mm ³ | 6:1 |
| 2 mm | 24 mm ² | 8 mm ³ | 3:1 |
| 4 mm | 96 mm ² | 64 mm ³ | 3:2 |

Ratio of Surface Area to Volume in Cells



| Cell Size | 1 cm | 2 cm | 3 cm |
|-----------------------------------|--|--|---|
| Surface Area (length x width x 6) | 1 cm x 1 cm x 6 = 6 cm ² | 2 cm x 2 cm x 6 = 24 cm ² | 3 cm x 3 cm x 6 = 54 cm ² |
| Volume (length x width x height) | 1 cm x 1 cm x 1 cm = 1 cm ³ | 2 cm x 2 cm x 2 cm = 8 cm ³ | 3 cm x 3 cm x 3 cm = 27 cm ³ |
| Ratio of Surface Area to Volume | 6 / 1 = 6 : 1 | 24 / 8 = 3 : 1 | 54 / 27 = 2 : 1 |

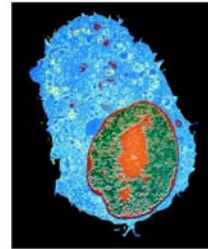
- Surface area and volume do not increase at the same rate
- Larger cells have difficulty exchanging oxygen and waste in and out of the cell
- Before cell becomes too large it undergoes cellular division and forms 2 daughter cells

B. Basic Parts of the Cell

1. Plasma Membrane
 - a. Acts as a barrier between the inside and outside of the cell.
 - b. Made mostly of phospholipids and proteins.
2. Cytoplasm
 - a. The region of the cell that is within the plasma membrane except the nucleus.
-That includes the fluid, the cytoskeleton, and all of the organelles.

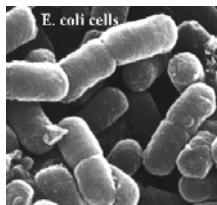
3. Nucleus

- a. A membrane-bound organelle that contains a cell's DNA.



C. Two Basic Types of Cells

1. Prokaryotes
 - a. Lack a nucleus and membrane-bound organelles.



2. Eukaryotic
 - a. Have a nucleus and a membrane-bound organelle.
 - b. They are larger and more complex than prokaryotic.



Review

Prokaryotic

- Simple
- Small
- Bacteria
- No organelles
- No nucleus

Prokaryotic Cell Structure

Eukaryotic

- Complex
- Larger
- Organelles
- Nucleus

D. Cellular Organization

1. In multicellular organisms, cells form tissues, organs, organ systems, and finally organisms.

2. Cell Specialization

- Occurs in multicellular organisms
- Each type of cell will have one job
- They will develop a specific shape

– Examples:

- Nerve Cells
- Root Hair Cells

3. Tissues and Organs

a) Tissues

- Composed of hundreds of a few types of cells.
- Have similar functions because the tissue has a specific function

Four types of tissue

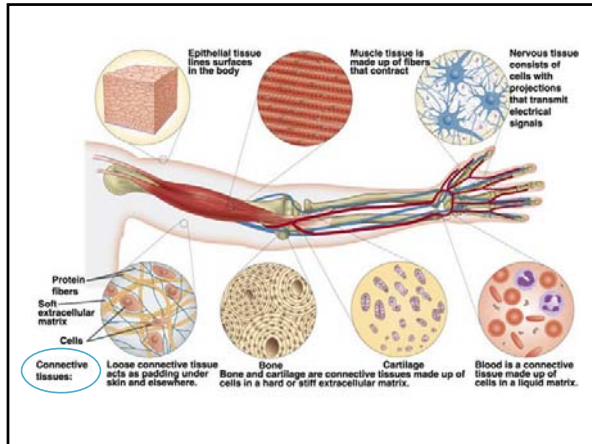
Connective tissue

Epithelial tissue

Muscle tissue

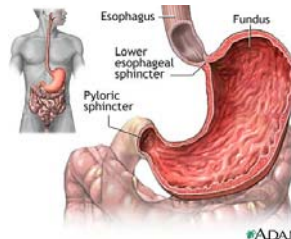
Nervous tissue

Human Body Tissues



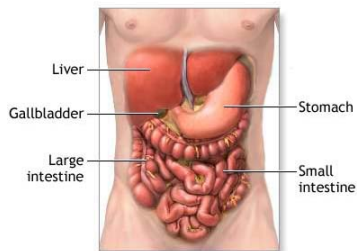
b. Organs

- Consists of several tissues grouped together.
- Perform a specific function.



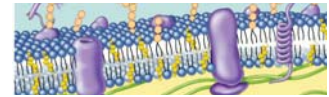
c. Organ System

-A group of organs whose functions are closely related.



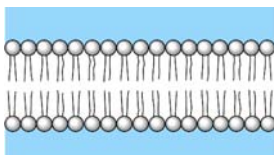
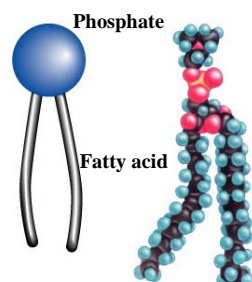
III. Structure and function

- Cell membrane **separates** living cell from nonliving surroundings
 - thin barrier = 8 nm thick
- Controls traffic in & out of the cell
 - **selectively permeable**
 - allows some substances to cross more easily than others
 - hydrophobic vs hydrophilic
- Made of **phospholipids, proteins** & other macromolecules



Phospholipids

- Fatty acid tails
 - **hydrophobic**
- Phosphate group head
 - **hydrophilic**
- Arranged as a **bilayer**

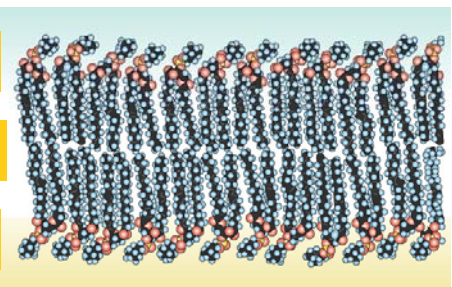


Phospholipid bilayer

polar hydrophilic heads

nonpolar hydrophobic tails

polar hydrophilic heads



A. Plasma Membrane

1. Membrane Lipids
 - a) Cell membrane consists of a phospholipid bilayer.
 - b) Proteins, cholesterol, carbohydrates

The diagram illustrates the structure of the plasma membrane. It shows a phospholipid bilayer with hydrophilic heads and hydrophobic tails. Various components are labeled: ALPHABETA PROTEIN, CARBOHYDRATE SIDE CHAIN, PHOSPHOLIPID, PERIPHERAL PROTEIN, HYDROPHOBIC REGION OF ALPHABETA PROTEIN, and CHOLESTEROL. A smaller inset shows a cross-section of the bilayer with 'WATER' on both sides.

Membrane Proteins

- Proteins determine membrane's specific functions
 - cell membrane & organelle membranes each have unique collections of proteins
- Membrane proteins:
 - peripheral proteins
 - loosely bound to surface of membrane
 - cell surface identity marker (**antigens**)
 - integral proteins
 - penetrate lipid bilayer, usually across whole membrane
 - **transmembrane** protein
 - transport proteins
 - channels, permeases (pumps)

The first diagram shows peripheral proteins on the surface of the membrane. The second diagram shows integral proteins, including a transmembrane protein and a transport protein (channel/permease).

Membrane is a collage of proteins & other molecules embedded in the fluid matrix of the lipid bilayer

This diagram shows a cross-section of the cell membrane. Labels include: Chain of Carbohydrates, Extracellular fluid, Glycoprotein, Glycolipid, Phospholipids, Channel protein, Cholesterol, Transmembrane proteins, Cytoplasm, and Filaments of cytoskeleton.

2. Membrane Proteins
 - a. Allow certain substances in and out of the cell
 - b. Maintain balance

The diagram shows four types of membrane proteins: TRANSPORTERS, ANCHORS, RECEPTORS, and ENZYMES. It also labels the EXTRACELLULAR SPACE and CYTOSOL.

3. Fluid Mosaic Model
 - a. The fluid mosaic model states that the phospholipid bilayer behaves like a fluid more than it behaves like a solid.

The diagram shows the fluid mosaic model with labels: Fibers of extracellular matrix (ECM), Carbohydrate, Proteoglycan, Collagen fiber, EXTRACELLULAR FLUID, Glycoprotein, Glycolipid, Filaments of cytoskeleton, Cholesterol, Peripheral protein, Integral protein, and CYTOPLASM.

More than lipids...

- In 1972, S.J. Singer & G. Nicolson proposed that membrane proteins are inserted into the phospholipid bilayer

*It's like a fluid...
It's like a mosaic...
It's the Fluid Mosaic Model!*

The diagram shows a phospholipid bilayer with a protein embedded. Labels include: Phospholipid bilayer, Hydrophilic region of protein, and Hydrophobic region of protein.

Managing water balance

Cell survival depends on balancing water uptake & loss

| Solution | Animal Cell | Plant Cell |
|---------------------------------|-------------|-----------------|
| Hypotonic solution (freshwater) | Lysed | Turgid (normal) |
| Isotonic solution (balanced) | Normal | Flaccid |
| Hypertonic solution (saltwater) | Shriveled | Plasmolyzed |

Managing water balance

- Isotonic
 - animal cell immersed in **mild salt** solution
 - **example:** **blood cells in blood plasma**
- **no net movement** of water
 - flows across membrane equally, in both directions
- volume of cell is stable

Isotonic solution

Normal

Flaccid

balanced

Blood

- A red blood cell placed in a **hypotonic** solution (pure water) bursts immediately from the influx of water.
- When red blood cells are placed in a 0.9% salt solution, they neither gain nor lose water by osmosis.
 - solution is **isotonic**
- If red cells are placed in sea water (about 3% salt), they lose water by osmosis and the cells shrivel up.
 - Sea water is **hypertonic** to their cytosol.

HEMOLYSIS ISOTONIC CRENATION

HYPOTONIC HEMOGLOBIN HYPERTONIC

(Kimball, 2011)

Managing water balance

- Hypotonic
 - a cell in **fresh water**
 - **example:** **Paramecium**
 - **problem:** **gains water**, swells & can burst
 - water continually enters *Paramecium* cell
 - **solution:** **contractile vacuole**
 - pumps water out of cell
 - ATP
 - **plant cells**
 - Turgid- pressure built up

Hypotonic solution

Lysed

Turgid (normal)

freshwater

Managing water balance

- Hypertonic
 - a cell in **salt water**
 - **example:** **shellfish**
 - **problem:** **lose water & die**
 - **solution:** take up water or pump out salt
 - **plant cells**
 - **plasmolysis** = wilt

Hypertonic solution

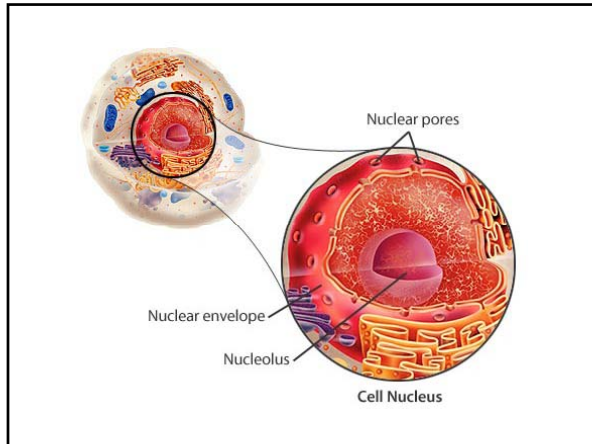
Shriveled

Plasmolyzed

saltwater

B. Nucleus

1. Directs the cell's activities and stores DNA.
2. Nuclear Envelope
 - a. A double membrane that surrounds the nucleus
3. Nucleolus
 - a. The place where DNA is concentrated when it is in the process of making ribosomal RNA.



C. Mitochondria

1. Transfers the energy in organic compounds into a form the cell can use: ATP

A diagram of a mitochondrion. It is bean-shaped with a highly folded inner membrane forming cristae. Labels include: Inner membrane (the folded membrane) and Outer membrane (the smooth outer boundary).

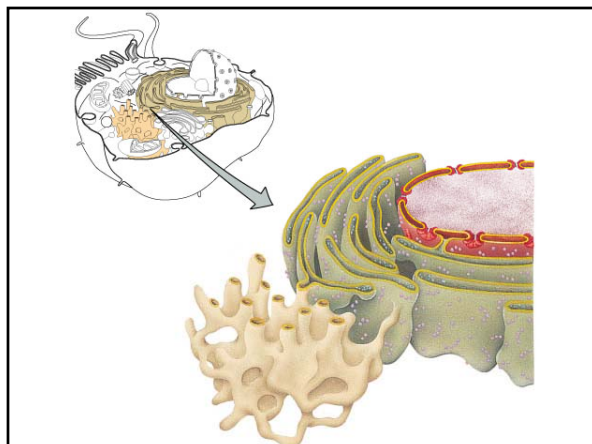
D. Ribosomes

1. Found either free-floating or attached to the endoplasmic reticulum.
2. Build protein.
3. No membrane

A diagram of a ribosome. It consists of two subunits: a smaller yellow one labeled 'Small subunit' and a larger blue one labeled 'Large subunit'. An arrow points to the assembled ribosome.

E. Endoplasmic Reticulum

1. The **rough ER** produces phospholipids and proteins for export or insertion into the cell membrane. *Includes digestive enzymes.*
2. The **smooth ER**
 - builds lipids (cholesterol)
 - produces steroid hormones (estrogen & testosterone) in the ovaries and testes
 - releases calcium in the skeletal and heart muscle cells
 - participates in detoxification of toxins in the liver and kidney



F. Golgi Apparatus

1. Processes and packages proteins.

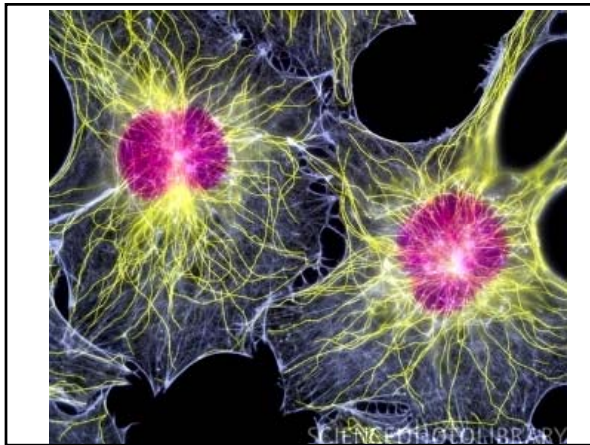
A detailed diagram of the Golgi apparatus. Labels include: Incoming Transport Vesicle (entering from the top left), Lumen (the space inside the cisternae), Cis Face (the top surface), Incoming Transport Vesicle (entering from the top right), Cisternae (the stacked sacs), Trans Face (the bottom surface), Newly Formed Vesicles (small vesicles at the bottom right), and Outgoing Transport Vesicles (leaving from the bottom left). The caption 'Figure 1' is at the bottom right.

G. Vesicles

1. Are classified by their contents.
 - a. Lysosomes: contain digestive enzymes
 - b. Peroxisomes: contain detoxification enzymes
2. Membrane-bound sacs

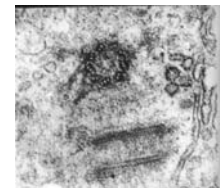
H. Cytoskeleton

1. Is made of protein fibers that help the cell move and also maintain its shape.
 - a. Fibers: Microtubules, microfilaments, and intermediate filaments.
2. Cilia and Flagella
 - a. Hairlike structures that extend from the surface of the cell.
 - b. Assist in movement of the cell.



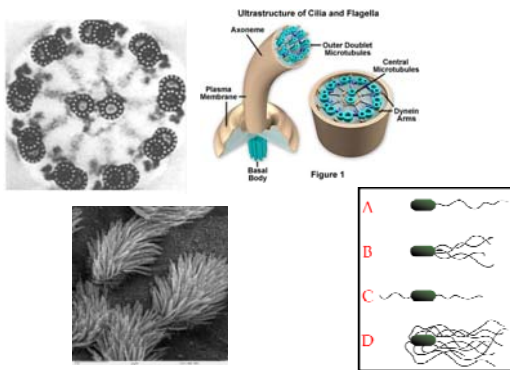
3. Centrioles

- a. Consists of two short cylinders of microtubules at right angles to each other.
- b. Involved in cell division.



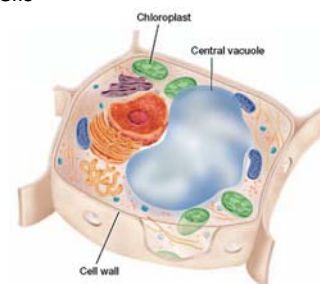
(Childs, 1996)

Cilia and Flagella



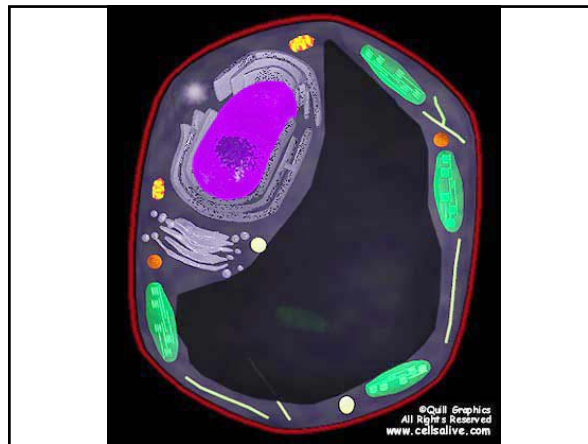
IV. Unique Features of Plant Cells

A. Plant Cells



1. Cell Wall
 - a. A rigid wall that covers the cell membrane and provides support and protection.

2. Central Vacuole/Tonoplast
 - a. Store water, enzymes, and waste products.
 - b. Provides support for plant and tissue.



3. Plastids
 - a. 3 types: **chloroplasts, chromoplasts and leucoplasts**
 - b. Surrounded by double membrane and contain their own DNA (like mitochondria)
 - c. Store starch and pigments
 - d. Chloroplast: converts light energy into chemical energy via photosynthesis.



Palisade Cell

- Closely packed, columnar cells, lying in the upper surfaces of leaves
- Contain many chloroplasts (where photosynthesis takes place) and are well adapted to receive and process the components necessary for photosynthesis – carbon dioxide, water, and sunlight.
- Vertical arrangement means that there are few cross-walls to interfere with the passage of sunlight.

(Farlex, 2009)

Plant Dermal Tissue

- **Xylem** carries water and minerals salts
- **Phloem** transports sugars and amino acids

DERMAL TISSUE
The cuticle is the primary water protective covering of the plant body. Some cells of the epidermis are modified to form stomata and other structures.

Epidermis
The epidermis consists of one layer of cells covering the entire leaf, root and stem of the young plant. The cells have thick cell walls and are covered on their outer surface by a waxy cuticle with an outer layer of cutin. They are in tight contact with adjacent cells.

Stomata
Stomata are openings in the epidermis, usually on the lower surface of the leaf, that regulate gas exchange in the plant. They are called *stoma* (singular), which regulates the diameter of the pore. Stomata are surrounded by two guard cells which regulate their opening and closing.

Vascular bundles
A vascular bundle is a single complex of different tissues that transport water and nutrients. These are arranged in discrete bundles in stems. In dicots, these are arranged in a ring. In monocots, they are scattered throughout the stem.

Xylem
Xylem carries water and dissolved ions in the plant. It is made up of large vessels and tracheids. The vessels are made of long, thin-walled cells with perforated end walls. The tracheids are shorter and have tapered ends.

Phloem
Phloem carries organic nutrients in the plant. The main conducting cells are sieve tube elements and companion cells. The sieve tube elements are long cells that are connected by perforations in their end walls. They have a thin cell wall and a large central vacuole. Companion cells are smaller and have a thick cell wall. They are connected to sieve tube elements by plasmodesmata.

(Access Excellence, 2009)

| Found in Plant and Animal Cells | Found Only in Plant Cells |
|---------------------------------|---------------------------|
| | |

Cell Comparison

| | Animal | Plant |
|----------------------------|-------------------------------|---|
| Exterior Structures | | |
| Cell wall | Absent | Present (cellulose) |
| Cell membrane | Present | Present |
| Flagella | May be present | Absent except in sperm of a few species |
| Interior Structures | | |
| Endoplasmic reticulum | Usually present | Usually present |
| Ribosomes | Present | Present |
| Microtubules | Present | Present |
| Centrioles | Present | Absent |
| Golgi Apparatus | Present | Present |
| Nucleus | Present | Present |
| Mitochondria | Present | Present |
| Chloroplasts | Absent | Present |
| Chromosomes | Multiple; DNA-protein complex | Multiple; DNA-protein complex |
| Lysosomes | Usually present | Present as "spherosomes" |
| Vacuoles | Absent or small | Usually a large single vacuole |

(MrsKingsbioweb, 2009)

Common Misconceptions

Remember

- Animal cells never have a cell wall, chloroplasts or sap vacuoles
 - (may have temp vacuoles where food is stored)
- Not all cells have all cell parts when mature
 - Red blood cells do not have a nucleus
 - Xylem cells do not have a nucleus or cytoplasm
- Animal cells have 3 parts: MNC...
 - membrane, nucleus, and cytoplasm

- Plant cells are usually larger than animal cells
- It is **not** true that all plant cells contain chloroplasts
 - Epidermis cells and root cells do not
- Chloroplasts are different from chlorophyll
 - Chloroplasts = organelle
 - Chlorophyll = chemical found in chloroplasts

Resources

Access Excellence. (2009). Plant tissues. Retrieved August 19, 2009 from website

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