

CELLS: LECTURE OUTLINE

I. DEVELOPMENT OF THE CELL THEORY

1. In 1663, *Robert Hooke* observed empty cell walls of cork, and coined the term "cell". He later observed living cells.
2. During the 19th century, *Theodor Schwann* concluded that **all living things are made of cells**.
3. **Spontaneous generation** (life from non-life or "**abiogenesis**") was the prevailing view of the era.
4. In 1858, Rudolf Virchow said that **cells could arise only from preexisting cells**.
5. In 1859, **Louis Pasteur** conducted experiments that finally **laid the idea of spontaneous generation to rest**.
6. During the 20th century, tenets of the **modern cell theory** emerged.

Cell Shapes

1. Cell shape varies widely. *Squamous* cells are flat and thin; *cuboidal* cells are cube-shaped.
2. Other shapes include *columnar*, *spheroid to ovoid*, *discoid*, *fusiform*, or *stellate*.
3. **Epithelial** cells that **line organs/surfaces** have a *basal* side, upon which the cell rests, and lateral sides that are adjacent to nearby cells, and the exposed *apical* surface.

Cell Size

1. Cell size is expressed in *micrometers*.
2. Most human cells range from 10-15 μm (same as microns; μ) but an egg cell may be 100 micrometers.
3. Cell size is limited due to **surface area-to-volume relationships**.

An Evolving Perspective on Cells

1. With the advent of the *transmission electron microscope*, biologists were able to see far more detail inside cells.
2. The **resolution** of the *light microscope* prevented early scientists from seeing organelles.
3. The *scanning electron microscope* views minute **surface** details.

II. The Cell Surface

A. The Plasma Membrane

1. Electron microscope revealed that the **cell (plasma) membrane** (also called *unit membrane*) is made up of **2 layers**.
2. The current model of membrane structure is called the *fluid-mosaic model*.

It suggests that the plasma membrane is made up of *mobile globular proteins in a layer of phospholipids*.

3. Membrane Lipids

- a. **Phospholipids** are amphiphilic (*amphipathic*), with a **hydrophilic** phosphate-containing **head** and **two hydrophobic fatty acid tails**.
- b. In the **plasma membrane**, the **phospholipids** are oriented with **heads out, and tails to the inside**, forming a **phospholipid bilayer**. The phospholipids are *not fixed* into position.
- c. Twenty percent of membrane lipids are **cholesterol**, which lends **stability** to the phospholipids.
- d. Another 5% of membrane lipids are *glycolipids*, which appear **only on the exterior of the membrane**.
- e. The plasma membrane can readily repair itself.

4. Membrane Proteins

- a. **Membrane proteins** can *span* the membrane (**integral or transmembrane proteins**), or lie on *one* side (**peripheral proteins**).
- b. Functions of membrane proteins include these groupings: **receptors** (receive chemical messages); **channel proteins**, motor molecules (cause **movement** within the cell); and cell identity **markers** (identify the cell).

B. The Glycocalyx

1. The *glycocalyx* consists of the *carbohydrates moieties* of the membrane **glycolipids** and **glycoproteins**. It is chemically unique in each individual.
2. The **glycocalyx** helps cells *adhere* to one another **as well as identifies cells as "self"**. The **glycocalyx** can also assist in **cellular uptake of substances from the extracellular fluid**.

C. Extensions of the Cell Surface

1. Microvilli

- a. **Microvilli** act to *increase the cell's surface area*, and occur in areas specialized for **absorption (intestines and kidneys)**.
- b. They appear as a *brush border*, with **stiff filaments of *actin* inside**.
- c. On cells of the *taste buds and inner ear*, cells with microvilli serve **sensory functions**.

2. Cilia

- a. **Cilia** are hair like extensions that are usually *motile*, and **move materials past the cell in the respiratory tract and uterine tubes**.
- b. Cilia beat in *waves* in the same direction (*power stroke*) then recover (*recovery stroke*).
- c. A *cilium* contains a **core** called an *axoneme* made up of *microtubules in a 9 + 2 arrangement*. **Peripheral microtubules** contain *dynein* arms that use energy to cause the cilium to beat back and forth.
- d. A *basal body*, **anchors** the cilium to the cell. (*triplet arrangement of microtubules*)

3. Flagella

- a. A *flagellum* is a **long, whiplike structure with an axoneme identical to that of the cilium**.
- b. In humans, flagella can be found in **sperm**.

III. THE CELL INTERIOR

A. Organelles

1. The Nucleus

- a. Of the organelles in the cell that are surrounded by a **double unit membrane**, the nucleus is the largest. Its nuclear envelope contains **pores**.
- b. The nucleus houses **DNA**, the genetic information for the cell.

2. Rough Endoplasmic Reticulum

- a. **Rough endoplasmic reticulum (ER)** is a system of branching *channels continuous with the outer plasma membrane*. Each channel contains a **space** called the *cisterna*.
Rough endoplasmic reticulum has **ribosomes** (sites of protein synthesis) associated with it.

3. Ribosomes

- Ribosomes** are small granules of *protein and RNA* that **read the messages encoded in mRNA**.
Attached to rough endoplasmic reticulum **OR free** in cytoplasm.

4. Golgi Complex and Vesicles

- a. The **Golgi complex** looks like a **series of cisternae with swollen edges**. Its function in the cell is to **receive polypeptide chains from the rough ER, modifies** them, and **packages** them into *vesicles*.
Some vesicles become *secretory vesicles*.
- b. The Golgi complex is also a **carbohydrate factory**, and in addition, **synthesizes some hormones and lipids**.

5. Lysosomes

- a. A **lysosome** is a **package of hydrolytic enzymes** enclosed by a **single unit membrane**.
- b. Many cells exhibit a **programmed cell death** in which contents of the **lysosomes digest cell contents**.
Lysosomes also exhibit **autophagy** when they **digest worn out cell contents**.

6. Peroxisomes

- a. **Peroxisomes** contain **different** enzymes than lysosomes, and are abundant in **the liver and kidney**.
- b. Peroxisome enzymes **detoxify alcohol and other drug; also neutralize free radicals**.

III. THE CELL INTERIOR CONT.

A. Organelles

7. Mitochondria

- The **mitochondrion** is surrounded by a *double unit membrane*.
The *folded portions* of the **inner mitochondrial membrane** are called *cris^tae*.
- Within the mitochondria, *energy is extracted from organic compounds and stored in ATP*.
- The mitochondrial *matrix* lies **between the cristae** and **contains mitochondrial DNA**.

8. Smooth Endoplasmic Reticulum

- Smooth ER is a **network of branching tubules, lacking ribosomes**.
- It functions to *detoxify drugs and alcohol, and also synthesizes triglycerides, cholesterol, and steroid hormones*.

9. Centrioles

- Centrioles** are *short assemblies of microtubules* arranged in *nine groups of three microtubules*.
- The **centrosome** is a place *within the cytoplasm* where *two centrioles lie perpendicular to each other*.
It plays a role in cell division.

B. Cytoskeleton

- The *cytoskeleton* is a collection of *protein filaments and cylinders* that helps **support** the cell, **organize** and **moves its contents**, and *helps the whole cell move*.
- Microfilaments* are 6 nm (1 nanometer = .001 μ) in diameter and composed of **actin**.
- Intermediate filaments* (8-10 nm) are **thicker and stiffer than microfilaments** and participate in *junctions* that hold epithelial cells together.
- A **microtubule** (25 nm) is a cylinder made of **13 parallel strands called protofilaments**, each of which is a long chain of **tubulin**. **Microtubules radiate from the centrosome and hold organelles in place and act like railroad tracks to guide organelles**, plus they participate as the *mitotic spindle during cell division*.
Microtubules are *not permanent structures*.

C. Inclusions

Inclusions are temporary cellular contents that take on a variety of activities.
Some contain *glycogen granules*, while others hold *oil droplets, mucus, or pigments*.

IV. Intercellular Junctions

A. Intercellular Junctions

- Intercellular junctions occur **between adjacent cells** and help maintain **structural integrity** of tissue as well as allow **communication between cells**.
- Tight Junctions**
 - Tight junctions are formed by a zipper-like fusion of membrane proteins of adjacent cells.
 - In the intestine, tight junctions keep bacteria out and ensure that nutrients are absorbed into cells, rather than passing between them.
- Desmosomes**

A desmosome is a "**spot weld**" between cells that holds them together to help the tissue resist mechanical stress.
- Gap (Communicating) Junctions**

Gap junctions are formed by a **ring like structure** made up of membrane proteins.
Chemical communication and **nutrients** can pass from one cell to the next through gap junctions.

V. MEMBRANE TRANSPORT - PASSIVE MECHANISMS

A. Filtration

1. **Filtration:** process whereby particles are driven through the **selectively permeable membrane** of the cell.
2. An *example* of filtration in the body is when **blood pressure forces fluid through the walls of capillaries.**

B. Simple Diffusion

1. **Simple diffusion** involves the **movement of particles from an area of greater concentration to one of lesser concentration because of their own kinetic energy.**
Particles are said to move *down a concentration gradient.*
2. Diffusion *rates increase with increasing temperature, decrease with molecular weight, increase with a steeper concentration gradient and larger surface area of membrane.*
Permeability of the membrane also influences diffusion rate.

C. Osmosis

1. **Osmosis** is a **special case of diffusion involving water movement from an area where water is more greatly concentrated to an area containing less water.**
2. **Tonicity** (*tonicity literally = strength*)
 - a. The ability of a solution to affect the fluid volume and pressure within a cell is called its *tonicity.*
 - b. **Hypotonic solutions** are *more dilute* (less solutes) **than the intracellular fluid;**
hypertonic solutions are more **concentrated.** **Isotonic solutions** contain the *same* quantities of solute.

D. Facilitated Diffusion

1. **Facilitated diffusion** is the movement of a solute *down a concentration gradient* with the help of a *carrier protein.*

E. Carrier-Mediated Transport

1. **Carrier-mediated transport:** *carrier proteins embedded in the plasma membrane.*

VI. MEMBRANE TRANSPORT - ACTIVE MECHANISMS

A. Active Transport

1. **Active transport** employs **carrier proteins**, but **USES ENERGY (ATP)** to move solutes up (against) their concentration gradients.
2. Active transport is a four-step process. First, the **ligand binds to the carrier.** Second, the **carrier hydrolyzes ATP** and becomes **phosphorylated.** Third, the **carrier undergoes a conformational change.** Fourth, the **carrier releases the ligand on the other side of the membrane and returns to its original shape.**

B. Bulk Transport (*note: ALL of these are active transport processes!*)

1. **Bulk transport** involves the moving of **larger substances (droplets) across a membrane.**
2. **Exocytosis** is the **expulsion** of material from the cell; **endocytosis** is the *opposite* process (**brings material IN**).
3. **Phagocytosis** is the process of "**cell eating**", wherein the cytoplasm flows into **pseudopods**, surrounds a particle, and traps it into a **vacuole** or **phagosome.**
4. **Pinocytosis** (cell "**drinking**") employs **pinocytotic vesicles to take in droplets of extracellular fluid.**
Receptor-mediated pinocytosis is *more selective*, and a **clathrin-coated pit** forms around a **protein receptor** that is bound to the target molecule. HIV employs this process to invade healthy cells.

Review: Prokaryotic vs. Eukaryotic cells from BIO 105