Human Cytology

Lecture One

The Cell

- **History of cell knowledge.**
- **The Cell theory.**
- **Eukaryotic and prokaryotic.**

Cell biology also known as cytology. It deals with cells and its organelles. you find curious of yours about cells and how they act like independent livings within bodies of living organisms. Cells are important parts of life and without them life can be impossible.

0.1- Cell biology history:

The word cell comes from the Latin word "cella", meaning "small room", and it was first coined by a microscope observing the structure of cork. The optical microscope was first invented in 17th century, shortly thereafter scientists began to examine living and dead biological tissues in order to better understand the science of life, and some of the most relevant discovery milestones of the time period include:

The discovery of the microscope influenced the discovery of cells. The microscopist and physicist from England Robert Hook in 1665 looked at cork under a microscope and described what he called cork **"cells".**

- **Anton van Leeuwenhoek** called the single-celled organisms that he saw under the microscope **"animalcules"**
- **Matthias Jakob Schleiden,** a botanist, in 1838 determined that all plants consist of cells.
- **Theodor Schwann**, a zoologist, in 1839 determined that all animals consist of cells.
- **Rudolf Virchow** proposed the theory that all cells arise from previously existing cells

- In 1838, the botanist **Matthias Jakob Schleiden** and the physiologist **Theodor Schwann** discovered that both plant cells and animal cells had nuclei. Based on their observations, the two scientists conceived of the hypothesis that all living things were composed of cells.
- In 1839, **Schwann** published 'Microscopic Investigations on the Accordance in the Structure and Growth of Plants and Animals, which contained the first statement of their joint **cell theory.**

The Cell Theory:

1- All organisms are composed of one or more of cells.

2- Cell is the basic unit of life.

3- The new cell arises only from pre-existing cell.

The Cell:

- Cells are the basic units of structure and function in the human body, as they are in all living things.
- Each cell carries out basic life processes that allow the body to survive, many human cells are specialized in form and function, each type of cell plays a specific role, for example, nerve cells have long projections that help them carry electrical messages to other cells, muscle cells have many mitochondria that provide the energy they need to move the body.
- The organisms composed of a single cell are called **unicellular organisms** and those of many cells are called **multicellular organisms**.
- All cells are broadly classified into **prokaryotic cells** and **eukaryotic cells,** according to whether their genetic materials are enclosed by a nuclear envelope or not.

Prokaryotic and Eukaryotic cells:

(A) Prokaryotic cells:

1- Very simple cells, small and that have few organelles.

2- These cells do not have a nucleus, but do have DNA, and some prokaryotic cell contain circular DNA which is called **Plasmid** are not essential for the life of cell. They may confer certain properties like toxigenicity, virulence and drug resistance.

3- There is a cell membrane surrounded by a cell wall that encloses its cytoplasm and a few other organelles.

4- **Bacteria** and **Archaea** are prokaryotic cells, notice that most bacteria contain some sort of a polysaccharide layer outside of the cell wall this layer is called a **capsule,** have several functions such as mediate adherence of cells to surfaces and protection, and some bacteria are covered with short hair-like structures known as **pili** as well as a long whip like **flagellum** that it can use to move.

(B) Eukaryotic cells:

1- A more complex cell with a nucleus and many organelles.

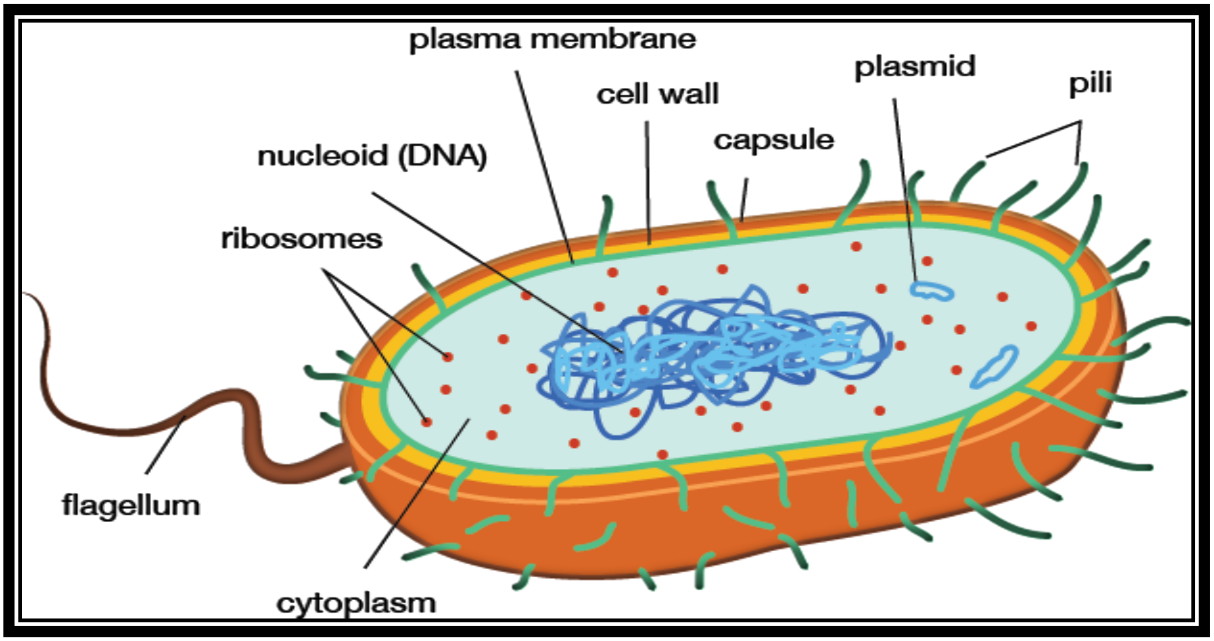
2- They can be just one cell or can make up more complex multi-cellular organisms.

3- They all have a nucleus where the genetic material of the cell is stored.

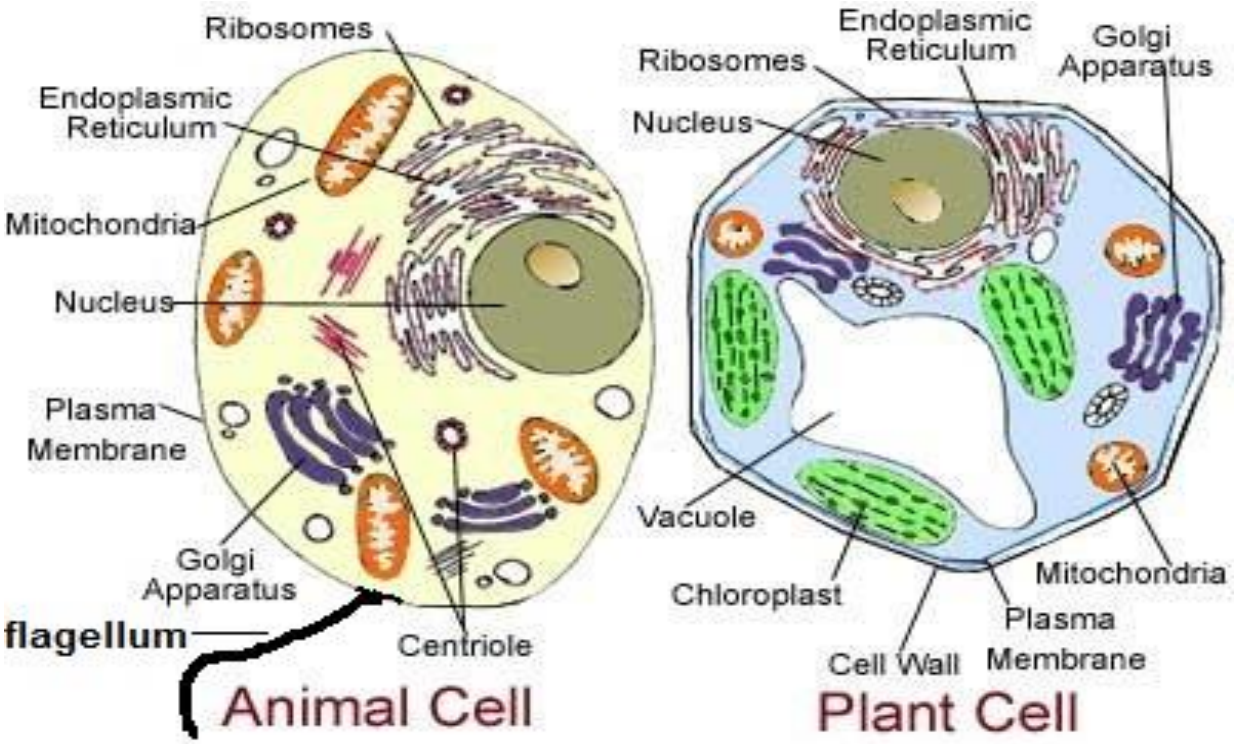
4- There is a cell membrane surrounded by a cell wall that encloses its cytoplasm and organelles. *(No cell wall in the animal cell), and some eukaryotic cell contain **flagellum**.

5- All plants, animals, fungi, and protists are eukaryotic cells.

Typical of Prokaryotic Cells Structure (Bacteria).

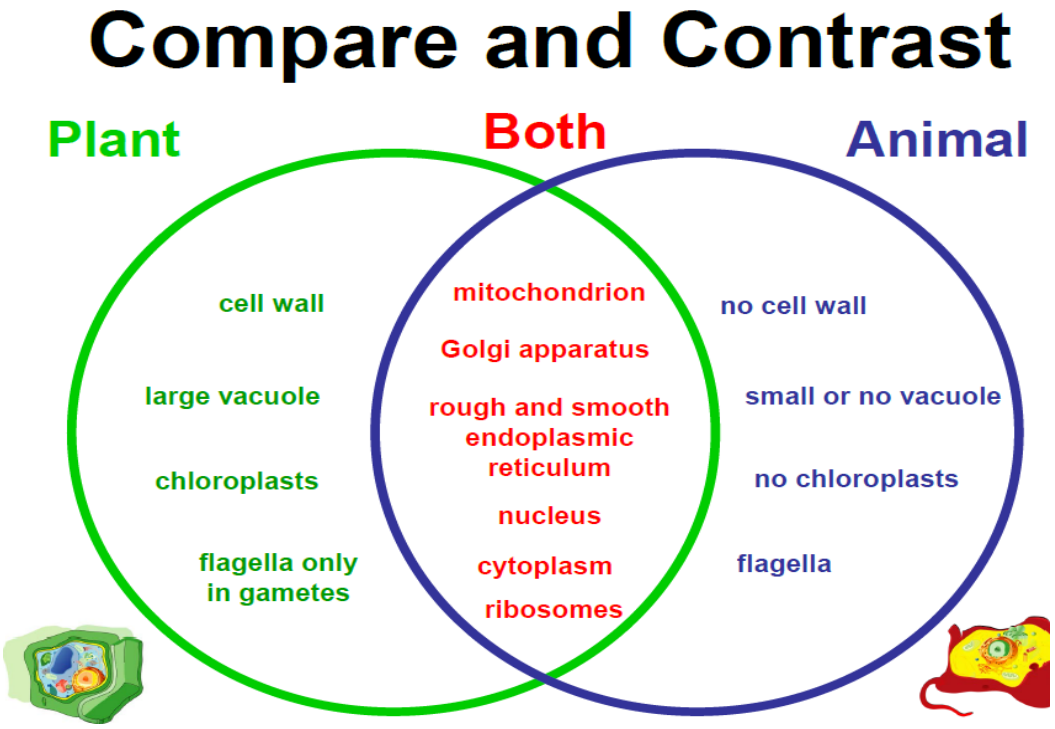


Typical of Eukaryotic Cells Structure (Plant and animal cell).



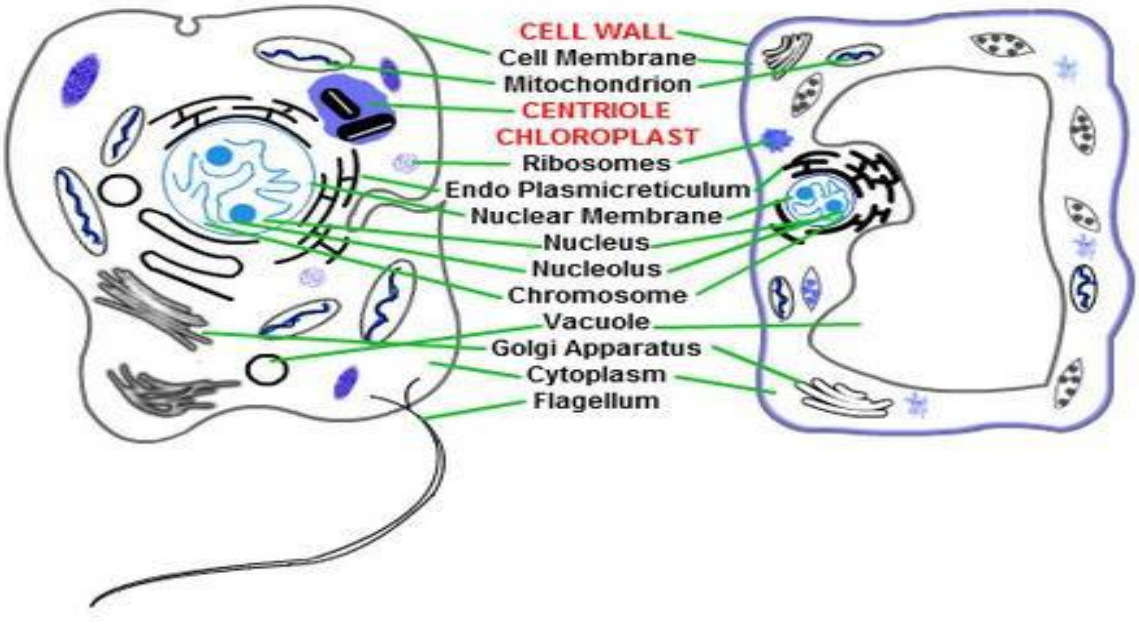
Lecture Two

Compare between animal and plant cell



Compare Animal and Plant Cells

Below you could see Comparison of Plant Cells and Animal Cells.



What are the types of cells on different basis?

Classification on the Basis of Cell Size

Type of cell	**Organism**	**Size**
Prokaryotic cell	Mycoplasma	0.1 - 0.3 μm
	Bacterium	1 to 2 μm
Eukaryotic cell	Animal cell	10 to 20 μm
	Plant cell	

Cell types

- Stem cells. Stem cells are cells that must choose what they are going to become. ...
- Bone cells. There are at least three main types of bone cells:
- Blood cells. There are many types of blood cells.
- Muscle cells. ...
- Sperm cells. ...
- Female egg cell. ...
- Fat cells. ...
- Nerve cells.

Why are cell types important?

Categorizing cells into types greatly reduces the complexity of investigating the organization and function of cells, especially for large organisms with billions to trillions of cells in the body, e.g., mammals.

What are the basics of cells?

A cell consists of three parts: the cell membrane, the nucleus, and, between the two, the cytoplasm.

Cellular organelles and structure:

Plasma Membrane (Cell membrane):

The cell membrane, also called the plasma membrane, is found in all cells and separates the interior of the cell from the outside environment. The cell membrane consists of a lipid bilayer that is semipermeable. The cell membrane regulates the transport of materials entering and exiting the cell.

Is cell membrane prokaryotic or eukaryotic?

Both prokaryotic and eukaryotic cells have a plasma membrane, a double layer of lipids that separates the cell interior from the outside environment. This double layer consists largely of specialized lipids called phospholipids.

What is membrane type?

The membranes can be classified into two categories epithelial and connective tissue membrane. Epithelial membranes are the ones that consist of epithelial tissues. The connective tissue is attached to it. There are two main types of epithelial membranes, which are mucous membranes and serous membranes.

What is membrane classification?

Membranes can be classified as impermeable, semipermeable, selectively permeable, and permeable membrane. An impermeable membrane does not allow any substances to pass through. On the other hand, a selectively permeable membrane allows only specific solutes pass through while blocking others.

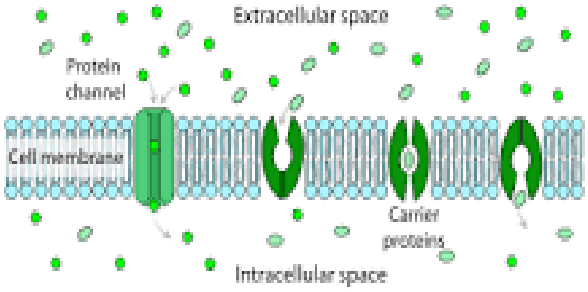
What is a body membrane?

Body membranes are thin sheets of tissue that cover the body, line body cavities, and cover organs within the cavities in hollow organs. Two main categories of body membranes are epithelial and connective tissue membranes. Sub-categories include mucous membranes, serous membranes, synovial membranes, and meninges.

What is the other main function of the cell membrane?

The cell membrane, therefore, has two functions: first, to be a barrier keeping the constituents of the cell in and unwanted substances out and, second, to be a gate allowing transport into the cell of essential nutrients and movement from the cell of waste products.

What are the two main types of cell transport?

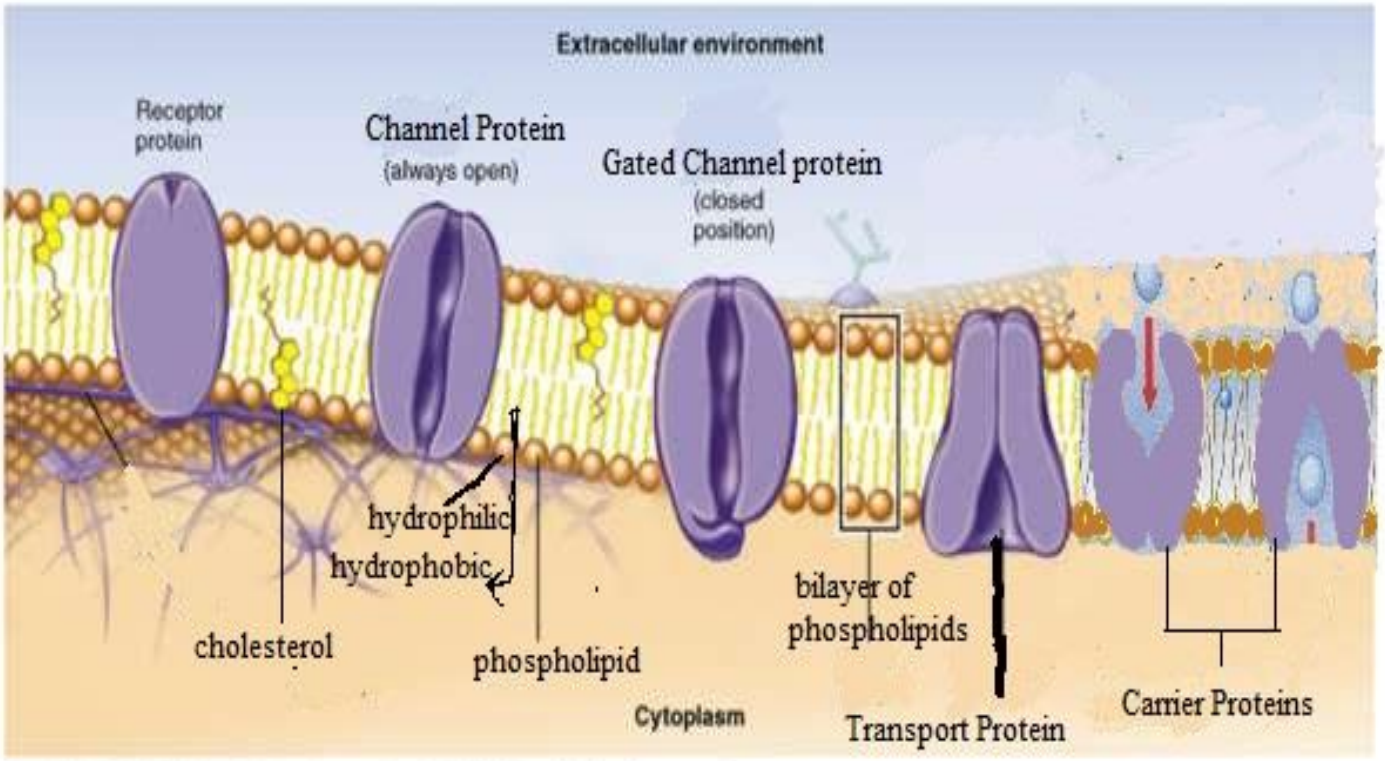


Moving things in and out of the cell is an important role of the plasma membrane. It controls everything that enters and leaves the cell. There are two basic ways that substances can cross the plasma membrane: passive transport, which requires no energy; and active transport, which requires energy.

Proteins Embedded in Membrane Serve Different Functions:

- **Transport Proteins:** regulate movement of substance.
- **Channel Proteins**: form small openings for molecules to diffuse through like water
- **Carrier Proteins:** Binding site on protein surface "grabs" certain molecules and pulls them into the cell.

- **Gated Channels Proteins:**
  - Similar to carrier proteins, not always "open"—eg. Bind and pull in calcium ions when needed.
  - This requires cell energy—active transport.



There are two ways in which substances can enter or leave a cell:

(1) Passive Transport

Cell doesn't use energy

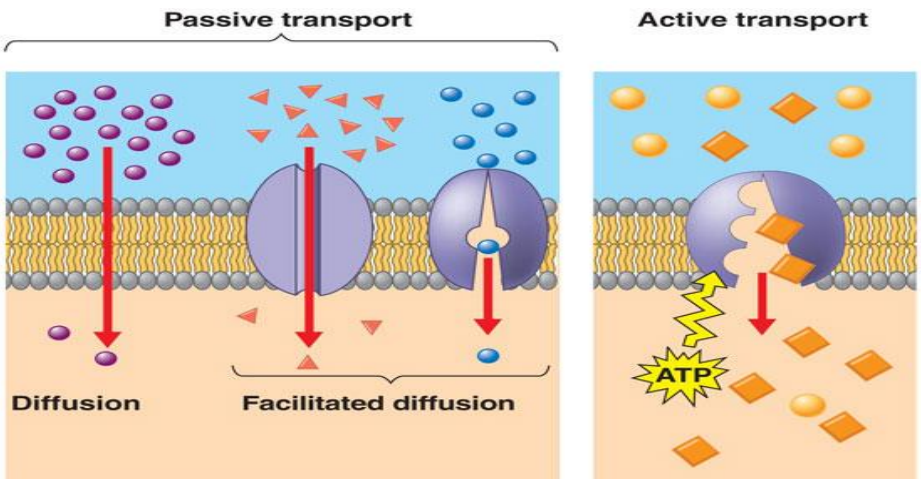
(a) Diffusion

(b) Facilitated Diffusi

(c) Osmosis

(2) Active Transport

Cell does use energy

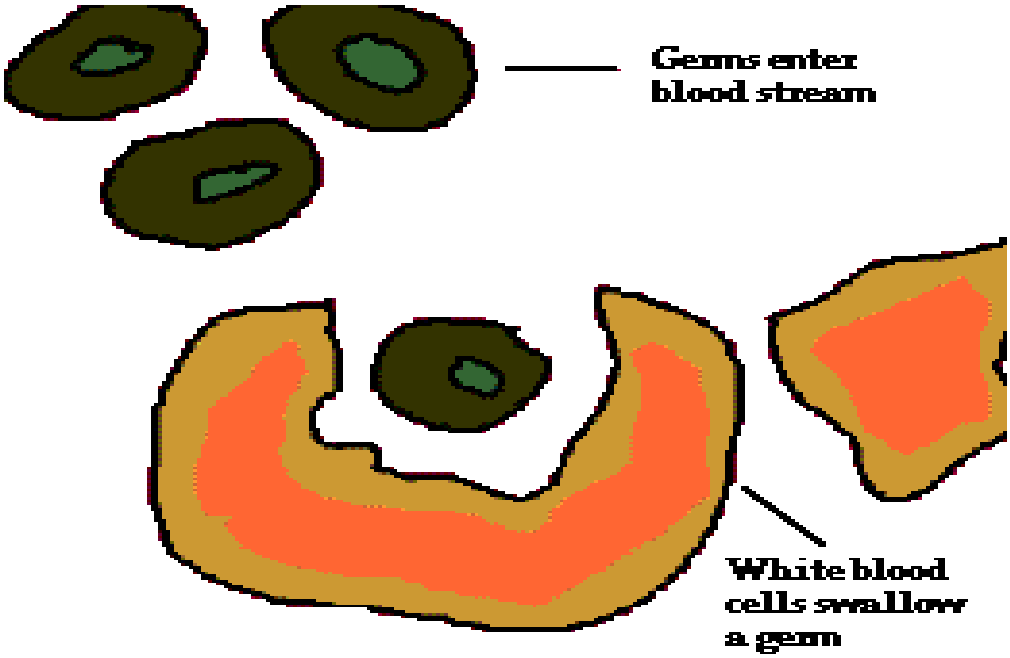


(a) Protein Pumps

(b) Vesicular transport

I. Endocytosis.
II. Exocytosis.

.



Lecture three

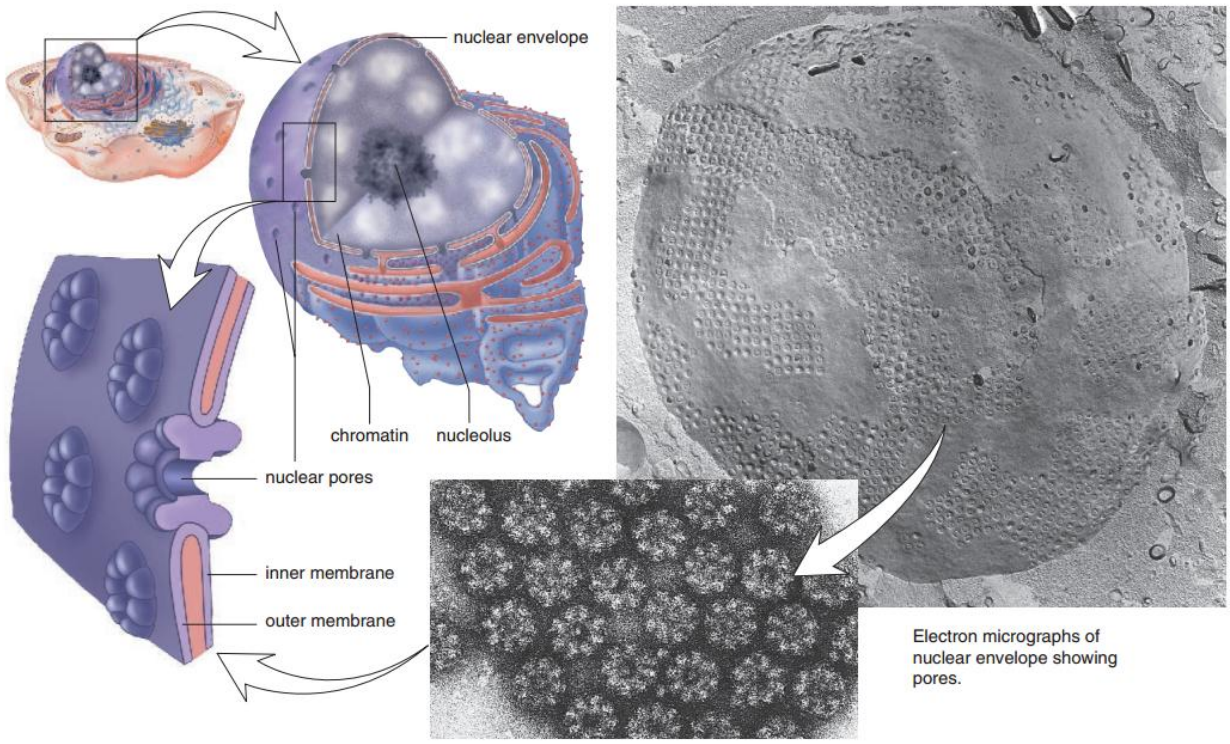
Cytoplasm:

The gelatinous liquid part of the cell included everything that is surrounded by the cell membrane except the nucleus, Inorganic and organic substances are present in it. **The functions** of the cytoplasm are to maintain a shape to the cell, bear cell organelles and carryout different metabolic processes.

The Nucleus:

Nucleus is the main organelle in a cell. It is surrounded by a nuclear envelope. One or two **nucleolus** and the chromatin body are present inside the nucleus. During cell division, the chromatin body converts into **chromosome** (The **chromatin**, looks grainy, but actually it is a threadlike material that undergoes coiling into rod-like structures called chromosomes just before the cell divides). **The functions of chromosomes** are the storage of genetic material and transfer inherited characters from generation to generation, the main function of the nucleus is the control of life activities of the cell.

The nucleus is separated from the cytoplasm by a double membrane known as the **nuclear envelope**, which is continuous with the endoplasmic reticulum. The nuclear envelope has nuclear pores of sufficient size (100 nm) to permit the passage of proteins into the nucleus and ribosomal subunits out of the nucleus.



(The nucleus and the nuclear envelope.)

The Endoplasmic Reticulum:

The term endoplasmic means "within the cytoplasm," and the term reticulum is Latin for "a little net." The endoplasmic reticulum has two portions.

- **Rough ER** is studded with ribosomes on the side of the membrane that faces the cytoplasm. Here, proteins are synthesized and enter the ER interior, where processing and modification begin. Some of these proteins are incorporated into membrane, and some are for export.
- **Smooth ER,** continuous with rough ER, does not have attached ribosomes. Smooth ER synthesizes the phospholipids that occur in membranes and has various

other functions, depending on the particular cell. In the testes, it produces testosterone. In the liver, it helps detoxify drugs.

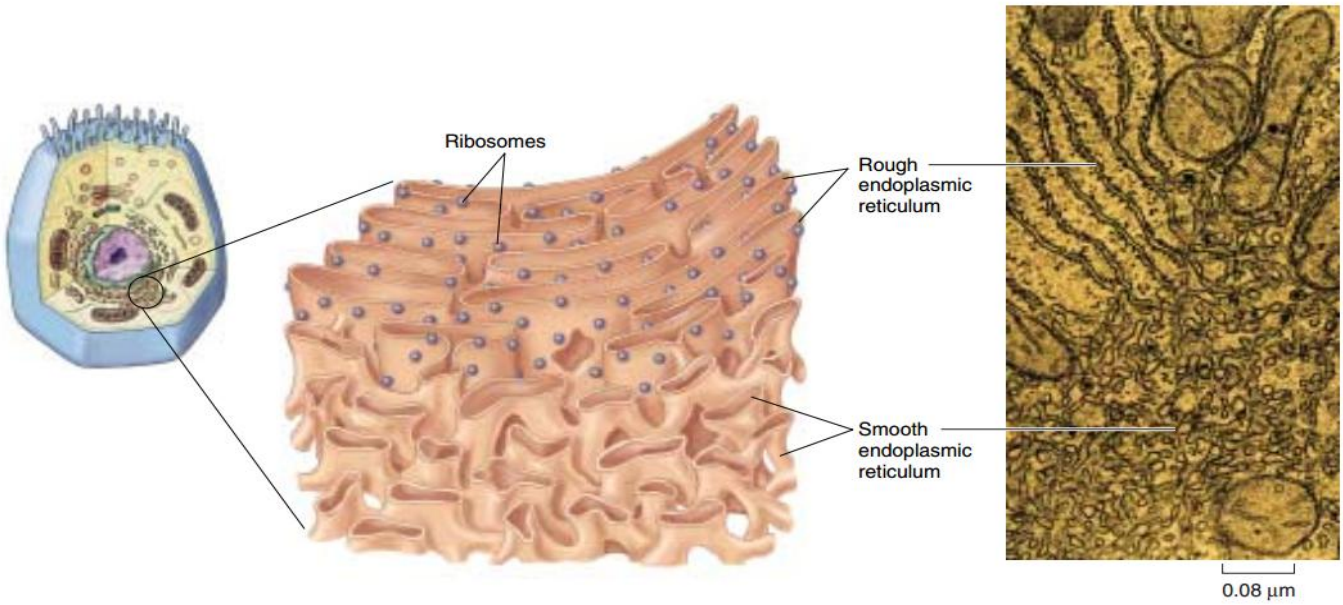


FIGURE
The endoplasmic reticulum. Ribosomes are associated with only one side of the rough ER; the other side is the boundary of a separate compartment within the cell into which the ribosomes extrude newly made proteins destined for secretion. Smooth endoplasmic reticulum has few to no bound ribosomes.

Cytology

Lecture Four

Ribosomes: Sites of Protein Synthesis:

Ribosomes are made up of several molecules of a special form of RNA called ribosomal RNA, or rRNA, bound within a complex of several dozen different proteins. Ribosomes are among the most complex molecular assemblies found in cells.

Each ribosome is composed of two subunits, the subunits join to form a functional ribosome only when they attach to another kind of RNA, called messenger RNA (mRNA) in the cytoplasm. To make proteins, the ribosome attaches to the mRNA, which is a transcribed copy of a portion of DNA, and uses the information to direct the synthesis of a protein.

Bacterial ribosomes are smaller than eukaryotic ribosomes. Also, a bacterial cell typically has only a few thousand ribosomes, while a metabolically active eukaryotic cell, such as a human liver cell, contains several million. Proteins that function in the cytoplasm are made by free ribosomes suspended there, while proteins bound within membranes or destined for export from the cell are assembled by ribosomes bound to rough ER

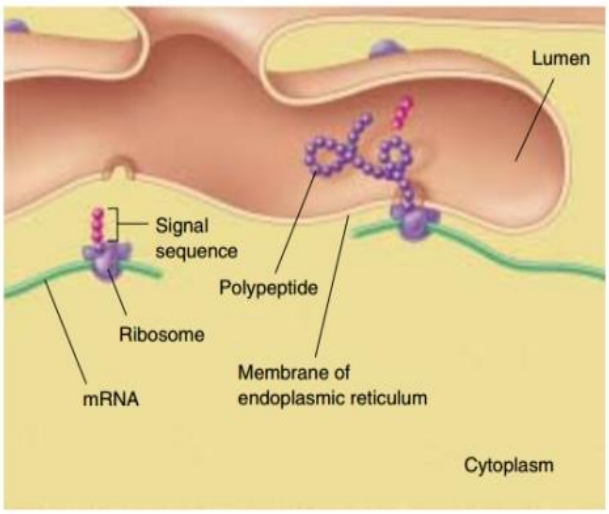


FIGURE
Signal sequences direct proteins to their destinations in the cell. In this example, a sequence of hydrophobic amino acids (the signal sequence) on a secretory protein attaches them (and the ribosomes making them) to the membrane of the ER. As the protein is synthesized, it passes into the lumen (internal chamber) of the ER. The signal sequence is clipped off after the leading edge of the protein enters the lumen.

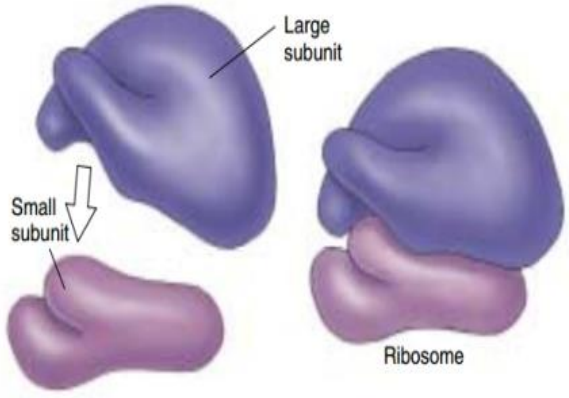


FIGURE
A ribosome. Ribosomes consist of a large and a small subunit composed of rRNA and protein. The individual subunits are synthesized in the nucleolus and then move through the nuclear pores to the cytoplasm, where they assemble. Ribosomes serve as sites of protein synthesis.

The Golgi apparatus:

The Golgi apparatus is named for **Camillo Golgi**, who discovered its presence in cells in 1898. The Golgi apparatus consists of a stack of three to twenty slightly curved saccules whose appearance can be compared to a stack of pancakes.

In animal cells, one side of the stack (the inner face) is directed toward the ER, and the other side of the stack (the outer face) is directed toward the plasma membrane. Vesicles can frequently be seen at the edges of the saccules.

Enzymes in the sacs put the finishing touches on proteins and lipids, then package the completed molecules in vesicles for shipment to specific locations. The vesicles that leave the Golgi apparatus move to other parts of the cell. Some vesicles proceed to the plasma membrane, where they discharge their contents. In all, **the Golgi apparatus is involved in processing, packaging, and secretion**. For example, an enzyme in one Golgi region might attach a phosphate group to a new protein and then "pack" the protein into a vesicle, thereby giving it a "mailing tag"

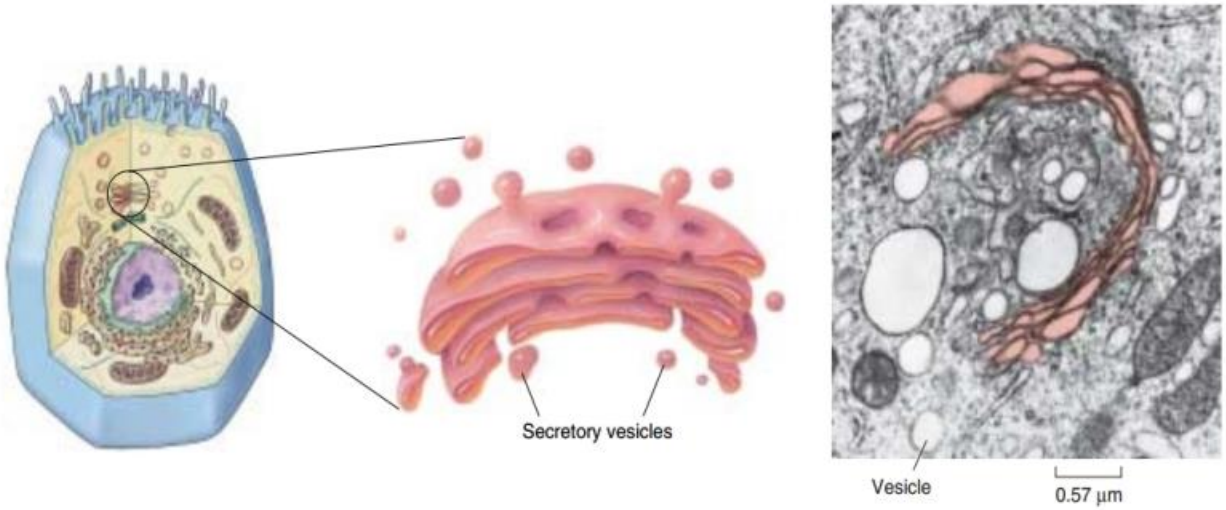
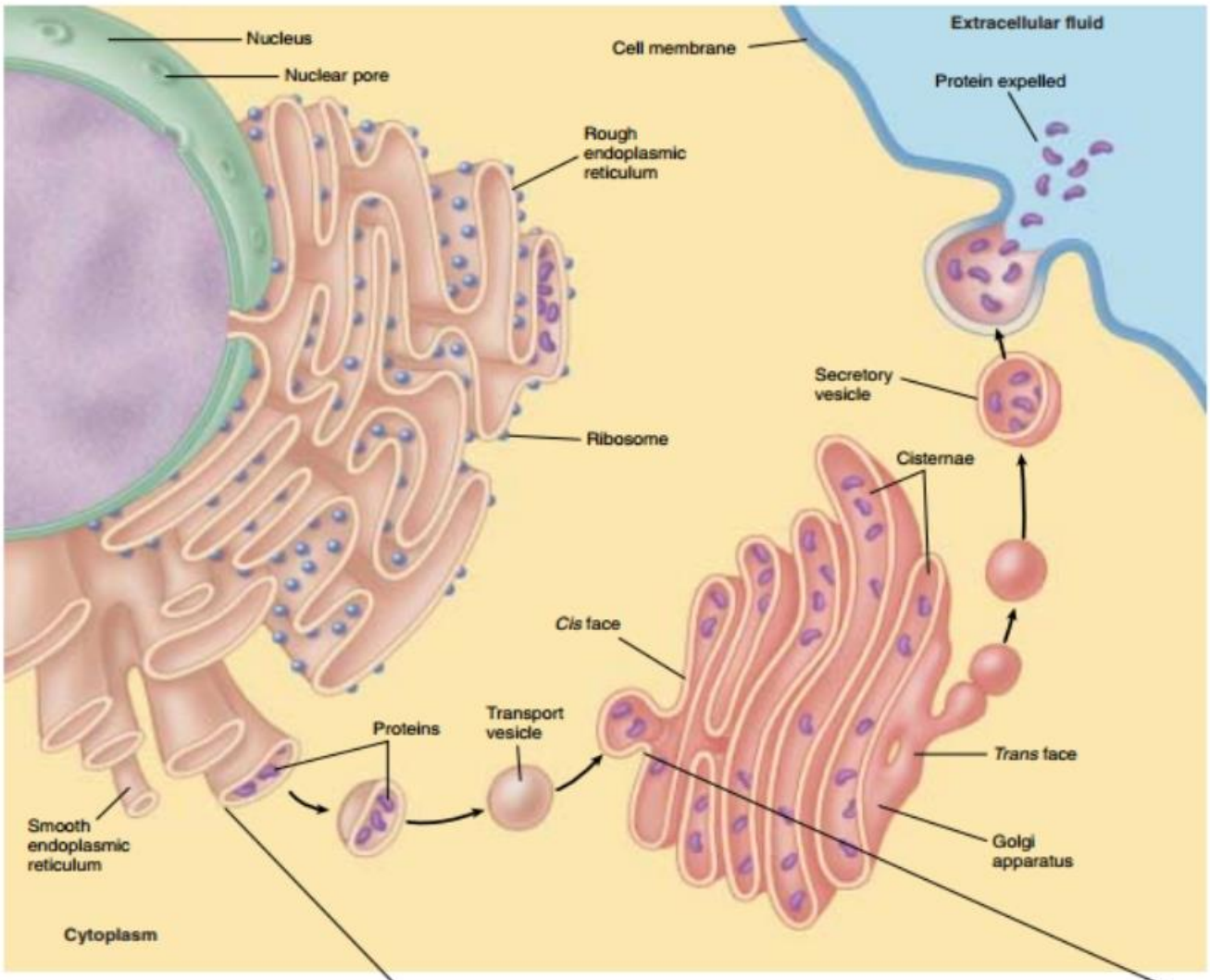
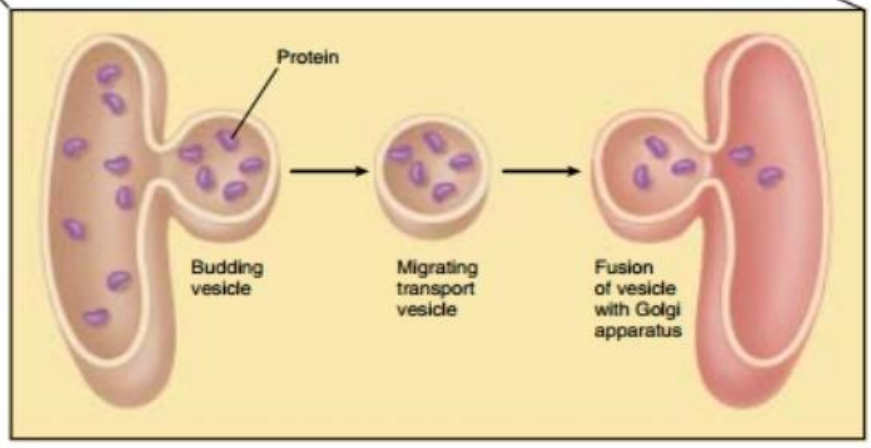


FIGURE
The Golgi apparatus. The Golgi apparatus is a smooth, concave membranous structure located near the middle of the cell. It receives material for processing on one surface and sends the material packaged in vesicles off the other. The substance in a vesicle could be for export out of the cell or for distribution to another region within the same cell.

How proteins are transported within the cell?





How proteins are transported within the cell. Proteins are manufactured at the ribosome and then released into the internal compartments of the rough ER. If the newly synthesized proteins are to be used at a distant location in or outside of the cell, they are transported within vesicles that bud off the rough ER and travel to the *cis* face, or receiving end, of the Golgi apparatus. There they are modified and packaged into secretory vesicles. The secretory vesicles then migrate from the *trans* face, or discharging end, of the Golgi apparatus to other locations in the cell, or they fuse with the cell membrane, releasing their contents to the external cellular environment.

Human cytology

Lecture six & seven

Lysosomes:

Lysosomes, membranous sacs produced by the Golgi apparatus, contain hydrolytic enzymes. Lysosomes are found in all cells of the body but are particularly numerous in white blood cells that engulf disease-causing microbes. When a lysosome fuses with such an endocytic vesicle, its contents are digested by lysosomal enzymes into simpler subunits that then enter the cytoplasm. In a process called auto-digestion, parts of a cell may be broken down by the lysosomes. Some human diseases are caused by the lack of a particular lysosome enzyme. Tay–Sachs disease occurs when an undigested substance collects in nerve cells, leading to developmental problems and death in early childhood.

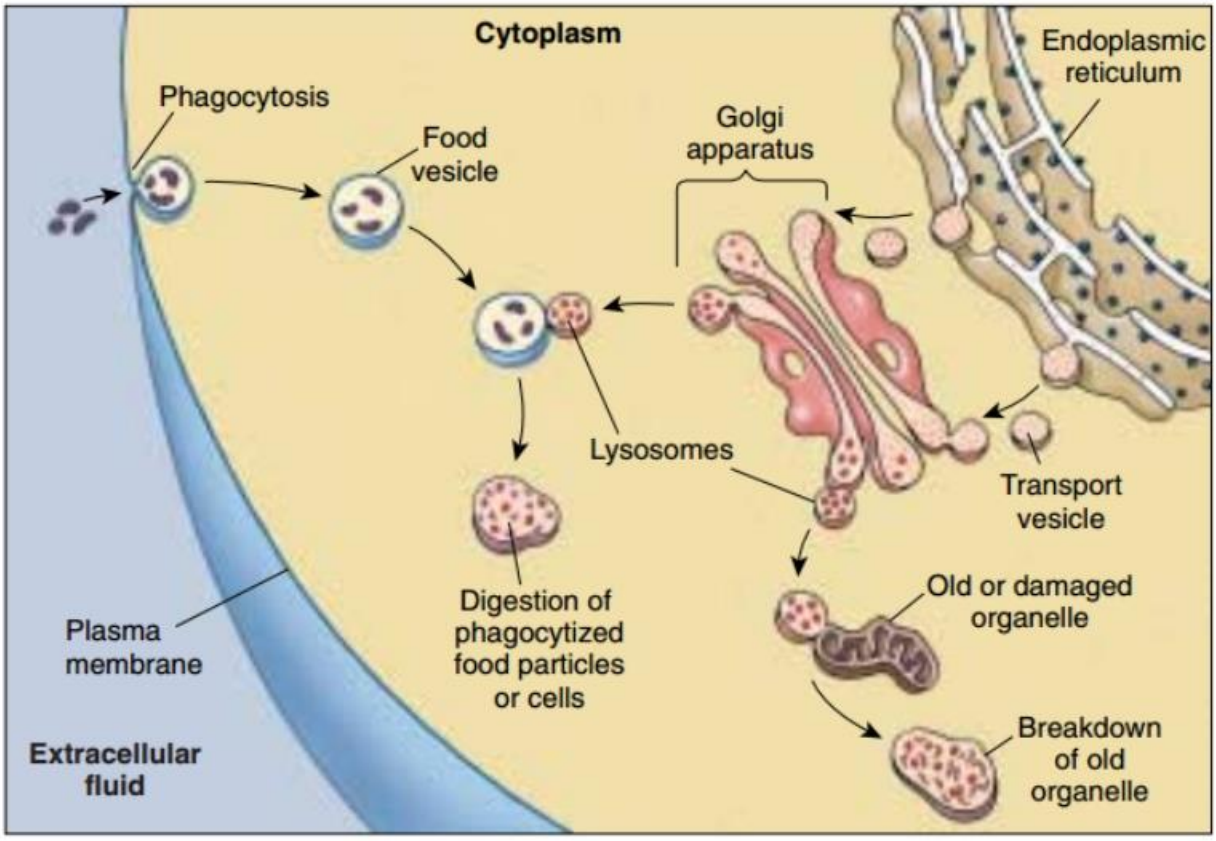
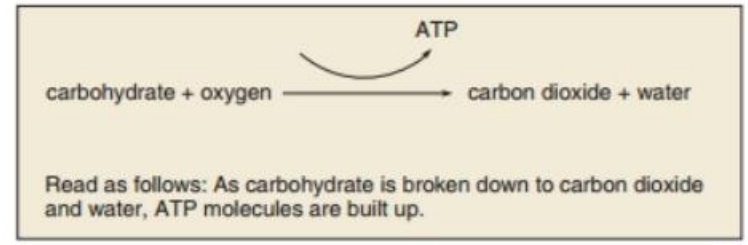


FIGURE
Lysosomes. Lysosomes contain hydrolytic enzymes that digest particles or cells taken into the cell by phagocytosis and break down old organelles.

Mitochondrion:



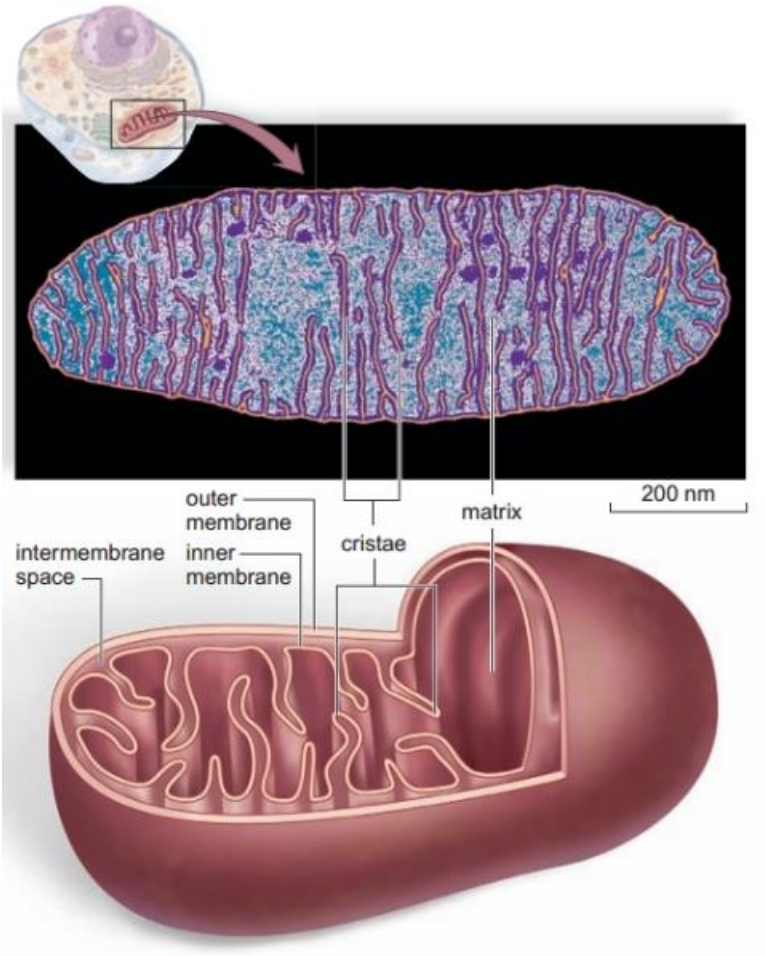


Figure The structure of a mitochondrion.
A mitochondrion (TEM, *above*) is bounded by a double membrane, and the inner membrane folds into projections called cristae. The cristae project into a semifluid matrix that contains many enzymes.

Mitochondria are often called the powerhouses of the cell. Just as a powerhouse burns fuel to produce electricity, the mitochondria convert the chemical energy of glucose products into the chemical energy of ATP molecules. In the process, mitochondria use up oxygen and give off carbon dioxide. Therefore, the process of producing ATP is called cellular respiration. The structure of mitochondria is appropriate to the task. The inner membrane is folded to form little shelves called cristae. These project into the matrix, an inner space filled with a gel-like fluid. The matrix of a mitochondrion contains enzymes for breaking down glucose products. ATP production then occurs at the cristae. Protein complexes that aid in the conversion of energy are located in an assembly-line

fashion on these membranous shelves. The structure of a mitochondrion supports the hypothesis that they were originally prokaryotes engulfed by a cell. Mitochondria are bounded by a double membrane as a prokaryote would be if taken into a cell by endocytosis. Even more interesting is the observation that mitochondria have their own genes, and they reproduce themselves!

Human cytology

Lecture seven & eight

Cytoskeleton:

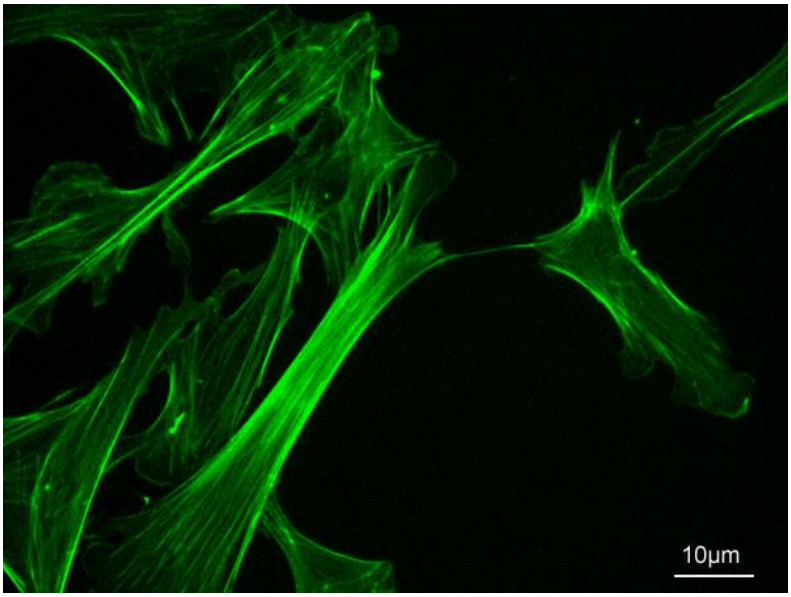
The cytoskeleton is a complex, dynamic network of interlinking protein filaments present in the cytoplasm of all cells, including those of bacteria and archaea. In eukaryotes, it extends from the cell nucleus to the cell membrane and is composed of similar proteins in the various organisms. It is composed of three main components: microfilaments, intermediate filaments, and microtubules, and these are all capable of rapid growth and or disassembly depending on the cell's requirements, In neurons the intermediate filaments are known as neurofilaments.

A multitude of functions can be performed by the cytoskeleton. Its primary function is to give the cell its shape and mechanical resistance to deformation, and through association with extracellular connective tissue and other cells it stabilizes entire tissues. The cytoskeleton can also contract, thereby deforming the cell and the cell's environment and allowing cells to migrate. Moreover, it is involved in many cell signaling pathways and in the uptake of extracellular material (endocytosis), the segregation of chromosomes during cellular division, the cytokinesis stage of cell division, as scaffolding to organize the contents of the cell in space and in intracellular transport (for example, the movement of vesicles and organelles within the cell) and can be a template for the construction of a cell wall. Furthermore, it can form specialized structures, such as flagella, cilia, lamellipodia and podosomes. The structure, function and dynamic behavior of the cytoskeleton can be very different, depending on organism and cell type. Even within one cell, the cytoskeleton can change through association with other proteins and the previous history of the network.

A large-scale example of an action performed by the cytoskeleton is muscle contraction. This is carried out by groups of highly specialized cells working together. A main component in the cytoskeleton that helps show the true function of this muscle contraction is the microfilament. Microfilaments are composed of the most abundant cellular protein known as actin and myosin.

Functions include:

- Muscle contraction
- Cell movement
- Intracellular transport/trafficking
- Maintenance of eukaryotic cell shape
- Cytokinesis
- Cytoplasmic streaming



Cytoskeleton Microfilaments

Centrioles:

In animal cells, centrioles are short cylinders with a 9 pattern of microtubules. There are nine outer microtubule triplets and no center microtubules. There is always one pair of centrioles lying at right angles to one another near the nucleus. Before a cell divides, the centrioles duplicate, and the members of the new pair are also at right angles to one another. During cell division, the pairs of centrioles separate so that each daughter cell gets one pair of centrioles.

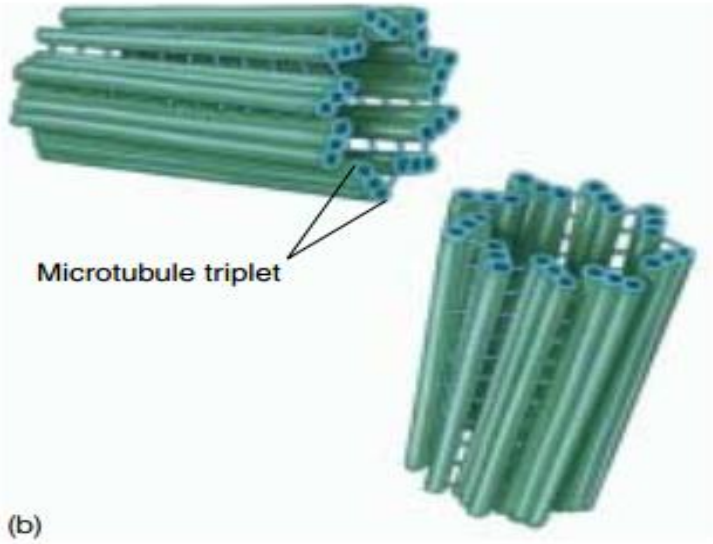


FIGURE
Centrioles. (*a*) This electron micrograph shows a pair of centrioles (75,000×). The round shape is a centriole in cross-section; the rectangular shape is a centriole in longitudinal section. (*b*) Each centriole is composed of nine triplets of microtubules.

Cilia and Flagella:

Cilia (sing., cilium) and flagella (sing., flagellum) are involved in movement. The ciliated cells that line our respiratory tract sweep debris trapped within mucus back up the throat. This helps keep the lungs clean. Similarly, ciliated cells move an egg along the oviduct, where it will be fertilized by a flagellated sperm cell.

A cilium is about 20 times shorter than a flagellum but both have the same organization of microtubules within a plasma membrane covering. Motor molecules, powered by ATP, allow the microtubules in cilia and flagella to interact and bend, and thereby move.

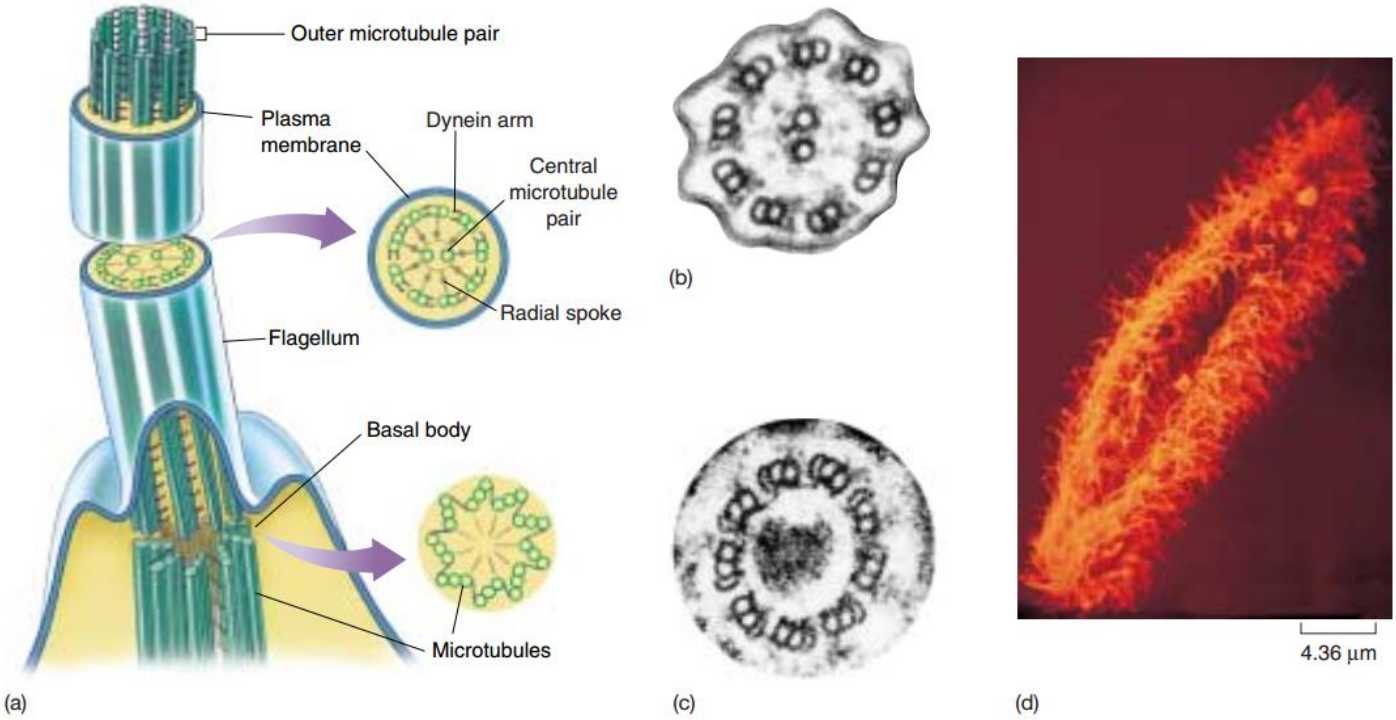


FIGURE
Flagella and cilia. (*a*) A eukaryotic flagellum originates directly from a basal body. (*b*) The flagellum has two microtubules in its core connected by radial spokes to an outer ring of nine paired microtubules with dynein arms. (*c*) The basal body consists of nine microtubule triplets connected by short protein segments. The structure of cilia is similar to that of flagella, but cilia are usually shorter. (*d*) The surface of this *Paramecium* is covered with a dense forest of cilia.