The cell

Lecture II

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TABLE 1.1: Major Organ Systems of the Human Body

Organ System	Major Tissues and Organs	Function
Cardiovascular	Heart; blood vessels; blood	Transports oxygen, hormones, and nutrients to the body cells. Moves wastes and carbon dioxide away from cells.
Lymphatic	Lymph nodes; lymph vessels	Defend against infection and disease, moves lymph between tissues and the blood stream.
Digestive	Esophagus; stomach; small intestine; large intestine	Digests foods and absorbs nutrients, minerals, vitamins, and water.
Endocrine	Pituitary gland, hypothalamus; adrenal glands; ovaries; testes	Produces **hormones** that communicate between cells.
Integumentary	Skin, hair, nails	Provides protection from injury and water loss, physical defense against infection by microorganisms, and temperature control.
Muscular	Cardiac (heart) muscle; skeletal muscle; smooth muscle; tendons	Involved in movement and heat production.
Nervous	Brain, spinal cord; nerves	Collects, transfers, and processes information.
Reproductive	Female: uterus; vagina; fallopian tubes; ovaries Male: penis; testes; seminal vesicles	Produces gametes (sex cells) and sex hormones.
Respiratory	Trachea, larynx, pharynx, lungs	Brings air to sites where gas exchange can occur between the blood and cells (around body) or blood and air (lungs).
Skeletal	Bones, cartilage; ligaments	Supports and protects soft tissues of body; produces blood cells; stores minerals.
Urinary	Kidneys; urinary bladder	Removes extra water, salts, and waste products from blood and body; controls pH; controls water and salt balance.
Immune	Bone marrow; spleen; white blood	Defends against diseases.

Cell

Most cells are small and can be seen only under a microscope. The small size of cells means that they are measured using the smaller units of the metric system, such as the *micrometer* (µm). A micrometer is 1/1,000 millimeter. The micrometer is the common unit of measurement for people who use microscopes professionally

- Most human cells are about 100 µm in diameter.

The Cell Theory

As stated by the **cell theory,**

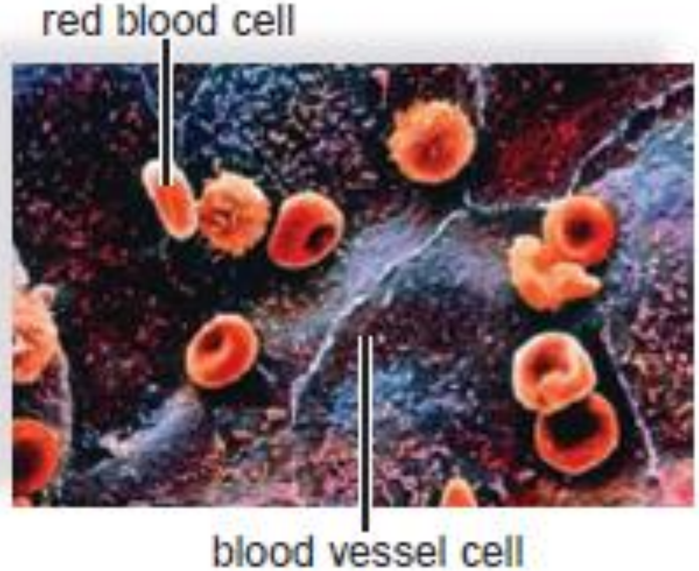
- *a cell is the basic unit of life*. Nothing smaller than a cell is alive. A unicellular organism exhibits the characteristics of life.

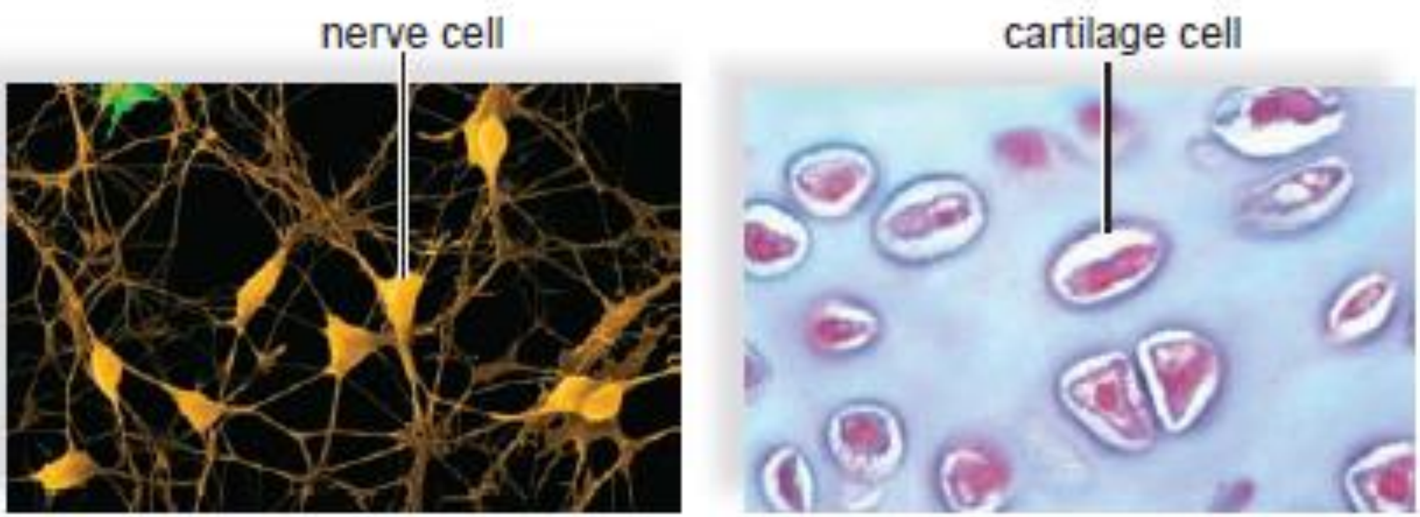
- *All living things are made up of cells.*

Is there any tissue in the human body not composed of cells? At first, you might be inclined to say that bone is not composed of cells.

However, if you were to examine bone tissue under the microscope, you would be able to see that it, too, is composed of cells surrounded by material they have deposited. Cells look different—a blood cell looks different than a nerve cell.

Figure **Cells vary in structure and function.** A cell's structure is related to its function. Despite differences in appearance, all exchange substances with their environment.





- *New cells arise only from pre-existing cells*.

- Until the nineteenth century, most people believed in spontaneous generation, that is, that nonliving objects could give rise to living organisms. In 1864, the French scientist Louis Pasteur conducted a now-classic set of experiments using bacterial cells. His experiments proved conclusively that spontaneous generation of life from nonlife was not possible

When mice or humans reproduce, a sperm cell joins with an egg cell to form a zygote. This is the first cell of a new multicellular organism. By reproducing, parents pass a copy of their genes onto their offspring. The genes contain the instructions that allow the zygote to grow and develop into the complete organism.

- **Microscopy**

Micrographs are photographs of objects most often obtained by using:

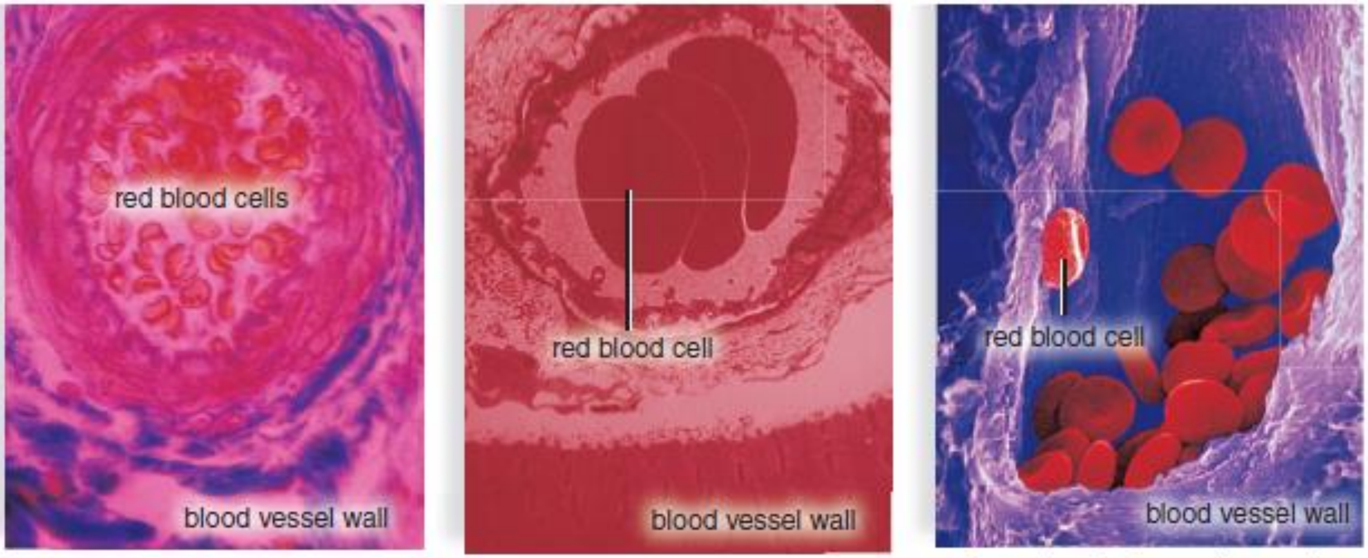
1. **Compound light microscope**: A *compound light microscope* uses a set of glass lenses and light rays passing through the object to magnify objects. The image can be viewed directly by the human eye.

2. Transmission electron microscope:

The *transmission electron microscope* makes use of a stream of electrons to produce magnified images. The human eye cannot see the image. Therefore, it is projected onto a fluorescent screen or photographic fi lm to produce an image that can be viewed. The magnification produced by a transmission electron microscope is much higher than that of a light microscope. Also, this microscope has the ability to produce enlarged images with greater detail. In other words, the transmission electron microscope has a higher resolving power—the ability to distinguish between two adjacent points.

3. Scanning electron microscope:

A *scanning electron microscope* provides a three dimensional view of the surface of an object. A narrow beam of electrons is scanned over the surface of the specimen, which is coated with a thin layer of metal. The metal gives off secondary electrons, which are collected to produce a television-type picture of the specimen's surface on a screen.



a. Light micrograph   b. Transmission electron micrograph   c. Scanning electron micrograph

Figure Micrographs of human red blood cells. Each of these micrographs is of a human red blood cell.
a. Light micrograph (LM) of many cells in a large vessel (stained). **b.** Transmission electron micrograph (TEM) of just three cells in a small vessel (colored). **c.** Scanning electron micrograph (SEM) gives a three-dimensional view of cells and vessels (colored).

How Cells Are Organized

Biologists classify cells into two broad categories—the **prokaryotes** and **eukaryotes**. The prokaryotic group includes the bacteria; the eukaryotic group consists of animals, plants,fungi, and some single-celled organisms. Despite their differences, both types of cells have a **plasma membrane,** an outer membrane that regulates what enters and exits a cell. The plasma membrane is a phospholipid bilayer.

All types of cells also contain **cytoplasm,** which is a semifluid medium that contains water and various types of molecules suspended or dissolved in the medium. The presence of proteins accounts for the semi fluid nature of the cytoplasm. The cytoplasm contains **organelles**. Eukaryotic cells have many different types of organelles.

Internal Structure of Eukaryotic Cells

The most prominent organelle within the **eukaryotic cell** is a **nucleus,** a membrane-enclosed structure in which DNA is found. **Prokaryotic cells** (such as bacterial cells) lack a nucleus **.** Although the DNA of prokaryotic cells is centrally placed within the cell, it is not surrounded by a membrane.

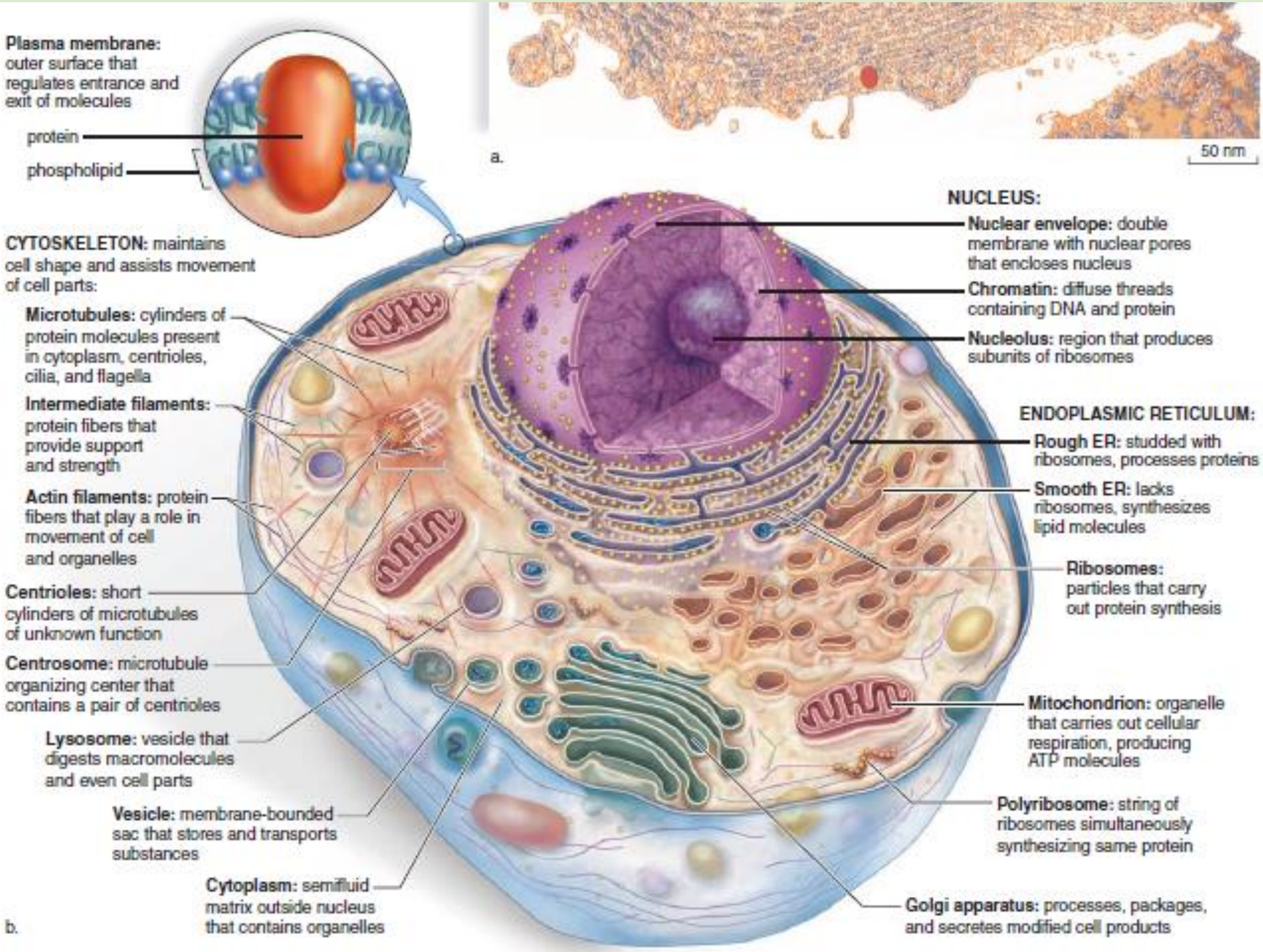


Figure 3.4 The structure of a typical eukaryotic cell.

The Plasma Membrane

The plasma membrane is a phospholipid bilayer with attached or embedded proteins. Aphospholipid molecule has a polar head and nonpolar tails. When phospholipids are placed in water, they naturally form a spherical bilayer. The polar heads, being charged, are hydrophilic (attracted to water).

The Plasma Membrane

They position themselves to face toward the watery environment outside and inside the cell. The nonpolar tails are hydrophobic (not attracted to water). They turn inward toward one another, where there is no water.

The Plasma Membrane

At body temperature, the phospholipid bilayer is a liquid. It has the consistency of olive oil. The proteins are able to change their position by moving laterally. The **fluid-mosaic model** is a working description of membrane structure. It states that the protein molecules form a shifting pattern within the fluid phospholipid bilayer. Cholesterol lends support to the membrane. Short chains of sugars are attached to the outer surface of some protein and lipid molecules. These are called *glycoproteins* and *glycolipids*, respectively.

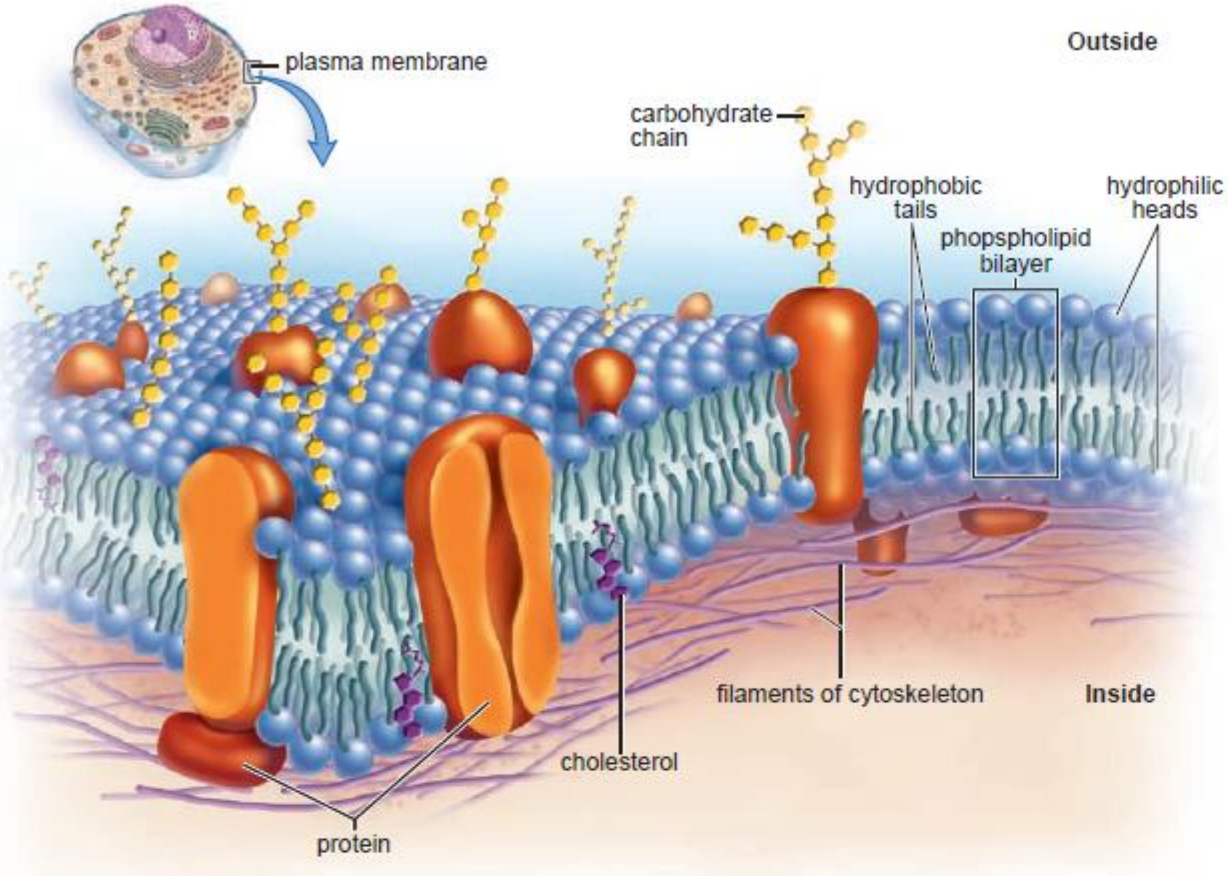


Figure **Organization of the plasma membrane.**
A plasma membrane is composed of a phospholipid bilayer in which proteins are embedded. The hydrophilic heads of phospholipids are a part of the outside surface and the inside surface of the membrane. The hydrophobic tails make up the interior of the membrane. Note the plasma membrane's asymmetry—carbohydrate chains are attached to the outside surface, and cytoskeleton filaments are attached to the inside surface. Cholesterol lends support to the membrane.

Plasma Membrane Functions

The plasma membrane keeps a cell intact. It allows only certain molecules and ions to enter and exit the cytoplasm freely. Therefore,

the plasma membrane is said to be selectively permeable Small, lipid-soluble molecules, such as oxygen and carbon dioxide, can pass through the membrane easily. The small size of water molecules allows them to freely cross the membrane by using protein channels called *aquaporins.* Ions and large molecules cannot cross the membrane without more

direct assistance.

The Nucleus

The **nucleus,** a prominent structure in cells, stores genetic information. Every cell in the body contains the same genes. Genes are segments of DNA that contain information for the production of specific proteins. Each type of cell has certain genes turned on and others turned off. DNA, with RNA acting as an intermediary, specifies the proteins in a cell. Proteins have many functions in cells, and they help determine a cell's specificity.

Nucleus

Chromatin is the combination of DNA molecules and proteins that make up the **chromosomes.** Micrographs of a nucleus do show one or more dark regions of the chromatin. These are nucleoli (sing., **nucleolus**), where ribosomal RNA (rRNA) is produced. This is also where rRNA joins with proteins to form the subunits of ribosomes.

Nucleus

The nucleus is separated from the cytoplasm by a double membrane known as the **nuclear envelope.** This is continuous with the **endoplasmic reticulum (ER),** a membranous

system of saccules and channels. The nuclear envelope has **nuclear pores** of sufficient size to permit the passage of ribosomal subunits out of the nucleus and proteins into the nucleus.

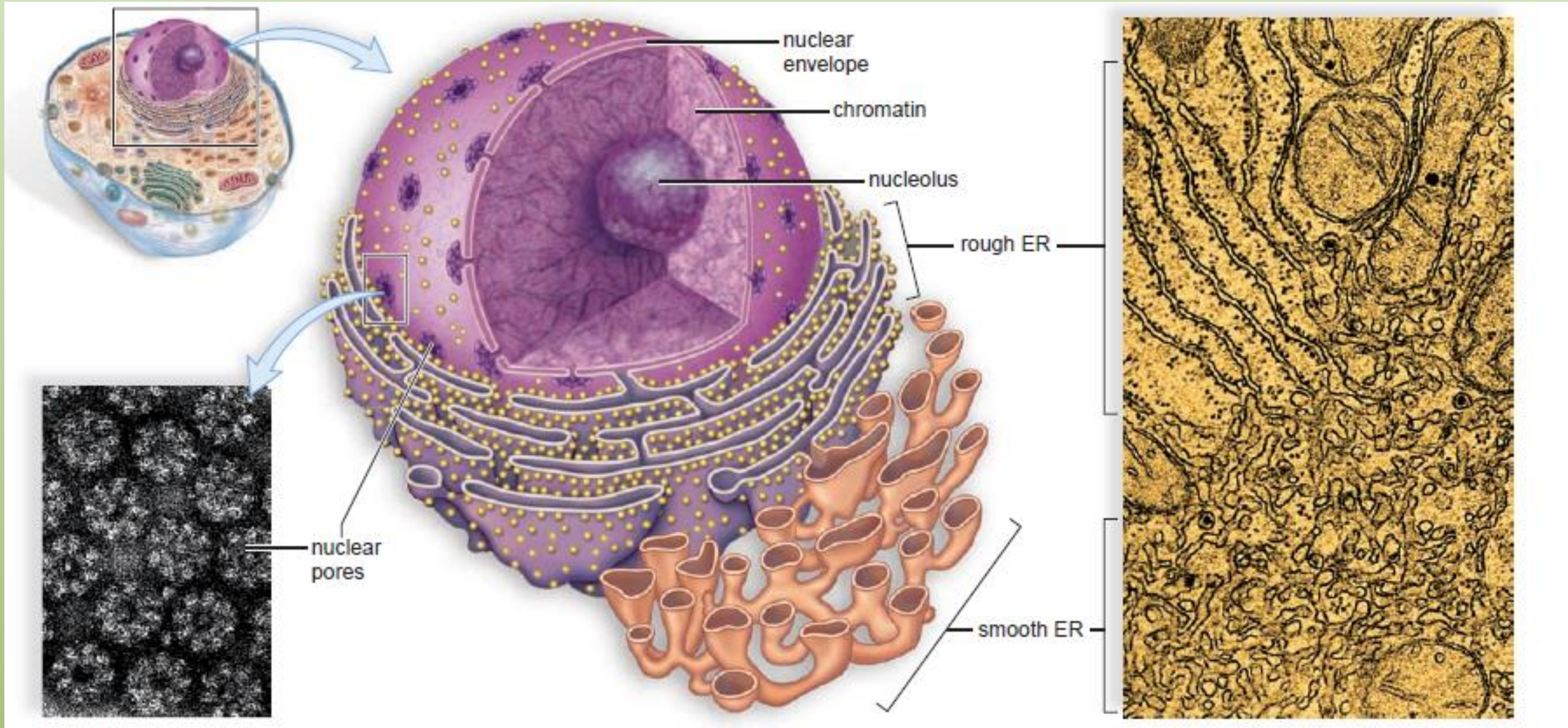


Figure **The nucleus and endoplasmic reticulum.**

• Ribosomes

Ribosomes are organelles composed of proteins and rRNA. Protein synthesis occurs at the ribosomes. Ribosomes are often attached to the endoplasmic reticulum; but they also may occur free within the cytoplasm, either singly or in groups called **polyribosomes.** Proteins synthesized at ribosomes attached to the endoplasmic reticulum have a different destination from that of proteins manufactured at ribosomes free in the cytoplasm.

The Endomembrane System

The **endomembrane system** consists of

the nuclear envelope,

the endoplasmic reticulum,

the Golgi apparatus,

lysosomes,

and **vesicles** (tiny membranous sacs)

The Endoplasmic Reticulum

- The endoplasmic reticulum has two portions. Rough ER is studded with ribosomes on the side of the membrane that faces the cytoplasm.

- 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.

The Endoplasmic Reticulum

- 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.

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 slightly curved saccules, whose appearance can be compared to a stack of pancakes.

- proteins and lipids received from the ER are modified. For example, a chain of sugars may be added to them. This makes them glycoproteins and glycolipids, molecules often found in the plasma membrane. In all, the Golgi apparatus is involved in processing, packaging, and secretion

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

Lysosomes

are digested by lysosomal enzymes into simpler subunits that then enter the cytoplasm. In a process called autodigestion, 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.

The Cytoskeleton, Cell Movement, and Cell Junctions

In the cytoskeleton, **microtubules** are much larger than actin filaments. Each is a cylinder that contains rows of a protein called tubulin. The regulation of microtubule assembly is under the control of a microtubule organizing center called the **centrosome.**

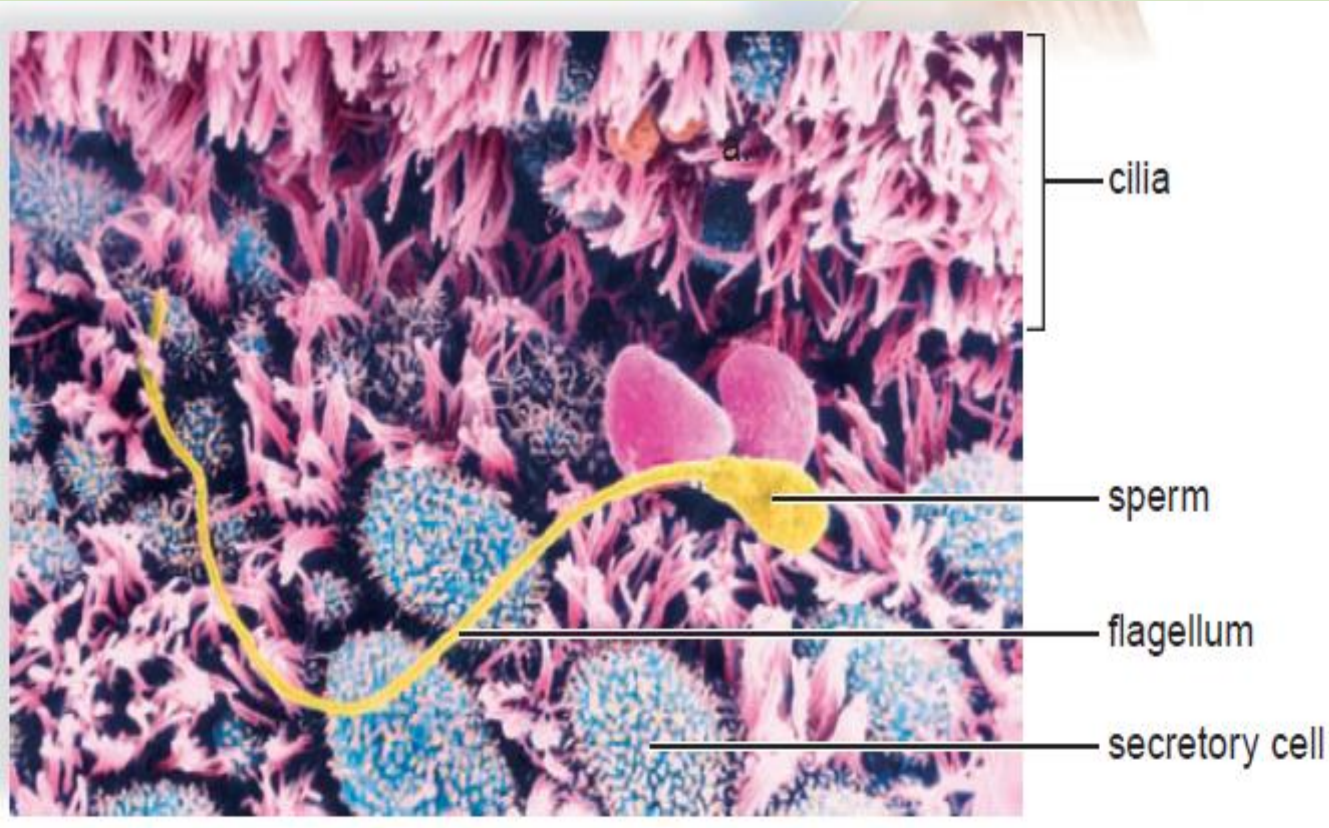
During cell division, microtubules form spindle fibers, which assist the movement of chromosomes.

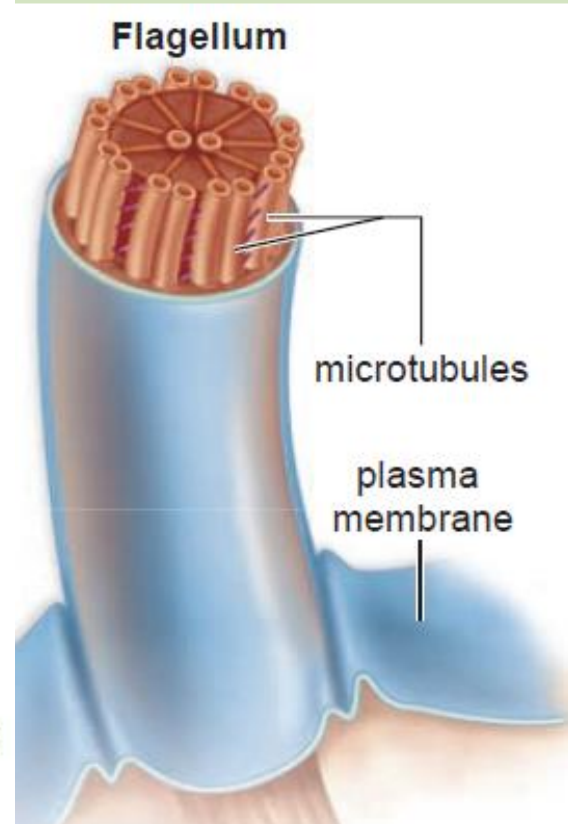
- **Actin filaments,** made of a protein called *actin,* are long, extremely thin fibers
- Actin filaments are involved in movement

- **Intermediate fi laments,** as their name implies, are intermediate in size between microtubules and actin fi laments. Their structure and function differ according to the type of cell.

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.


cilia
sperm
flagellum
secretory cell


Flagellum
microtubules
plasma membrane

Mitochondria and Cellular Metabolism

- Mitochondria (sing., **mitochondrion**) 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 producin ATP is called **cellular respiration**

Mitochondria

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.

Mitochondria

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