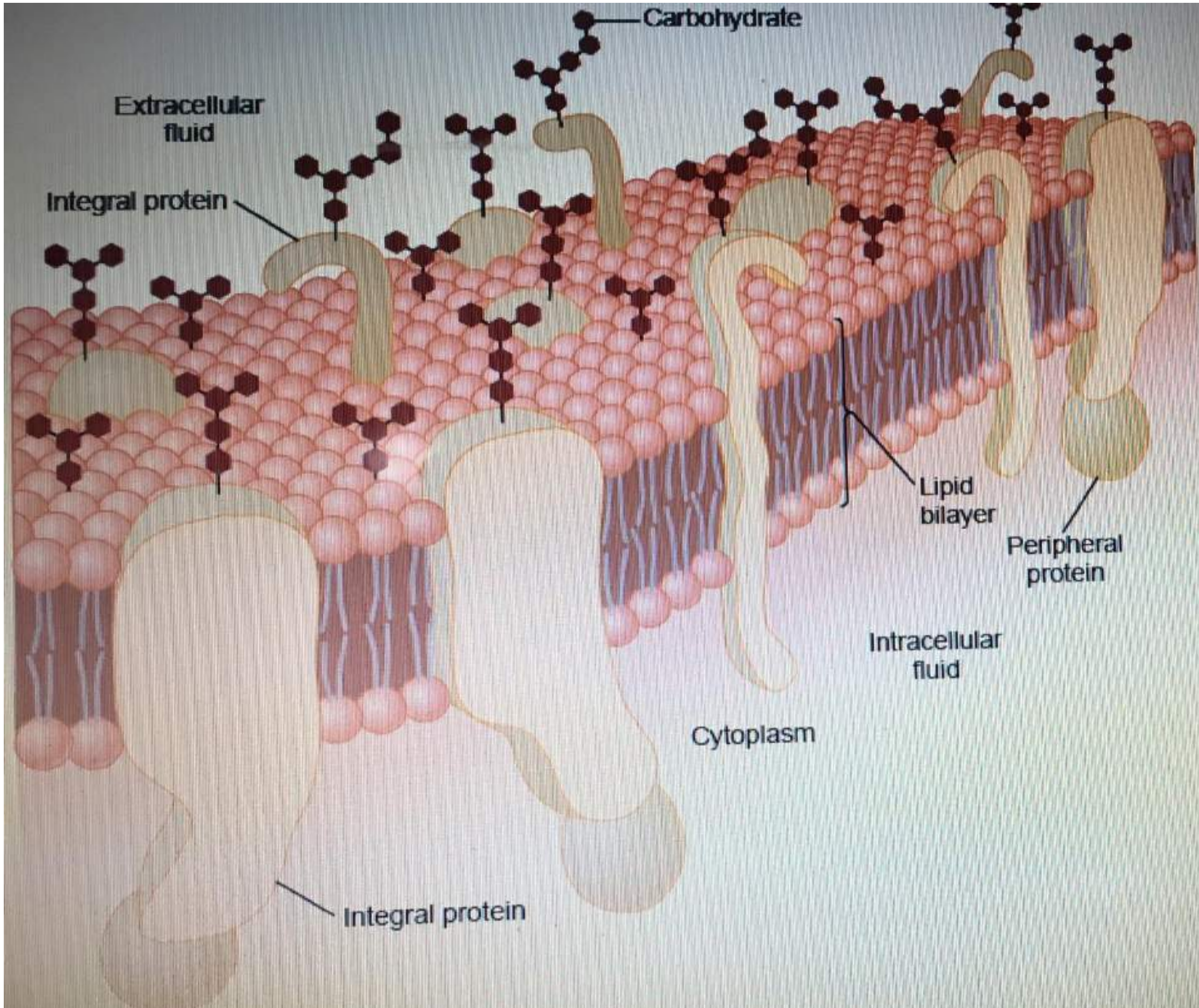


Figure 2–3

Structure of the cell membrane, showing that it is composed mainly of a lipid bilayer of phospholipid molecules, but with large numbers of protein molecules protruding through the layer. Also, carbohydrate moieties are attached to the protein molecules on the outside of the membrane and to additional protein molecules on the inside. (Redrawn from Lodish HF, Rothman JE: The assembly of cell membranes. Sci Am 240:48, 1979. Copyright George V. Kevin.)

Integral membrane proteins can also serve as recep- ... cell surface. Many other carbohydrate compounds

Membrane Carbohydrates
The Cell "Glycocalyx." Membrane

- **Carbohydrates occur almost invariably in combination with *integral* proteins or membrane lipids in the form of *glycoproteins or glycolipids*. The "glyco" portions protrude to the outside of the cell.**
- **Many other carbohydrate compounds, called *proteoglycans. Those* substances bound to small protein cores and attached to the outer surface of the cell as well forming loose carbohydrate coat called the *glycocalyx.***

Glycocalyx Functions

- **They have several important functions:**
- **(1) They have a negative electrical charge giving cells an overall negative surface charge that repels other negative objects.**
- **(2) The glycocalyx attaches cells to one another.**
- **(3) Carbohydrates act as *receptor substances* for binding hormones, such as insulin.**
- **(4) Some carbohydrate moieties enter into immune reactions.**

Cytoplasm and Its Organelles

- **The cytoplasm is filled with both minute and large dispersed particles and organelles.**

- **The clear fluid portion of the cytoplasm in which the particles are dispersed is called *cytosol; this contains mainly dissolved proteins,* electrolytes, and glucose.**

- **Dispersed in the cytoplasm are neutral fat globules, glycogen granules, ribosomes, secretory vesicles, and five especially important organelles: the *endoplasmic reticulum, the Golgi apparatus, mitochondria, lysosomes,* and *peroxisomes.***

Endoplasmic Reticulum

- **Structure**
- **A network of tubular and flat vesicular structures in the cytoplasm; this is the *endoplasmic reticulum.***
- ***The tubules and vesicles interconnect* with one another.**
- **Function**

Substances formed in some parts of the cell enter the space of the endoplasmic reticulum and are then conducted to other parts of the cell.

Also, the vast surface area of this reticulum and the multiple enzyme systems attached to its membranes provide machinery for a major share of the metabolic functions of the cell.

Functions of Endoplasmic Reticulum

Ribosomes and the Granular Endoplasmic Reticulum

Attached to the outer surfaces of the *granular endoplasmic reticulum* are large numbers of minute granular particles called *ribosomes. The ribosomes are composed of a* mixture of RNA and proteins.

Function: Synthesize of new protein molecules in the cell.

Agranular Endoplasmic Reticulum.

Part of the endoplasmic reticulum has no attached ribosomes (*agranular, or smooth, endoplasmic reticulum).*

Function: Synthesis of lipid substances and for other processes of the cells promoted by intrareticular enzymes.

Golgi Apparatus

Structure:

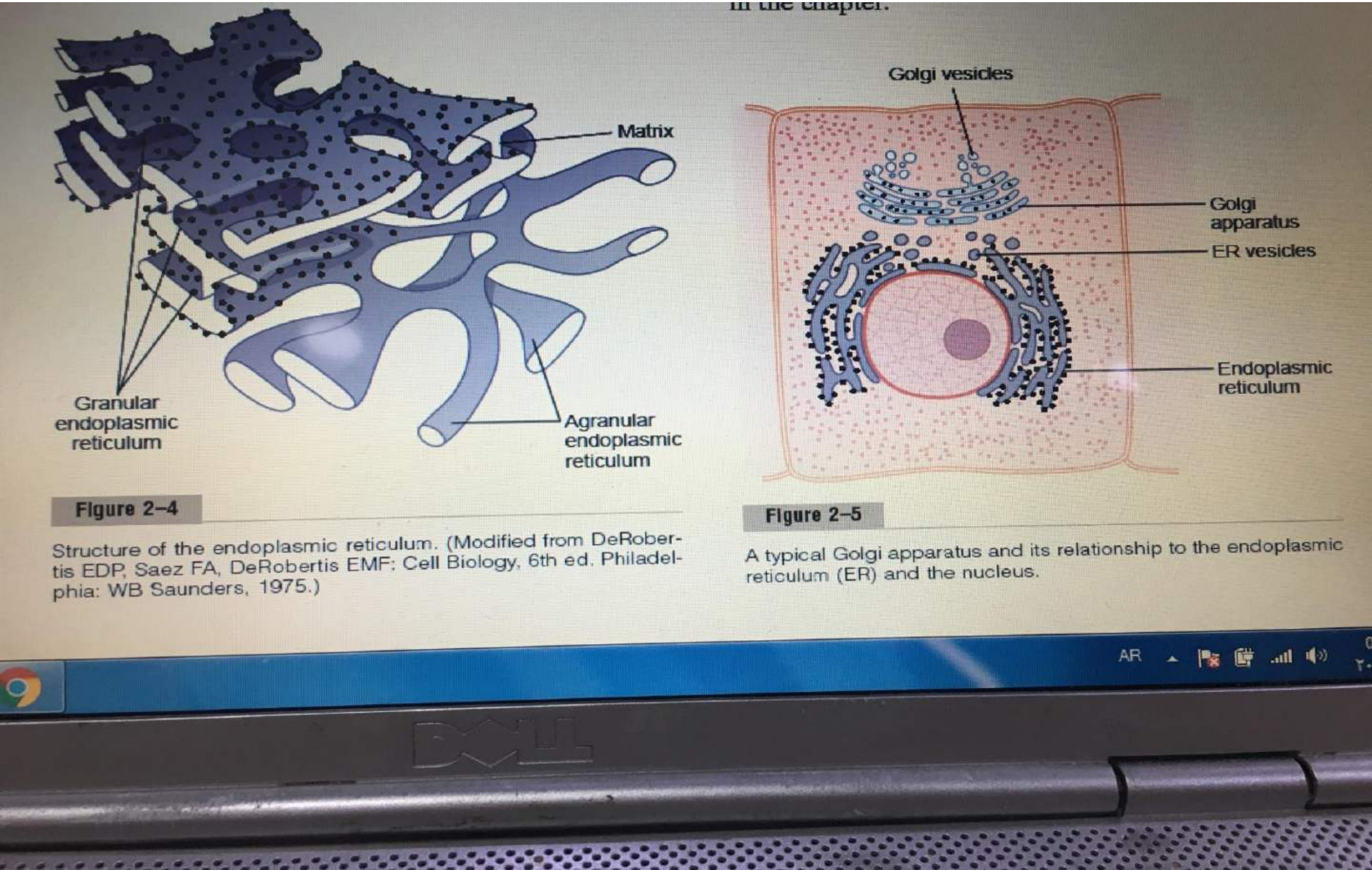
It has membranes similar to those of the agranular endoplasmic reticulum. It is composed of four or more stacked layers of thin, flat, enclosed vesicles lying near one side of the nucleus. This apparatus is prominent in secretory cells,

Function:

The Golgi apparatus functions in association with the endoplasmic reticulum. small "transport vesicles" (also called endoplasmic reticulum vesicles, or *ER vesicles) continually pinch off* from the endoplasmic reticulum and shortly thereafter fuse with the Golgi apparatus.

In this way, substances entrapped in the ER vesicles are transported from the endoplasmic reticulum to the Golgi apparatus to form lysosomes, secretory vesicles, and other cytoplasmic components.

ER & Golgi Apparatus



Lysosomes

Lysosomes, are vesicular organelles that form by breaking off from the Golgi apparatus and then dispersing throughout the cytoplasm.

Function

The lysosomes provide an *intracellular digestive system that allows the cell to digest:*

***(1) damaged cellular* structures.**

(2) food particles that have been ingested by the cell.

(3) unwanted matter such as bacteria.

Structure

- **The lysosome is quite different in different types of cells, but it is usually 250 to 750 nanometers in diameter.**
- **It is surrounded by a typical lipid bilayer membrane and is filled with large numbers of small granules 5 to 8 nanometers in diameter, which are protein aggregates of as many as 40 different *hydrolase (digestive) enzymes.***
- **Ordinarily, the membrane surrounding the lysosome prevents the enclosed hydrolytic enzymes from coming in contact with other substances in the cell and, therefore, prevents their digestive actions.**

Mitochondria

The mitochondria, are called the "powerhouses" of the cell. Without them, cells would be unable to extract enough energy from the nutrients, and essentially all cellular functions would cease.

Mitochondria are present in all areas of each cell's cytoplasm, but the total number per cell varies from less than a hundred up to several thousand, depending on the amount of energy required by the cell.

The basic structure of the mitochondrion is composed mainly of two lipid bilayer–protein membranes: an *outer membrane and* an *inner membrane.*

The inner cavity of the mitochondrion is filled with a *matrix that contains large* quantities of dissolved enzymes that are necessary for extracting energy from nutrients.

Mitochondria

These enzymes operate in association with the oxidative enzymes on the shelves to cause oxidation of the nutrients, thereby forming carbon dioxide and water and at the same time releasing energy.

The liberated energy is used to synthesize a "high-energy" substance called *adenosine triphosphate (ATP).*

***ATP is then transported out of the* mitochondrion, and it diffuses throughout the cell to release its own energy wherever it is needed for performing cellular functions.**

Nucleus

- The nucleus is the control center of the cell.
- Briefly, the nucleus contains large quantities of DNA, which are the *genes.*
- *The genes determine the characteristics of* the cell's proteins, including the structural proteins, as well as the intracellular enzymes that control cytoplasmic and nuclear activities.
- The genes also control and promote reproduction of the cell itself.
- The genes first reproduce to give two identical sets of genes; then the cell splits by a special process called *mitosis to form two daughter cells, each* of which receives one of the two sets of DNA genes.

Nuclear Membrane

The *nuclear membrane, also called the nuclear envelope,* is actually two separate bilayer membranes, one inside the other.

The outer membrane is continuous with the endoplasmic reticulum of the cell cytoplasm, and the space between the two nuclear membranes is also continuous with the space inside the endoplasmic reticulum.

The nuclear membrane is penetrated by several thousand *nuclear pores.*

The central area of each pore allow molecules to pass through with reasonable ease.

Nucleoli

- **The nuclei of most cells contain one or more highly staining structures called *nucleoli.***
- ***The nucleolus,* unlike most other organelles, does not have a limiting membrane.**
- **Instead, it is simply an accumulation of large amounts of RNA and proteins of the types found in ribosomes.**
- **The nucleolus becomes considerably enlarged when the cell is actively synthesizing proteins.**

Formation of Ribosomes

- Formation of the nucleoli (and of the ribosomes in the cytoplasm outside the nucleus) begins in the nucleus:
- First, specific DNA genes in the chromosomes cause RNA to be synthesized. Some of this is stored in the nucleoli, but most of it is transported outward through the nuclear pores into cytoplasm.
- Here, it is used in conjunction with specific proteins to assemble "mature" ribosomes that play an essential role in forming cytoplasmic proteins.

Functional Systems of the Cell

Ingestion by the Cell

If a cell is to live and grow and reproduce, it must obtain nutrients and other substances from the surrounding fluids. Most substances pass through the cell membrane by *diffusion and active transport.*

Diffusion involves simple movement through the membrane caused by the random motion of the molecules of the substance; substances move either through cell membrane pores or, in the case of lipid soluble substances, through the lipid matrix of the membrane.

Active transport involves the actual carrying of a substance through the membrane by a physical protein structure that penetrates all the way through the membrane.

Endocytosis

Pinocytosis and Phagocytosis

Large particles enter the cell by a specialized function of the cell membrane called *endocytosis.*

The* principal forms of endocytosis are *pinocytosis and phagocytosis.

Pinocytosis: **I*ngestion of minute* particles that form vesicles of extracellular fluid.**

Phagocytosis: **Ingestion of large particles, such as bacteria, whole cells, or portions of degenerating tissue.**

DIFFUSION

- There is a net flux of solute particles from areas of high to areas of low concentration.
- The magnitude of the diffusing tendency from one region to another is directly proportionate to:

  - The cross-sectional area across which diffusion is taking place.

  - The concentration gradient, Or Chemical gradient, which is the difference in concentration of the diffusing substance divided by the thickness of the boundary.
- Fick's law of diffusion ($J = -DA. \Delta c / \Delta x$)

where: J is the net rate of diffusion,

D is the diffusion coefficient,

A is the area,

$\Delta c/\Delta x$ is the concentration gradient.

Osmosis

- The diffusion of solvent molecules into a region in which there is a higher concentration of a solute to which the membrane is impermeable—is called osmosis. It is an important factor in physiologic processes.
- This can be prevented by applying pressure to the more concentrated solution. The pressure necessary to prevent solvent migration is the osmotic pressure of the solution.
- In an ideal solution, osmotic pressure (P) is related to temperature and volume in the same way as the pressure of a gas:

$$P = n RT / V$$

where n is the number of particles, R is the gas constant, T is the absolute temperature, and V is the volume.

Body Fluids

- **The cells exist in an "internal sea" of extracellular fluid (ECF) enclosed within the integument of the human body.**
  - **- From this fluid, the cells take up O2 and nutrients.**
  - **- Into it, they discharge metabolic waste products.**

- **In a closed vascular system, the ECF is divided into two components:**

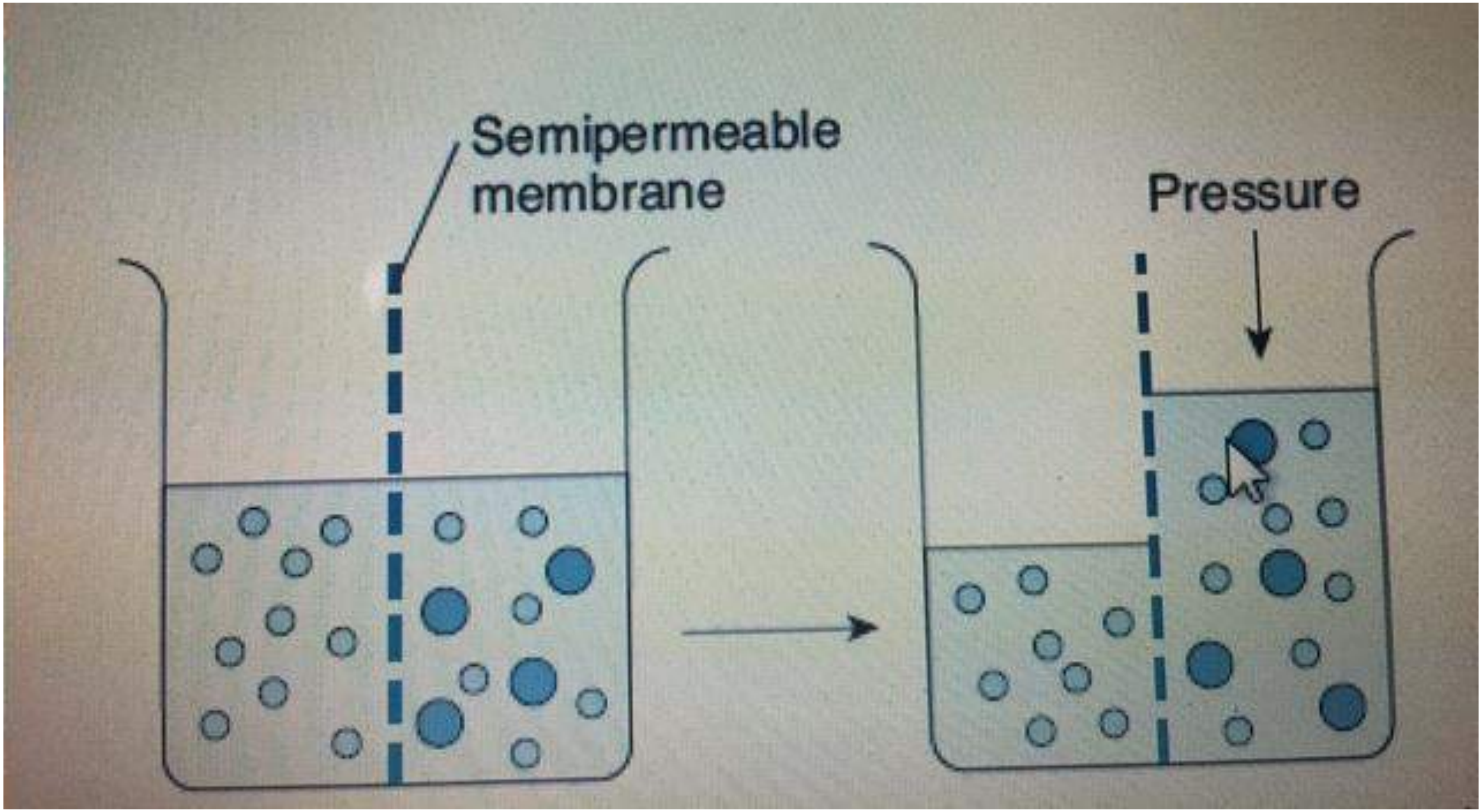
  1. The interstitial fluid

  The part of the ECF that is outside the vascular system, bathing the cells.

  2. The circulating blood plasma.

  The plasma and the cellular elements of the blood which fill the vascular system, Together they constitute the total blood volume.

- **About a third of the total body water is extracellular.**
- **The remaining two thirds is intracellular (intracellular fluid).**



Diagrammatic representation of osmosis
Water molecules are represented by small open circles, solute molecules by large solid circles.

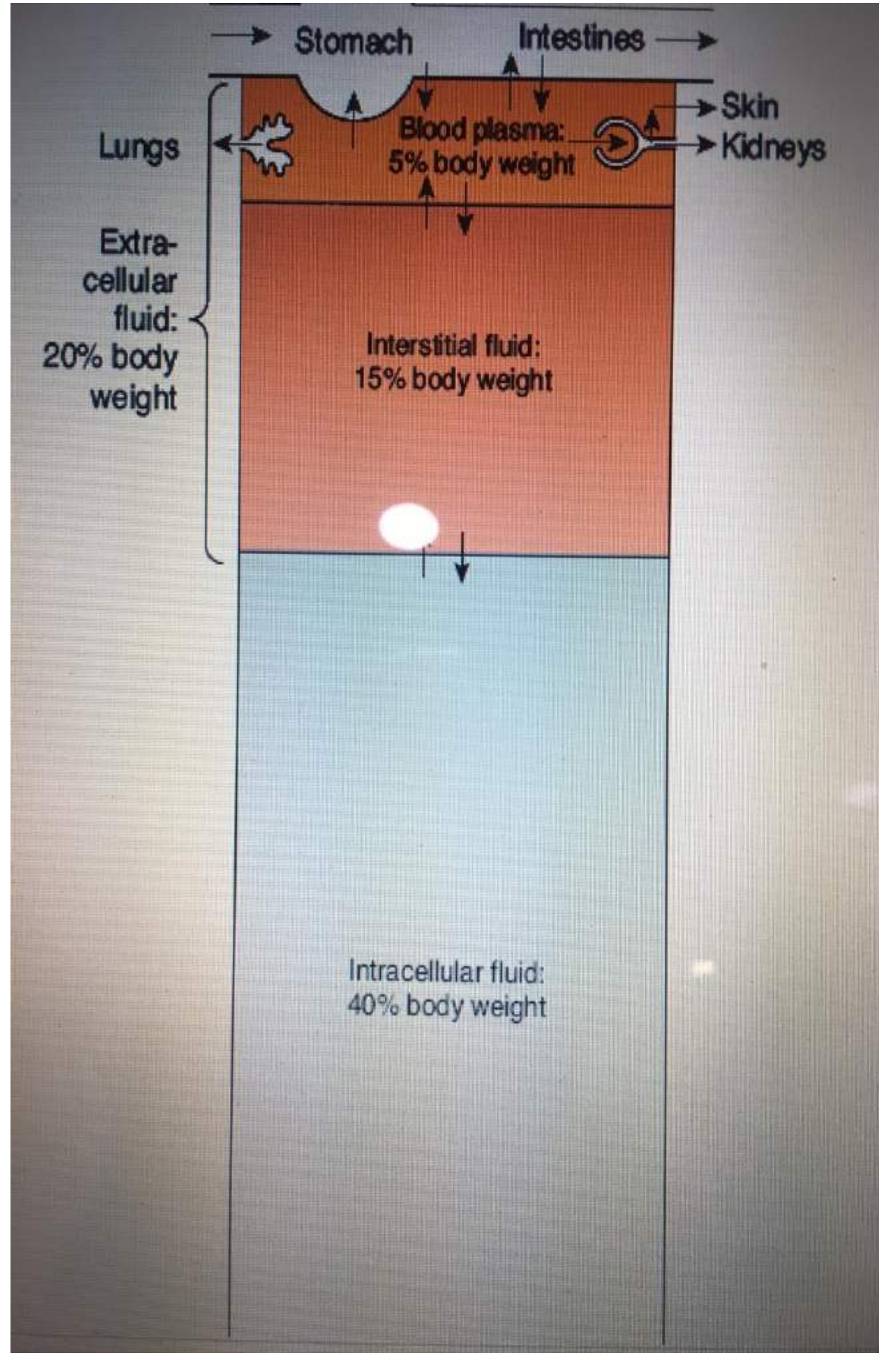
In the average young adult male, 18% of the body weight is protein and related substances, 7% is mineral, and 15% is fat. The remaining 60% is water.

The intracellular component of the body water accounts for about 40% of body weight and the extracellular component for about 20%.

Approximately 25% of the extracellular component is in the vascular system (plasma = 5% of body weight) and 75% outside the blood vessels (interstitial fluid = 15% of body weight).

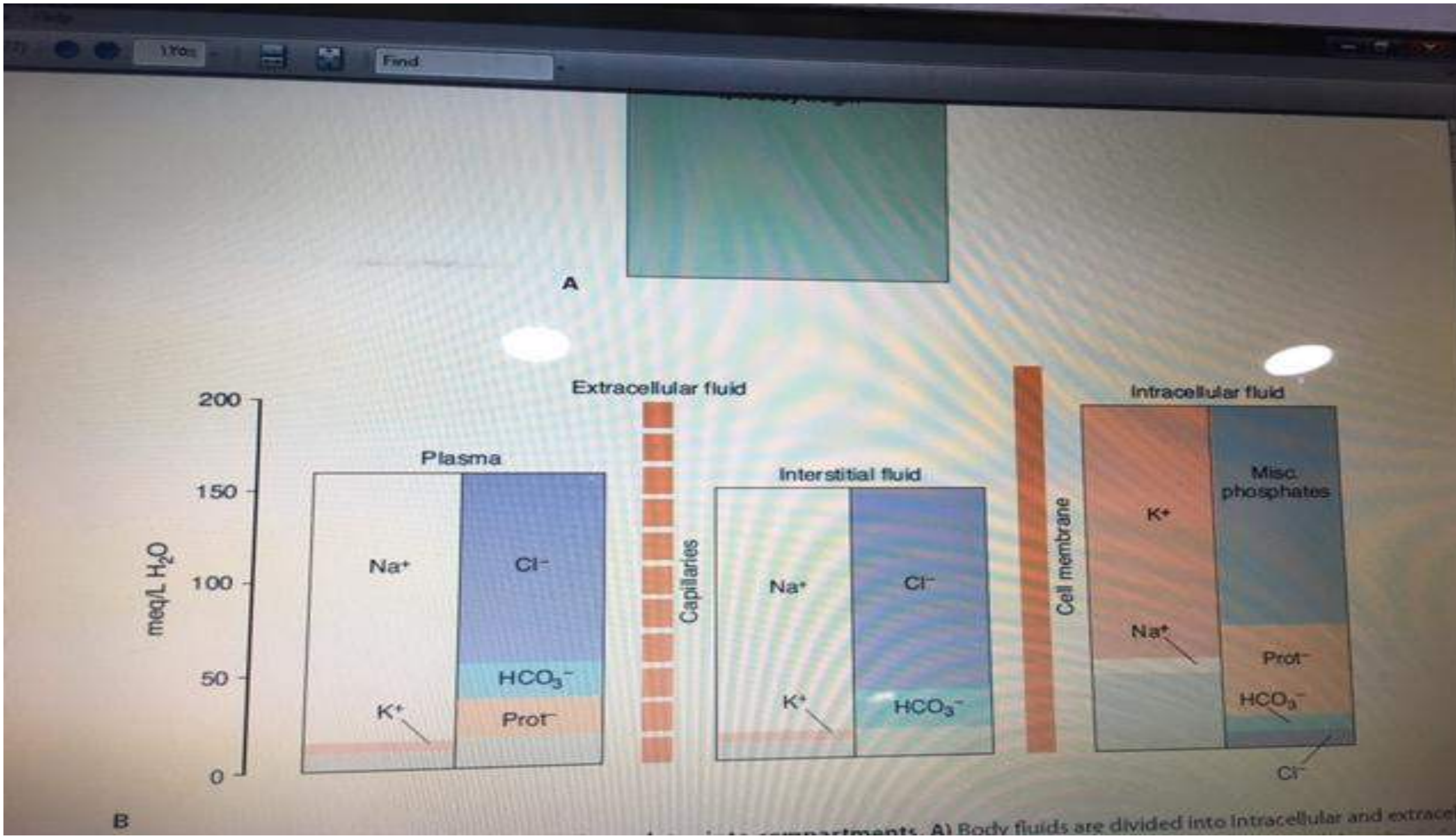
The total blood volume is about 8% of body weight.

Flow between these compartments is tightly regulated.



There are many important electrolytes in physiology, notably Na, K, Ca, Mg, Cl and HCO. It is important to note that electrolytes and other charged compounds (eg, proteins) are unevenly distributed in the body fluids.

These separations play an important role in physiology.



Differences Between Extracellular and Intracellular Fluids

- The extracellular fluid contains large amounts of
  - *Sodium, chloride, and bicarbonate ions*
  - *Nutrients* for the cells, such as *oxygen, glucose, fatty acids, and amino acids.*
  - *Carbon dioxide that is* being transported from the cells to the lungs to be excreted.
  - Cellular waste products that are being transported to the kidneys for excretion.
- The intracellular fluid differs significantly from the extracellular fluid; specifically, it contains:
  - large amounts of *potassium, magnesium, and phosphate ions*.

Concentration of some ions inside and outside mammalian spinal motor neurons.

	Concentration (mmol/L of H_2O)		
Ion	**Inside Cell**	**Outside Cell**	**Equilibrium Potential (mV)**
Na^+	15.0	150.0	+60
K^+	150.0	5.5	–90
Cl^-	9.0	125.0	–70

Resting membrane potential = –70 mV

Homeostasis

- **Homeostasis is the ability to maintain a relatively stable internal environment in an ever-changing outside world. The internal environment of the body is in a dynamic state of equilibrium**
- ***Essentially all organs and tissues of* the body perform functions that help maintain these constant conditions.**
- **For instance, the lungs provide oxygen to the extracellular fluid to replenish the oxygen used by the cells, the kidneys maintain constant ion concentrations, and the gastrointestinal system provides nutrients.**

- **Homeostatic Imbalance**

  1. Disturbance of homeostasis or the body's normal equilibrium caused by disease

  2. Overwhelming of negative feedback mechanisms allowing destructive positive feedback mechanisms to take over

Homeostatic Control Mechanisms

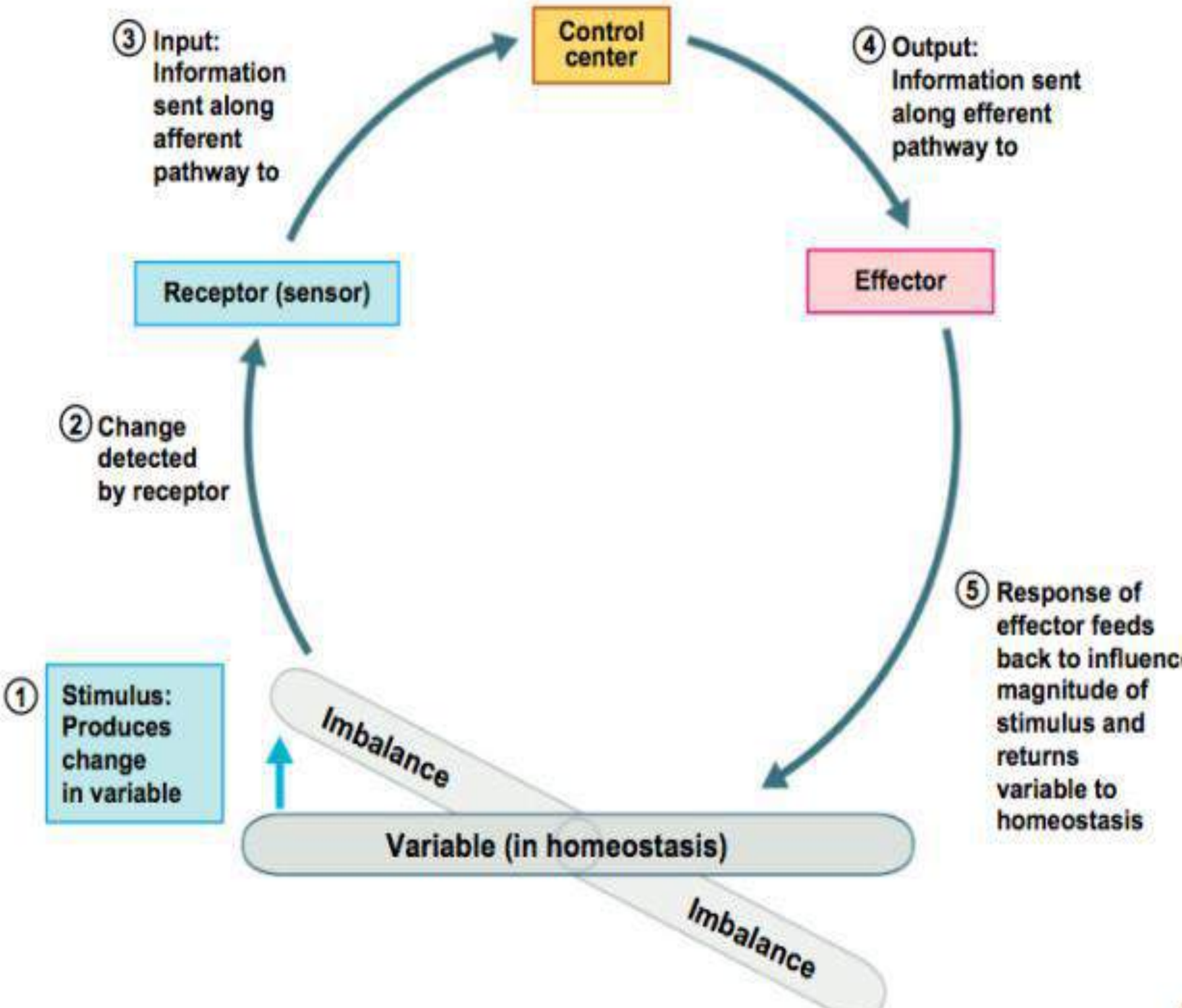


Figure 1.4

Homeostatic Control Mechanisms

1. Negative Feedback systems, the output shuts off the original stimulus . Example: Regulation of blood glucose levels