# Human Physiology
# Lecture No. 1

# GENERAL AND CELLULAR BASICS OF MEDICAL PHYSIOLOGY

Prof. Dr. Nader Abo-Tubikh

Mazaya University College

# Anatomy & Physiology

Anatomy “ana-tome” means cutting up in Greek. It’s the study of the **structures of the body parts and their relationship to one another:** what they are made of ,where they are located & associated structures

Physiology is the study of: **functions of anatomical structures, both individual and cooperative .**

All physiological **functions are performed by specific anatomical structures.**

Principle of complementarity says that **structure and function are complementary :**

Function always reflects structure .

What a structure can do depends on its specific form.

Key to learning anatomy is understanding function For example:

- Left side of heart is larger than right. Why is that?

- Structure (anatomy) and function (physiology) are intimately related = principle of complementarity

# Anatomy

- **Gross Anatomy**:  Structures large enough that one can see with the unaided eye.

  1. Surface Anatomy - study of superficial markings.

  2. Regional Anatomy - the study of specific areas of the body (e.g. head, trunk).

  3. Systemic Anatomy - study of the 11* specific organ systems.

- **Microscopic Anatomy:** Involves studying anatomical structures that cannot be seen with the unaided eye

  1. Cytology - cells

  2. Histology - tissue

# Physiology

- Physiology = Function : Considers the operation of specific organ systems
  - Renal – kidney function
  - Neurophysiology – workings of the nervous system
  - Cardiovascular – operation of the heart and blood vessels.

Focuses on the functions of the body, often at the cellular or molecular level

# Levels of Organization

1. **Chemical level: - atoms (e.g. carbon) combine to form molecules (e.g. glucose)**

2. **Cellular level:** smallest **living units in organisms.**Cells contain organelles, each with a function

3. **Tissue level - different groups of cells that perform a function**

4. **Organ level - Different types of tissues that perform a common function**

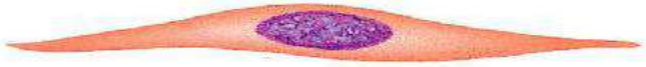
5. **Organ system – consists of different organs that work closely together**

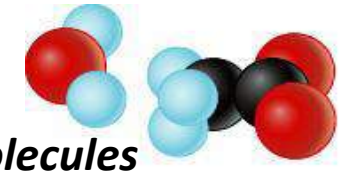
Other levels

1. Organismal Level - All systems working together (e.g. humans)

2. Ecological level - How organisms interact with each other and their environment

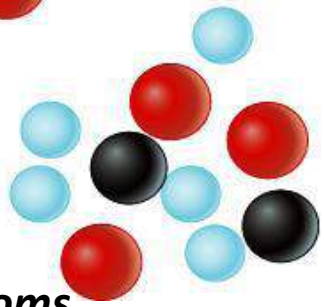
*Smooth muscle cell*





*Molecules*

**Cellular level**
**Cells are made up of molecules.**



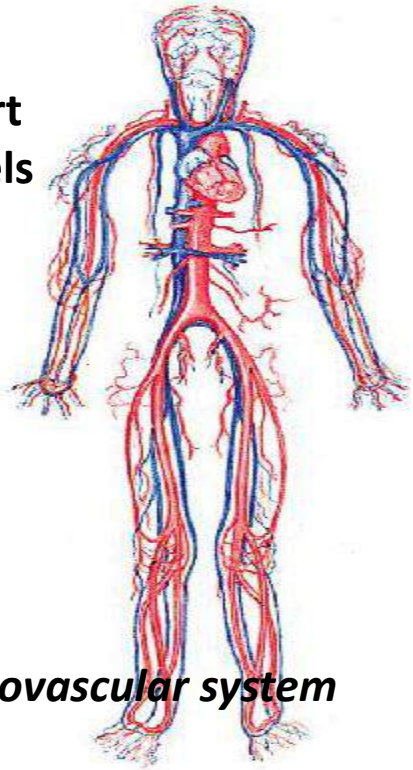
*Atoms*

**Chemical level**

**Tissue level: Tissues consist of similar types of cells**

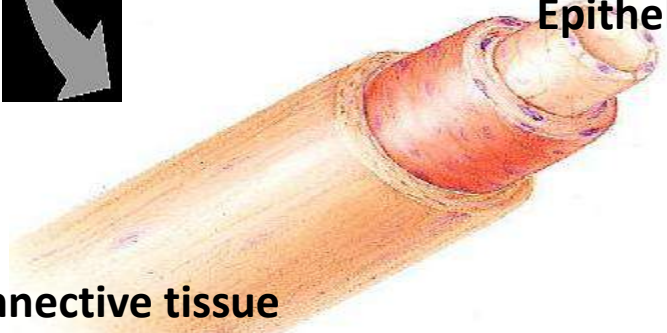
*Smooth muscle tissue*

**Heart**
**Blood vessels**



**Epithelial tissue**

**Organ systems consist of different organs that work together closely.**



**Connective tissue**
**Blood vessel (organ)**

*Cardiovascular system*

**Organ level Organs are made up of different types of tissues.**

**Organ system level**

# Necessary Life Functions

- 1.Maintaining boundaries – the internal environment remains distinct from the external
  - Cellular level – accomplished by plasma membranes
  - Organismal level – accomplished by the skin
- 2.Movement – locomotion, propulsion (peristalsis), and contractility
- 3.Responsiveness – ability to sense changes in the environment and respond to them
- 4.Digestion – breakdown of ingested foodstuff
- 5.Metabolism – all the chemical reactions that occur in the body
- 6.Excretion – removal of wastes from the body
- 7.Reproduction –
  - Cellular – original cell divides & produces two identical daughter cells
  - Organismal – sperm and egg unite to make a new person
- 8.Growth – increase in size of a body part or of the organism

# Survival Needs

- **1.Nutrients – chemical substances used for energy and cell building**
- **2.Oxygen – needed for metabolic reactions**
- **3.Water – provides the necessary environment for chemical reactions**
- **4.Maintaining normal body temperature – necessary for chemical reactions to occur at life-sustaining rates**
- **5.Atmospheric pressure – required for proper breathing and gas exchange in the lungs**

# Cellular Physiology

- In **unicellular organisms**, all vital processes occur in a single cell.
- As the evolution of **multicellular organisms** has progressed, various cell groups organized into tissues and organs have taken over particular functions.

- **In humans** and other vertebrates, the specialized cell groups include:

- Gastrointestinal system to digest and absorb food;
- Respiratory system to take up O and eliminate CO;
- Urinary system to remove wastes;
- Cardiovascular system to distribute nutrients, O, and the products of metabolism;
- Reproductive system to perpetuate the species;
- Nervous and endocrine systems to coordinate and integrate the functions of the other systems.

- General concepts and biophysical and biochemical principles that are basic to the function of all the systems are presented in the following sections.

# Cells as the Living Units of the Body

- The basic living unit of the body is the cell.
- **Each type of cell is specially adapted to perform one or a few particular functions**.
- For instance, the **red blood cells**, numbering **25 trillion** in each human being, transport oxygen from the lungs to the tissues.
- There are about **75 trillion** additional cells of other types that perform functions different from those of the red cell.
- The entire body, then, contains about **100 trillion cells**.
- Each of the 100 trillion cells in a human being is a living structure that can survive for months or many years, *provided its surrounding fluids contain appropriate nutrients.*
- To **understand the function** of organs and other structures of the body, it is essential that we first understand
- 1. The basic organization of the cell.
- 2. The functions of its component parts.

# Cells as the Living Units of the Body

- **Although the many cells of the body often differ markedly from one another, all of them have certain basic characteristics that are alike such as:**

1. In all cells, oxygen reacts with carbohydrate, fat, and protein to release the energy required for cell function.
2. The general chemical mechanisms for changing nutrients into energy are basically the same in all cells.
3. all cells deliver end products of their chemical reactions into the surrounding fluids.
4. Almost all cells also have the ability to reproduce additional cells of their own kind.

# Organization of the Cell

- The two major parts of a typical cell are the *nucleus* and the *cytoplasm.*
- The nucleus is separated from the cytoplasm by a *nuclear membrane,* and the cytoplasm is separated from the surrounding fluids by a *cell membrane,* also called the *plasma membrane.*
- The different substances that make up the cell are collectively called *protoplasm.* Protoplasm is composed mainly of five basic substances: water, electrolytes, proteins, lipids, and carbohydrates.

# Cell Basic Structure

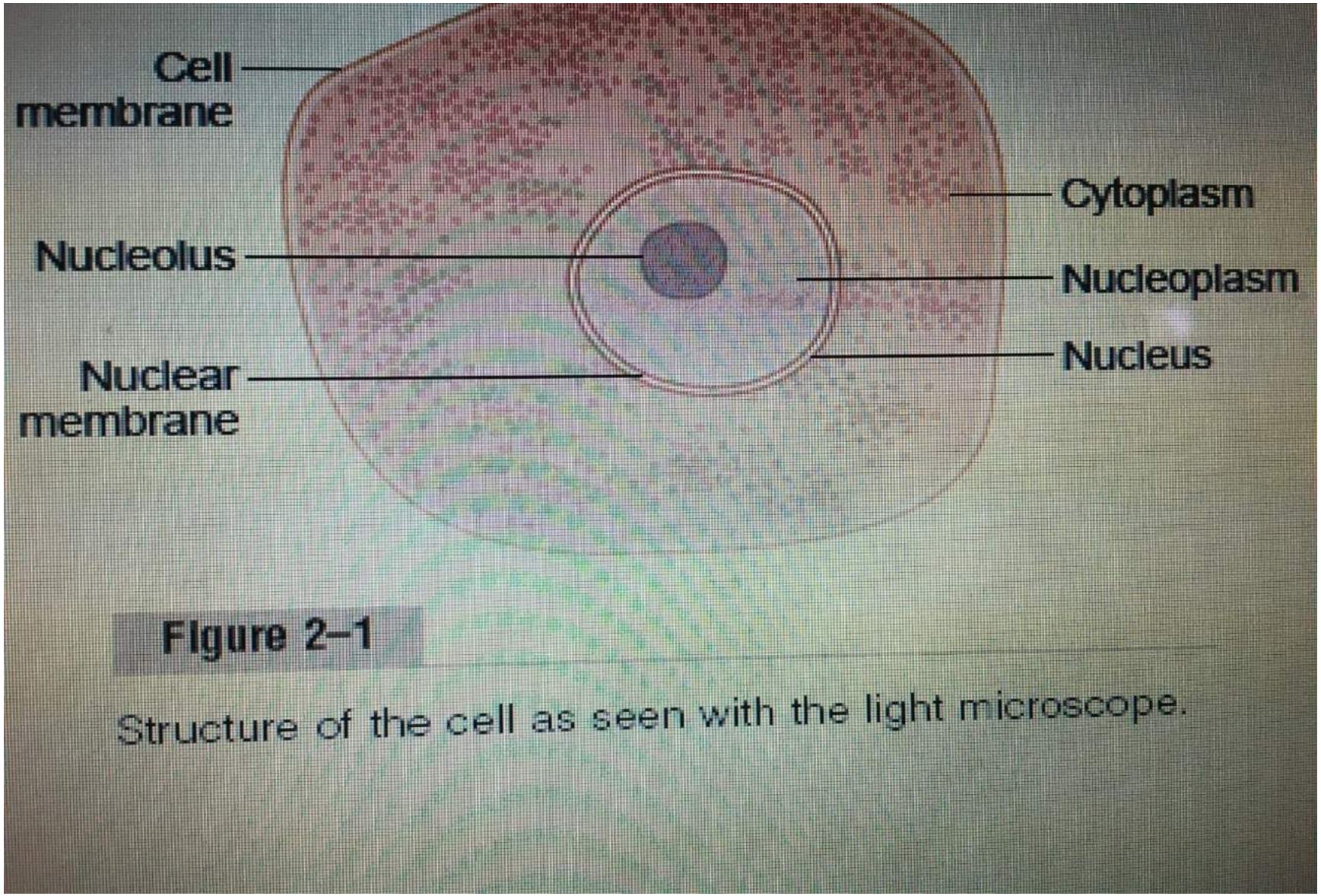
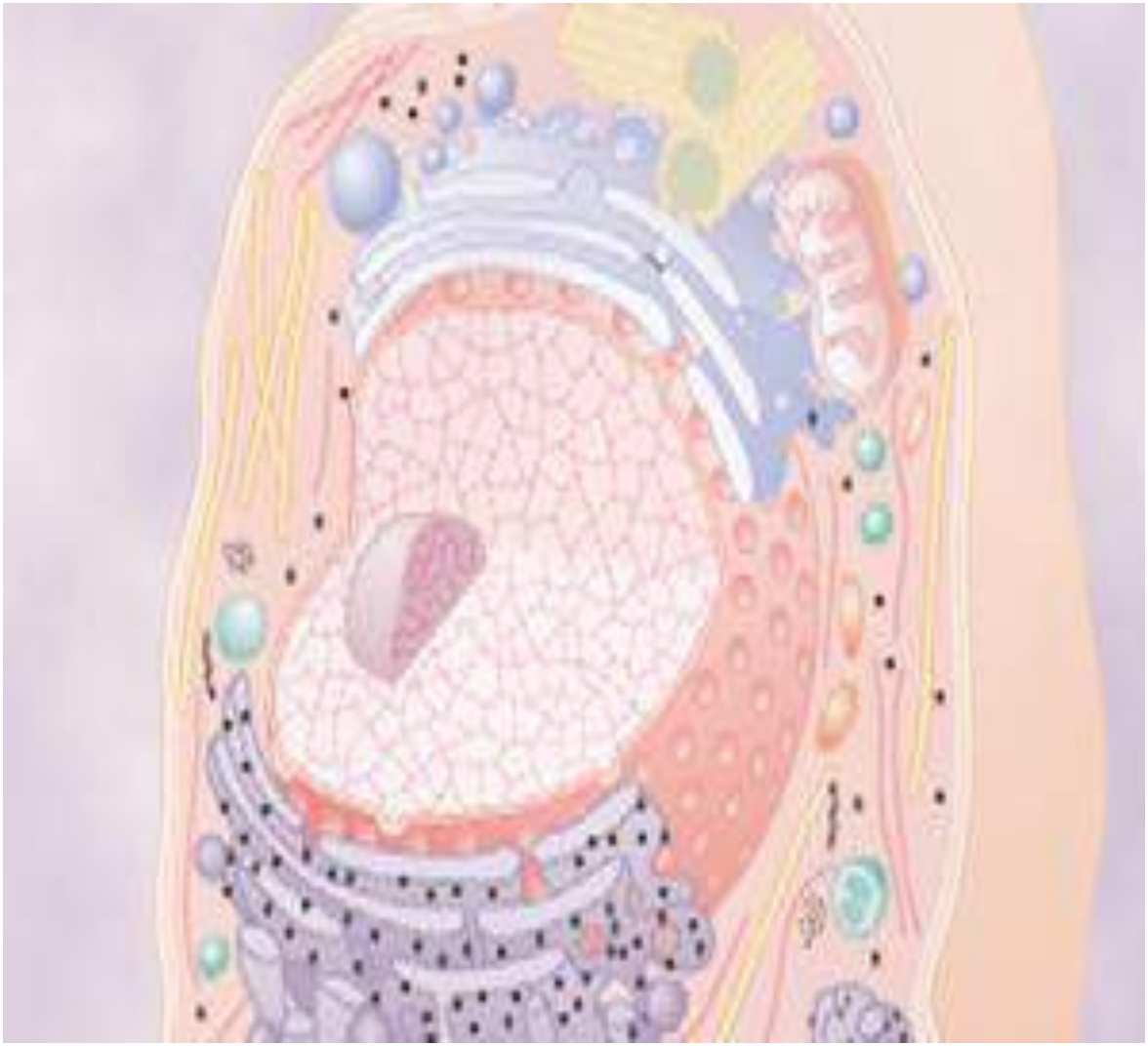



**Figure 2–1**

Structure of the cell as seen with the light microscope.



# Water

- The principal fluid medium of the cell is water, which is present in most cells, except for fat cells, in a concentration of 70 to 85 per cent.
- Many cellular chemicals are **dissolved** in the water.
- Others are **suspended** in the water as solid particulates.
- **Chemical reactions** take place among the dissolved chemicals or at the surfaces of the suspended particles or membranes.

# Ions

- **The most important ions in the cell are *potassium, magnesium, phosphate,*** *sulfate, bicarbonate, and smaller quantities of sodium, chloride, and calcium.*
- The ions provide:
  1. Inorganic chemicals for cellular reactions.
  2. They are necessary for operation of cellular control mechanisms.
- For instance, ions acting at the cell membrane are required for transmission of electrochemical impulses in nerve and muscle fibers.

# Proteins

- After water, the most abundant substances in most cells are proteins, which normally constitute 10 to 20 per cent of the cell mass.
- Proteins can be divided into two types:

- ***Structural proteins*** are present in the cell mainly in the form of long filaments that themselves are polymers of many individual protein molecules.

- A prominent use of such intracellular filaments is to form *microtubules* that provide the "cytoskeletons" of such cellular organelles as cilia, nerve axons, the mitotic spindles of mitosing cells, and a tangled mass of thin filamentous tubules that hold the parts of the cytoplasm and nucleoplasm together in their respective compartments.
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# *Functional proteins*

- They are an entirely different type of protein, usually composed of combinations of a few molecules in tubular-globular form.
- These proteins are mainly the ***enzymes*** of the cell They are **mobile** in the cell fluid.
- Many are **adherent** to membranous structures inside the cell.
- The enzymes come into direct contact with other substances in the cell fluid and thereby **catalyze** specific **intracellular chemical reactions.**

# Lipids

- Especially important lipids are

  ***1. phospholipids* and *cholesterol,*** which together constitute only about **2 %** of the total cell mass.
- They are mainly insoluble in water and, therefore, are used to form: 1. C**ell membrane**
- **2. intracellular membrane** barriers that separate the different cell compartments.

- Large quantities (**95 %** of the cell mass) of ***triglycerides***
- stored in the cells represents the body's main storehouse of energy-giving nutrients.

# Carbohydrates

Minor Role

- Carbohydrates have little structural function in the cell except as parts of **glycoprotein** molecules,

Major Role:

- They play a major role in **nutrition** of the cell.

Most human cells do not maintain large stores of carbohydrates; the amount usually averages about **1 %** of their total mass **3 % in muscle cells and,, 6% in liver cells.**

However, carbohydrate in the form of **dissolved glucose** is always present in the surrounding **extracellular fluid** so that it is readily available to the cell.

Also, a small amount of carbohydrate is virtually always stored in the cells in the form of ***glycogen,*** which is an insoluble polymer of glucose that can be depolymerized and used rapidly to supply the cells' **energy needs**.

# Physical Structure of the Cell

- The cell is not merely a bag of fluid, enzymes, and chemicals; it also contains highly organized physical structures, called ***intracellular organelles***.

- *The physical* nature of each organelle is as important as the cell's chemical constituents for **cell function**.
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- For instance, without one of the organelles, the ***mitochondria***, *more* than 95 per cent of the cell's **energy** release from nutrients would cease immediately.

# Typical Cell

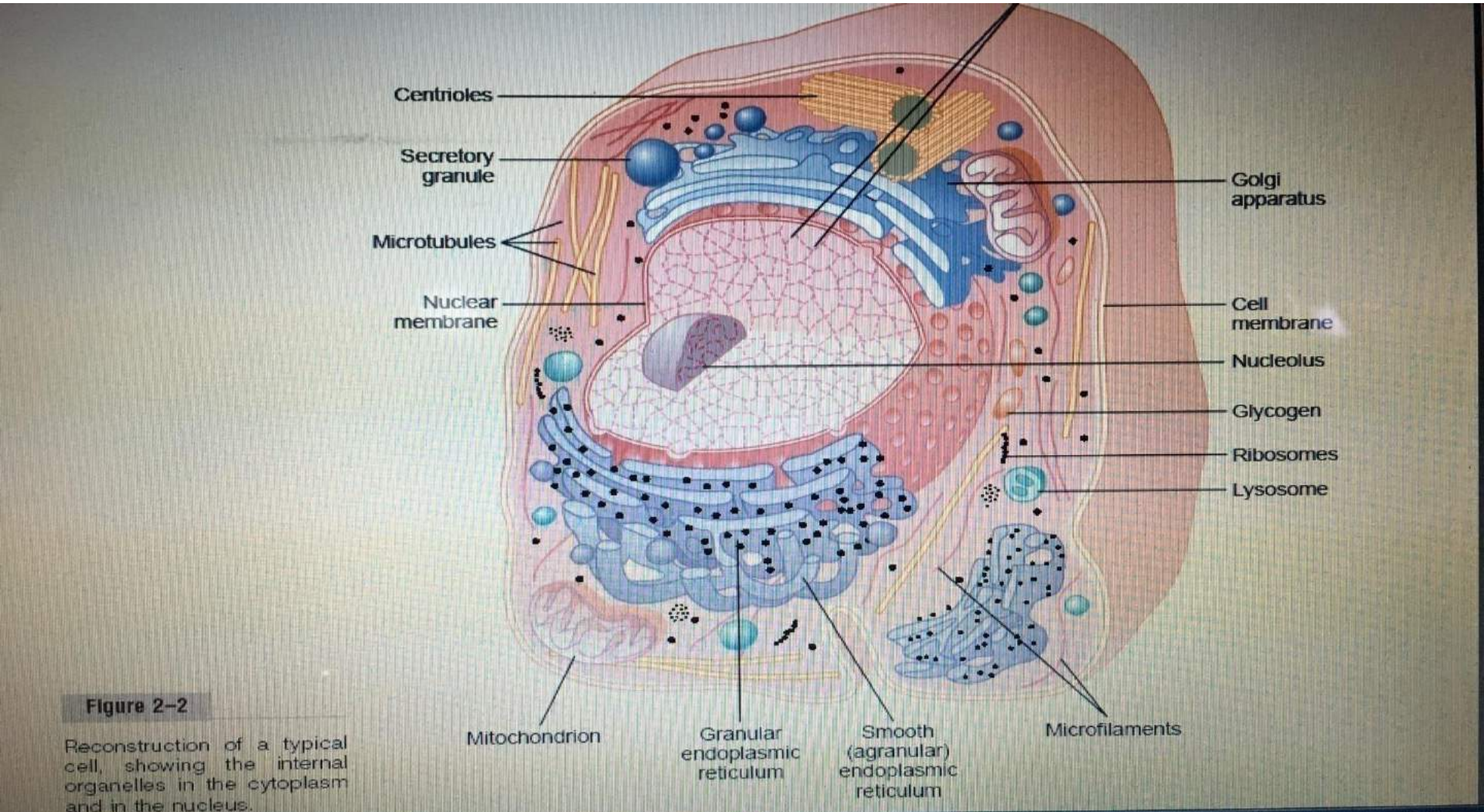


**Figure 2–2**

Reconstruction of a typical cell, showing the internal organelles in the cytoplasm and in the nucleus.

# Membranous Structures of the Cell

- **Most organelles of the cell are covered by membranes composed primarily of lipids and proteins.**

- **These membranes include the *cell membrane, nuclear membrane, membrane of the endoplasmic reticulum, and membranes of the mitochondria, lysosomes, and Golgi apparatus.***

**The lipids of the membranes provide a barrier that impedes the movement of water and water-soluble substances from one cell compartment to another because water is not soluble in lipids.**

**However, protein molecules in the membrane often do penetrate all the way through the membrane, thus providing specialized pathways, often organized into actual *pores, for* passage of specific substances through the membrane.**

# Structure of the Cell Membrane

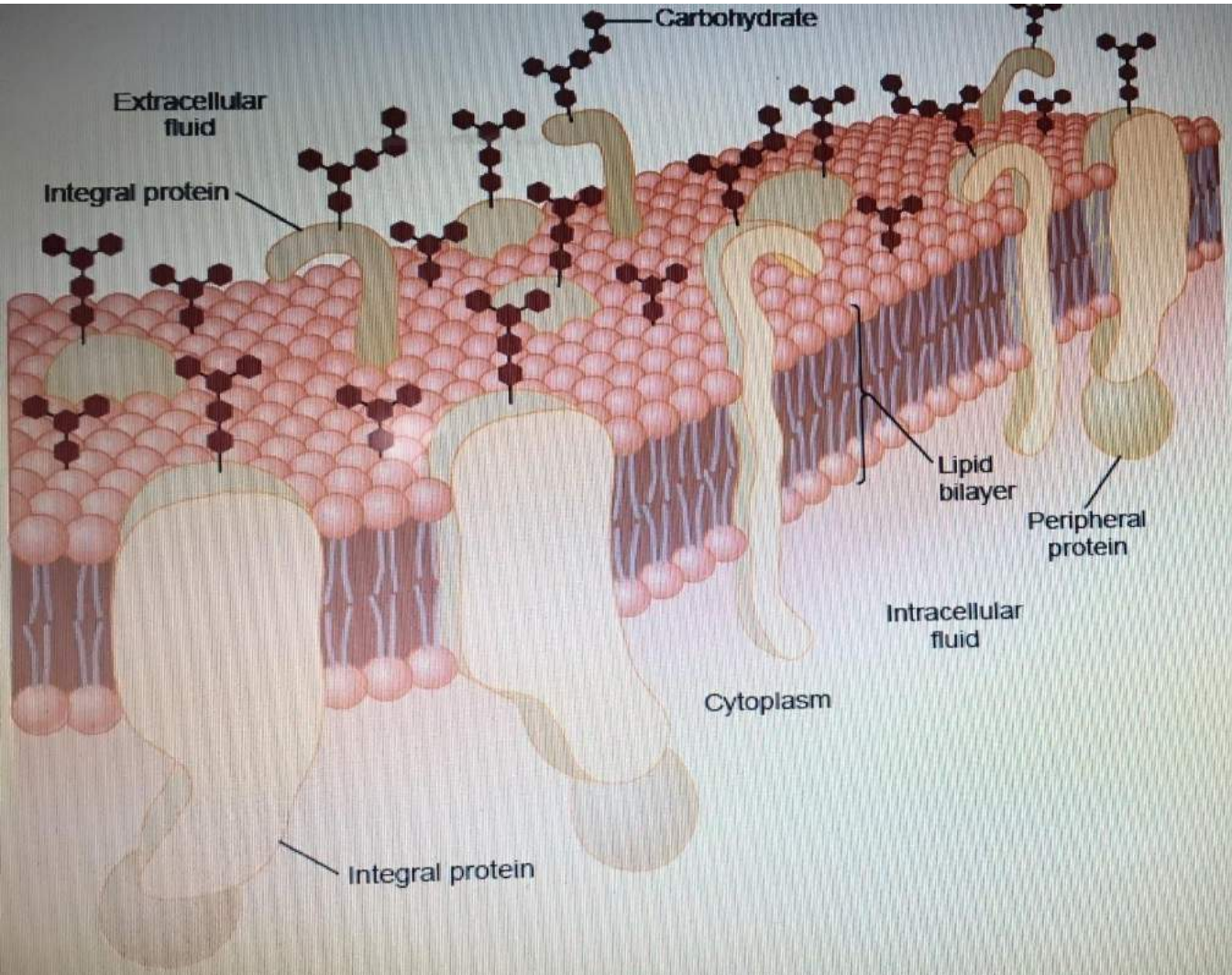


**Figure 2–3**

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

# Cell Membrane

- **The cell membrane (also called the plasma membrane), which envelops the cell, is a thin, elastic structure only 7.5 to 10 nanometers thick.**

- **It is composed almost entirely of proteins and lipids. The approximate composition is:**

  **Proteins, 55 %**

  **Phospholipids, 25 %**

  **Cholesterol, 13 %**

  **Other lipids, 4 %**

  **Carbohydrates, 3 %**

# Lipid Barrier of the Cell Membrane Impedes Water Penetration

- **The basic lipid bilayer is composed of phospholipid molecules.**
- **Phosphate end of each phospholipid molecule is soluble in water; that is, it is *hydrophilic*.**
- ***The* fatty acid end is soluble only in fats; that is, it is *hydrophobic*.**

# Cell Membrane Proteins

**Most of the membrane proteins are *glycoproteins* appeared as Globular masses floating in the lipid bilayer.**

- ***Two* types of proteins occur:**

1. ***Integral proteins that protrude* all the way through the membrane,**
2. ***Peripheral proteins* that are attached only to one surface of the membrane and do not penetrate all the way through.**

# Integral Protein

**Many of the integral proteins provide structural *channels* *(or pores) through which water molecules* and water-soluble substances, especially ions, can diffuse between the extracellular and intracellular fluids.**

**These protein channels also have selective properties that allow preferential diffusion of some substances over others.**

**Other integral proteins act as *carrier proteins* *for* transporting substances that otherwise could not penetrate the lipid bilayer.**

**Sometimes these even transport substances in the direction opposite to their natural direction of diffusion, which is called "active transport." Still others act as *enzymes.***