Physiology
Sheet **No.**

1

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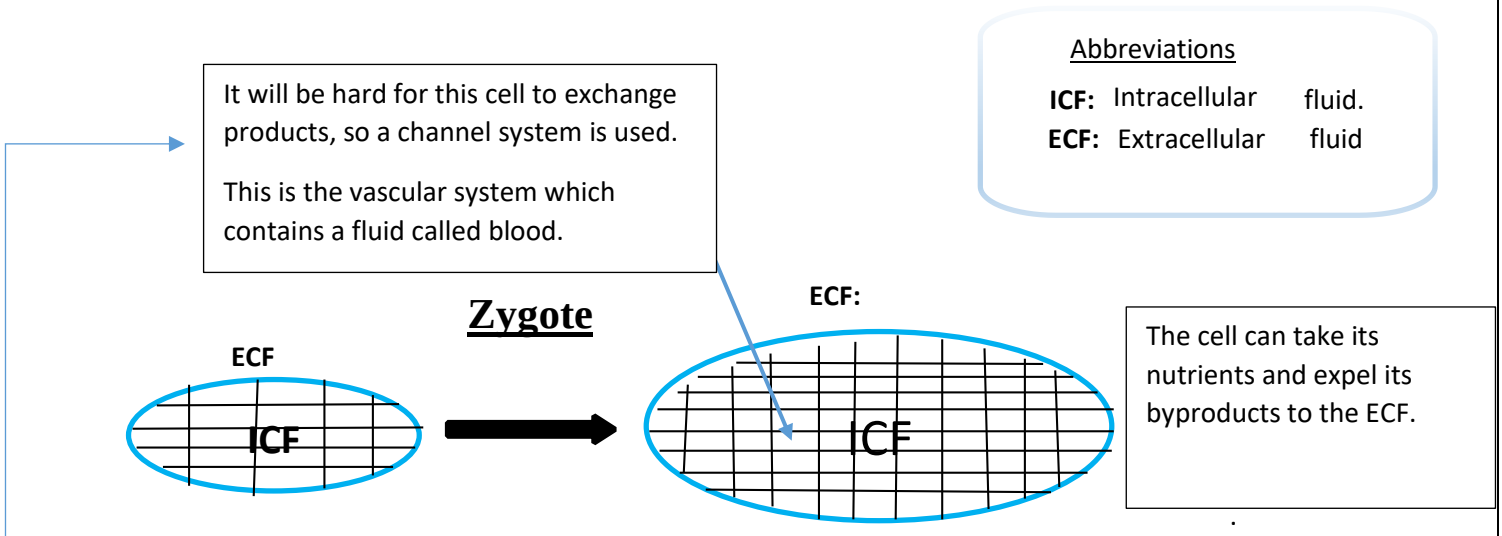
Definitions:

- Anatomy →The science of body **structures** and relationships.
    1. First studies by dissection (cutting apart).
    2. Imaging techniques.

Physiology → The science that is concerned with the **function** of the living organism and its parts such as (tissue, cells, organs, systems) and of the physical and chemical



processes involved. (The science of body functions)

Humans start as 1 cell called the zygote. We can observe from the figure above that the no. of cells increases by dividing. The *zygote* (which is implanted in the internal tissues of the ***uterus)*** soon starts dividing.

- At the beginning the zygote divides into two cells but both remain in contact with the ECF, then it divides into four cells, followed by eight cells, and so on (etc..). Note that at this stage all the dividing cells remain in contact with the ECF.
- However, soon the 8 cells will divide to form 16 cells which divide to form multiple cells where it becomes difficult for the cells located on the inside (middle of clump of cells) to take in the nutrients from the surrounding and expel the wastes. As a result, a system of channels is formed to bring nutrients to the fluid inside and around these channels which in turn transports them to almost any cell.

The emergence of **systems** is to meet the need for supplying the cells with the nutrients it needs.

- **The vascular system** is made up of channels called vessels and these channels are connected to almost all cells.

- For the vascular system to reach all the cells (up and down) we need a pump which is the **heart**. The vascular system along with the heart (blood vessels +the heart) is called the **cardiovascular system.**
- The cardiovascular system is one of the first systems to develop in the human being.
- Note: if we want to include the blood with the cardiovascular system so that the system is made of the blood, heart, and vessels, then it will be called the **circulatory system.**

System levels: A system consists of related organs with a common function.

Organ-system level: Digestive system breaks down and absorbs food. It includes organs such as the mouth, small and large intestines, liver, gallbladder, and pancreas.

Some of our important systems:

In human body we have ***11*** systems, and each has certain function:

- **RESPIRATORY SYSTEM:** takes in and transport essential gases mainly Oxygen (which is needed to form ATP energy through metabolism) and expel other gases such as CO2 (which is a byproduct of metabolism).
- **CIRCULATORY SYSTEM:** transports nutrients to all cells.
- **URINARY SYSTEM (RENAL SYSTEM)**: expels byproducts of fluid metabolism and filters plasma and blood. It expels urine containing wastes, excess water, and electrolytes.
- **DIGESTIVE SYSTEM (Gastrointestinal system):** which takes in food, nutrients, water, and electrolytes from the outside, breaks it down to smaller pieces, then absorbs them. It also gets rid of wastes and byproducts.
- **MUSCULOSKELETAL SYSTEM (muscular system and skeletal system):** essential for moving. They also enable the body to interact with the external environment
- **INTEGUMENTARY SYSTEM (skin, hair, nails):** which provides protection for the human body from the external dangers and keeps internal fluid in and foreign materials out.
- **IMMUNE SYSTEM**: to protect the organism from bacteria and viruses (foreign invaders).
- **REPRODUCTIVE SYSTEM**: needed for reproduction to maintain the species. It is the only system that differs from male to female (all other systems are similar in structure for both genders).
- **CONTROL SYSTEMS:** each of the systems has its own function, however these systems cannot work by themselves; they must be controlled by 2 other systems. These System regulate the function of other systems to keep it almost constant **(Homeostasis):**

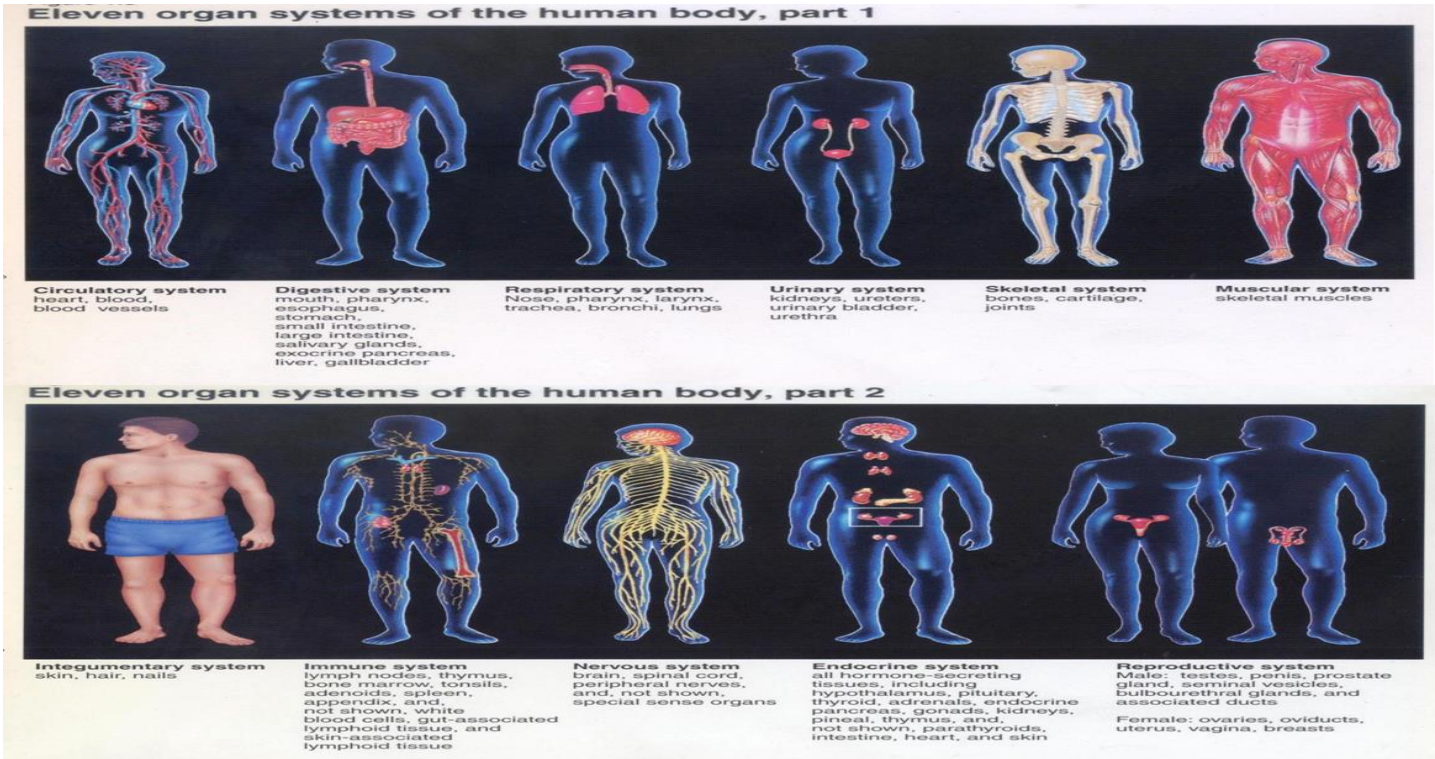
Complement each other.

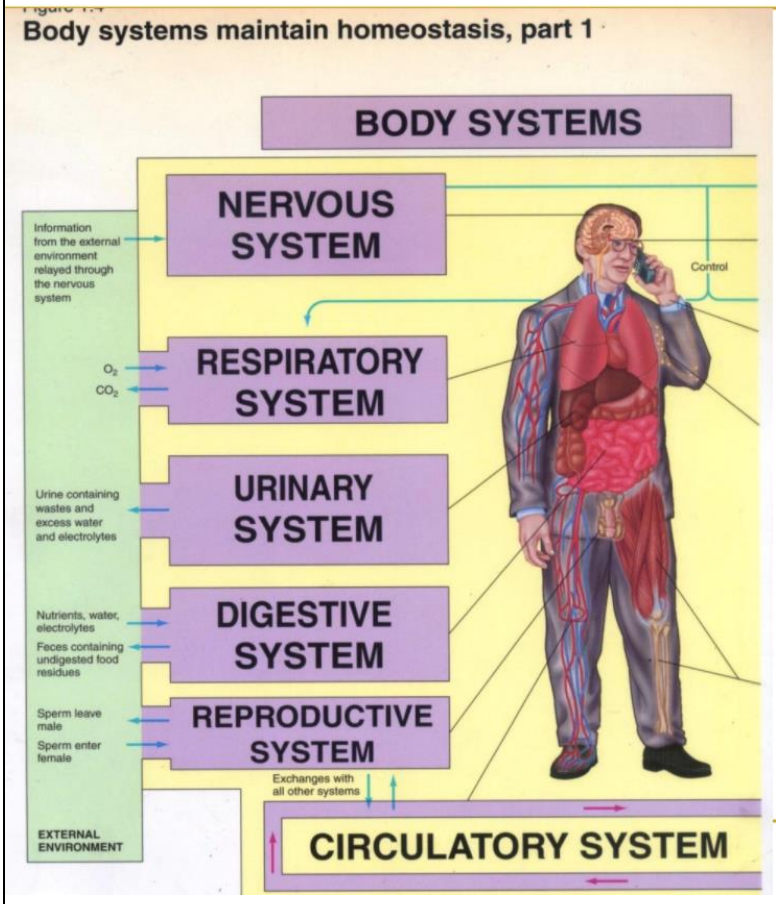
1. Nervous system: which uses signals, nerves and neurons (very fast).
2. Endocrine system: which uses chemicals called hormones (slower).

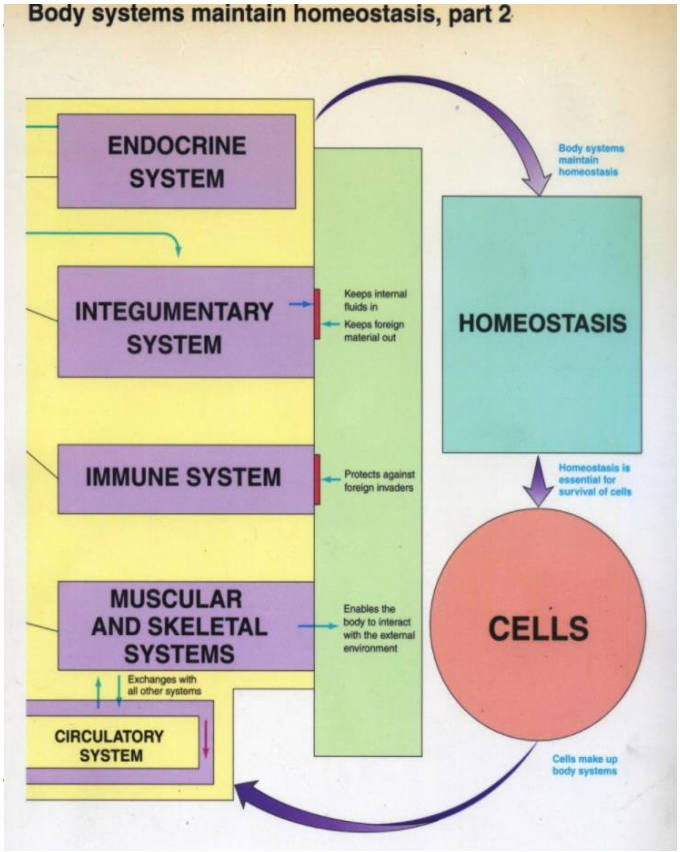
*Each system works for a certain function which differs from one system to another, and they both work at the same time but on different levels.

* However, all the systems work for a general function which is to keep the internal environment almost constant (maintain it). This is also known as the homeostatic function.

Introduction to Physiology and Transport lecture 1: Time: 10:00







So, what is Homeostasis?

Homeostasis:

- A condition of equilibrium (balance) in the body's internal environment, where it's maintained at an almost constant level.
- Homeostasis is dynamic not static; the body has a normal range of values for each variable (within narrow variation).

Examples of the variables in our body:

Blood pressure (BP), Blood Glucose Level (BGL), body temperature, PH of blood, the concentration of [CO2, O2, Na+, K+, Ca2+].

*The Blood glucose levels range between 70 and 110 mg of glucose/dL of blood.

- All the systems in our body work to maintain **homeostasis** except the **reproductive system**, it has no homeostatic function, and only exists to maintain species (therefore humans can live without it).

Homeostatic Imbalances

- Normal equilibrium of body processes are sometimes disrupted.
- Imbalances in our internal environment (breakdown of homeostasis / dis-homeostasis) signifies presence of diseases.

  TYPES OF IMBALANCES:

  1. Moderate imbalance:

  ⇨ It is a disorder or abnormality of structure and function.

  ⇨ Caused by a disease specific for an illness with recognizable signs and symptoms, and sometimes it may lead to death.

- Signs: (are objective changes) / what you can see in the patient or measure, such as fever, swelling, heart rate.
- Symptoms: (are subjective changes) what the patient describes but you can't detect/measure, such as pain and headache.

  2. Severe imbalance: which can lead to death.

- Homeostasis is constantly being disrupted by:

✦ Physiological stress: (demands of work or school).

✦ Physical insults: intense heat or lack of oxygen.

✦ Change in the internal environment: Drop of blood sugar due to lack of food.

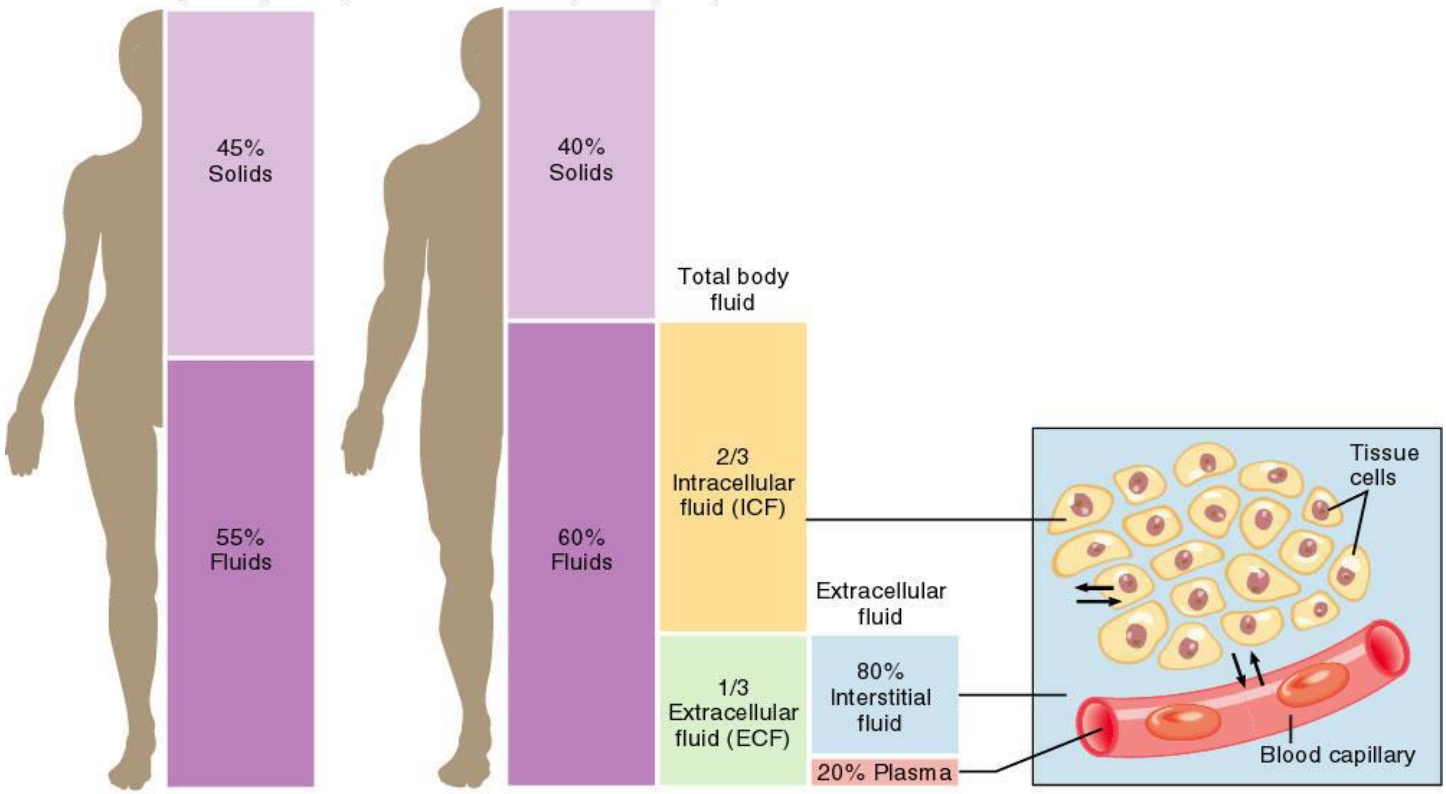
✦ Disruptions:

1- Mild and temporary (balance is quickly restored)

2- Intense and Prolonged (Poisoning or severe infections)

Homeostasis and body fluids

- Maintaining the volume and composition of body fluids are important.
- Body fluids are defined as dilute, watery solutions containing dissolved chemicals inside or outside of the cell.
- **Body fluids:**
  - ICF (Intracellular Fluid): Fluid within cells
  - ECF (Extracellular Fluid): Fluid outside cells.
    - **INTERSTITIAL FLUID :** **(ECF between tissuse and cells – internal Enviroment)**
    - **FLUIDS OUTSIDE THE CELLS :** **(such as vascular fluid (plasma) inside the vessels)**



(a) Distribution of body solids and fluids in an average lean, adult female and male

(b) Exchange of water among body fluid compartments

●**Example:** suppose we have a **70kg** man, then:

*__fluids__ make 70*0.60 = 42 liters.

__intracellular fluids__ make 42(2/3) = 28 liter (inside the cell).

__extracellular fluids__ make 42(1/3) =14 (3 liters in the __plasma__, 11 liters are __Interstitial fluids__).

● **females** have less percentage of fluids, because they have more fat, and fat is hydrophobic.

Interstitial Fluid and Body Function

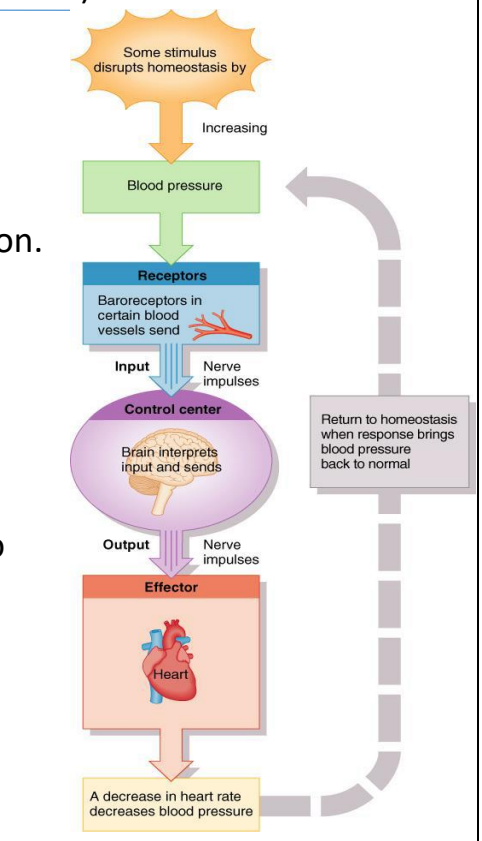
- Cellular function depends on the regulation of composition of interstitial fluid.
- The interstitial fluid is known as the body's internal environment.
- Composition of interstitial fluid changes as it moves.
  The Movement back and forth across capillary walls to provide nutrients (glucose, oxygen, ions) to tissue cells and removes waste (carbon dioxide).

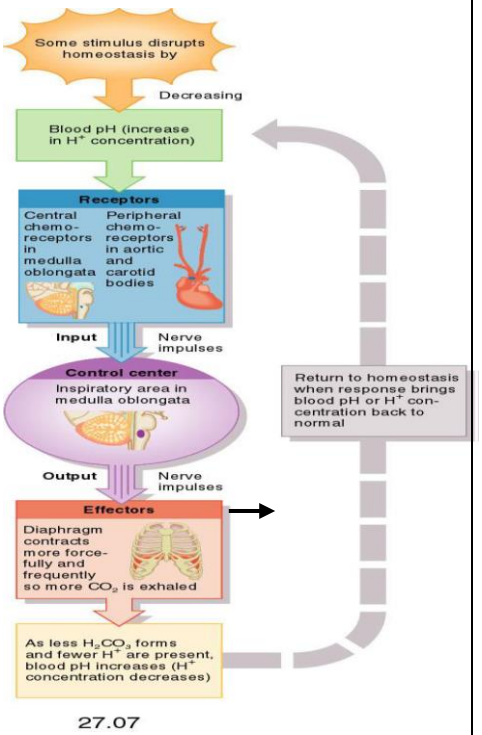
Feedback System

- keeps the internal environment constant.
- Cycle of events.
  - Body is monitored and re-monitored.
  - Each monitored variable is termed a controlled condition.

There are three Basic components:

1. Receptors:
   - Body **structures** that **monitor** changes in a controlled condition.
   - Sends **input** to the control center.
   - Example: Nerve ending of the skin in response to temperature change.
2. Control center:
   - Brain
   - Sets the **range of values** to be maintained.
   - Evaluates input received from receptors and **generates output** command.
   - Nervous system (nerve impulses) and endocrine system (hormones)
   - Example: Brain acts as a control center by receiving nerve impulses from skin temperature receptors.
3. Effectors:
   - **Receives output** from the control center.
   - Produces a **response** or effect that changes the controlled condition.
   - Found in nearly every organ or tissue.
   - Example: Body temperature drops → skin receptors sense drop → the brain sends impulse to effector (skeletal muscles) muscles contract rapidly causing shivering which generates heat.





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Introduction to Physiology and Transport lecture 1: Time: 30:00

Negative and Positive Feedback systems

Negative Feedback systems

- **Reverses** a change in a controlled condition.
  - ⇨ Regulation of blood pressure (force exerted by blood as it presses again the walls of the blood vessels)

Positive Feedback systems

- **Strengthen** or reinforce a change in one of the body's-controlled condition. Examples:
  - ⇨ Normal childbirth: During the process of a delivering a newborn, the uterus starts contracting (also known as labor), the contraction starts as slow and infrequent but will increase and happen more frequently until delivery of baby takes place. Once the delivery is finished, everything will return to its normal condition.
    *Notice that the response (increase in contractions) is in the same direction as the stimulus (which is the beginning of the contractions)
  - ⇨ Blood Loss: In Normal conditions: heart pumps blood to body cells at high blood pressure (to deliver oxygen and nutrients).
    In Severe blood loss: Blood pressure drops / and cells receive less oxygen / so they function less efficiently.
    If blood loss continues / heart cells become weaker /BP continues to fall / Heart doesn't pump.
    (When someone is bleeding, the blood coagulates (stimulus).
    The (response) will be an increase in coagulation to prevent blood loss)

Introduction to Physiology and Transport lecture 1: Time: 40:00

Regulation of blood pressure as an example OF negative feedback:

1. When the blood pressure increases, this simulates the pressure sensitive receptors which are called "Baroreceptors."
2. These Receptors detect higher Blood pressure (BP).
3. The receptors send this change (input) to the control center (brain) as nerve impulses for interpretation.
4. The Control system will analyze the input received from receptors and generates an (output) command, then sends it to certain (effectors). ➔ In this case, the blood vessels and the heart are the effectors.
5. Effectors receive the output from the control center, then produce a (response) which is here "vasodilation" (decreasing BP)
6. BP is dropped and homeostasis is restored.
7. Dropping in BP negates (cancels) the original stimulus.

- Vasodilation: to decrease the resistance and therefore decrease the blood pressure to its normal range.

- Vasoconstriction: to increase the resistance and therefore increase the blood pressure to its normal range.

The PH as an example OF Negative feedback:

PH is inversely related with the concentration of H+

Feedback Gain : A measure of the effectiveness of a feedback system.

$$\text{Gain} = \frac{\text{Correction}}{\text{Error}}$$

Example: The normal BP is 100. If the BP increases to 120, the control system will try to decrease it, and drops it to 105. Find the Gain of the control system.

Solution:

Correction = after-before=105-120= -15 Error = 105-100= 5

Therefore, Gain = -15/5= -3 ((very small gain))

Introduction to Physiology and Transport lecture 1: Time: 50:00

Generalized Body Cell :

Plasma membrane:

- forms the cell's outer boundary.
- separates the cell's internal environment from the external environment.
- is a selective barrier.
- plays a role in cellular communication.
- Flexible yet sturdy barrier.
- The fluid mosaic model: the arrangement of molecules within the membrane resembles a sea of lipids containing many types of proteins.
- The lipids act as a barrier to certain substances.
- The proteins act as "gatekeepers" to certain molecules and ions.

Structure of a Membrane:

a. A lipid bilayer is made up of phospholipids, cholesterol and glycolipids.

• There is two layers of phospholipids with 1 hydrophilic head and 2 hydrophobic tails.

• The membrane is not static (Dynamic) and it is constantly moving.

- The ICF has a higher concentration of K (potassium) ions, and the ECF has a higher concentration of Na (sodium) ions (they differ in concentration).

b. Integral proteins: extend into or through the lipid bilayer.

c. Transmembrane proteins: most integral proteins, span the entire lipid bilayer.

d. Peripheral proteins (surface proteins): attached to the inner or outer surface of the membrane, do not extend through it.

Glycoproteins: membrane proteins with a carbohydrate group attached that protrudes into the extracellular fluid.

Glycocalyx: the “sugary coating” surrounding the membrane made up of the carbohydrate portions of the glycolipids and glycoproteins (especially for the heart).

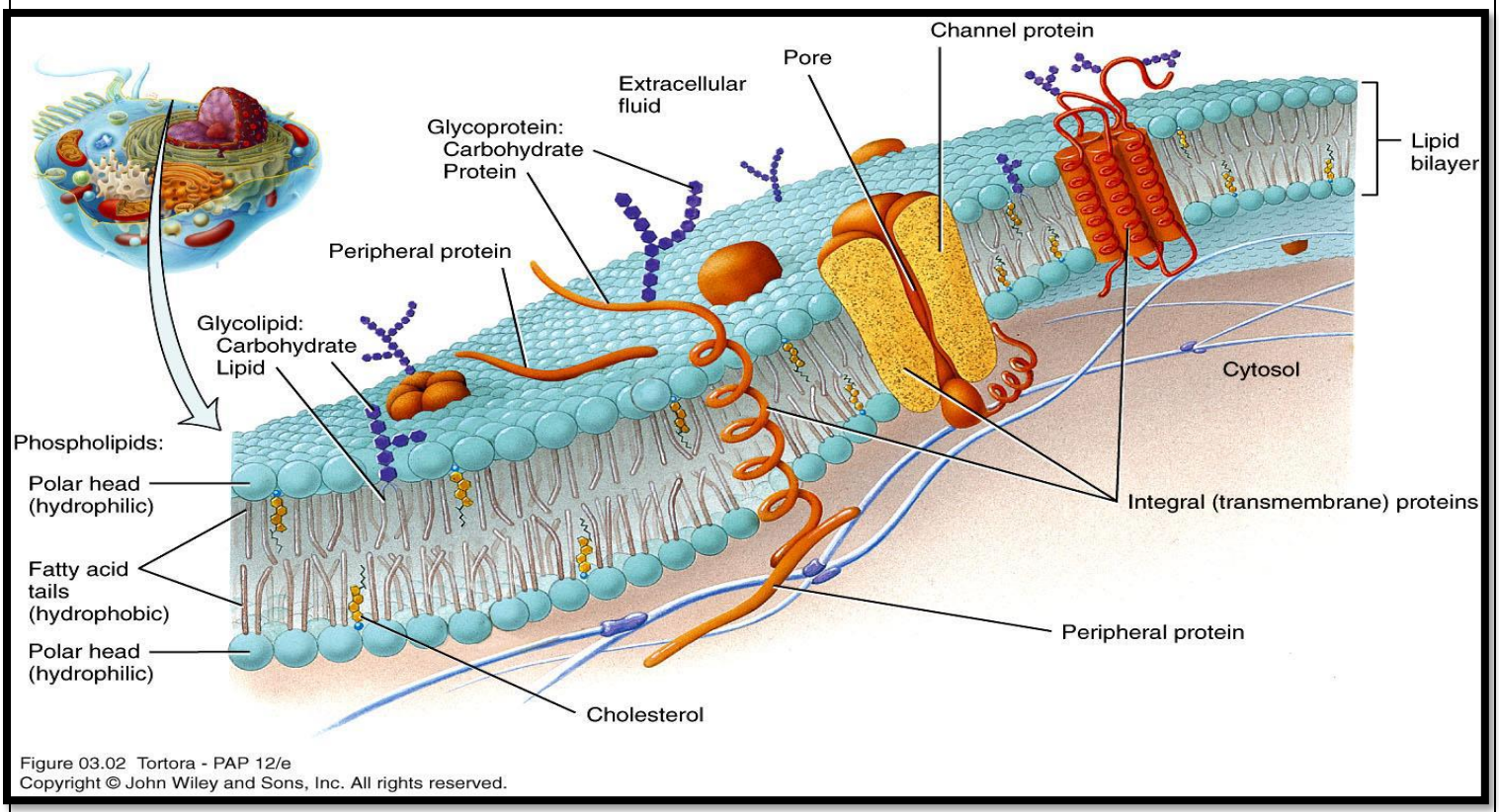


Figure 03.02 Tortora - PAP 12/e

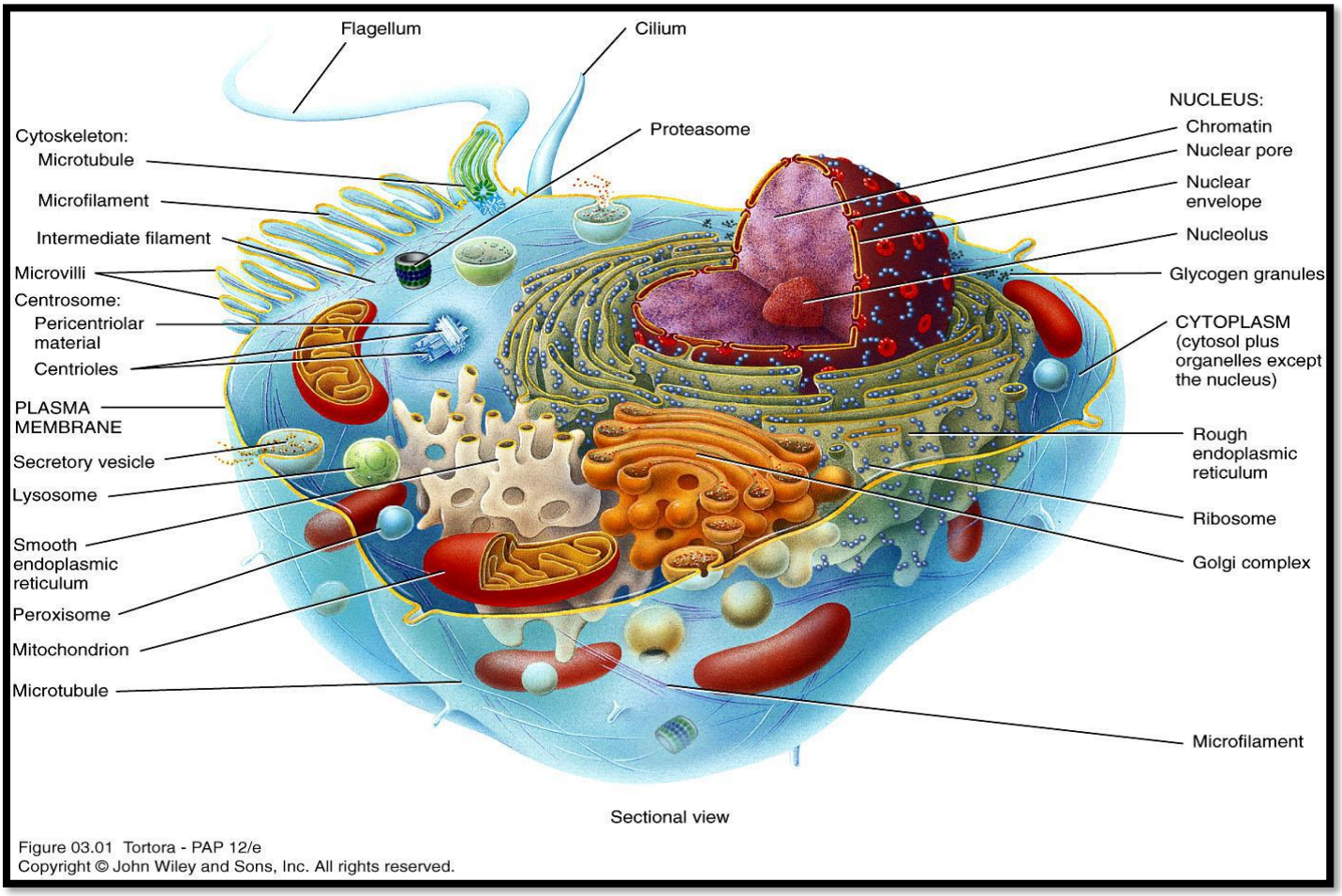


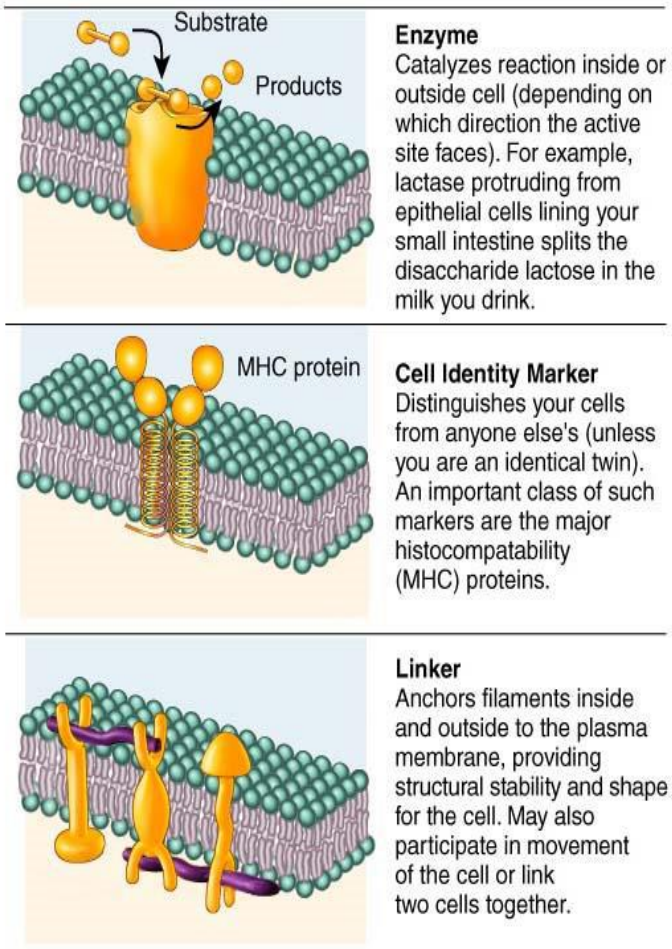
Figure 03.01 Tortora - PAP 12/e

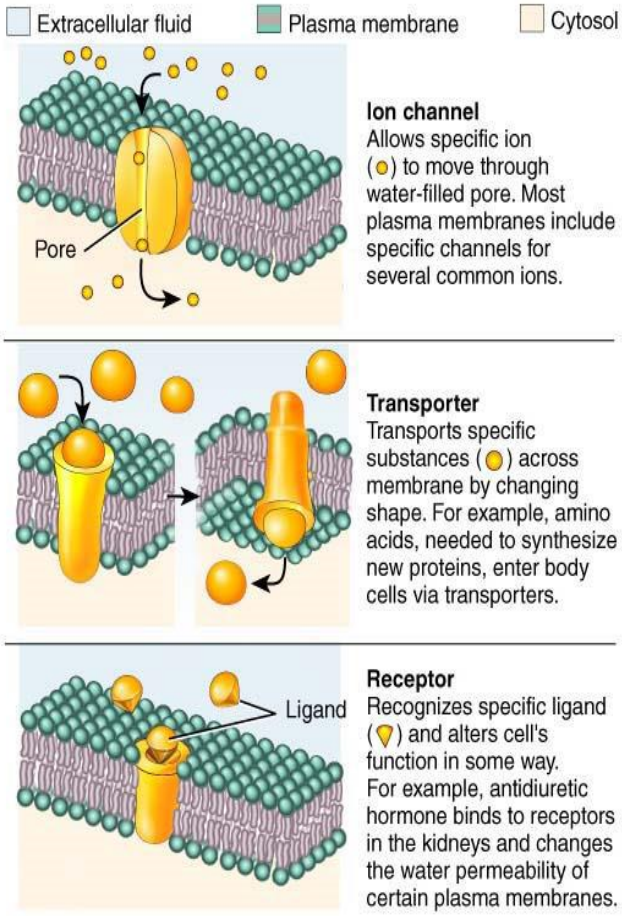
Functions of Membrane Proteins:

a. Some integral proteins are ion channels.
b. Transporters: selectively move substances through the membrane.
c. Receptors: for cellular recognition; a ligand is a molecule that binds with a receptor.
d. Enzymes - catalyze chemical reactions.
e. Others act as cell-identity markers.

*The amount of protein differs from one cell to the other.

Gated Proteins: → Chemical – Gated; → Voltage – Gated





QUICK NOTES:

- **Normal** blood sugar level: **NORMOGLYCEMIA**
- **Increasing** blood sugar level: **HYPERGLYCEMIA**
- **Decreasing** blood sugar level: **HYPOGLYCEMIA**
- **HYPERNATREMIA (**increasing sodium (Na+) concentration**)**
- **HYPOTENSION (**low blood pressure**), HYPERTENSION (**high blood pressure**).**
- **HYPERKLAMIA (**increasing potassium (K+) concentration**).**

Introduction to Physiology and Transport lecture 1: Time: 1:03:51