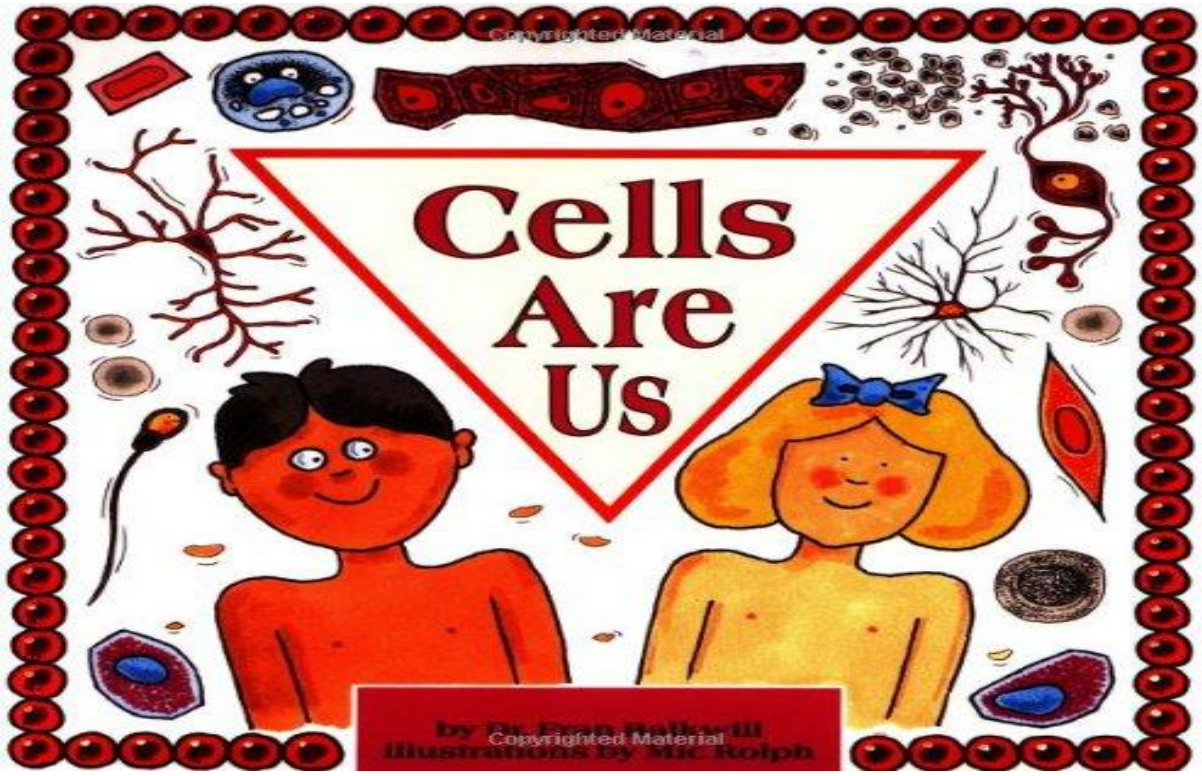
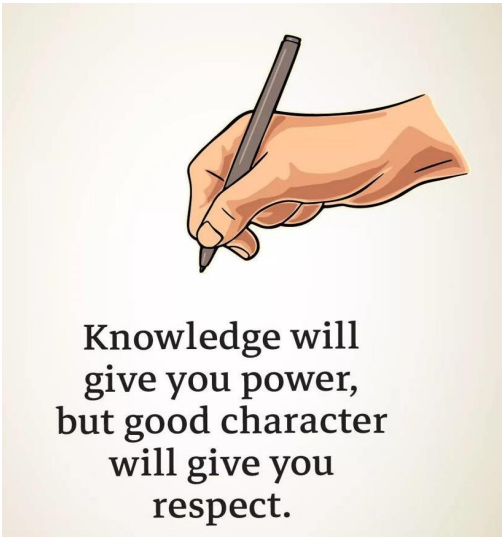
CELL, TISSUE AND BODY FLUID





Physiology is the science that seeks to explain the physical and chemical mechanism that is responsible for the origin, development and progression of life. It deals how organisms perform their vital functions.

An example is the study of how a muscle contracts or the force contracting muscles exert on the skeleton.

Human physiology is the science of studying the rule of physiological functions in human body.

Types of human physiology

Human physiology is the study of functions of the human body that can be divided into the following types:

Cell physiology.

This is the cornerstone of human physiology; it is the study of the functions of cells.

Special physiology

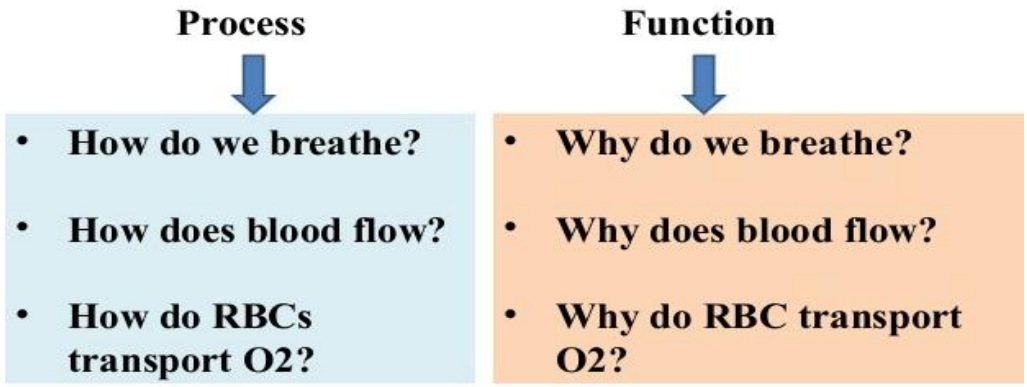
This is the study of the functions of specific organs. For example, renal physiology is the study of kidney function.

Systemic physiology

It includes all aspects of the function of the body systems, such as cardiovascular physiology, respiratory physiology, reproductive physiology etc.

Pathophysiology

It is the study of the effects of diseases on organ or system functions (pathos is the Greek word for disease).



- Aristotle emphasized the relationship between structure and function
- Galen was the first to perform experiments to understand the function of the body; so known to be father of physiology
- The first "physiologist" of the world, in the modern sense, was William Harvey. In the 17th century William Harvey first describes the circulatory system and its interaction with the body
- Claude Bernard (1813-1878) propounded the concept of milieu interieur or internal environment and established physiology as the scientific basis of medicine.
- THE FATHER OF MODERN PHYSIOLOGY IS THE FRENCH PHYSIOLOGIST CLAUDE BERNARD

Organelles: An organelle is a small organ of a cell, which performs a particular function (cell membrane, cytoplasm and nucleus)

Cell: The cell is the basic unit of structure and function of living organisms.

Tissue: A tissue is a group of similar cells that perform a specialized function (epithelia, connective, muscle and nervous).

Organ: An organ is a structure consisting of a group of tissues that perform a specialized function (skin, heart, brain, etc.).

System: A system is a group of organs that act together to perform a specialized function.

Human body: A living organism is the most complex level of organization. It consists of all the systems arranged in a discrete manner so as to facilitate functioning of the various organ systems in synchronicity.

Seven characteristics of life:

1. **Cells:** All living organisms have cells; cells are the building blocks of life.
2. **Metabolism:** All living organisms eat, drink, breathe and excrete.
3. **Growth:** All living organisms take in material from the environment to enlarge and sustain.
4. **Reproduction:** All living organisms are able to produce a copy of themselves.
5. **Irritability:** All living organisms are able to react to a change in their environment.
6. **Adaptation:** All living organisms are able to compete with each other for food and space to survive.
7. **Movement:** All living organisms are able to move.

Organs

Organ is a group of tissues arranged in a special manner to perform a particular function.
Internal organs are called Viscera.

Internal organs: Stomach, Heart, Lungs, Kidneys.

External organs: Hands

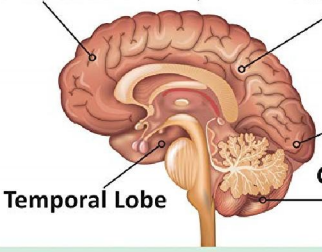
System is a group of organs working together to perform certain function of the body.

The systems of the body are-

1. **Circulatory or Cardiovascular system**: Carries oxygen & nourishment and removes waste materials.
2. **Respiratory system**: Allows exchange of gases between body & environment.
3. **Digestive system:** Concerned with digestion & absorption.
4. **Urinary system**: Deals with excretion of water-soluble waste products from the body.
5. **Endocrine system**: Produces hormones, which control varieties of functions.
6. **Reproductive system:** Responsible to give birth of same kind.
7. **Nervous system:** Governs & coordinates the activities of same kind.
8. **Musculo-skeletal system:** Responsible for movement.
9. **Integumentary System:** Skin, Hair & Nail

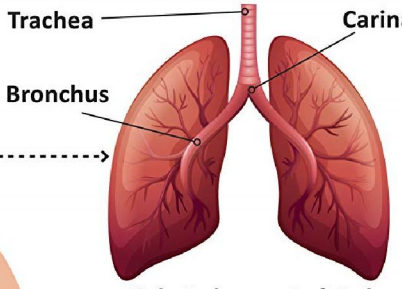
BODY ORGAN SYSTEM

BRAIN



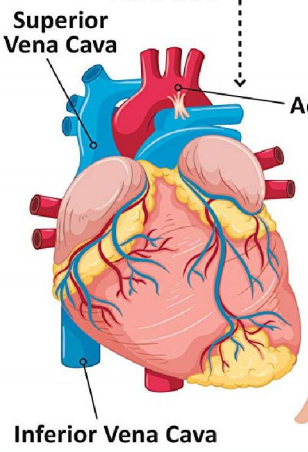
Control centre of the body.

LUNGS



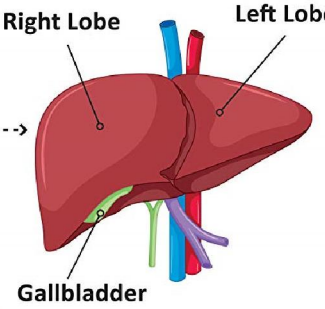
Helps to breathe.

HEART



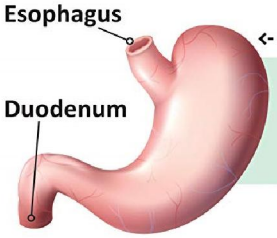
Pumps blood around the body.

LIVER



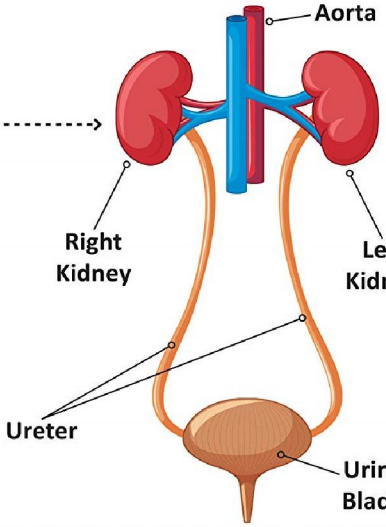
Cleans the blood.

STOMACH



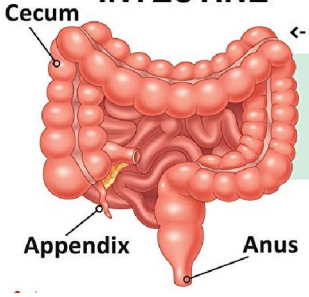
Helps in the breakage of food.

KIDNEYS



Helps filter the waste material out from the body.

INTESTINE



Helps in the digestion of food.

Cell is the basic structural, functional, and biological unit of all known living organisms. A cell is the smallest unit of life. Cells are often called the "building blocks of life". Human has more than 10 trillion (10^{13}) cells.

Cells are organized into three main regions: Nucleus, cytoplasm and plasma membrane.

1) The nucleus: It is the center of the cell because it contains genetic material (DNA). It consists of three main regions: the nuclear membrane, the nucleolus and chromatin.

- **Nuclear membrane:** Nuclear membrane serves as a barrier of nucleus. It consists of a double phospholipid membrane and contains nuclear pores that allow for the exchange of material with the rest of the cell.
- **Nucleolus:** Nucleus contains one or more nucleoli. It functions as site of ribosome production. Ribosomes then migrate to the cytoplasm through nuclear pores.
- **Chromatin:** It is composed of DNA and protein scattered throughout the nucleus. Chromatin condenses to form chromosomes when the cell divides.

2) Plasma membrane: It is the barrier for cell contents. It consists of double phospholipid layer and monolayer of protein scattered around phospholipid layer. Other materials in plasma membrane such as cholesterol and glycoproteins.

3) Cytoplasm: It is a thick jelly like fluid. It represents the material outside the nucleus and inside the plasma membrane. It consists of Cytosol.

- **Cytosol**: It is a fluid that suspends other elements - organelles.
- **Organelles:** That perform the metabolic activity of the cell.
- **Cytoplasmic organelles:** These are the organelles which are present scattered into the cytoplasm and performs specific functions.

These are as follows:-

- **Ribosomes:** They represent sites of protein synthesis in the cell. They are found at two locations: Free in the cytoplasm and attached to endoplasmic reticulum.
- **Endoplasmic reticulum (ER):** They are fluid-filled tubules for carrying substances. There are two types of ER :

- **Rough endoplasmic reticulum:** They Carry ribosomes that represent sites of protein synthesis.
- **Smooth endoplasmic reticulum:** They function in cholesterol synthesis and breakdown, fat metabolism, and detoxification of drugs.
- **Golgi apparatus:** It modifies and packages proteins, secrete vesicles, plasma membrane components and lysosomes.
- **Lysosomes:** They contain enzymes that digest non-usable materials within the cell.
- **Peroxisomes:** These are membranous sacs of oxidase enzymes. They detoxify harmful substances and break down free radicals.
- **Mitochondria:** They represent powerhouse of the cell. They can change shape continuously. They also carry out reactions where oxygen is used to break down food to provide ATP for cellular activities.
- **Centrosome**: The centrosome is composed of two centrioles surrounded by an amorphous mass of protein. Centrosomes are associated with the nuclear membrane during prophase of the cell cycle. In mitosis the nuclear membrane breaks down and the centrosome can interact with the chromosomes to build the mitotic spindles.
- **Centrioles:** These are self-replicating organelles made up of nine bundles of microtubules. They appear to help in organizing cell division, but aren't essential to the process.
- **Cytoskeleton:** It's a network of protein structures that extend throughout the cytoplasm. It provides the cell with an internal framework. For example, microfilaments and microtubules.

  A-Microfilaments: Microfilaments are solid rods made of proteins called actin. These filaments are important supports of the cytoskeleton.

  B-Microtubules: These straight, hollow cylinders are found throughout the cytoplasm of all human cells and carry out a variety of functions, ranging from transport to structural support.

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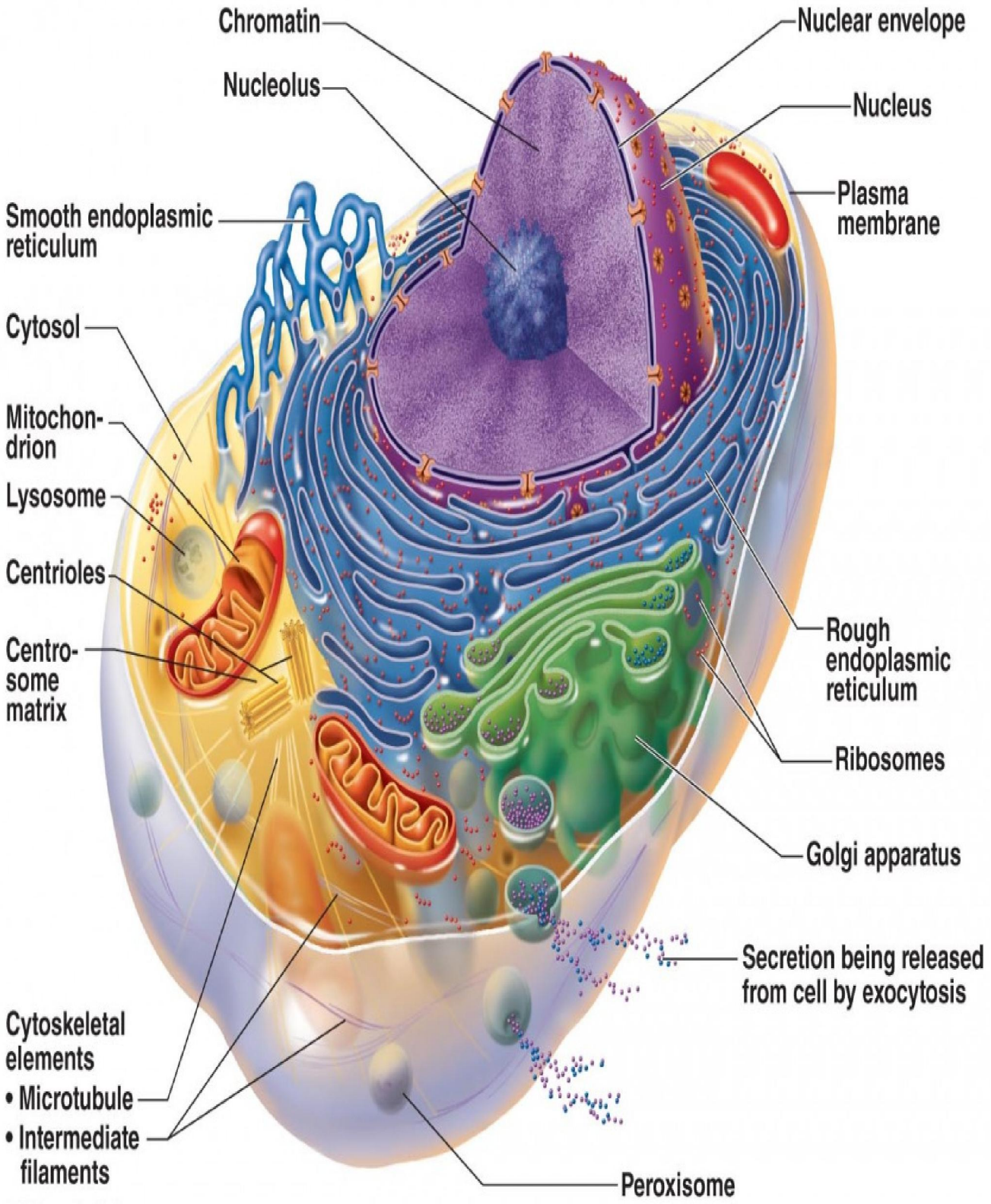
The cell is the structural and functional unit of the living organism. Every human contains more than 100 trillion cells. A typical cell has two major parts, the nucleus and cytoplasm. The nucleus is separated from the cytoplasm by nuclear membrane and the cytoplasm is separated from surrounding fluid by plasma membrane.



Lysosomes

1. Lysosome are the organelle that is found in all types of eukaryotic cells.
2. They are responsible for the digestion of macromolecules, old cell parts, and microorganisms.
3. Each lysosome is surrounded by an acidic membrane.
4. Lysosomes contain a wide variety of hydrolytic enzymes (acid hydrolases) that break down macromolecules such as nucleic acids, proteins, and polysaccharides.

Functions:

i) Release enzymes outside of the cell, which destroy the materials around the cell.
ii. Provide an intracellular digestive system for cell to digest cellular substances.
iii. Removal of damaged cells from the body.
iv. Kills the bacteria harmful for the body.

Peroxisomes

They are small vesicles found around the cell.

They have a single membrane that contains digestive enzymes for breaking down toxic materials in the cell.

They **differ** from lysosomes in **the type of enzyme** they hold.

Peroxisomes hold on **oxidative enzymes**.

Main Function	**Lysosomes** break down biological polymers like proteins and polysaccharides.	**Peroxisomes** oxidize organic compounds, breaking down metabolic hydrogen peroxides.
Composition	Lysosomes consists of degradative enzymes.	Peroxisomes consist of oxidative enzymes.
Function	Lysosomes are responsible for the **digestion in the cell.**	Peroxisomes are responsible for the **protection of the cell** against metabolic hydrogen peroxide.
Presence	Lysosomes are **only found in animals**.	Peroxisomes are found in all eukaryotes.
Origin	Lysosomes are derived from either Golgi apparatus or endoplasmic reticulum.	Peroxisomes are derived from the smooth endoplasmic reticulum.
Size	Lysosomes are comparatively large in size.	Peroxisomes are small.
Energy Generation	Degradative reactions in the lysosomes do not generate energy.	Oxidative reactions in peroxisomes generate ATP energy.

CELL DIVISION

The **cell cycle** is a series of events containing cell growth and cell division that produces two new daughter cells. The cell cycle has two major phases:

G1: Cell growth phase

S: DNA Synthesis phase

G2: More cell growth phase

1. Interphase

During interphase, the cell **undergoes** normal **growth processes** while also **preparing** for cell division. Before a cell can enter cell division, it needs to take in nutrients. All of the preparations are done during interphase. The three stages of interphase are called G1, S and G2.

a. **G1 Phase (first Gap)**

During the G1 stage, the cell is **accumulating** chromosomal DNA and associated proteins. The cell **increases** its supply of proteins and **grows** in size.

b. **S Phase (Synthesis of DNA)**

S phase starts when DNA synthesis commences. At the end, all of the chromosomes have been replicated. Thus, during this phase, the amount of DNA in the cell has effectively **doubled.**

c. **G2 phase**

During the gap between DNA synthesis and mitosis, the cell will continue to grow and produce new proteins. G2 phase occurs after DNA replication and is a period of protein synthesis and rapid cell growth to prepare the cell for mitosis.

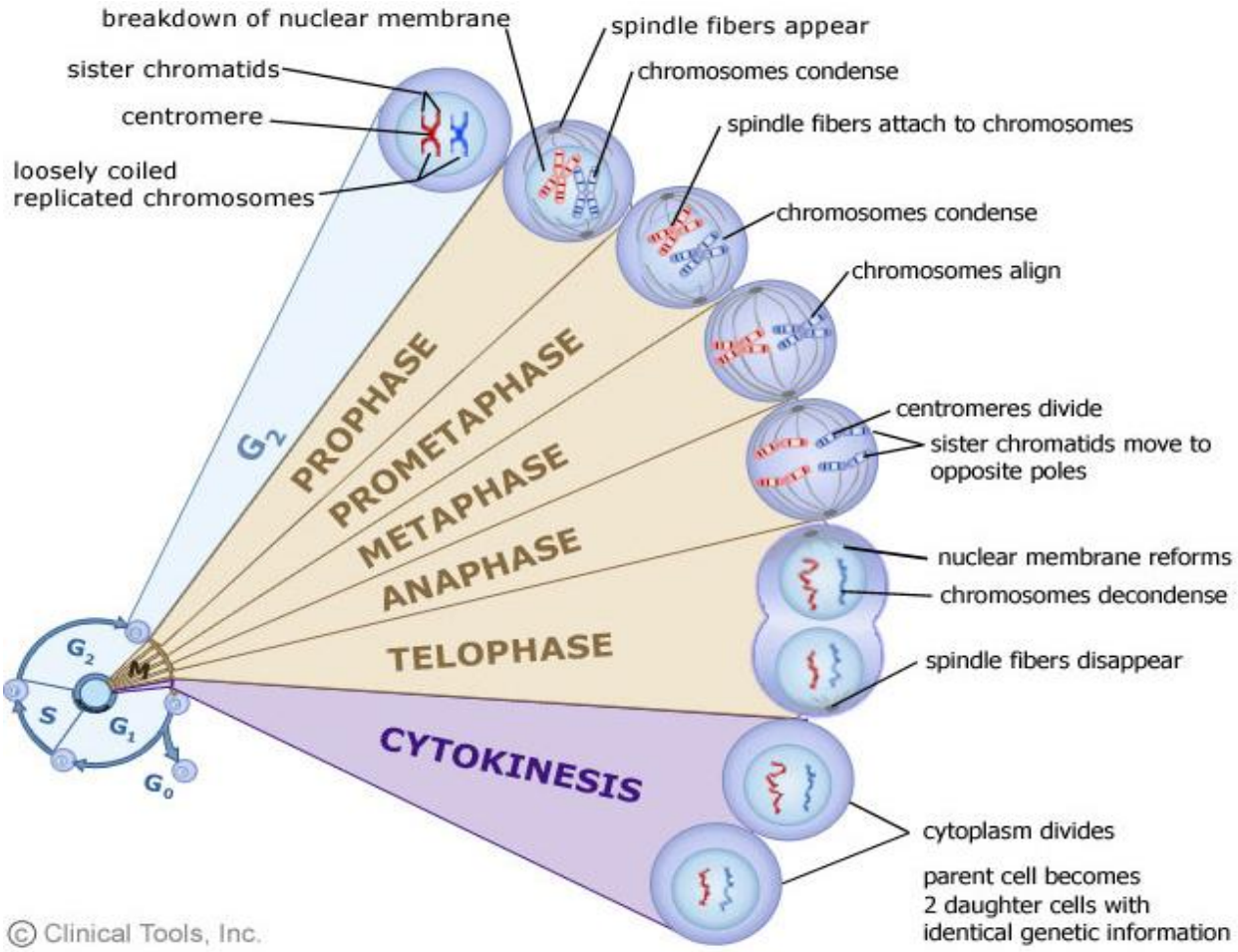
2. Mitotic Phase

Cell growth and protein production stop at this stage in the cell cycle. All of the cell's energy is focused on the complex and orderly **division into two similar daughter cells**, called mitosis cell division.

Mitosis is a type of cell division in which one cell (the **mother**) divides to produce two new cells (the **daughters**) that are genetically identical to itself.

In this process DNA of the cell's nucleus is split into **two equal sets** of chromosomes. The great majority of the cell divisions that happen in your body involve mitosis.

During development and growth, mitosis populates an organism’s body with cells, and throughout an organism’s life, it replaces old, worn-out cells with new ones.

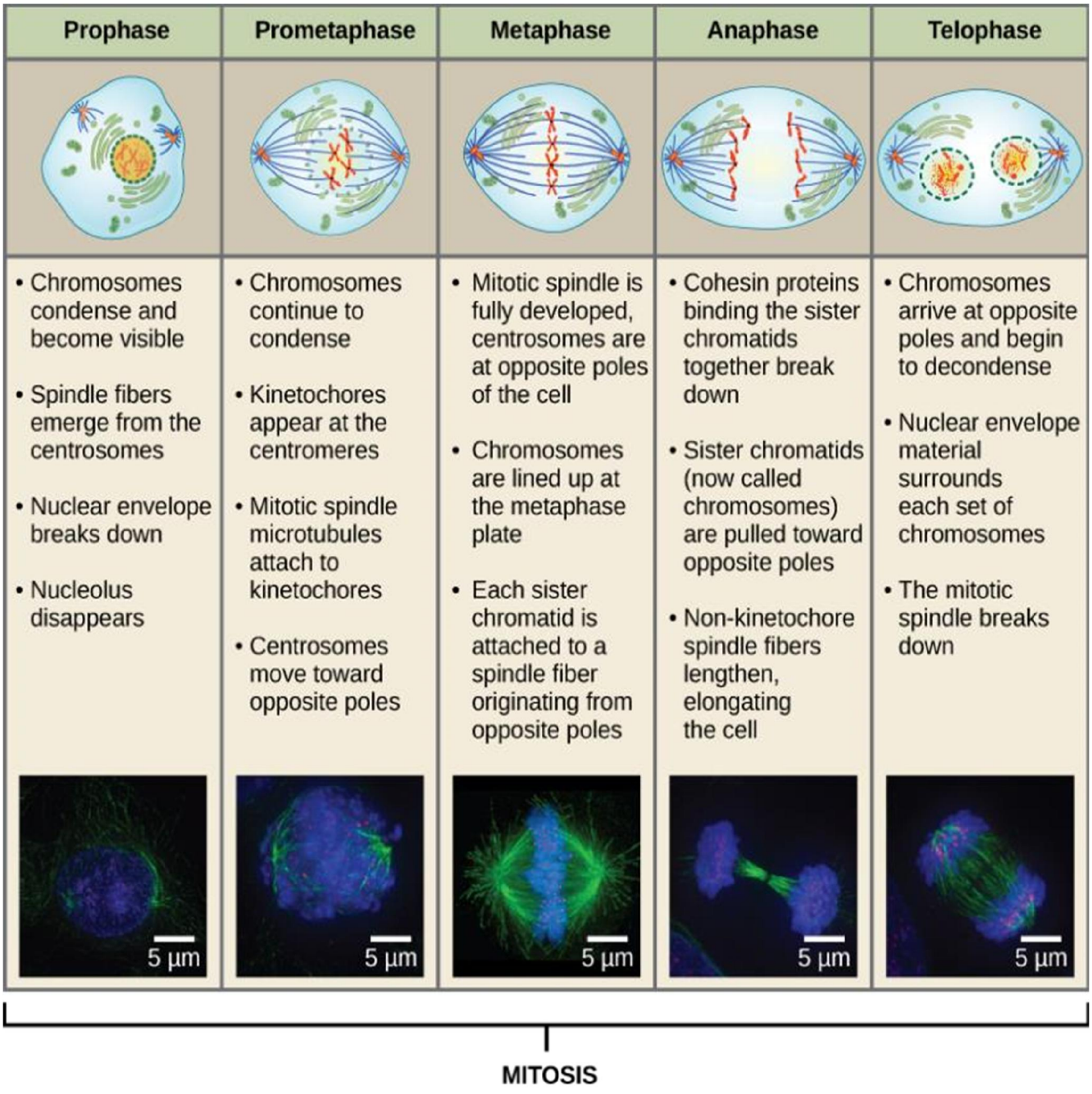


The table below shows the differences between **meiosis and mitosis.**

	Mitosis	**Meiosis**
End result	Normally four cells, each with half the number of chromosomes as the parent	Two cells, having the same number of chromosomes as the parent
Function	Production of gametes (sex cells) in sexually reproducing eukaryotes with diplont life cycle	Cellular reproduction, growth, repair, asexual reproduction
Where does it happen?	Almost all eukaryotes In gonads, before gametes	All proliferating cells in all eukaryotes
Steps	Prophase I, Metaphase I, Anaphase I, Telophase I, Prophase II, Metaphase II, Anaphase II, Telophase II	Prophase, Prometaphase, Metaphase, Anaphase, Telophase

Mitosis

Mitosis, is divided into a series of phases—**prophase, prometaphase, metaphase, anaphase, and telophase**—that result in the division of the cell nucleus.



Tissue

A tissue is an ensemble of similar cells from the same origin that together perform a specific function. Biological tissue is a collection of interconnected cells that perform a similar function within an organism.

 # Classification

The human body is composed of four basic types of tissues; epithelium, connective, muscular, and nervous tissues.

1. Epithelium- lines and covers surfaces
2. Connective tissue- protect, support, and bind together
3. Muscular tissue- produces movement
4. Nervous tissue- receive stimuli and conduct impulses

1. **Epithelium tissue**

i. The epithelial tissues are formed by cells that cover the organ surfaces such as skin, the airways, the reproductive tract, and the inner lining of the digestive tract.

ii. The cells consist of a semipermeable epithelial layer that provides a barrier between the external environment and the organ.

iii. In addition, epithelial tissue also functions in secretion, excretion and absorption.

iv. Epithelial tissue helps to protect organs from microorganisms, injury, and fluid loss.

v. Some common kinds of epithelium are listed below:

   a. Simple squamous epithelium
   b. Stratified squamous epithelium
   c. Simple cuboidal epithelium
   d. Pseudostratified columnar epithelium
   e. Columnar epithelium
   f. Glandular epithelium
   g. Ciliated columnar epithelium

2. Connective tissue

i. Connective tissues are fibrous tissues.

ii. They are made up of cells separated by extracellular matrix. This matrix can be liquid or rigid.

iii. Connective tissue gives shape to organs and holds them in place.

iv. Blood, bone, tendon, ligament and adipose tissues are examples of connective tissues.

v. Connective tissues are divide into three types: fibrous connective tissue, skeletal connective tissue, and fluid connective tissue.

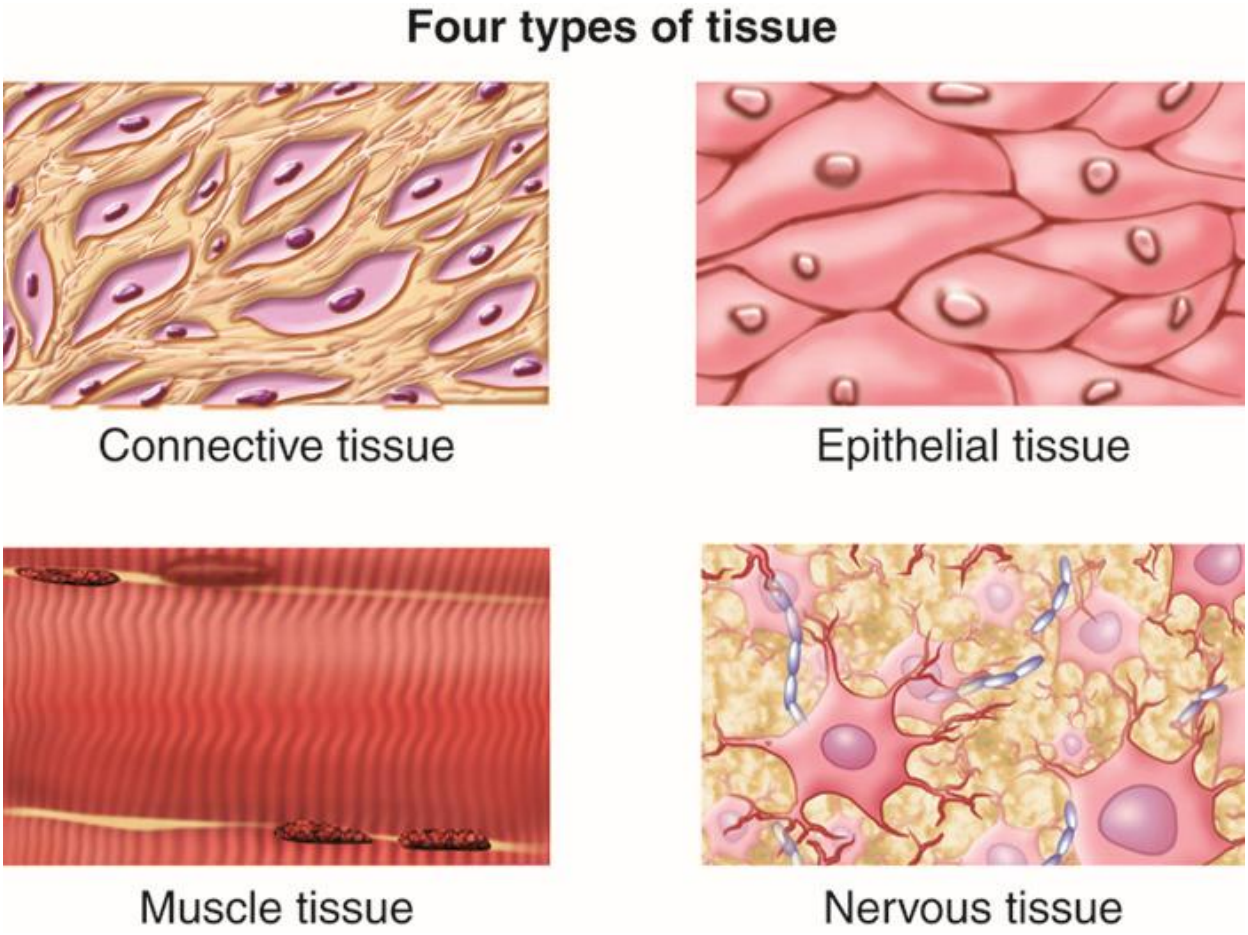
vi. Connective tissues tend to be very vascular (have a rich blood supply).

3. Muscular tissue

i. Muscle tissue is a soft tissue that composes muscles in animal bodies.
ii. It is formed during embryonic development.
iii. Muscle cells form the active contractile tissue of the body known as muscle tissue or muscular tissue.
iv. Its functions are to produce force and cause movement within internal organs.
v. Muscle tissue is separated into three distinct categories: visceral or smooth muscle, found in the inner linings of organs; skeletal muscle, attached to bones; and cardiac muscle, found in the heart.

4. Nervous tissue

i. Cells comprising the central nervous system and peripheral nervous system are classified as nervous (or neural) tissue.
ii. In the central nervous system, neural tissues form the brain and spinal cord. iii. In the peripheral nervous system, neural tissues form the cranial nerves and spinal nerves.
iv. Nervous tissue is made up of different types of nerve cells, all of which have an axon, and dendrites.
v. Functions of the nervous system are sensory input, integration, control of muscles and glands, homeostasis, and mental activity.



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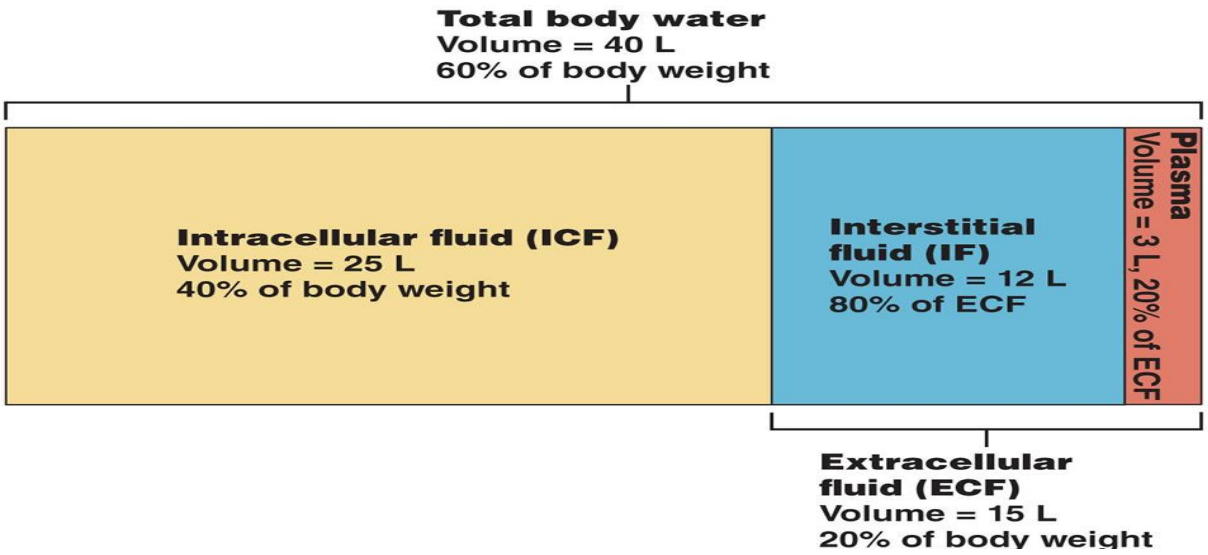
Body Fluids

- Water content in body is divided into 2 compartments:

1. **Extracellular fluid (ECF):** (internal environment or the milieu intérieur)
   - fluid outside the cells.
   ≈ 1/3 volume of fluids in body (≈ 33% of total body water).
   - contains ions & nutrients needed for cellular life.
   Extracellular fluid is further divided into
   A. Interstitial Fluid: Fluid between the cells
   B. Plasma: Fluid portion of blood

2. **Intracellular fluid (ICF):**
   - fluid inside the cells.
   ≈ 2/3 volume of fluids in body (≈ 67% of total body water).



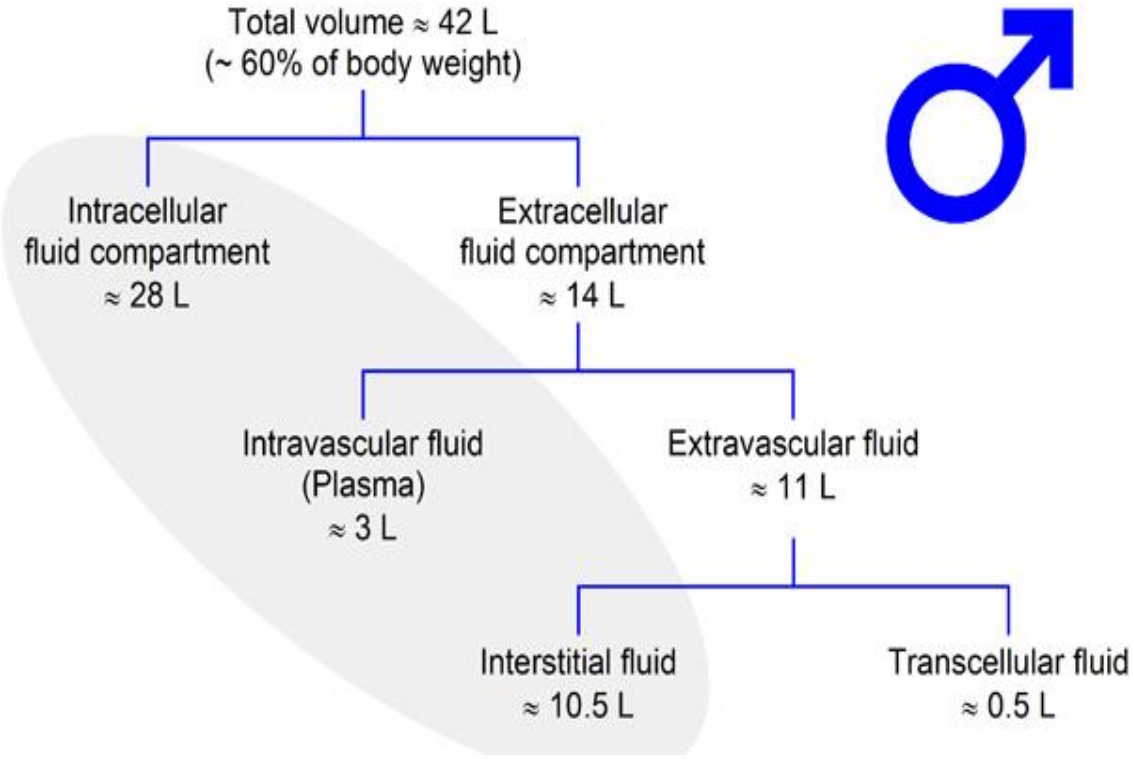
Calculate TBW for a 70 kg man.

TBW = 60% of body weight

TBW = 60% X 70 = 42 L of water

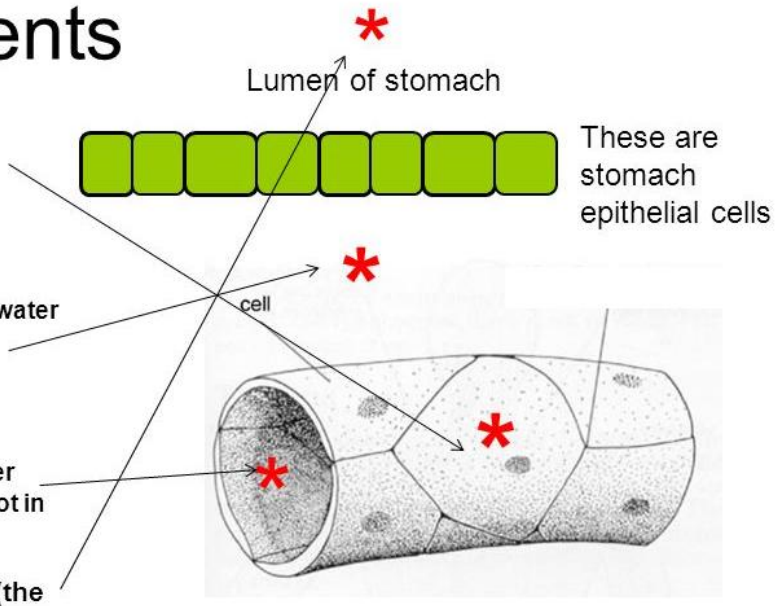
- 28 liters intracellular fluid (ICF) – (2/3rd)
- 14 liters extracellular fluid (ECF)- (1/3rd)
  -3 liters plasma
  -11 liters interstitial fluid (ISF)

Body Fluid Compartments of a 70-kg Adult Man



Compartments

- **Intracellular Fluid** (60% Body Wt)
- **Extracellular Fluid**
  - **Interstitial fluid** (the water immediately outside cells, between and around cells) (30%)
  - **Plasma fluid** (the water inside blood vessels, but not in blood cells) (9%)
  - **Transcellular fluid** (the water enclosed in chambers lined by epithelial membranes) (1%)



#**Body compartment fluid**

1. Synovial fluid

i. Synovial fluid is an egg-white like viscous fluid found in the cavities of synovial joints.

ii. The principal role of synovial fluid is to reduce friction between the articular cartilage of synovial joints during movement.

iii. The inner membrane of synovial joints is called the synovial membrane and secretes synovial fluid into the joint cavity.

iv. Synovial fluid is an ultrafiltrate from plasma, and contains proteins derived from the blood plasma.

v. This fluid forms a thin layer (roughly 50 μm) at the surface of cartilage.

vi. It contains two cell types (type A and type B). Type A is derived from blood monocytes, and it removes the debris from the synovial fluid. Type B produces hyaluronan, that lubricates the joints.

vii. The functions of the synovial fluid include:

   a. It keeps the bones slightly apart, protecting their cartilage from frictions.
   b. It absorbs shocks and protects the cartilage
   c. It lubricates the join and helping to work freely

2. Pericardial fluid

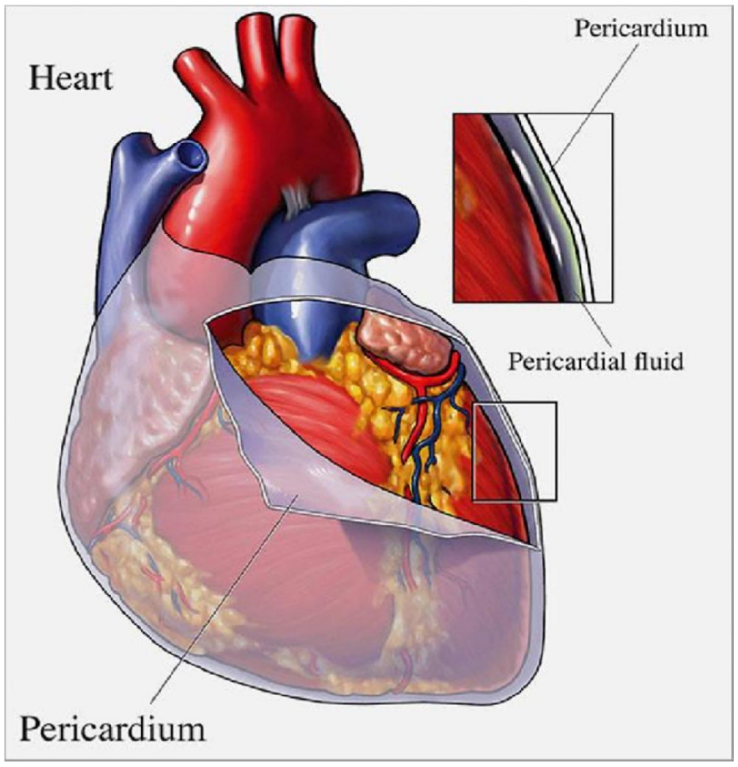
i. Pericardial fluid is the fluid secreted by the serous layer of the pericardium into the pericardial cavity.

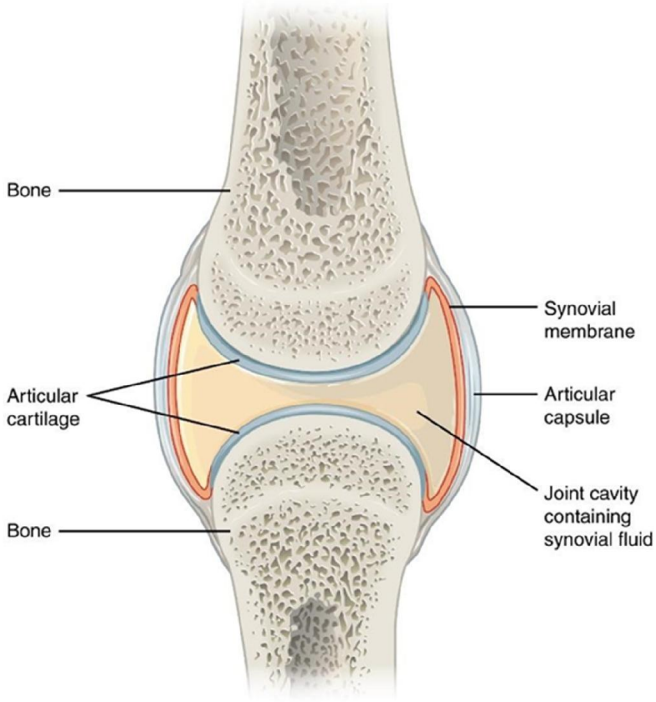
ii. The pericardium consists of two layers, an outer fibrous layer and the inner serous layer.

iii. This serous layer has two membranes which enclose the pericardial cavity into which is secreted the pericardial fluid.

iv. The fluid is made up of a high concentration of lactate dehydrogenase (LDH), protein and lymphocytes.

v. In a healthy adult, there is up to 50 ml of clear, straw-colored fluid. vi. The fluid serves to cushion and allow some movement of the organ.





3. Intraocular fluid

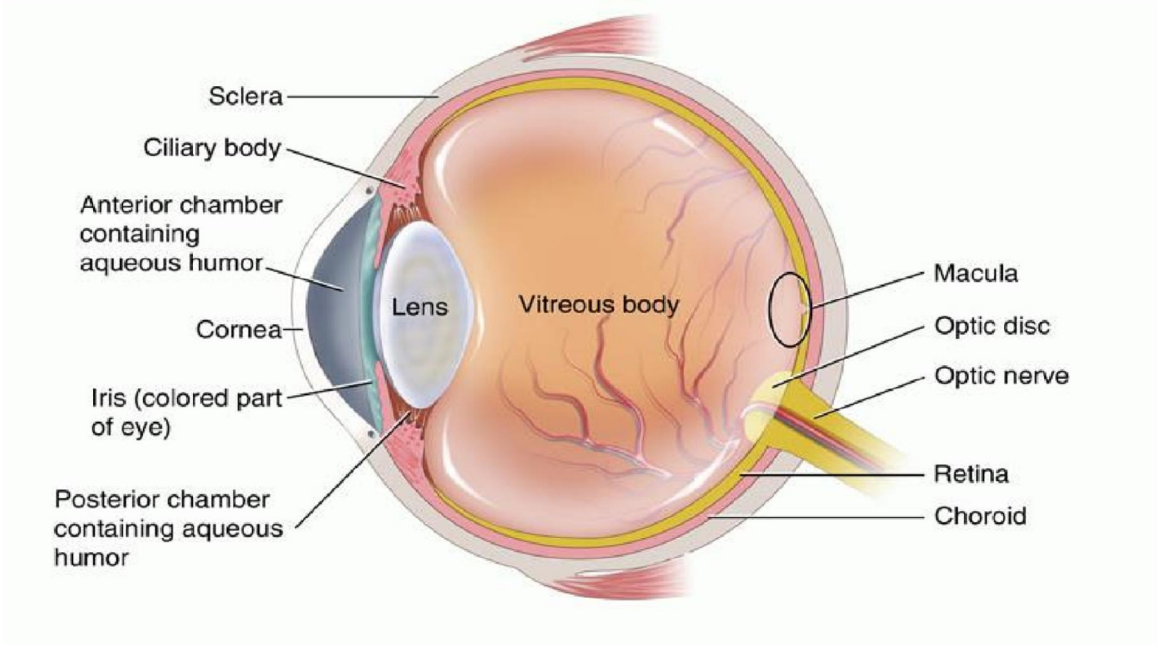
i. Intraocular fluid or aqueous humour is a transparent, watery fluid, containing low protein concentrations.

ii. It is secreted from the ciliary body.

iii. It fills both the anterior and the posterior chambers of the eye.

iv. It contains Amino acids, water, electrolytes, Ascorbic acid and Immunoglobulins.

v. The function of intraocular fluid is to maintain intraocular pressure.



4. Cerebrospinal fluid

i. Cerebrospinal fluid (CSF) is a clear, colourless liquid that fills and surrounds the brain and the spinal cord

ii. It formed primarily in the ventricles of the brain.

iii. CSF is slightly alkaline and is about 99 percent water.

iv. It contains 15 to 45 mg/dl protein and 50-80 mg/dl glucose.

v. There are about 100 to 150 ml of CSF in the normal adult human body.

vi. It provides a mechanical barrier against shock.

vii. It also provides lubrication between surrounding bones and the brain and spinal cord.

viii. It protects the brain tissue from injury when hit.

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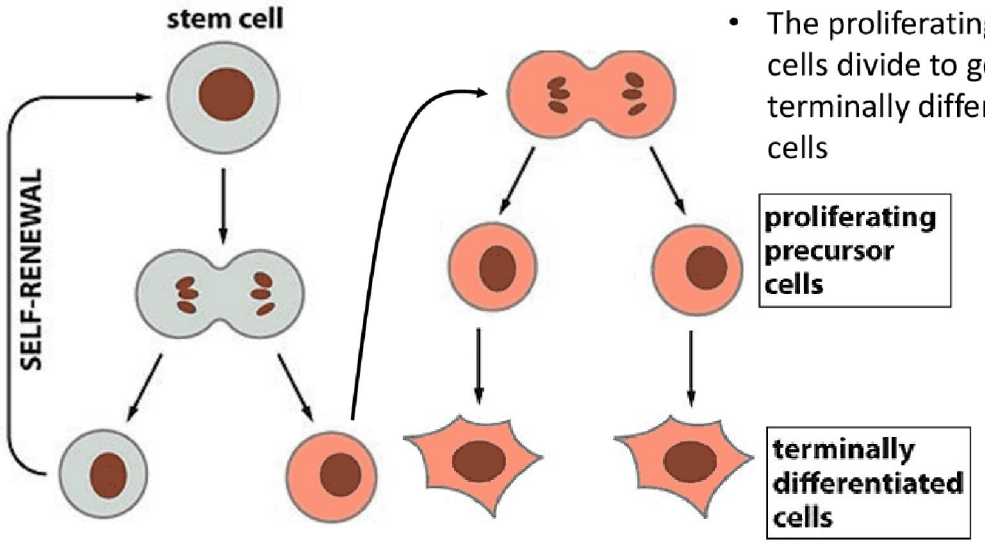
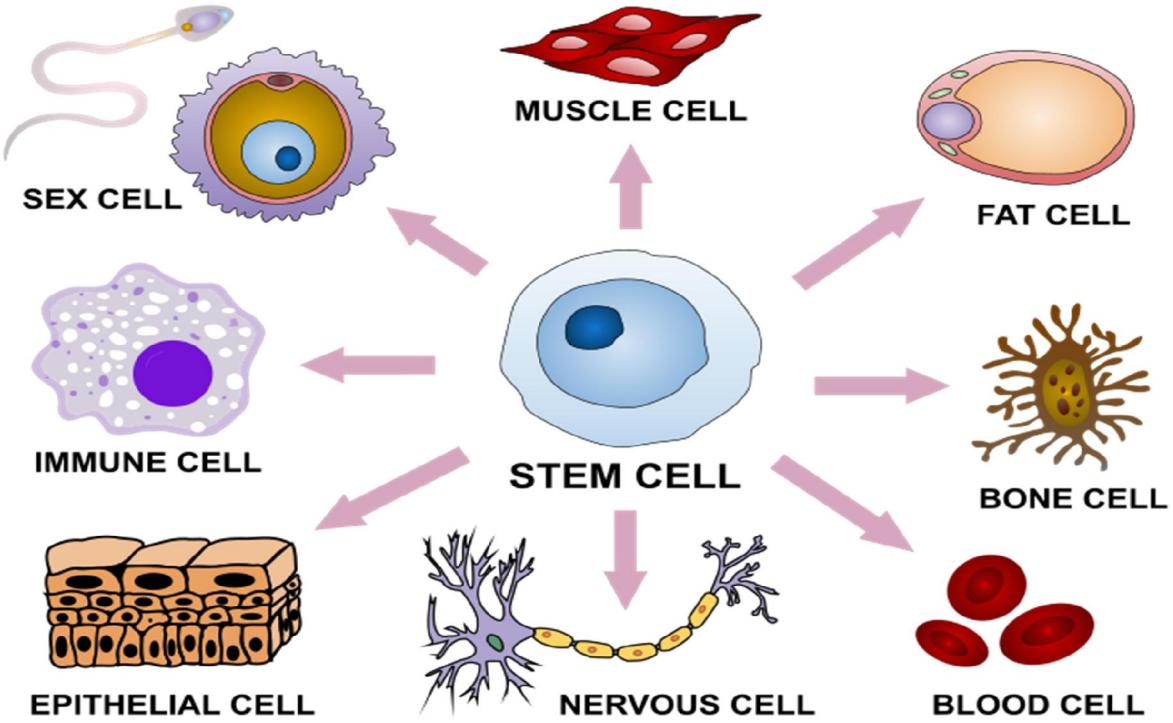
Stem cells

Definition: A population of cells that can divide to generate more of the same type of cell (self-renewal) and a variety of other cell types

- Often the first progeny are also stem cells but much more restricted in what type of cell can form from them. They only divide a limited number of times (proliferating precursor cells)



- The proliferating precursor cells divide to generate terminally differentiated cells



What is homeostasis?

Homeostasis is the maintenance of an organism's internal environment **within set limits**.

Body temperature and blood concentration are both controlled by homeostasis. The limits on these conditions may be quite broad, but if factors vary outside them it is damaging.

Internal conditions are regulated by the **endocrine** and **nervous systems**, as well as by behavioural patterns.

Organisms increase their survival chances by modifying their internal environment in response to external changes.