

# Lectures 1-2-3

**BT 636**

## **Tissue Engineering and Regenerative Medicine (3-0-0-6)**

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# Preamble

- ❑ Human tissue and/or organ failure, as a result of disease or trauma, is a major health concern world over.
- ❑ Treatment options include donor based transplantation, surgical repair, artificial prostheses etc. Ultimately, however, major damage may never be repaired in a truly satisfactory way.
- ❑ For such cases tissue engineering/regenerative medicine has emerged as a potential alternative, whereby tissue and organ failure is addressed by implanting lab grown tissue grafts and organ mimics that are fully functional and compatible.
- ❑ A variety of approaches are used to engineer these tissues in combination with stem cells/biomaterial/growth factors etc.
- ❑ Stem cells because of their remarkable regenerative potential are a preferred choice.

# Syllabus

- Introduction to tissue engineering & regenerative medicine: principles underlying tissue engineering/regenerative medicine strategies, key concepts of tissue engineering/regenerative medicine, its need and current available technologies.
- Structure and organization of tissues: various cell and tissue types, its organization, structure-function relationship.
- Stem cells: stem cell types, their characteristics, potency Cell isolation, culture and differentiation: primary cell isolation techniques, cell culture needs, differentiation abilities of stem cells towards specific lineages.
- Biomaterials in tissue engineering & regenerative medicine: knowhow on current biomaterials, natural vs. synthetic, role of a biomaterial in tissue engineering, its properties, biodegradable polymers and 3D scaffold processing techniques; Cell-cell and cell-matrix interactions: knowhow and importance of such interactions, extracellular matrices; tissue repair and angiogenesis.
- Biocompatibility and immune rejection: biomaterial/graft compatibility, host acceptance and rejection Drug, growth factor and gene delivery: knowhow and importance of sustained and controlled delivery, implications and applications.

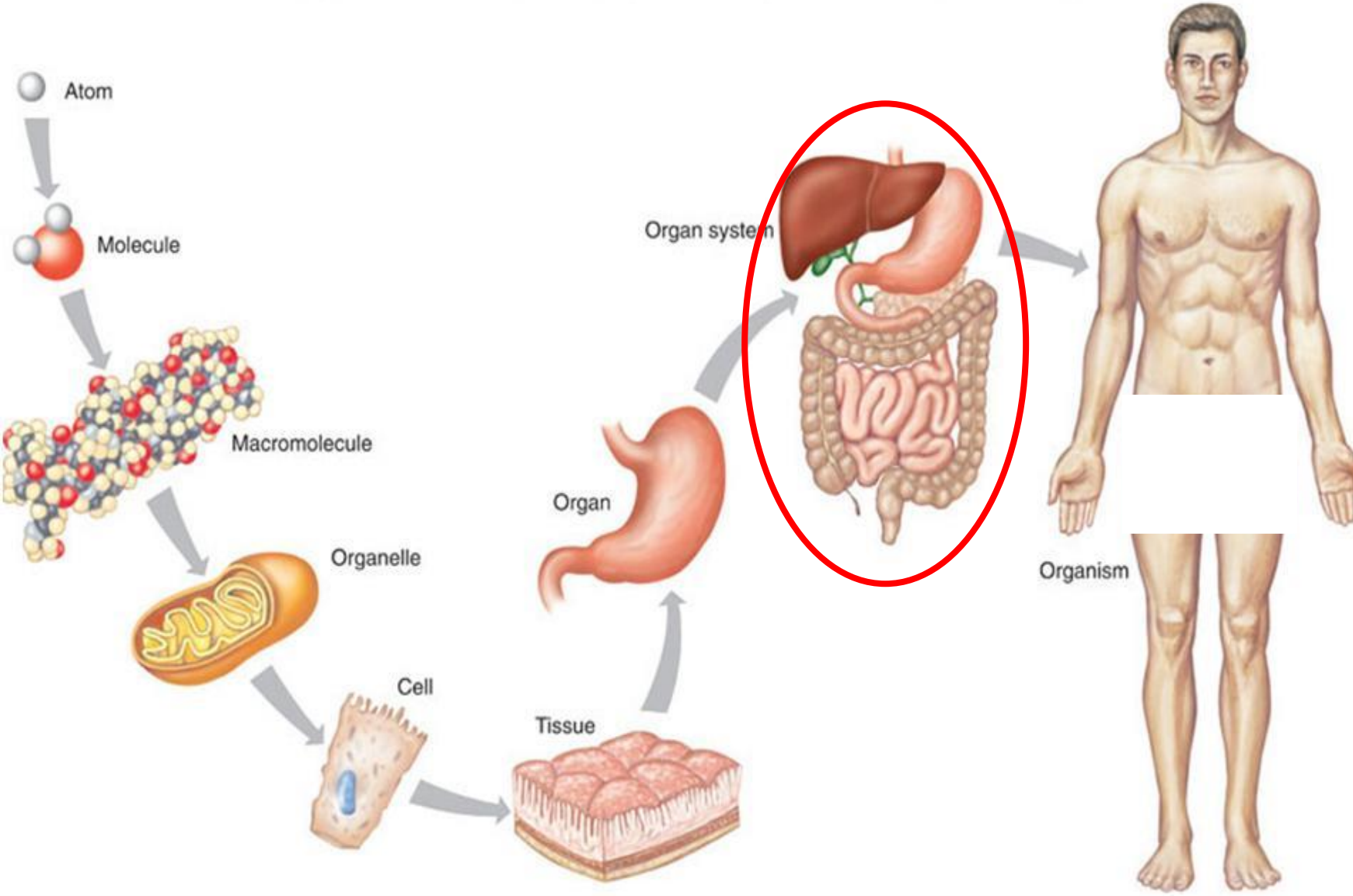
# Texts and References

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- Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications (6th edition), by R. Ian Freshney. Wiley-Blackwell. 2010
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- An Introduction to Tissue-Biomaterial Interactions by K.C. Dee, D.A. Puleo and R. Bizios. Wiley 2002.

# Eukaryote – Homo sapiens (Human)

Fig. 1.03

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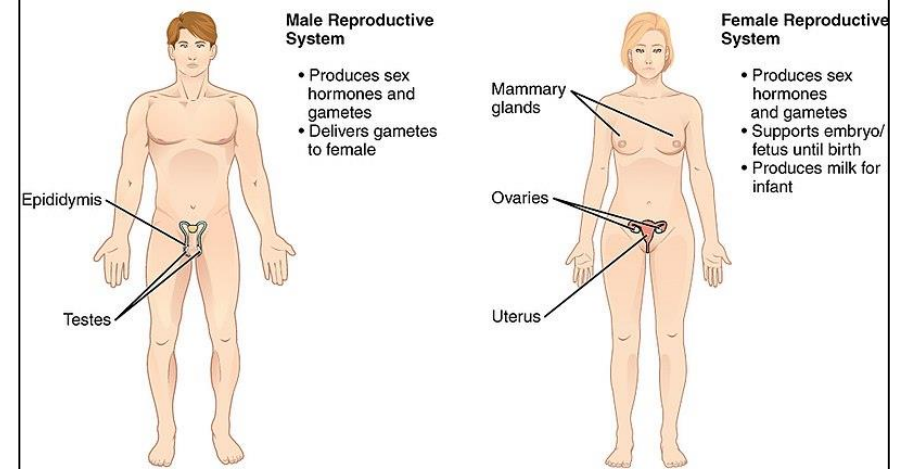
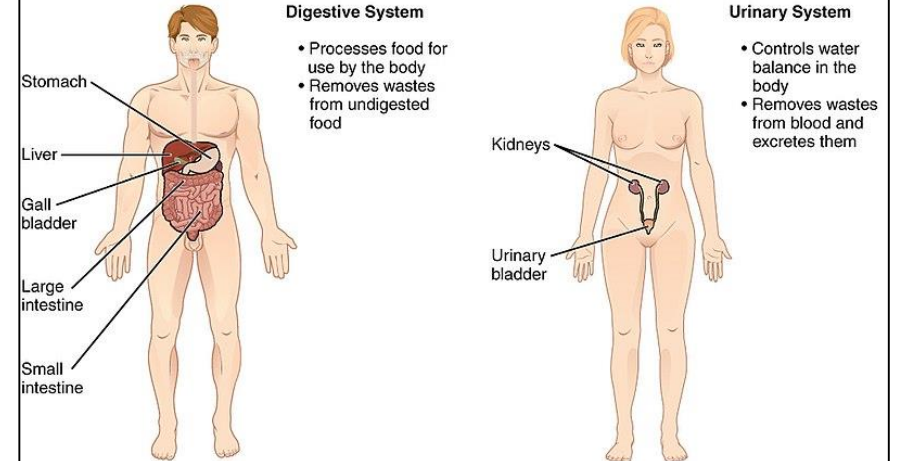
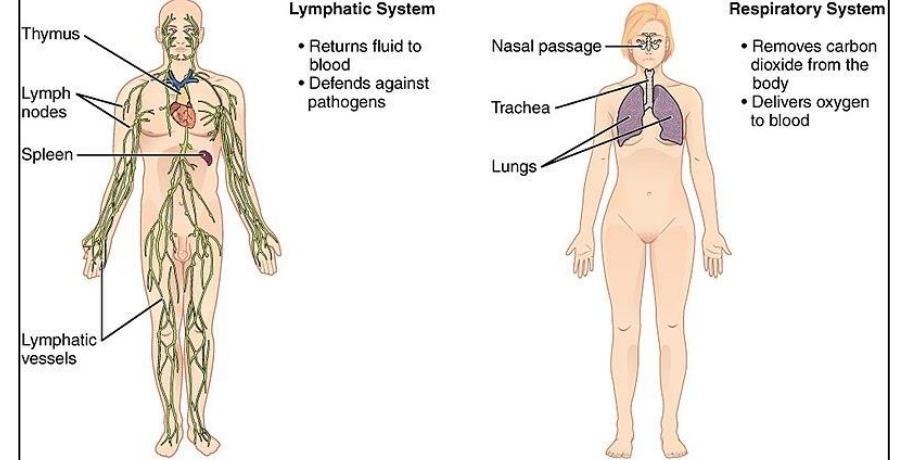
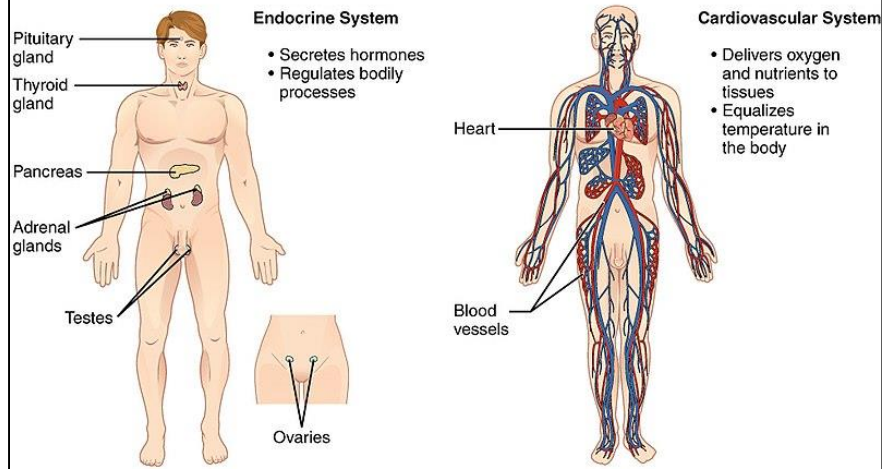
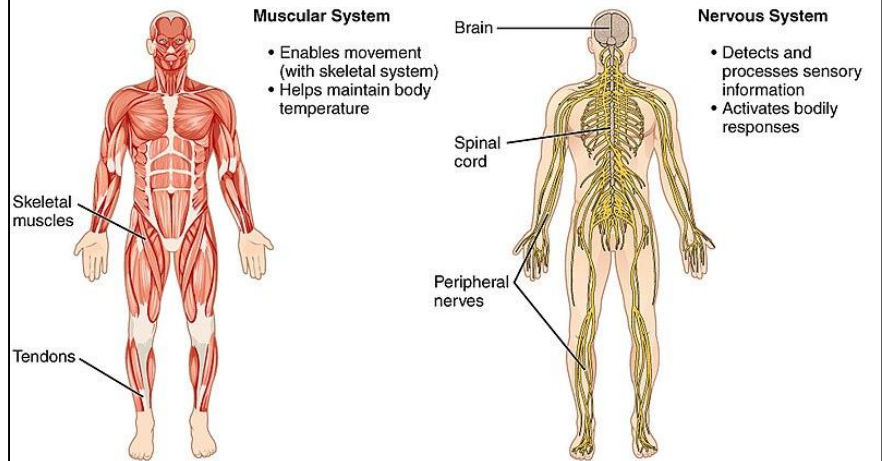
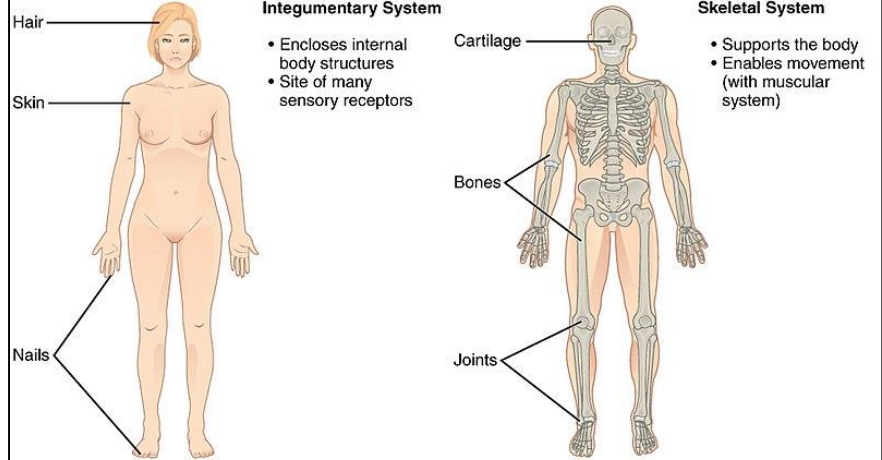


- ☐ The human body is the structure of a human being.
- ☐ It is composed of many different types organ systems.
- ☐ They ensure homeostasis and the viability of the human body.

# Various body systems present in a human body

1. Respiratory system
2. Cardiovascular system (heart and circulatory system)
3. Digestive system
4. Nervous system
5. Lymphatic system (or Immune system)
6. Endocrine system
7. Integumentary system (or Exocrine system)
8. Musculoskeletal system
9. Urinary system (or Excretory system or Renal system)
10. Reproductive system

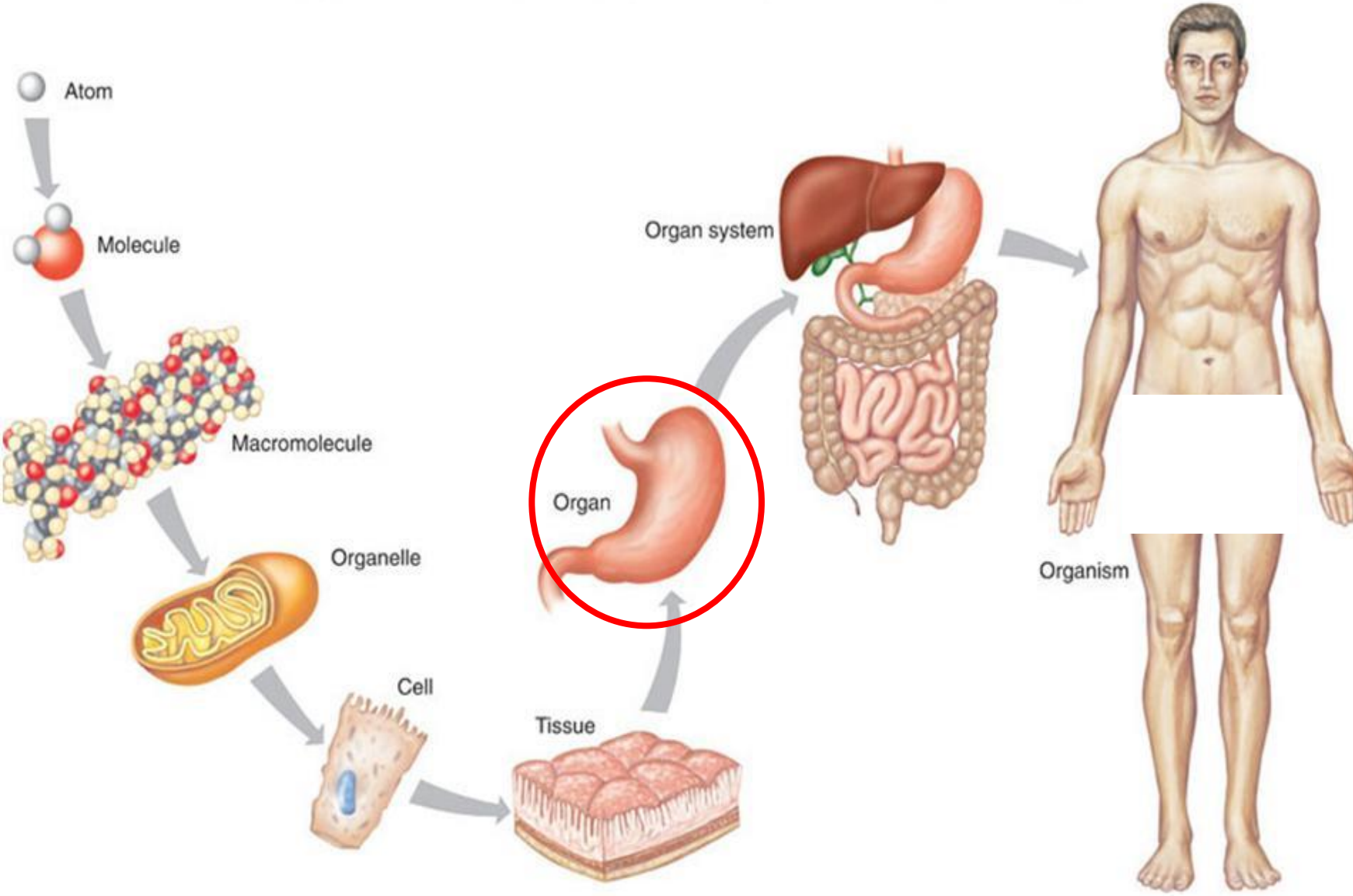




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# Number of organs present in a human body

- **79 organs** have been identified in the human body.
- **Skin** is the **largest and longest organ** according to its size and weight.
- **Pineal gland** near the center of the brain, in a groove between the hemispheres, is the **smallest organ**.
- **Liver** is the **largest internal** organ of the body.
- The **heart** is the **first major functional organ to develop** and starts to beat and pump blood at about three weeks into embryogenesis.
- The **last major organ** to develop and mature before birth are the **lungs**.
- The **brain** is the **last to reach its final mature** form and develops even after birth.

**SENSORY ORGANS** are as follows:-

- **Eyes**
- **Ears**
- **Nose**
- **Tongue**
- **Skin**

# Number of organs present in a human body

News > Science

## Mesentery: New organ discovered inside human body by scientists (and now there are 79 of them)

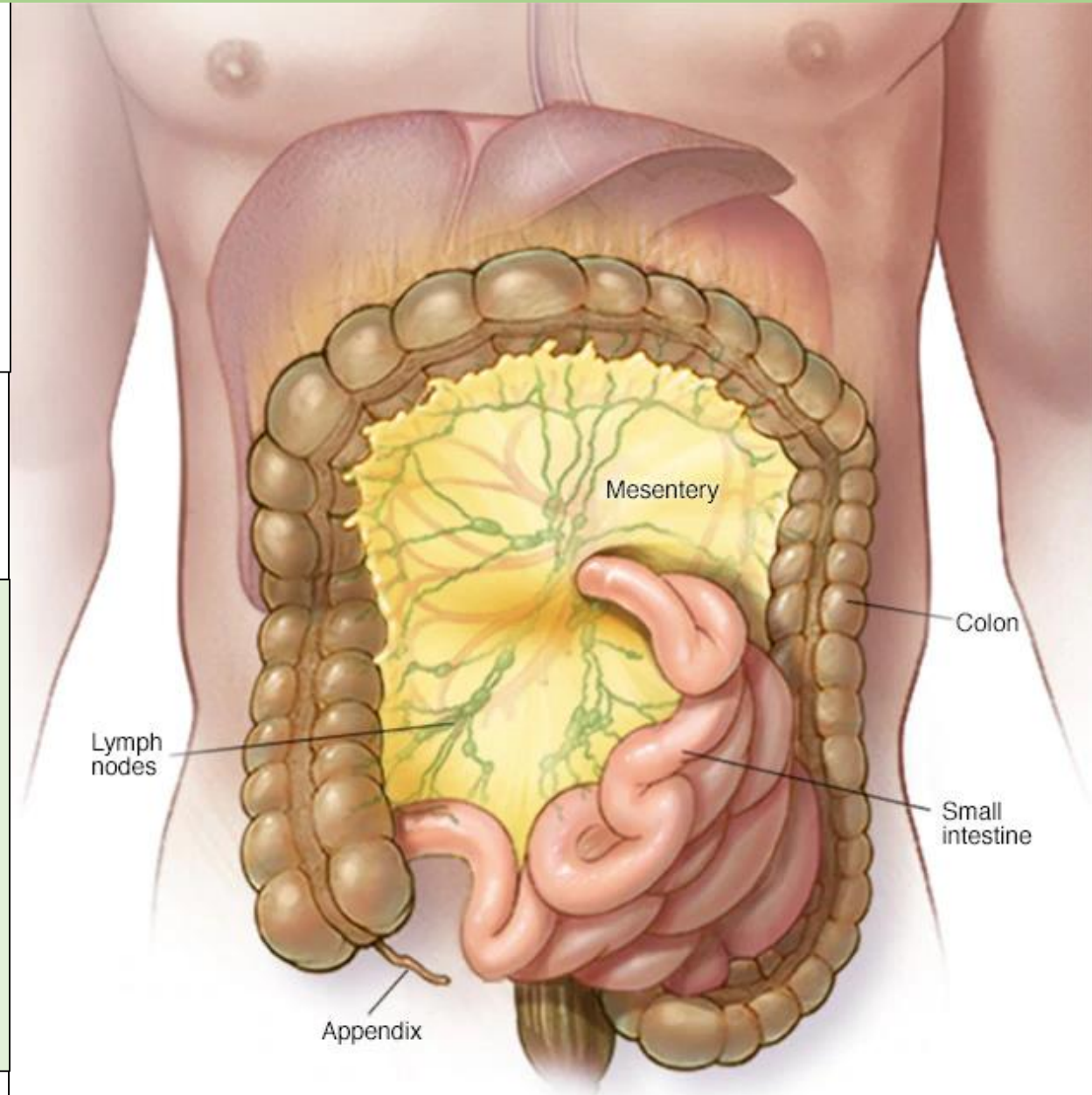
The finding opens up 'a whole new area of science'

Tom Embury-Dennis | @tomemburyd | Tuesday 3 January 2017 17:27 |  
325 shares | 57 comments



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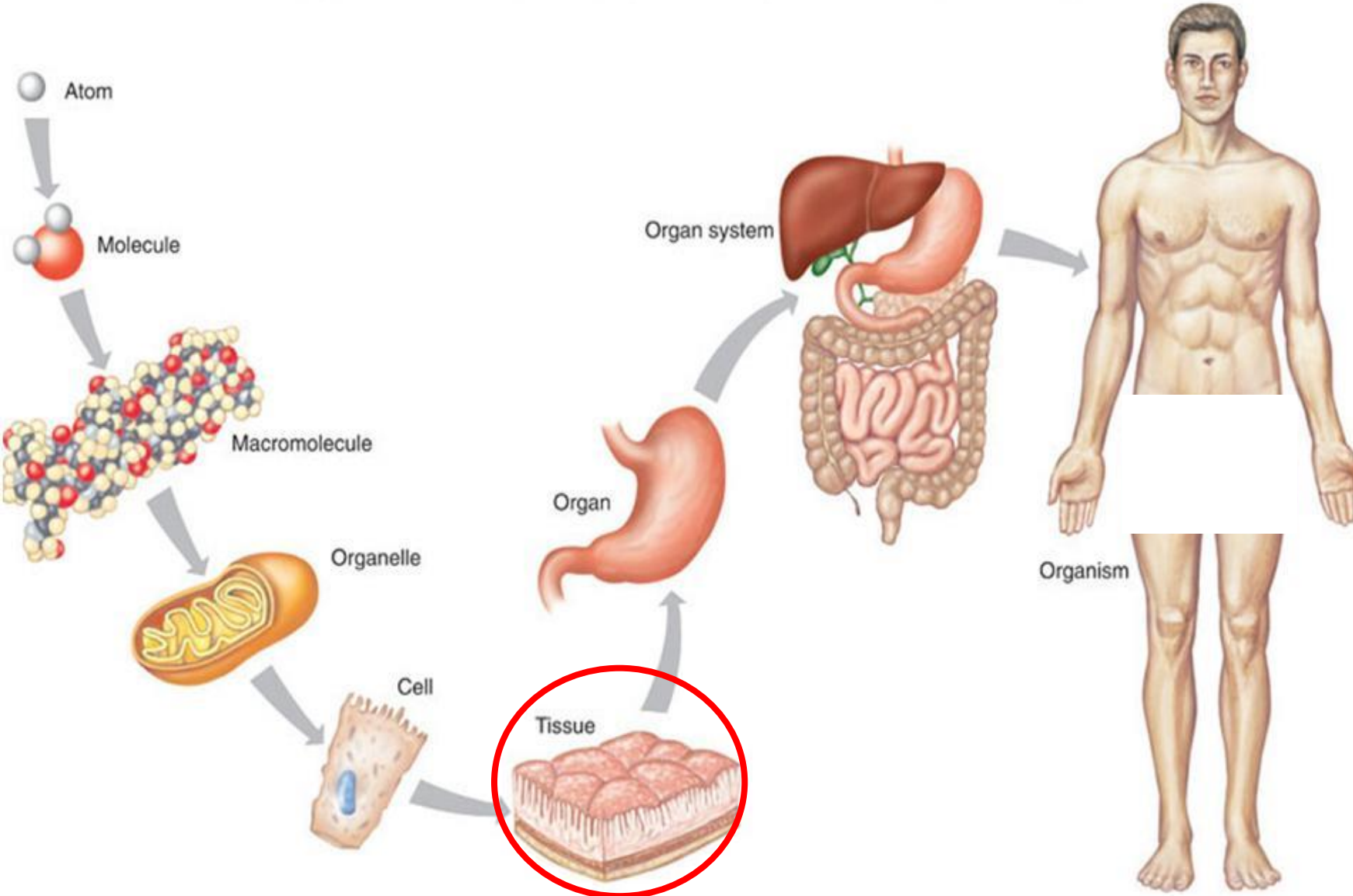
- ☐ Large single continuous stretch of tissue that support and position all the digestive organs in the abdomen.
- ☐ The organ is responsible for transporting blood and lymphatic fluid between the intestine and the rest of the body.



# Eukaryote – Homo sapiens (Human)

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# Different types of tissues present in a human body

Human body tissue consists of groups of cells with a similar structure working together for a specific function. There are **four** main types of tissues in a body.

## Epithelial tissue (epithelium)

- is made of layers (sheets) of cells that cover the surfaces of the body that come into contact with the exterior world, lines internal cavities and passageways, and form glands.

## Connective tissue

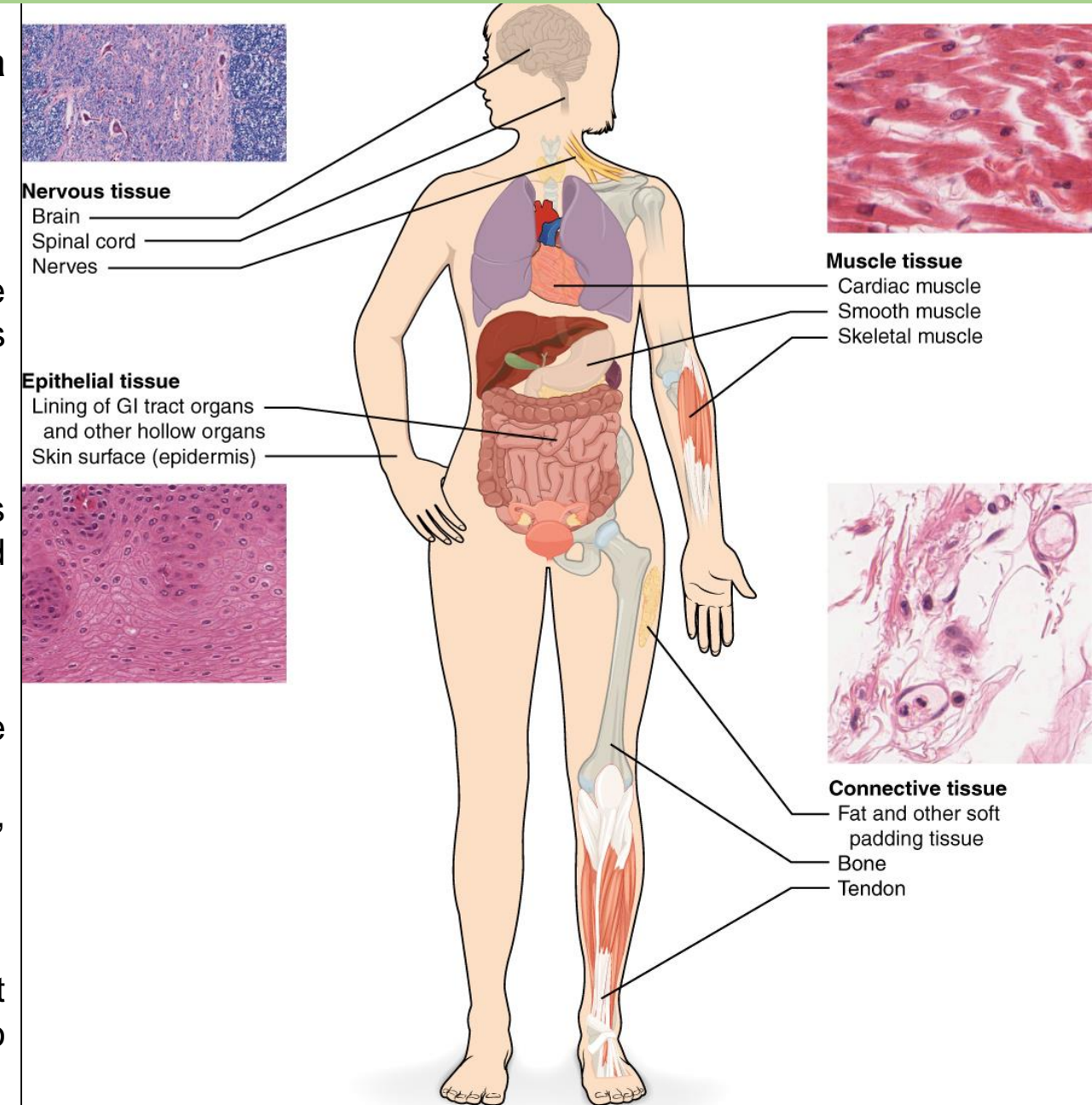
- binds the cells and organs of the body together and performs many functions, especially in the protection, support, and integration of the body.

## Muscle tissue

- is excitable, responds to stimulation and contracts to provide movement.
- occurs as three major types: skeletal (voluntary) muscles, smooth muscles, and the cardiac muscle in the heart.

## Nervous tissue

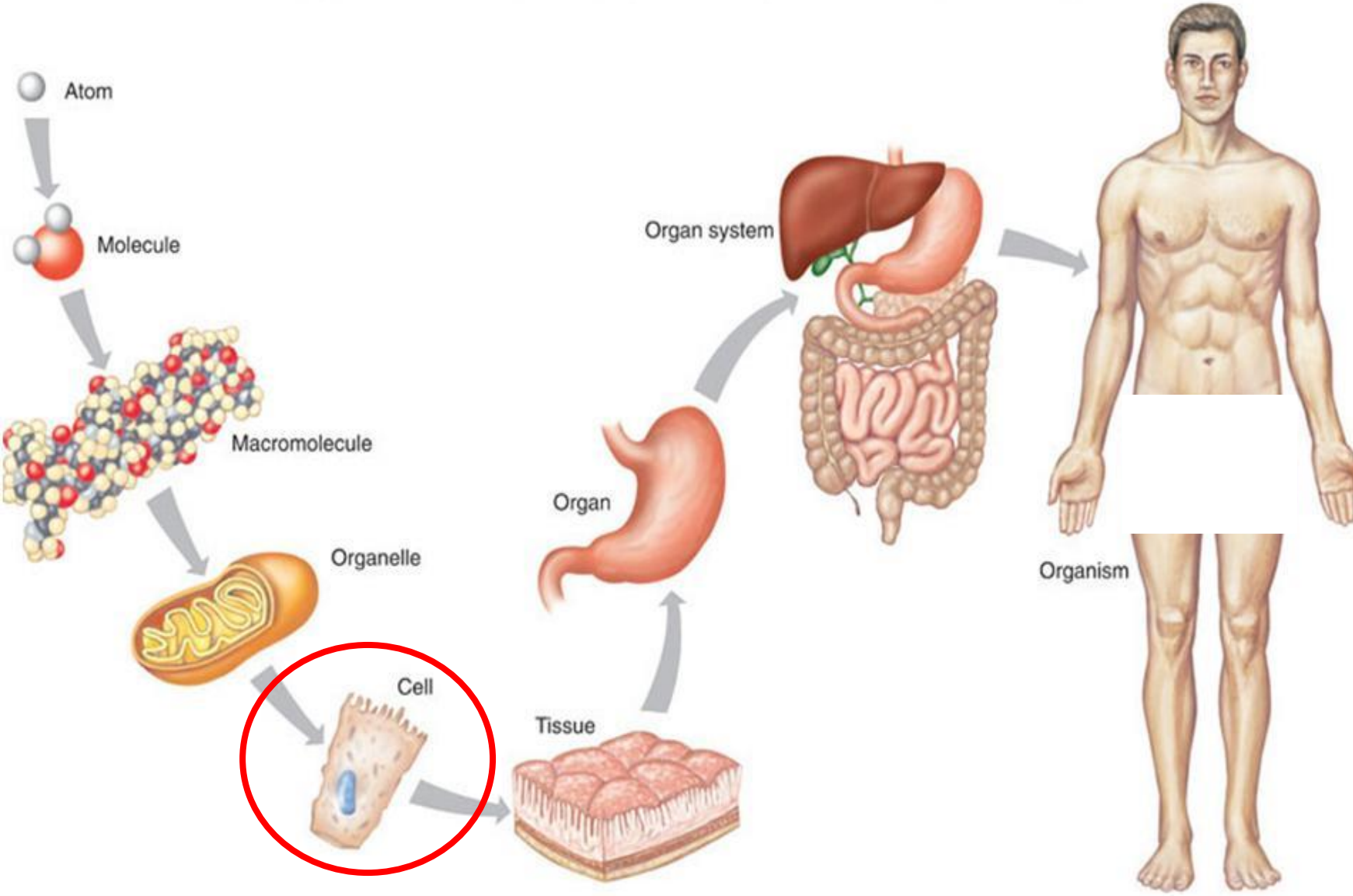
- is also excitable, allows the body to receive signals and transmit information as electric impulses from one region of the body to another.



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# Number of cells / different cell types present in a human body

Total number of human cells present in a human body:

- ❑ There are 37.2 Trillion Cells in Your Body
- ❑ 1 trillion = 1,000,000,000,000 ( $1 \times 10^{12}$ ); so 37,200,000,000,000

➤ Note: This does not include any of the millions of microbes living inside our body

Total number of different human cell types present in a human body:

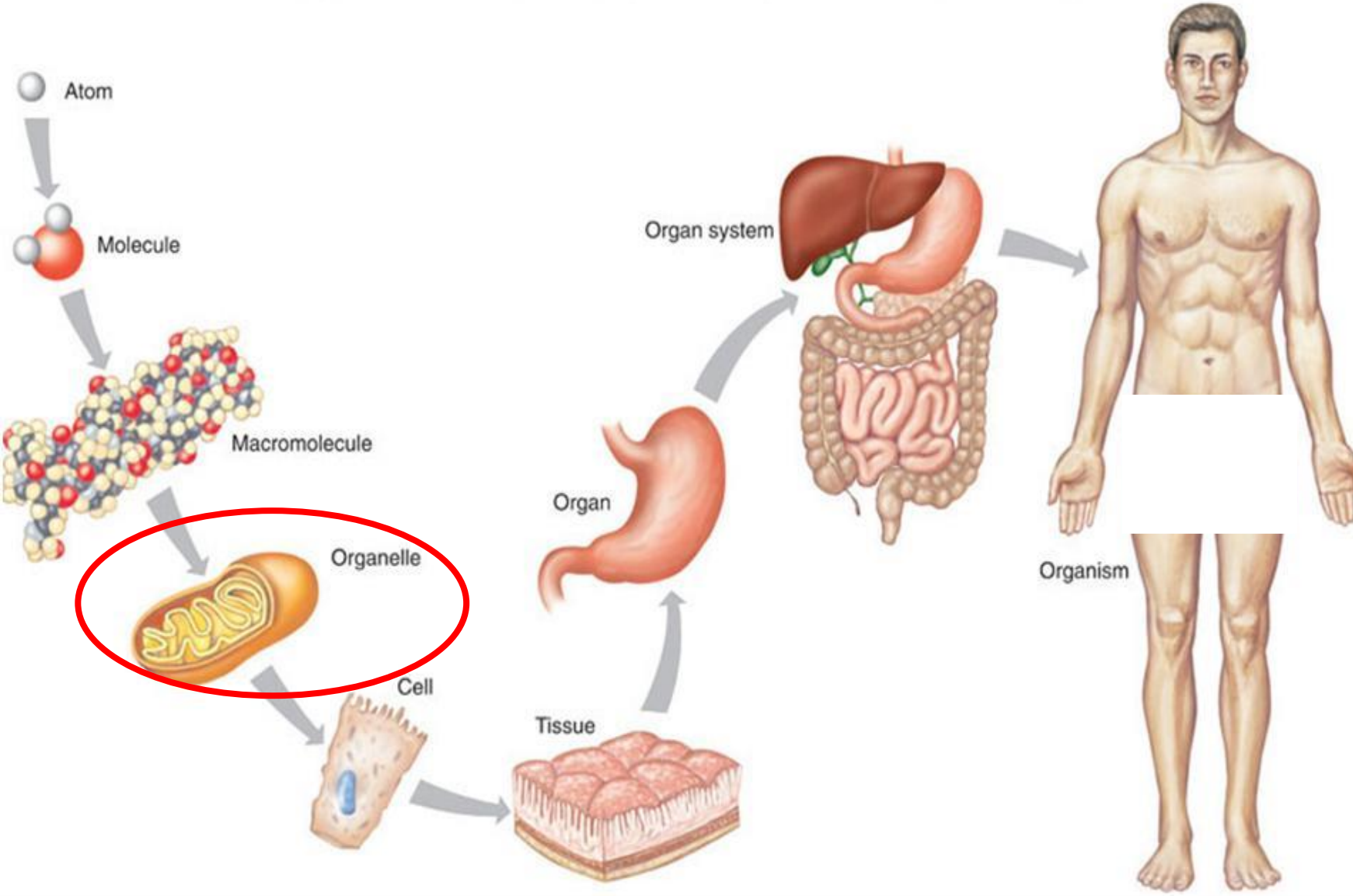
- ❑ 200-220 cell types
- ❑ (neuron, cardiomyocyte, beta-cell, hepatocyte, fibroblast, keratinocyte, RBC, T lymphocyte, B lymphocyte, natural killer cell, etc.)



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# Various organelles in a human cell and its major function(s)

1. **Cell membrane** – (is a membrane that separates the interior of all cells from the outside environment (the extracellular space) and protects the cell from its environment; acts as a barrier for cell contents. It consists of double phospholipid layer and monolayer of protein scattered around phospholipid layer. The other components in plasma membrane are cholesterol and glycoproteins).
2. **Cytosol** – (fluid that contains organelles; represents the material outside the nucleus and inside the cell membrane)
3. **Cytoskeleton** – (a network of protein structures that extend throughout the cytoplasm; provides the cell with an internal framework (e.g. microfilaments and microtubules))
4. **Nucleus** – (control center of the cell; contains genetic material; 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.
  - Chromatin:** It is composed of DNA and protein scattered throughout the nucleus. Chromatin condenses to form chromosomes when the cell divides)
5. **Nucleolus** – (functions as site of ribosome production; ribosomes then migrate to the cytoplasm through nuclear pores)
6. **Ribosome** (little dots) – sites of protein synthesis in the cell.

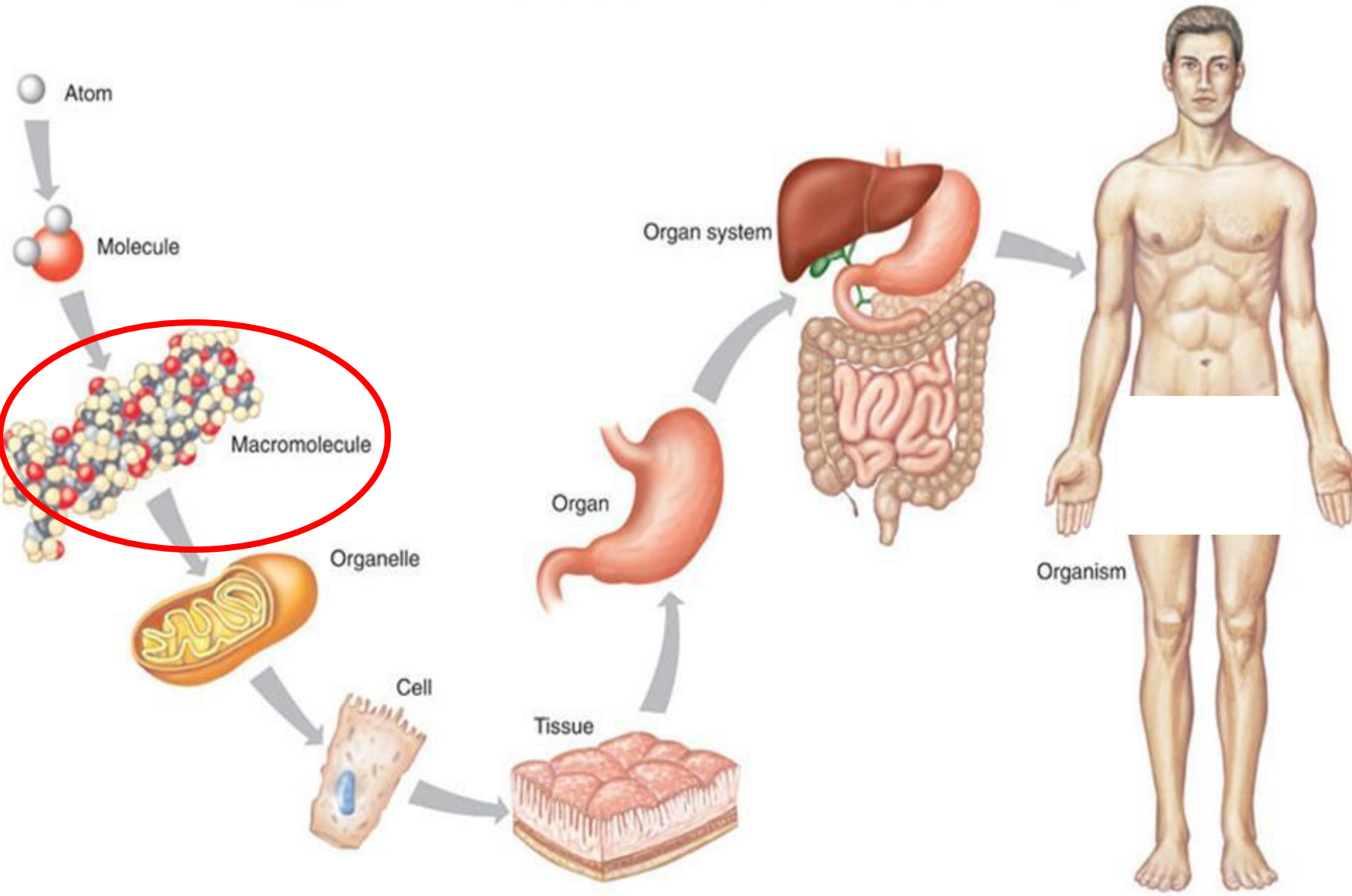
# Various organelles in a human cell and its major function(s)

7. **Rough endoplasmic reticulum** – (carry ribosomes that represent sites of protein synthesis)
8. **Smooth endoplasmic reticulum** – (function in cholesterol synthesis and breakdown, fat metabolism, and detoxification of drugs)
9. **Smooth endoplasmic reticulum** – (function in cholesterol synthesis and breakdown, fat metabolism, and detoxification of drugs)
10. **Golgi apparatus** (or "Golgi body") – (modifies and packages proteins, secrete vesicles, plasma membrane components and lysosomes)
11. **Mitochondrion** – (powerhouse of the cell; generate ATP for cellular activities)
12. **Lysosomes** – (suicidal bag of the cell; contain enzymes that digest non-usable materials within the cell)
13. **Peroxisomes** – (detoxify harmful substances and break down free radicals; involved in catabolism of very long chain fatty acids,)
14. **Centrioles** – (involved in the organization of mitotic spindle fibers during cell division and in the completion of cytokinesis)
15. **Centrosomes** – (serves as the main microtubule organizing center (MTOC) of the animal cell, as well as a regulator of cell-cycle progression; are composed of two centrioles arranged at right-angles to each other)
16. **Vesicles** – (involved in metabolism, transport, buoyancy control, and temporary storage of food and enzymes)

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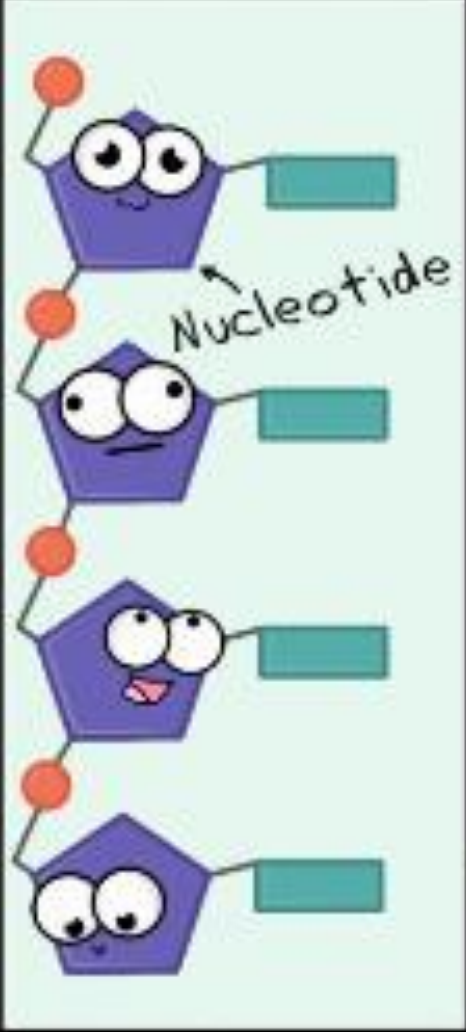
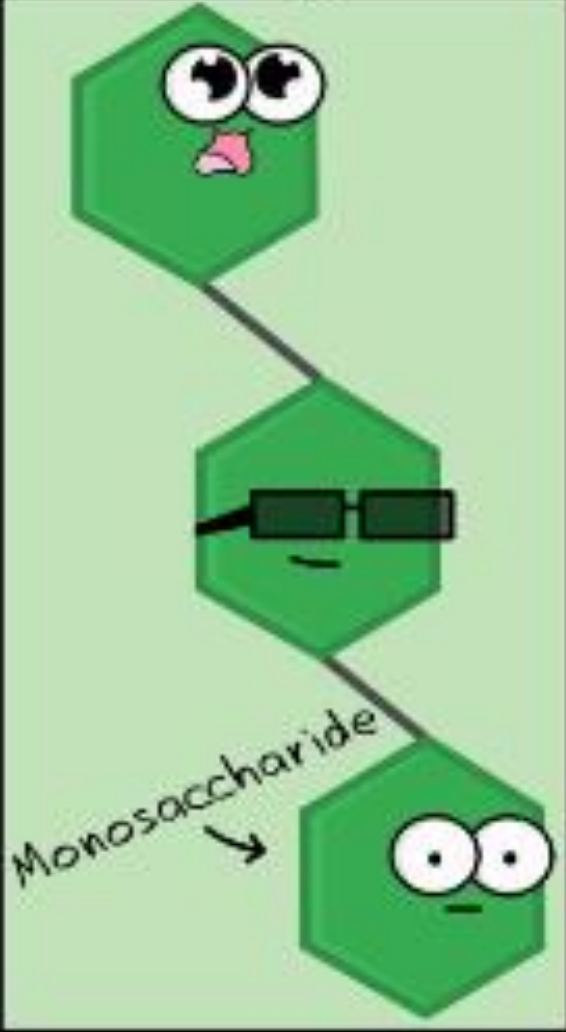
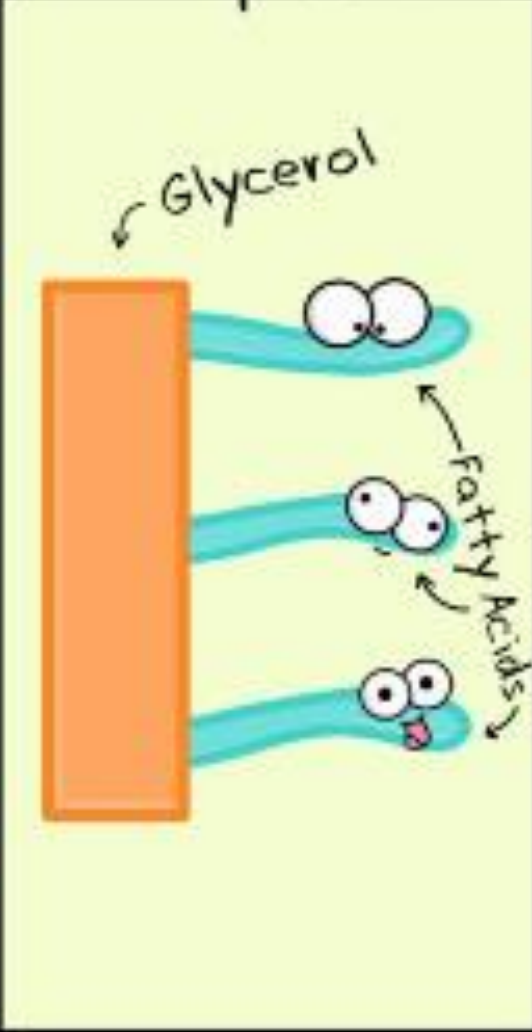
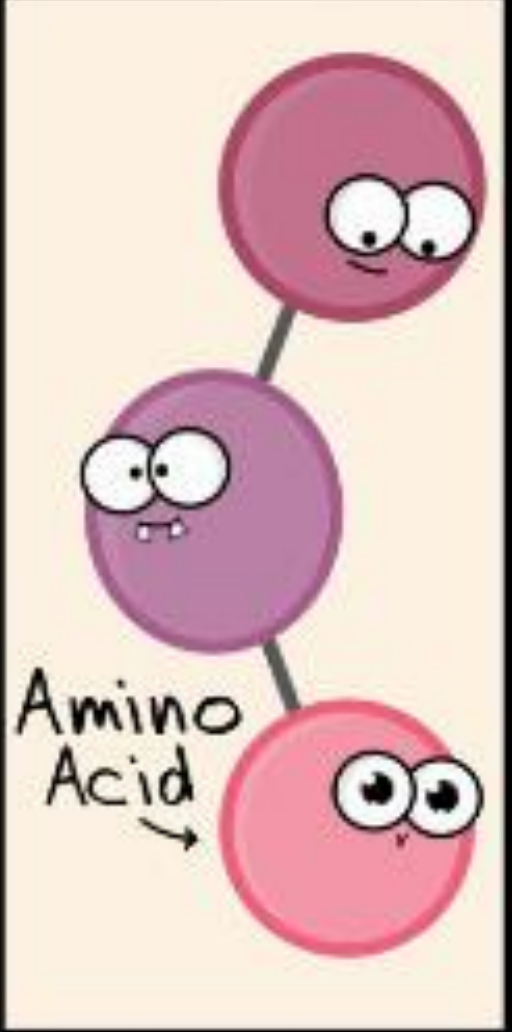
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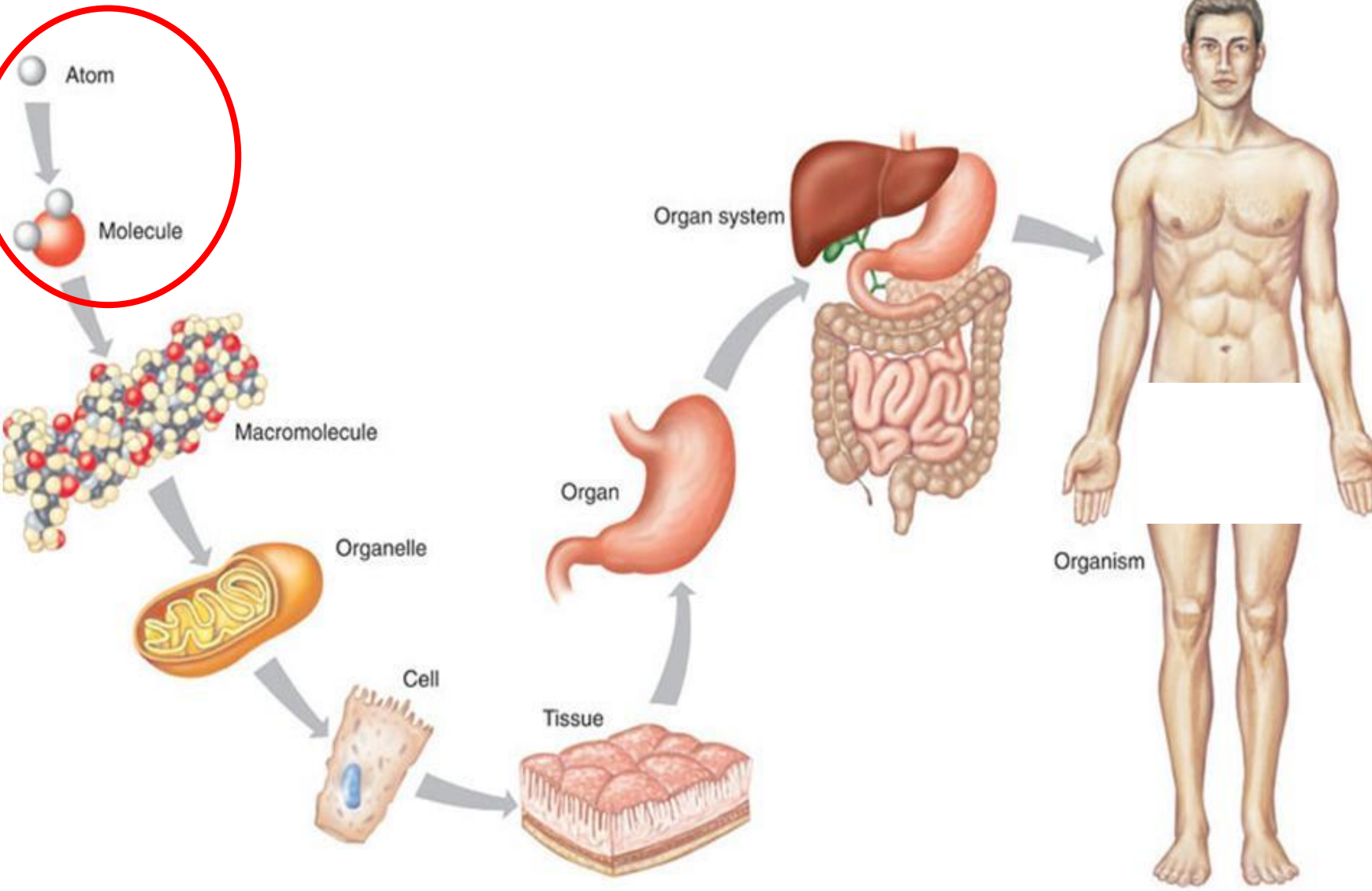
# Macromolecules

Nucleic Acid	Carbohydrate	Lipid	Protein
 <p>A vertical chain of four purple pentagonal nucleotides. Each nucleotide has a red circle on its left side and a teal rectangle on its right side. They are connected by red circles. An arrow points to one of the nucleotides with the label "Nucleotide".</p>	 <p>A vertical chain of three green hexagonal monosaccharides. The top hexagon has a surprised face, the middle one has a face wearing black-rimmed glasses, and the bottom one has a neutral face. They are connected by black lines. An arrow points to the bottom hexagon with the label "Monosaccharide".</p>	 <p>A vertical structure representing a lipid. On the left is a thick orange vertical bar. To its right are three light blue horizontal wavy lines. Each wavy line has a small face. An arrow points to the orange bar with the label "Glycerol". An arrow points to the wavy lines with the label "Fatty Acids".</p>	 <p>A vertical chain of three rounded amino acid molecules. The top one is purple, the middle one is a darker purple, and the bottom one is pink. Each has a face. They are connected by black lines. An arrow points to the bottom molecule with the label "Amino Acid".</p>

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# Number of molecules and atoms in human body

## ❑ How many molecules are there in the human body?

❑ <https://socratic.org/questions/how-many-molecules-are-in-the-human-body>

➤ The human body consists of about  **$2 \times 10^{25}$  molecules**, and more than 99% of is water.

## ❑ How many atoms are there in the human body?

❑ <https://www.thoughtco.com/how-many-atoms-are-in-human-body-603872>

❑ [https://education.jlab.org/qa/mathatom\\_04.html](https://education.jlab.org/qa/mathatom_04.html)

➤ There are approximately  **$7 \times 10^{27}$  atoms** in the average human body. This is the estimate for a **70 kg** adult human male. Generally, a smaller person would contain fewer atoms; a larger person would contain more atoms.

➤ According to an estimate made by engineers at Washington University, there are around  **$10^{14}$  atoms in a typical human cell**.

➤ **Carbon, hydrogen, nitrogen, oxygen, calcium and phosphorus** together account for **99 percent** of the atoms in a person.

# Different Levels of organization

## Atom:

An atom is the smallest particle of an element or a molecule.  
[carbon (C), Hydrogen (H), Oxygen (O), Nitrogen (N), etc.]

## Molecule:

A molecule is a particle composed of two or more joined atoms by chemical bonds.  
(carbon dioxide (CO<sub>2</sub>), water (H<sub>2</sub>O))

## Macromolecule:

A macromolecule is a very large molecule.  
(carbohydrates, lipids, proteins, and nucleic acids)

## Organelle:

An organelle is a specialized subunit within in a cell which performs a particular function.  
(cell membrane, cytoplasm, nucleus, mitochondria, etc.)

## Cell:

The cell is a structural and functional unit of a living organism.  
(neuron, cardiomyocyte, beta-cell, hepatocyte, fibroblast, keratinocyte, etc.)

# Different Levels of organization

## **Tissue:**

A tissue is a group of similar cells that perform a specialized function (epithelial, 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.).

## **Body System:**

A body system is a group of organs that act together to perform a specialized function.  
In total, there are 10 body systems.

## **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 a synchronous manner.

**Thank you for your attention**