Molecular and Cellular Physiology: Understanding the Basics and Beyond

Silvia Di Angelantonio

Silvia.diangelantonio@uniroma1.it

LM GENETICS AND MOLECULAR BIOLOGY

AA 2025/2026

Introduction

- Practical Informations
- Course Overview
- Importance of Physiology in Genetics and Molecular Biology
- Learning Objectives

Prof. Silvia Di Angelantonio

Dip. Fisiologia e Farmacologia

Email: silvia.diangelantonio@uniroma1.it

Room: Aula B Tecce CU026

MONDAY 4-6 pm – WEDNESDAY 4-6 pm

START ON WEDNSDAY OCTOBER 1st 2025

eLearning:

https://elearning.uniroma1.it/course/view.php?id=6161

The learning objectives of the course on Molecular and Cellular Physiology for the Master Degree in Genetics and Molecular Biology are:

1. Understand the mechanisms underlying the comunication of neuronal and glial cells in the homeostatic control and in the pathogenesys of brain diseases

2. Develop the ability to critically analyze and interpret primary literature in molecular and cellular physiology, and to effectively communicate scientific findings through written and oral presentations.

3. Apply molecular and cellular physiology concepts to design and execute a research project, and to develop independent research skills, such as experimental design, data analysis, and interpretation.

Course Evaluation:

Students attending the course

- Class participation and attendance +

Student project work and presentation (60%)

- Written exam (40%)

Students non attending the course

- Written exam (100%)

Student Project Work 2025
Clinical–Molecular Case Simulation
Groups of 3–4 students

Project Overview

- You will work in small groups (3–4 students).
- Duration: 2–3 months, with progress Q&A sessions.
- Task: analyze a simulated clinical–molecular case based on a rare genetic mutation.
- Goal: integrate knowledge of molecular & cellular physiology with critical thinking and experimental design.

Project Work Overview

•Goals of the Project Work

The goal of the project work for the students is to apply the knowledge and skills they have gained during the course to investigate and analyze a specific topic related to molecular and cellular physiology.

The project work is designed to enhance the students' critical thinking, problem-solving, and communication skills, as well as their ability to work independently and collaboratively.

The ultimate goal is to produce a high-quality research project that demonstrates a thorough understanding of the chosen topic and showcases the students' ability to apply their knowledge to real-world situations.

Project Work Overview

Guidelines and Deadlines #1

Group Work: The project work must be completed in small groups of 3-4 students.

Research Project: The project work consists of preparing a research project proposal in the field of molecular and cellular physiology, with a focus on neuroscience. The project proposal should include a clear hypothesis, detailed methodology, expected results, and potential implications of the research.

PPT Presentation: The research project proposal must be presented in a PPT format, with a minimum of 15 and a maximum of 20 slides. The presentation should be clear, concise, and well-organized.

Project Work Overview

Guidelines and Deadlines #2

Intermediate Deadlines: There will be intermediate deadlines every two weeks to ensure that the project is progressing as planned. These deadlines will include short presentations by each group, which will serve as an opportunity for feedback and discussion.

Literature Review: The project proposal should be based on a thorough literature review of the relevant scientific literature. Students are expected to use primary research articles, reviews, and other relevant sources to support their proposal.

Plagiarism: Plagiarism will not be tolerated. Students must properly cite all sources used in their proposal and presentation.

Project Work Overview

Guidelines and Deadlines #3

Grading: The project work will be graded based on the quality of the proposal, the clarity of the presentation, the level of engagement and participation in the intermediate deadlines, and the ability to answer questions and defend the proposal during the final presentation.

Deadline: The final deadline for the project work is …… No late submissions will be accepted without prior approval from the instructor.
Submit the PowerPoint presentation as well as a written summary of the research proposal (maximum 2 pages, double-spaced) to the instructor by the assigned deadline.

Project Work Overview

Project Work Final Deadline

January …..

Intermediate Deadlines

Every 2 weeks

Introduction to Physiology

But first….

Introduction to Physiology

Why to study Anatomy & Physiology?

- To Understand structure - ANATOMY
- To Study the function of a structure - PHYSIOLOGY
- Structure is ALWAYS related to function

What is Physiology?

What is Physiology?

Physiology is the science of life

What is Physiology?

- **Physiology**: biological sciences
  - dealing with the normal life phenomena exhibited by all living organisms.
- **Human physiology**: basic sciences
  - dealing with normal life phenomena of the human body.
- **Goal of physiology**:
  - explain the physical and chemical factors that are responsible for the origin, development and progression of **life**.

What is Physiology?

- Questions and observations that have led to knowledge.

- Knowledge about structure and function of the human body.

Human Physiology

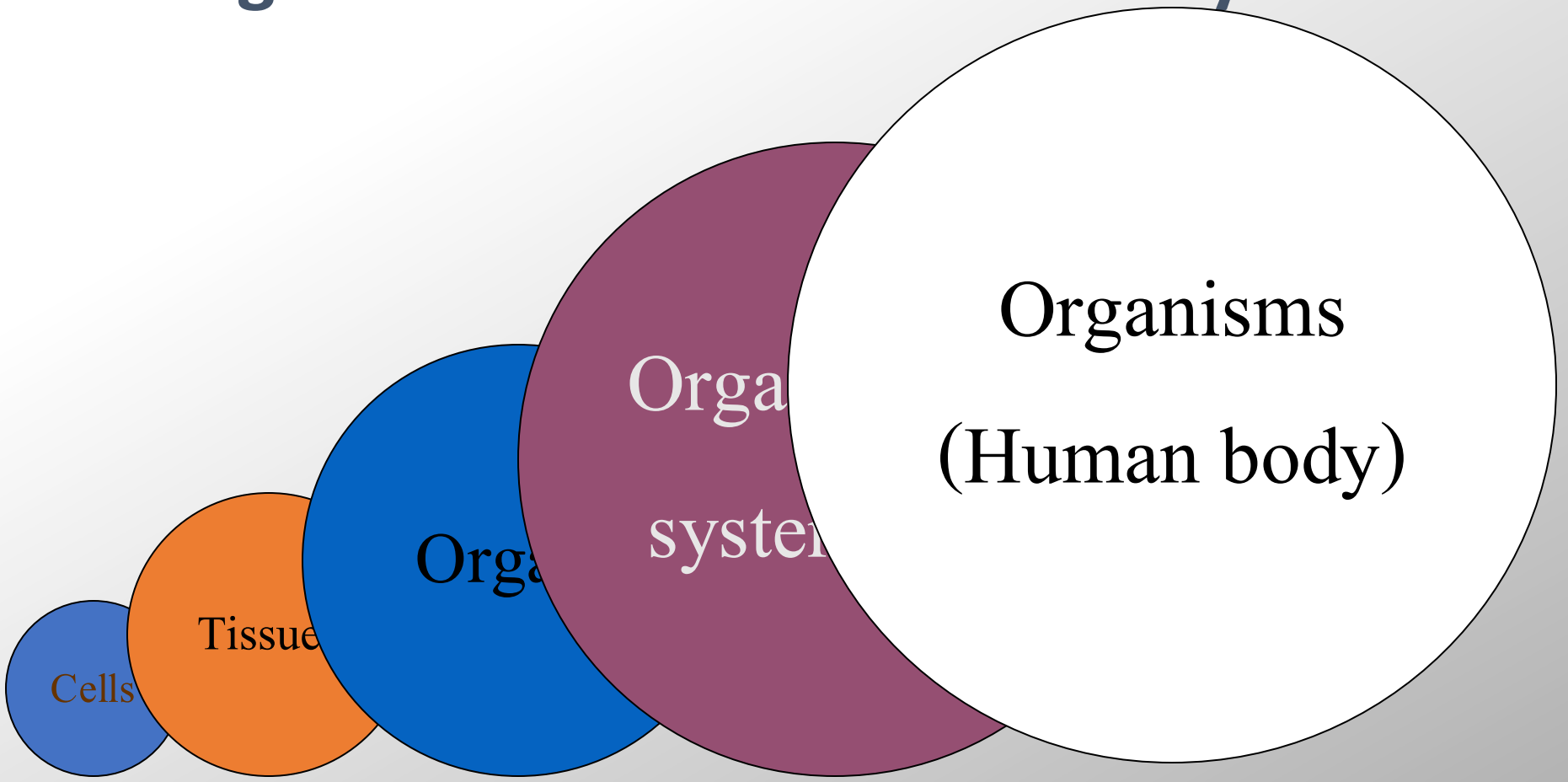
- Physiology: (Greek) The study of nature, the involvement of Physics and Chemistry.
- The basis for
  - Pathophysiology
  - Pharmacology
  - Immunology
  - Biochemistry
  - Microbiology

Why do we study Physiology?

- Understand the physical and chemical principle underlie normal function in order to cure the impairments.

Different Level of Physiological Research

Organization of the human body



HUMAN BODY

- The systematic study of human body – performed in two ways

1. ANATOMY (STRUCTURE)
2. PHYSIOLOGY (FUNCTION)

Anatomy & Physiology

- Anatomy – the study of the structure of the human body

- Physiology – the study of the function of the human body

"The complementarity of structure and function."

Why?

- Its base for understanding of physiology and pathophysiology
- Helps to study human evolution and development
- To understand pathology of disease and pathological changes
- For determining the techniques of surgeries

Physiology vs. Anatomy

While human anatomy is the study of the body's structures, physiology is the study of how those structures work.

An imaging scan like an X-ray or ultrasound can show your anatomy, but doctors use other tests --
like urine and blood tests or electrocardiograms (EKGs) -- to reveal details about your body's physiology.

Anatomy

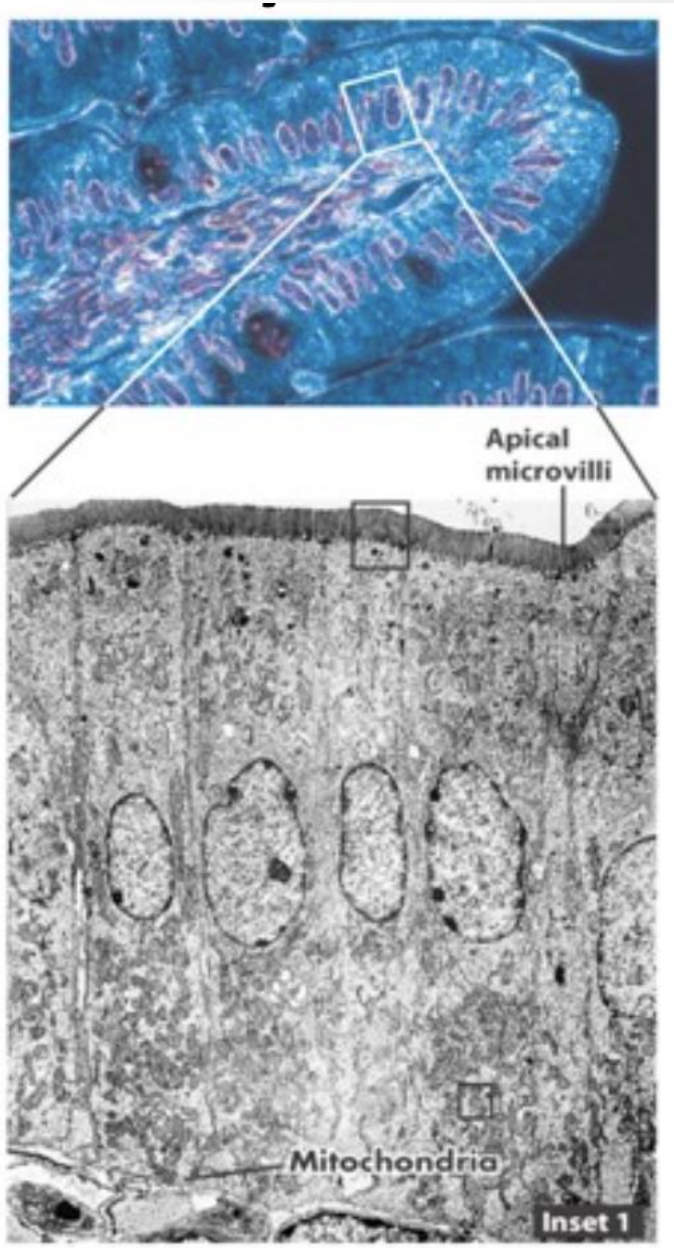
"It is the branch of medical science which involves the study of different structures of the human body and their relationship with each other"

- **The term anatomy comes from the Greek word- meaning - DISSECTION.**

Subdivisions of Anatomy

- **Gross Anatomy** is the study of structures with the naked eye.
- **Histology** is the study of **tissues**.
- **Cytology**, like histology, uses a microscope, but restricts the study to individual **cellular structures** .

This micrograph is typical of an histological and cytological examination under light microscopy



Physiology

"Study of functioning of human body and its parts"

SUBTYPES:

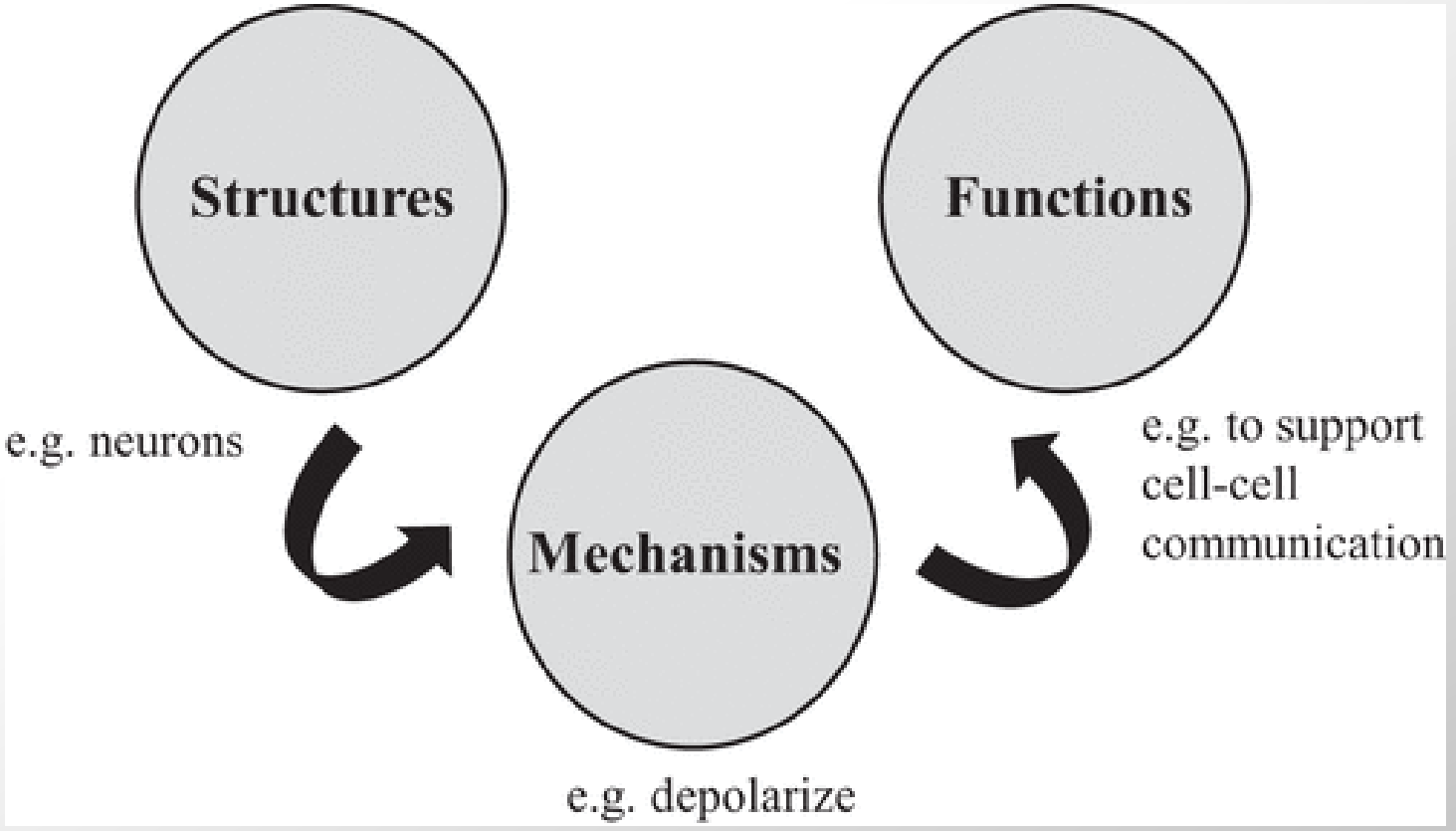
neurophysiology

explains the working of the nervous system,

Cardiac physiology

studies the function of the heart.

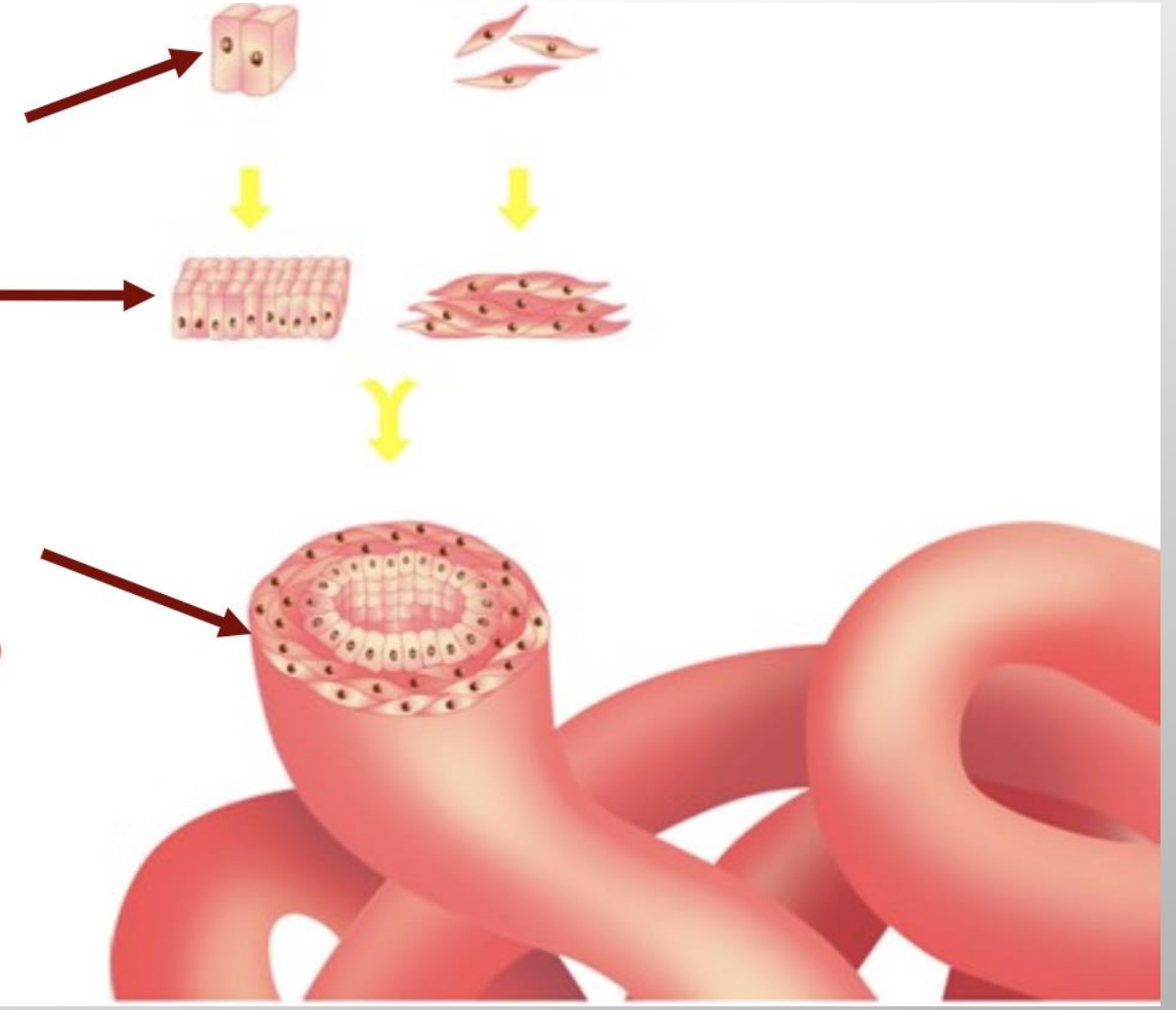
Anatomy & Physiology



"The complementarity of structure and function."

Believe it or not … you are organized

Can you identify the 3 levels of organization shown here?



Levels of Organization

The Human Body has several "layers" of organization beginning with the simplest and becoming more complex.

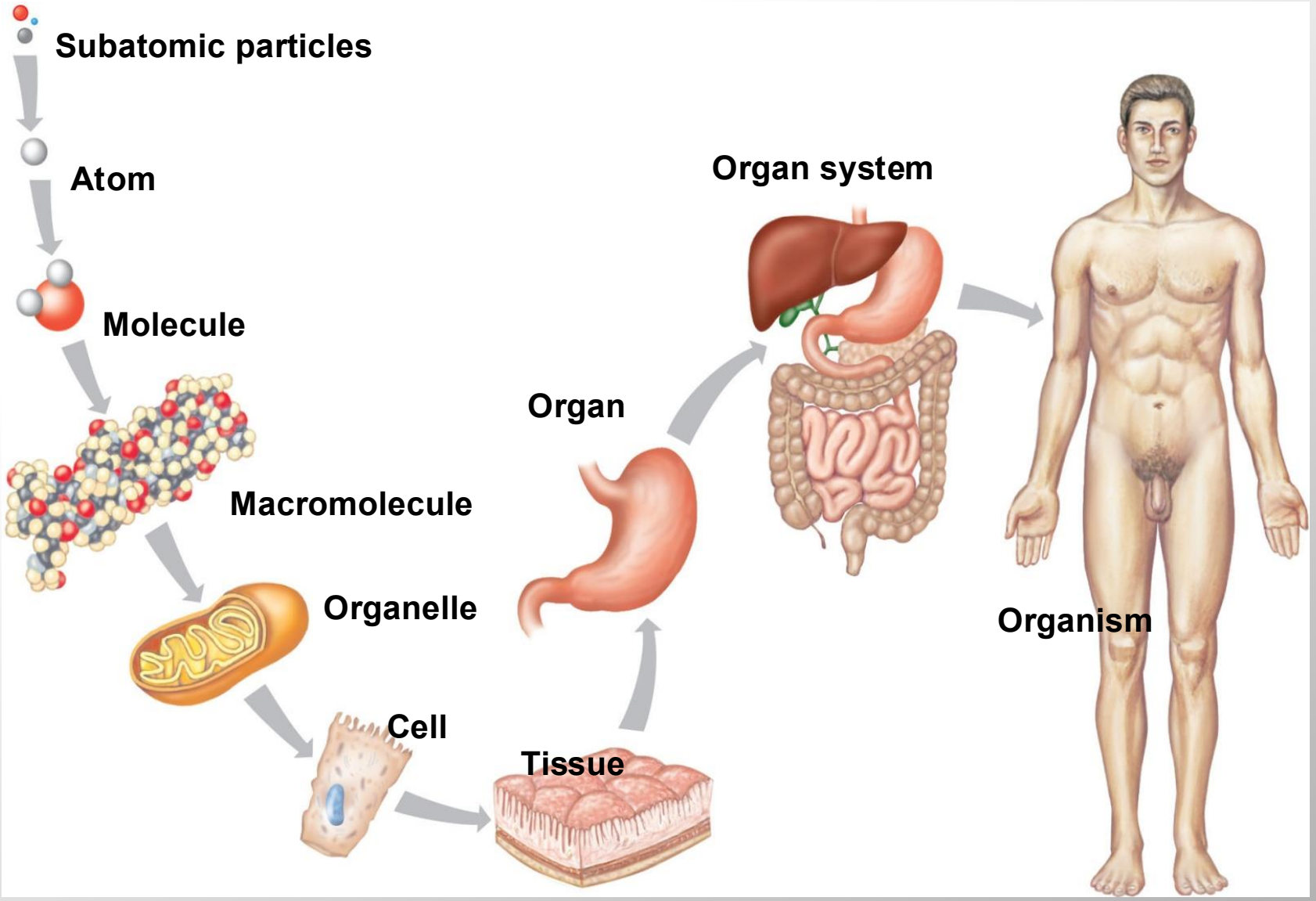
Level of Organization				
 Atom and Molecule	 Cell	 Tissue	 Organ	 Organ System
Definition				
Atom: Smallest unit of an element of matter. **Molecule:** More than one atom in a stable association.	Smallest unit of life.	An association of cells with the same general structure and function.	An association of several tissue types that carry out a specific function.	Two or more organs that work together to carry out a general function, such as digestion or movement.
Current Issues and Controversies				
• How to dispose of radioactive wastes. • Role of free radicals in cancer and aging.	Cloning adult animals, plants and humans from a single cell.	The use of human fetal tissues in research.	• How to increase the supply of human organs for transplantation. • Transplanting animal organs into humans.	• Enhancing human performance with drugs or by genetic engineering.

Answers to previous slide: cell, tissue, organ (small intestine).

Levels of Organization

- Subatomic Particles – electrons, protons, and neutrons
- Atom – hydrogen atom, lithium atom, etc.
- Molecule – water molecule, glucose molecule, etc.
- Macromolecule – protein molecule, DNA molecule, etc.
- Organelle – mitochondrion, Golgi apparatus, nucleus, etc.
- Cell – muscle cell, nerve cell, etc.
- Tissue – epithelia, connective, muscle and nerve
- Organ – skin, femur, heart, kidney, etc.
- Organ System – skeletal system, digestive system, etc.
- Organism – the human

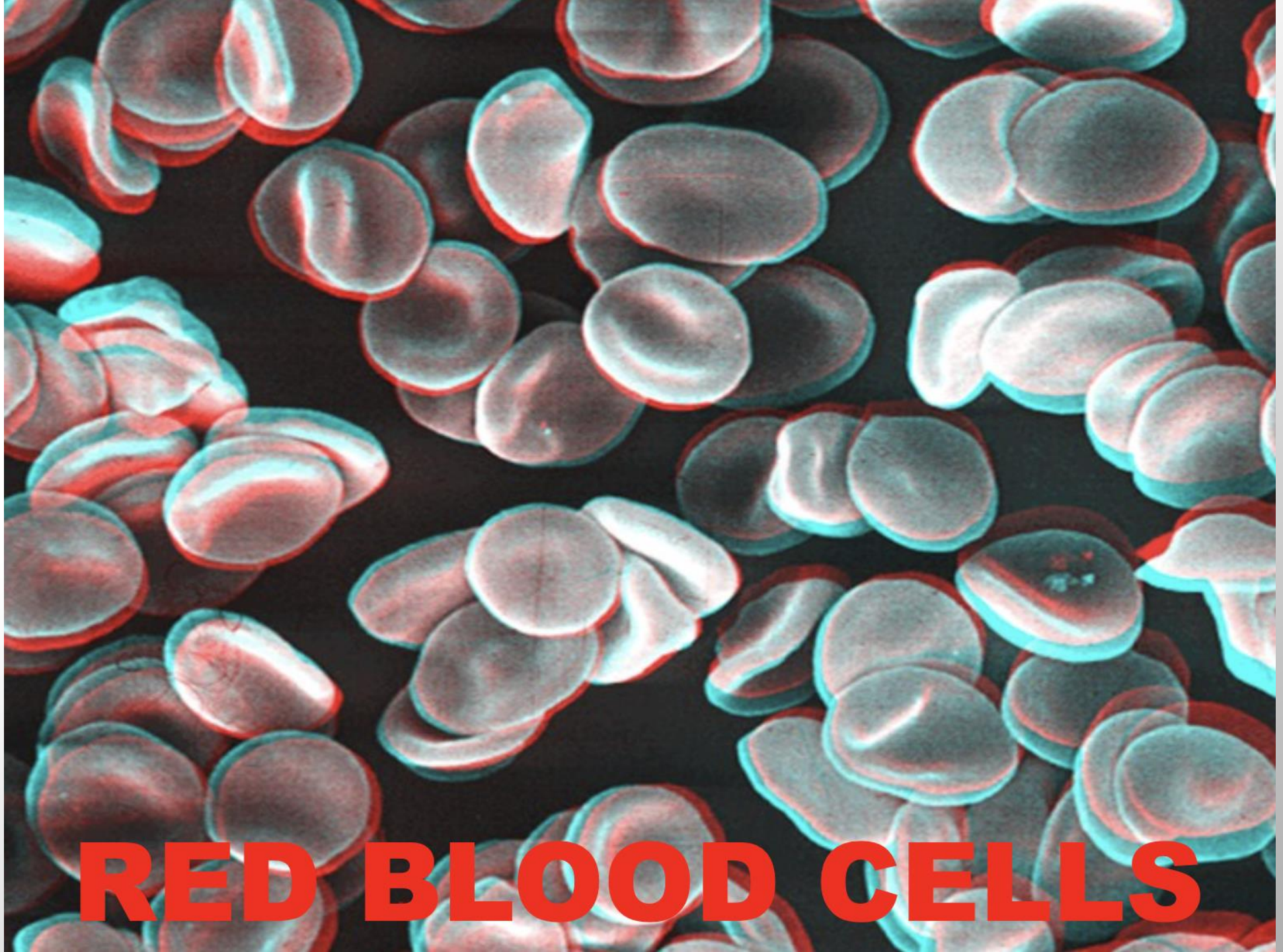
Levels of Organization



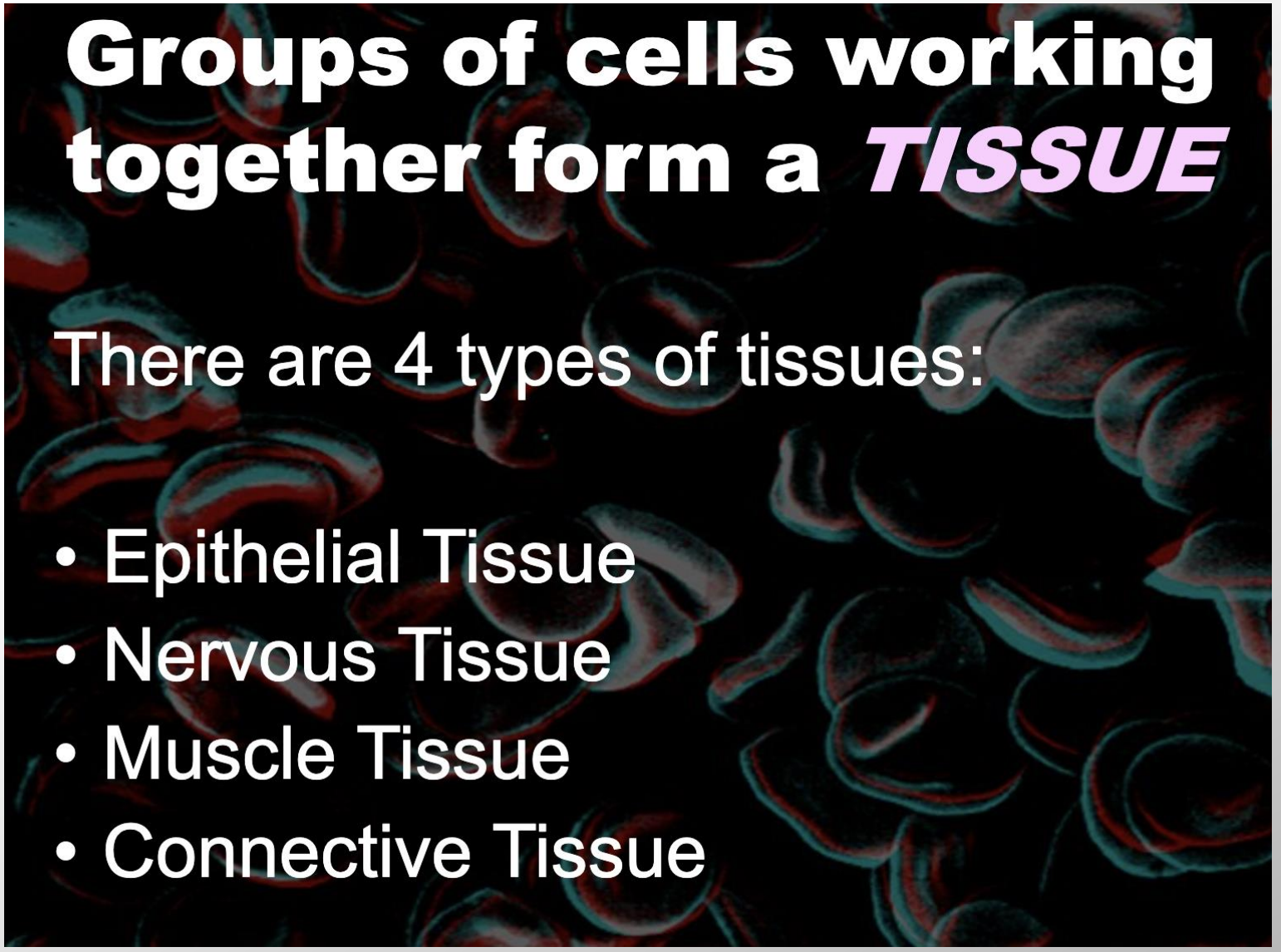
The work of cells

On a baseball team, every player has his job.

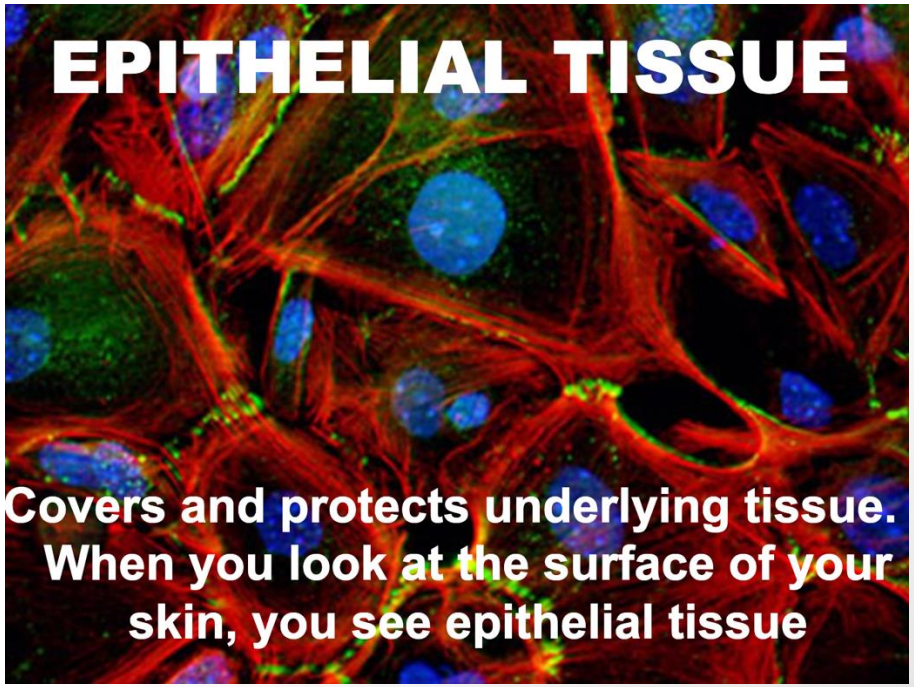
Cells have their own positions (or jobs) in the body!

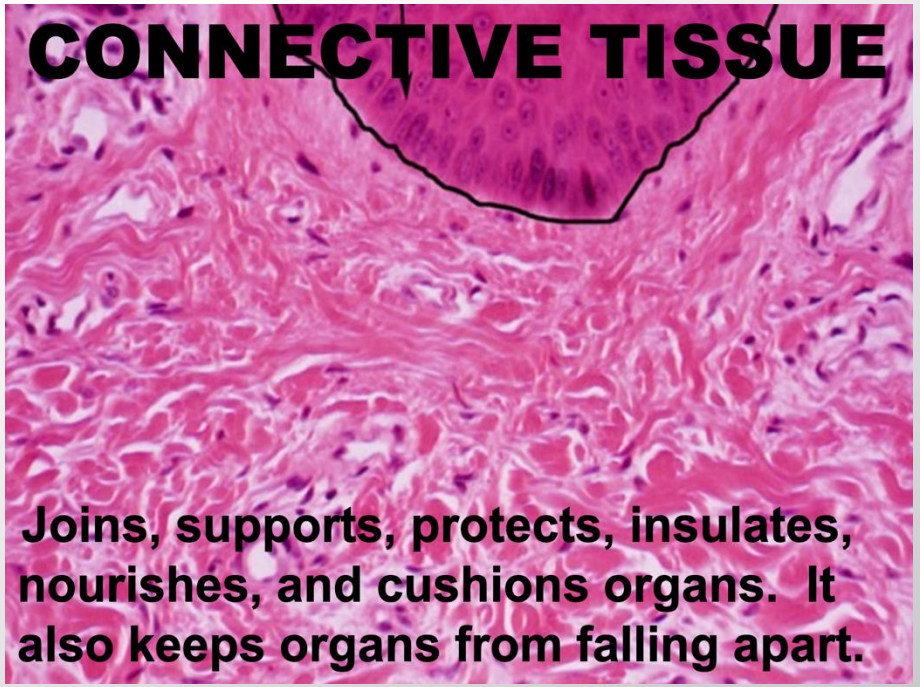

RED BLOOD CELLS

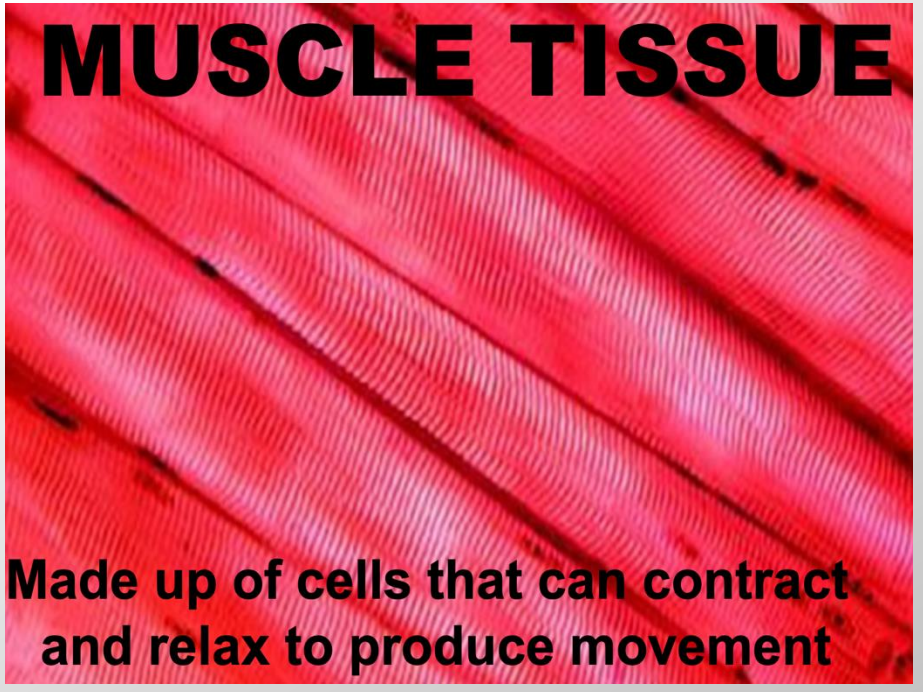
Tissues

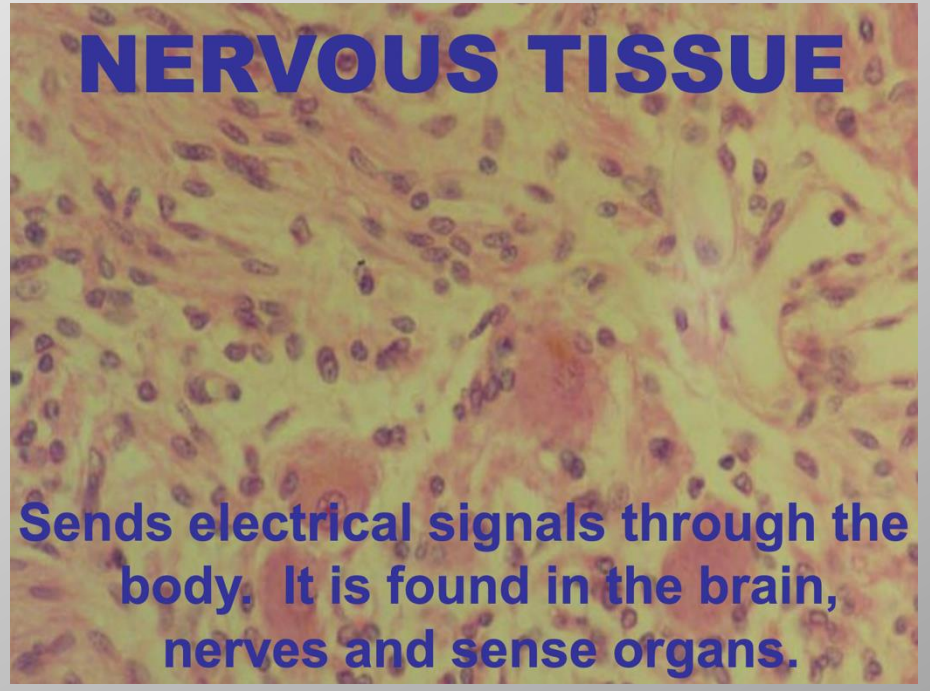

Groups of cells working together form a TISSUE
There are 4 types of tissues:
• Epithelial Tissue
• Nervous Tissue
• Muscle Tissue
• Connective Tissue

Tissues


EPITHELIAL TISSUE
Covers and protects underlying tissue. When you look at the surface of your skin, you see epithelial tissue


CONNECTIVE TISSUE
Joins, supports, protects, insulates, nourishes, and cushions organs. It also keeps organs from falling apart.

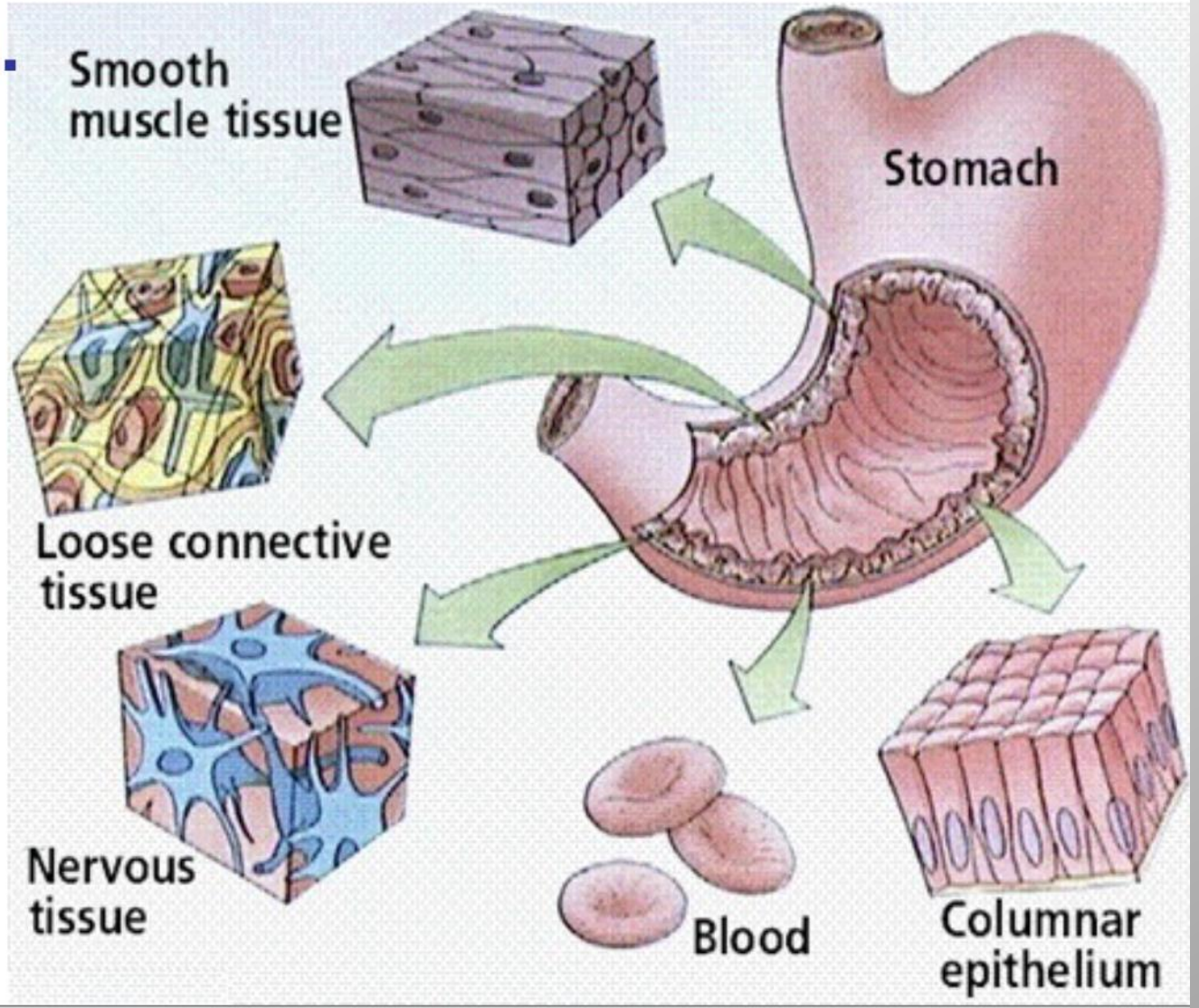

MUSCLE TISSUE
Made up of cells that can contract and relax to produce movement


NERVOUS TISSUE
Sends electrical signals through the body. It is found in the brain, nerves and sense organs.

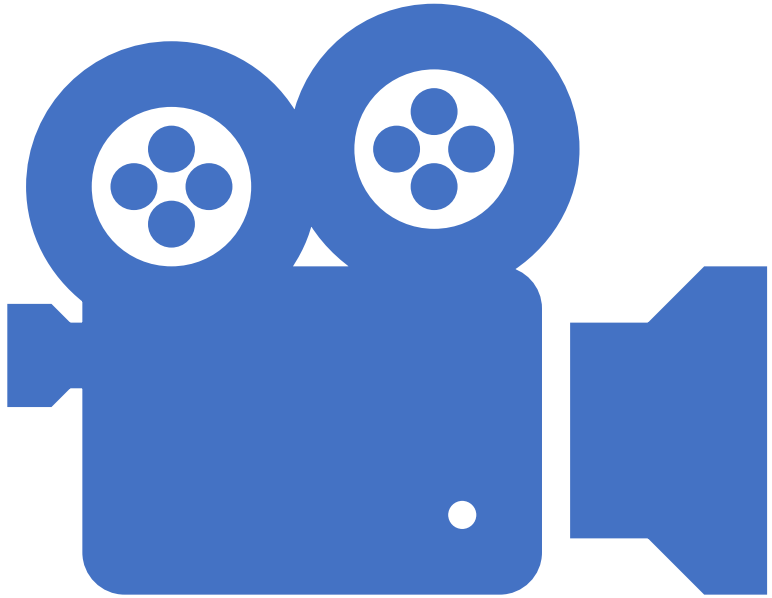
Organ

Two or more tissues working together, form an organ.

One type of tissue alone cannot do all of the things that several types working together can do.



Video



Practice:

What are the levels of organisation in organisms, from least complex to most complex?

Organelles → _____ → tissues → _____ → organ systems

Answer:

What are the levels of organisation in organisms, from least complex to most complex?

Organelles ➔ cells ➔ tissues ➔ organs ➔ organ systems

Practice:

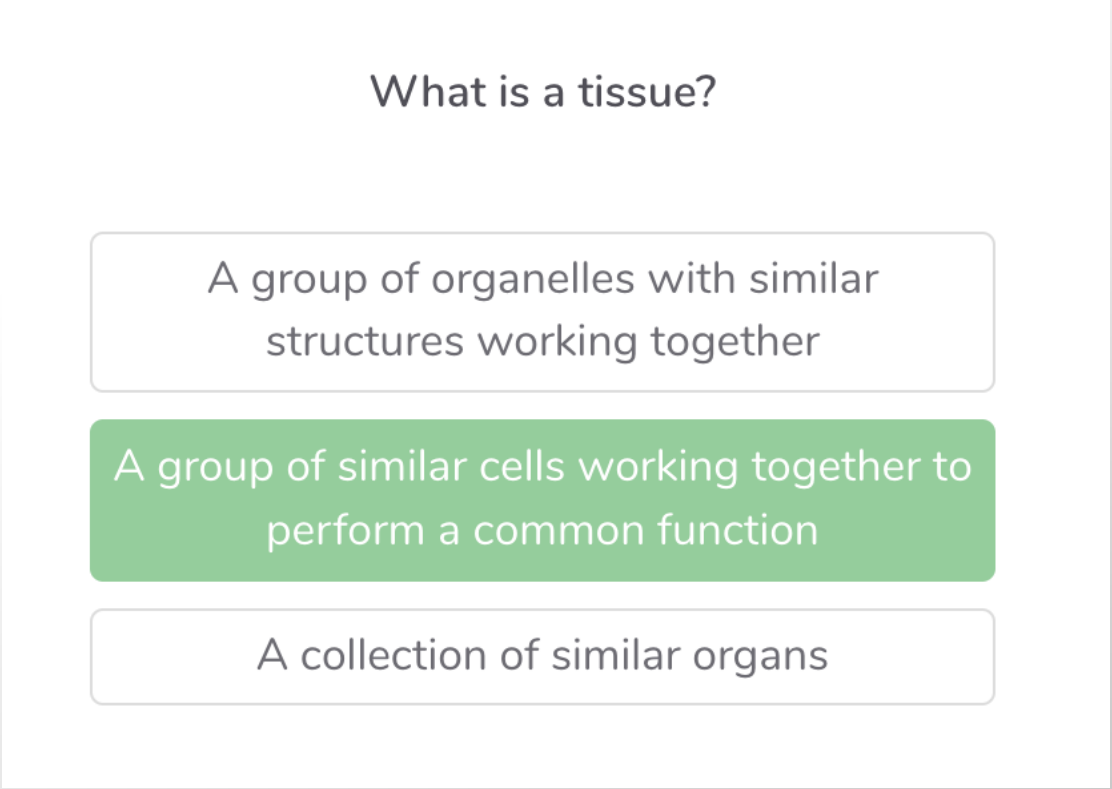
What is a tissue?

A group of organelles with similar structures working together

A group of similar cells working together to perform a common function

A collection of similar organs

Answer:



https://cognitoedu.org

Organs + Organ +.. =Organ System

CAUTION

The failure of any part can affect the entire system

Organ Systems

Integumentary system

ORGANS

- Skin

FUNCTIONS

- Waterproofs, cushions, protects deeper tissue
- Excretes salts & urea; pain, pressure
- Regulates body temp; synthesize vitamin D

Organ Systems

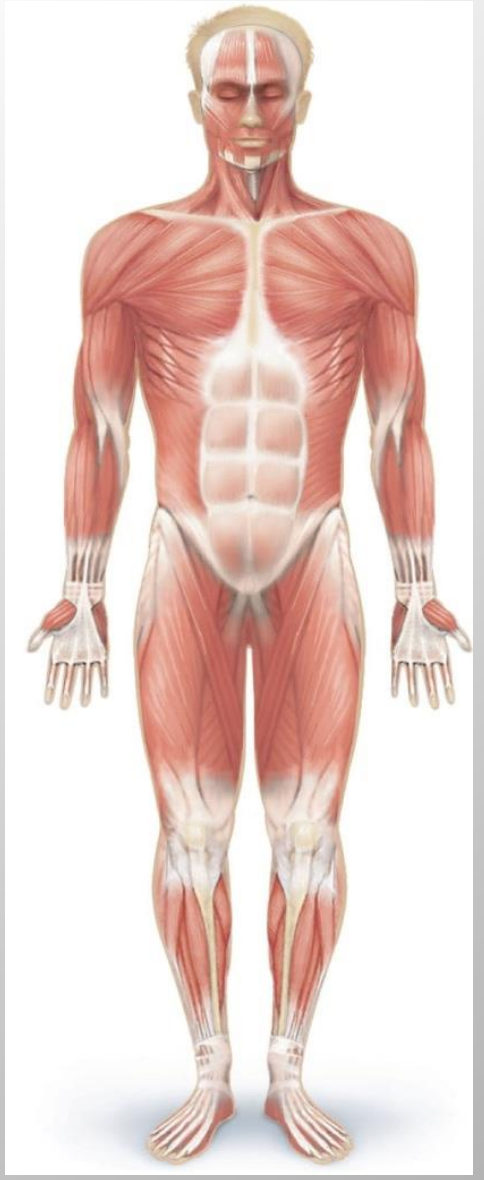
Muscular system

ORGANS

- Skeletal muscle attached to bone)
- Smooth muscle
- Cardiac muscle

FUNCTIONS

- Contraction & mobility (locomotion)
- Facial expression, posture
- Produce body heat



Organ Systems

Skeletal system

ORGANS

- Bones, cartilages, ligaments, joints

FUNCTIONS

- Protects & supports body organs
- Framework for muscles & movement
- Hematopoiesis, store minerals

Organ Systems

Nervous system

ORGANS

- Brain, spinal cord, nerves, & sensory receptors

FUNCTIONS

- Fast-acting central control system
- Responds to external/internal stimuli via nerve impulses (electrical messages)

Organ Systems

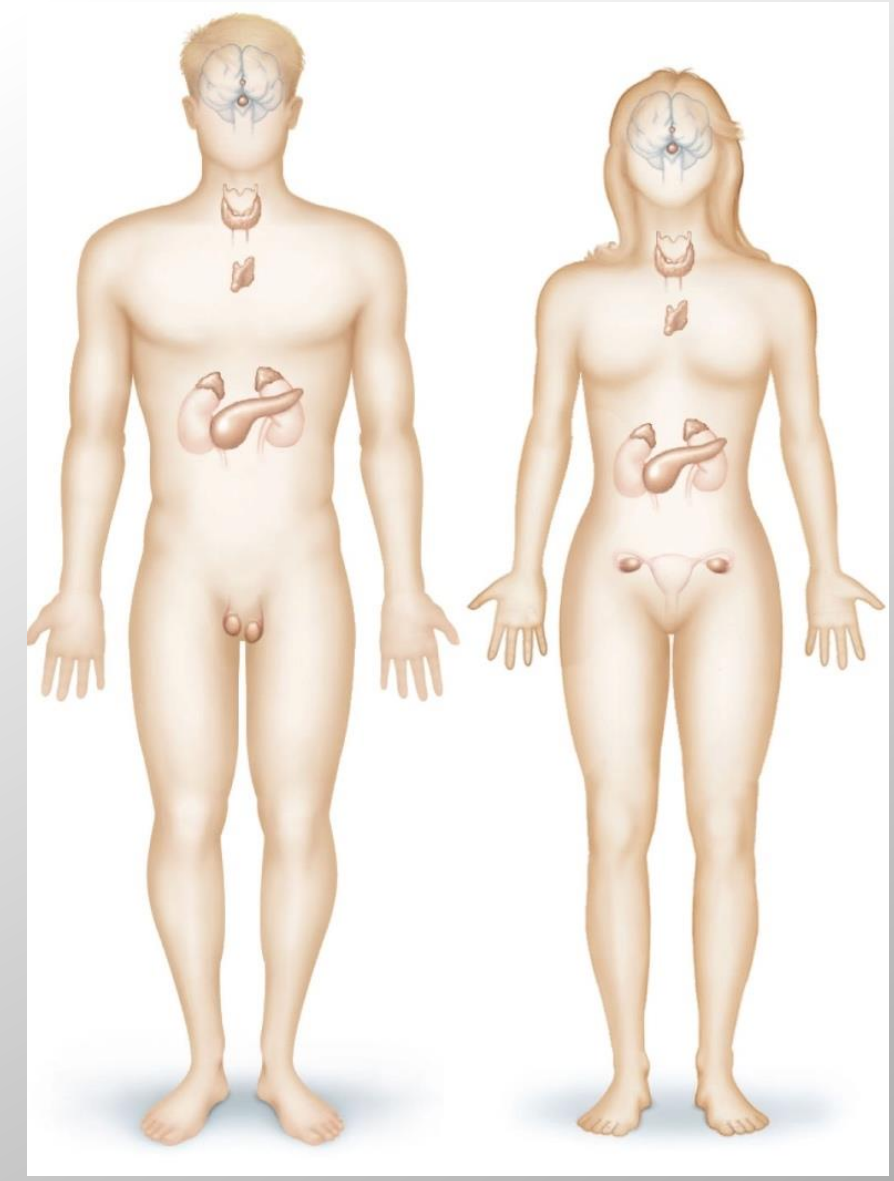
ORGANS

- Pituitary, thyroid, parathyroids, adrenals, thymus, pancreas, pineal, ovaries, testes…..etc.

FUNCTIONS

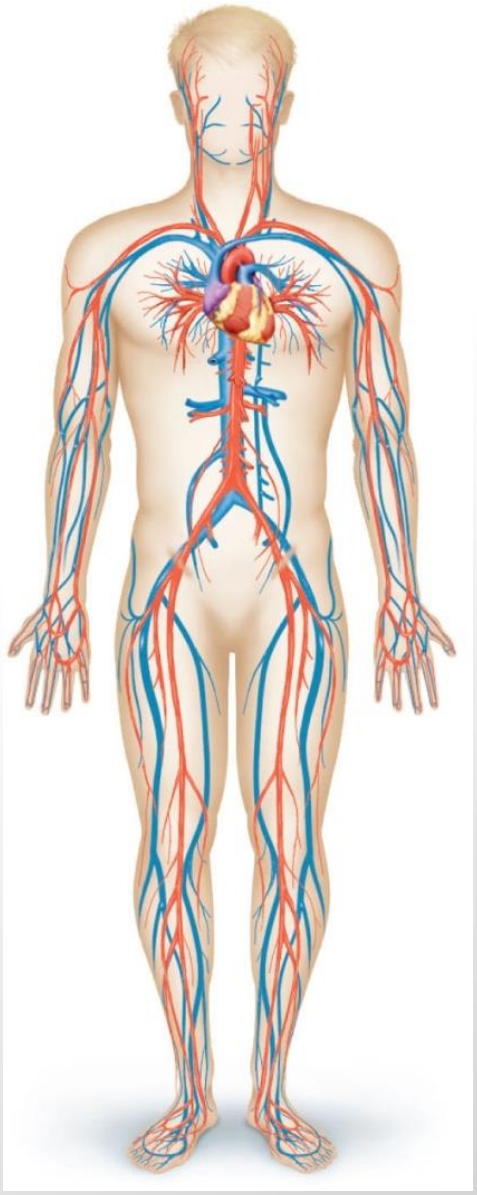
- Slow -acting control system
- Glands produce hormones that regulate growth, reproduction, metabolism,…. etc.

Endocrine system



Organ Systems

Cardiovascular system



ORGANS

- Heart, blood vessels, capillaries &blood

FUNCTIONS

- Carries O_2 nutrients, hormones, & other substances
- White blood cells protect against bacteria, toxins, tumors

Organ Systems

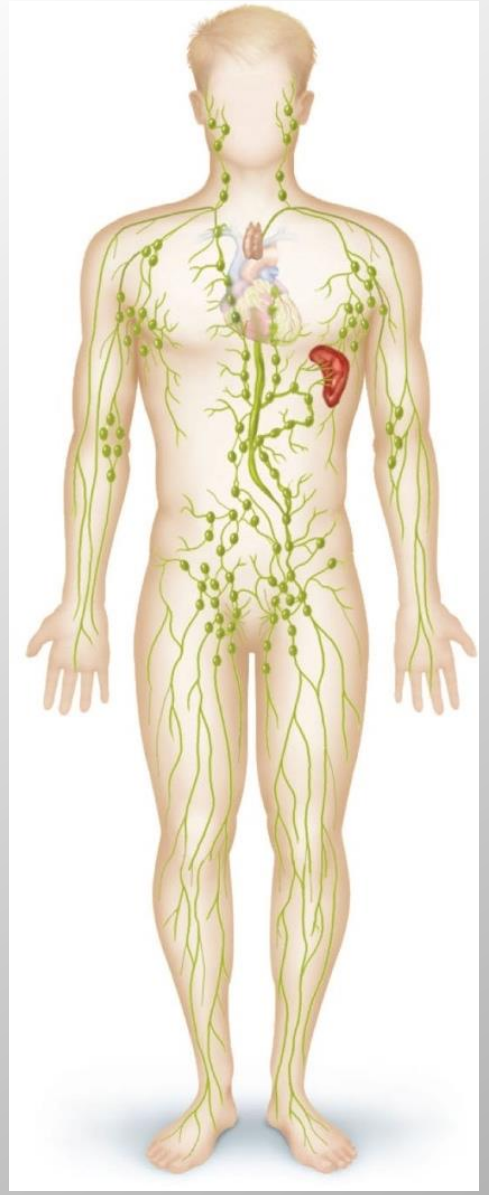
Lymphatic system

ORGANS

- Lymphatic vessels, lymph nodes, spleen, tonsils

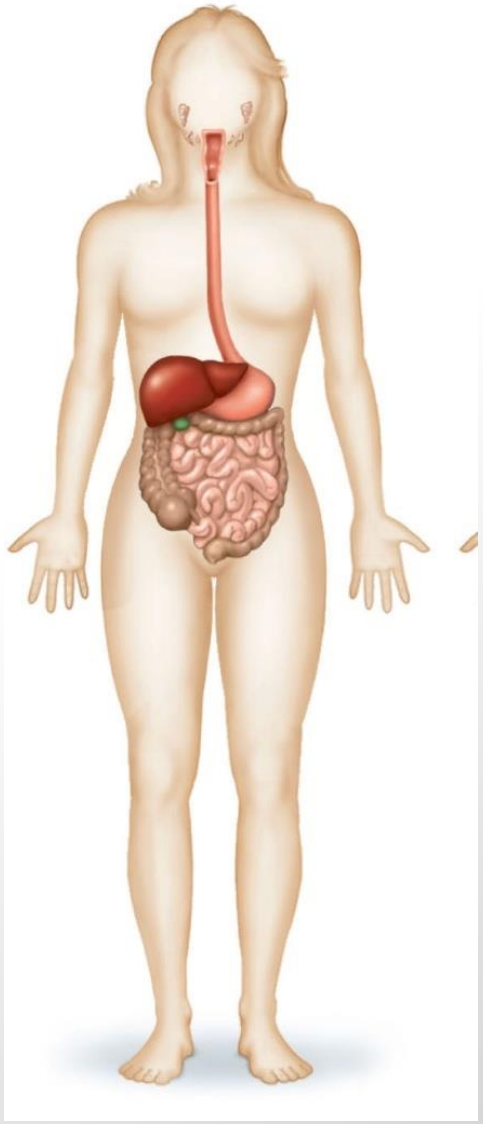
FUNCTIONS

- Provides immunity against disease and infections



Organ Systems

Digestive system



ORGANS

- Oral cavity, esophagus, stomach, small intestine, large intestine, rectum, anus (liver & pancreas)

FUNCTIONS

- Breaks food down into absorbable units that enter the blood; indigestible food eliminated as feces

Organ Systems

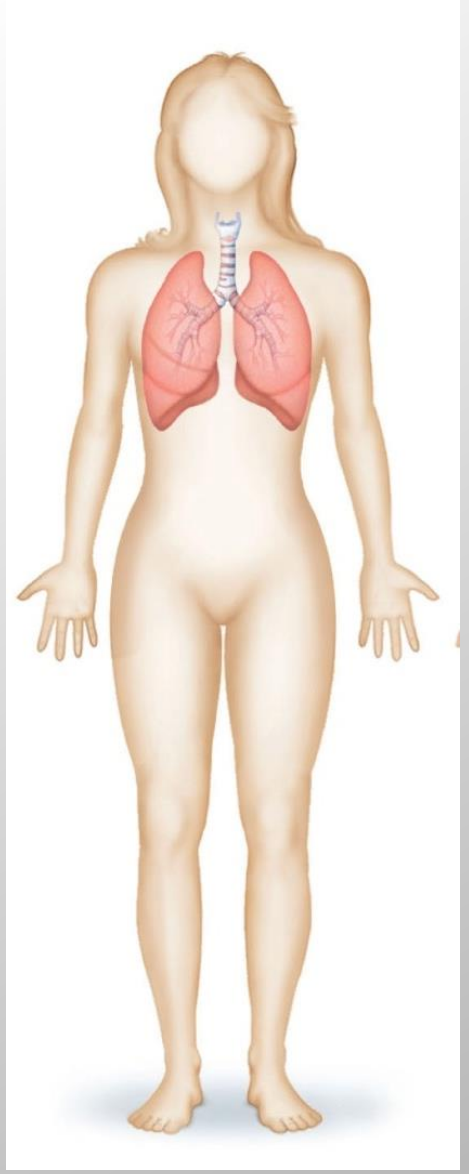
Respiratory system

ORGANS

- Nasal cavity, pharynx, larynx, trachea, bronchi, & lungs

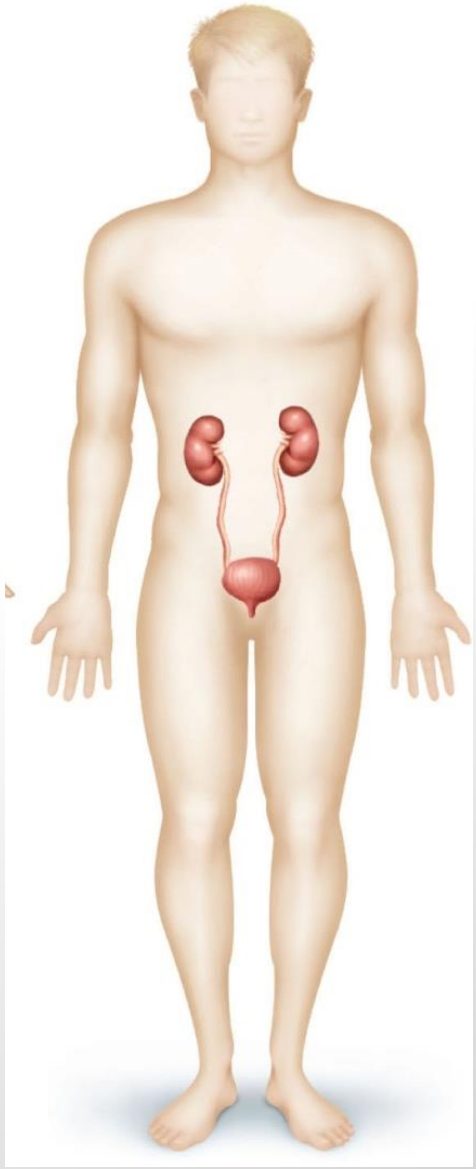
FUNCTIONS

- Keeps blood supplied with O_2 & removes CO_2
- Carries gas exchanges



Organ Systems

Urinary system



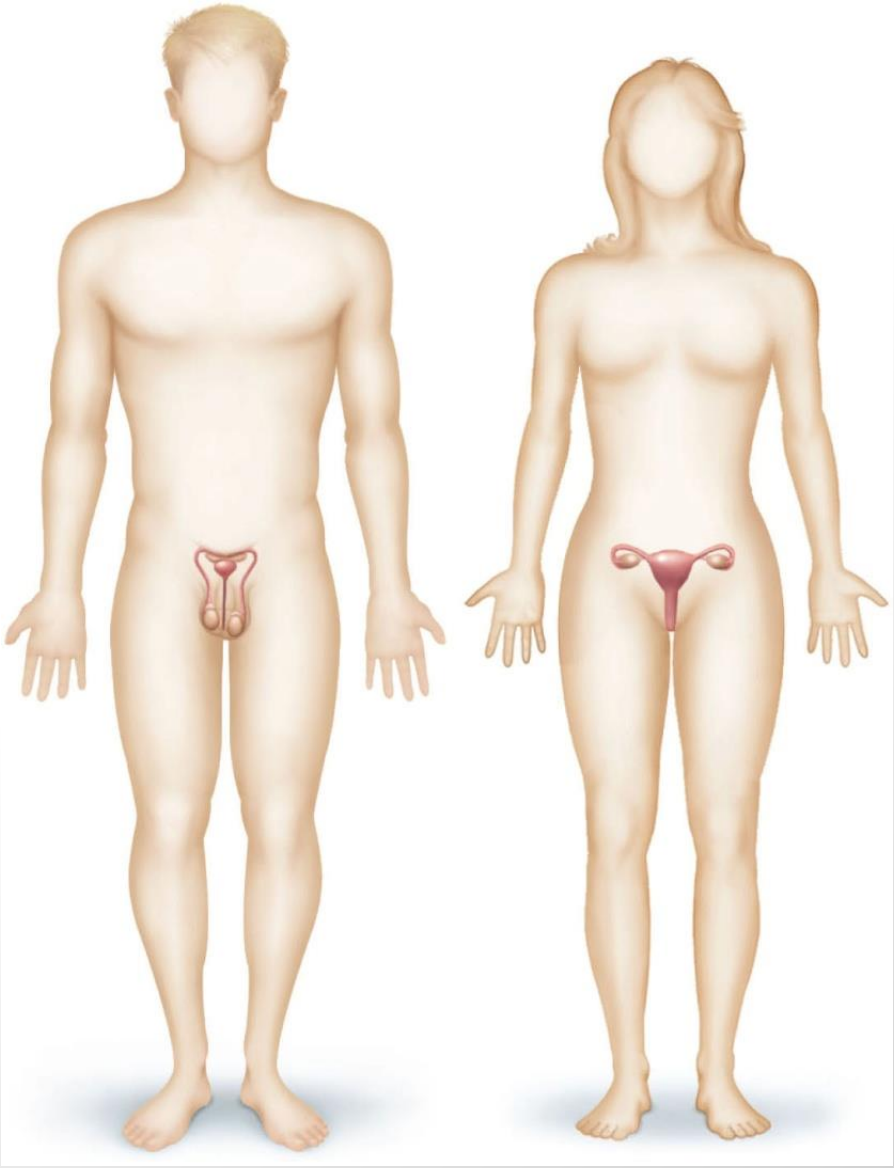
ORGANS

- Kidney, ureter, urinary bladder, urethra

FUNCTIONS

- Eliminates waste products from the body (urea & uric acid)
- Regulates water, electrolytes, & acid-base balance of the blood

Organ Systems



Reproductive system

ORGANS

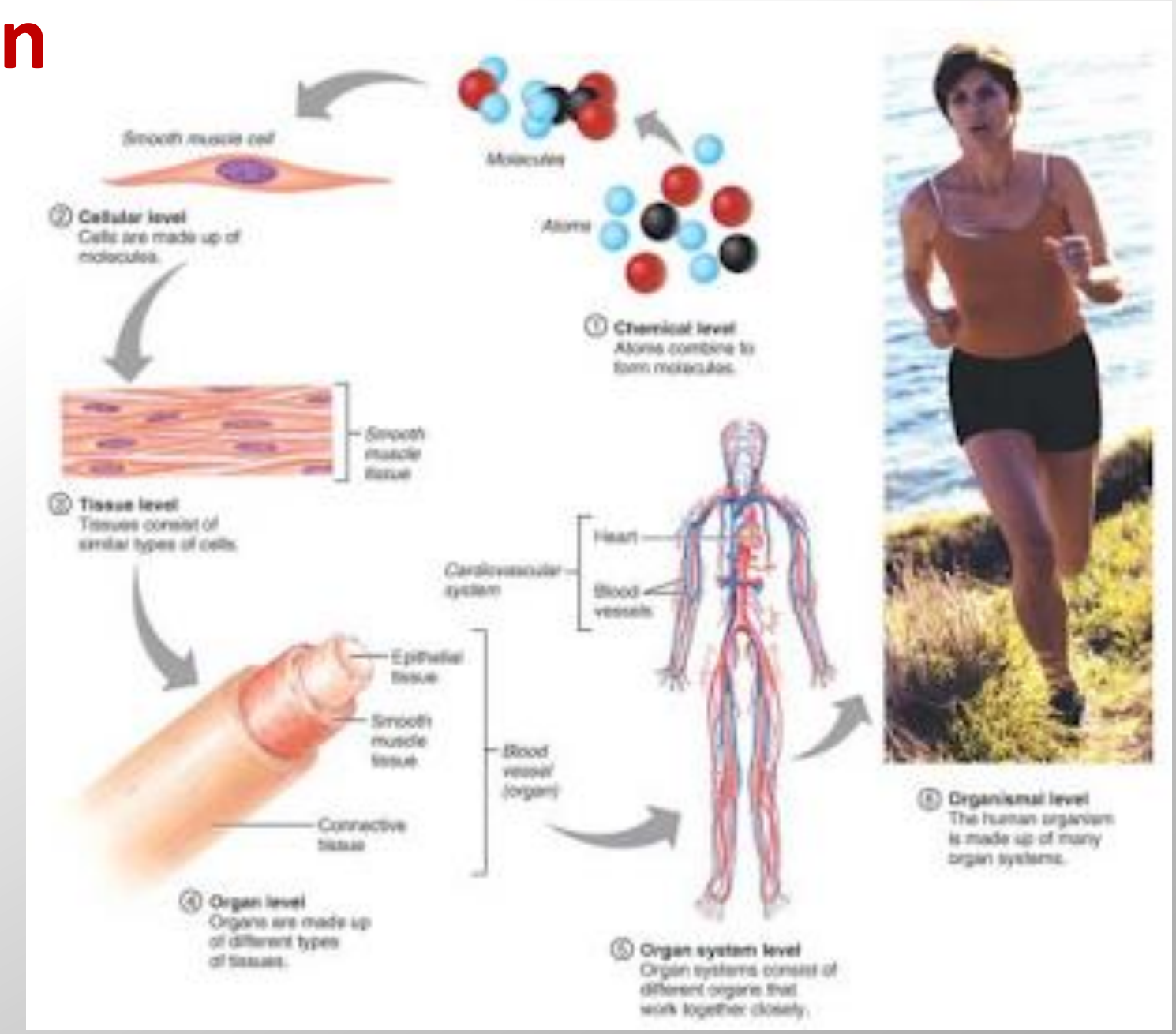
- Male
  - Seminal vesicles, prostate, penis, vas deferens, testis, scrotum
- Female
  - Ovaries, mammary glands, uterus, vagina, uterine tube

FUNCTIONS

- Primary function for both sexes is to produce offspring
- Male – testes produce sperm & male sex hormones
- Female – ovaries produce eggs & female sex hormones;

Levels of Organization

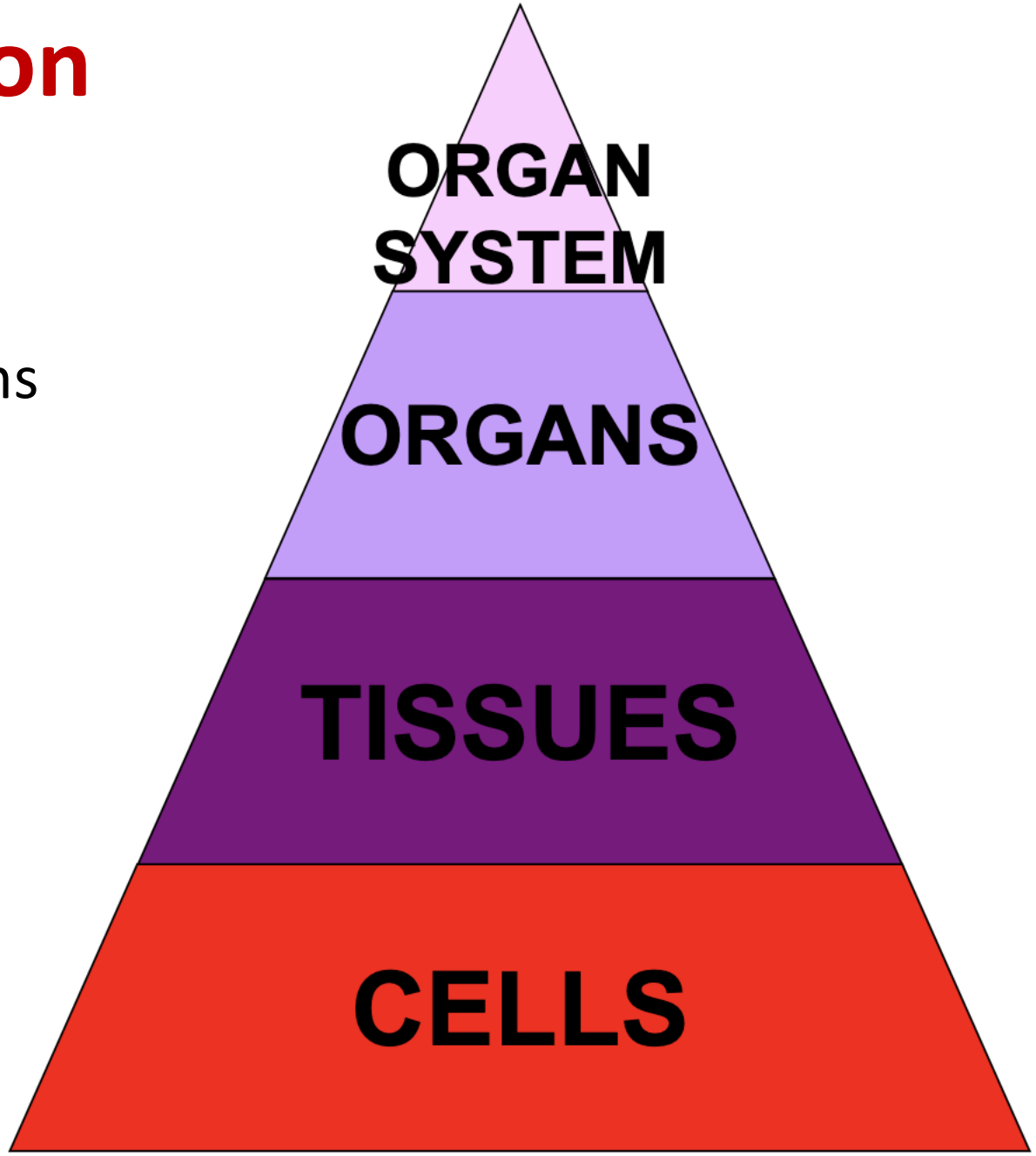
- An **organism** is a system possessing the characteristics of living things—the ability to obtain and process energy, the ability to respond to environmental changes, and the ability to reproduce.



Levels of Organization

- atoms/ molecules < cells < tissues < organs < organ systems < organisms

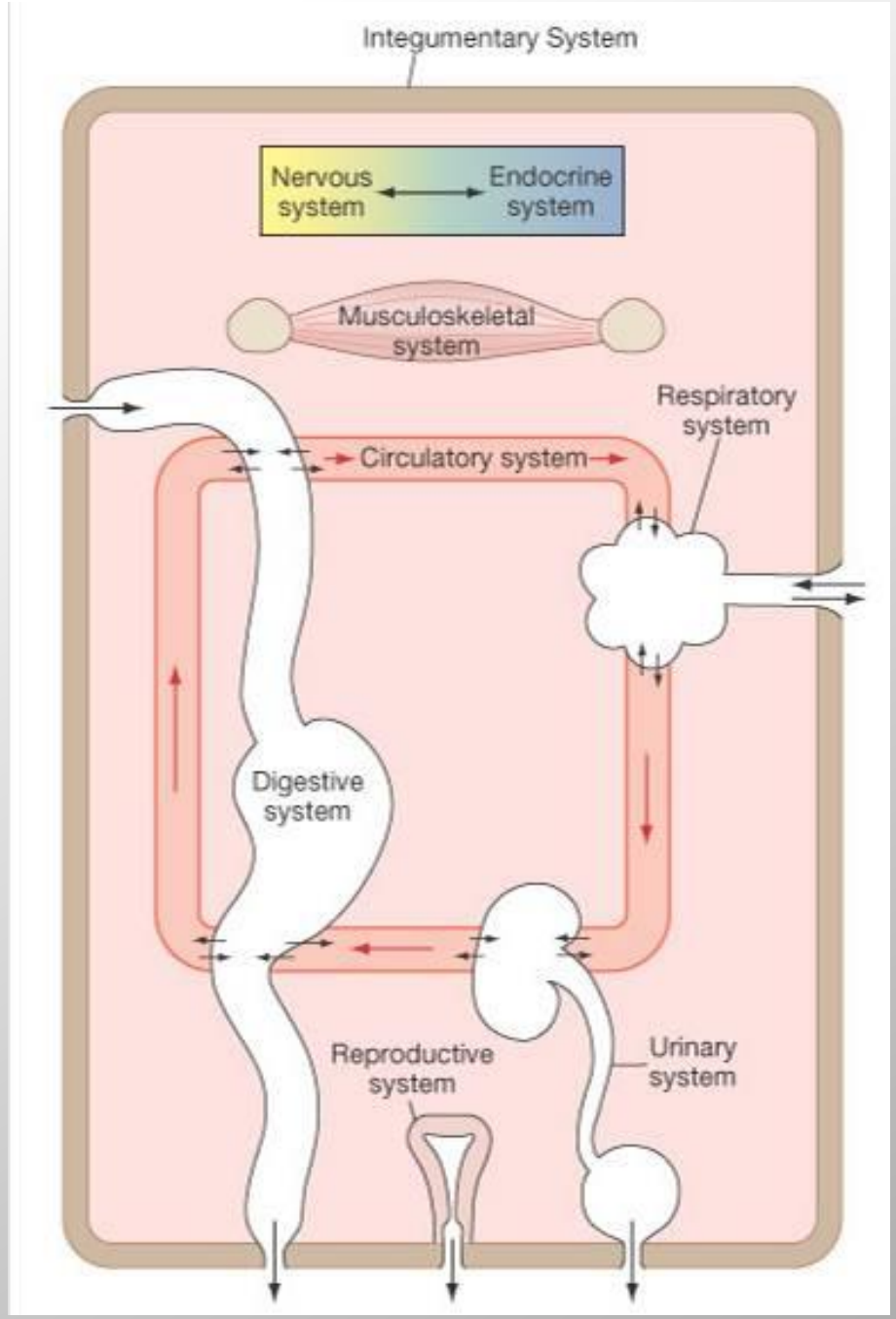
- Each level is more complex than the previous.



Recap: Cellular structures and functions

The integration between systems of the body

- Many systems combines to form ORGANISM
- An individual can survive only if all the systems of the body works harmony



What is Physiology?

Physiology is the science of life.

It is the branch of biology that aims to understand the mechanisms of living things, from the basis of cell function at the ionic and molecular level to the integrated behaviour of the whole body and the influence of the external environment.

Research in physiology helps us to understand how the body works in health and how it responds and adapts to the challenges of everyday life; it also helps us to determine what goes wrong in disease, facilitating the development of new treatments and guidelines for maintaining human and animal health.

The emphasis on integrating molecular, cellular, systems and whole body function is what distinguishes physiology from the other life sciences.

Discussion questions:

1. Explain the relationship between cells, tissues, organs and organ systems.

2. Compare the four kinds of tissues found in the human body.