Introduction to Anatomy Physiology

Danil Hammoudi, MD
"Dispel from your mind the thought that an understanding of the human body in every aspect of its structure can be given in words; the more thoroughly you describe the more you will confuse... I advise you not to trouble with words unless you are speaking to blind men."

*Leonardo da Vinci*
Smooth muscle cell

Molecules

Atoms

1 Chemical level
Atoms combine to form molecules.

2 Cellular level
Cells are made up of molecules.

3 Tissue level
Tissues consist of similar types of cells.

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

5 Organ system level
Organ systems consist of different organs that work together closely.

6 Organismal level
The human organism is made up of many organ systems.

Levels of Structural Organization

Figure 1.1
Levels of Structural Organization

- Chemical – atoms combined to form molecules
- Cellular – cells are made of molecules
- Tissue – consists of similar types of cells
- Organ – made up of different types of tissues
- Organ system – consists of different organs that work closely together
- Organismal – made up of the organ systems
In order to understand how something is built and how something works, you must look at all of its components and analyze them both individually and together. In doing these collective and separate analyses, you must examine things at multiple structural levels, i.e., one must break them down from large to small—this is called reductionism. An organism (such as a human being) may be broken down as illustrated on the left.
Overview of Anatomy and Physiology

- Anatomy – the study of the structure of body parts and their relationships to one another
  - Gross or macroscopic
  - Microscopic
  - Developmental
- Structure refers to
  - the shapes,
  - sizes,
  - and characteristics of the components of the human body.
- The word anatomy comes from 2 words:
  - *Ana* which means “up or apart”
  - *Tomes* which means “to cut”
Gross Anatomy

Study of stuff seen by the naked eye (Gross Anatomy).

- **Regional** – all structures in one part of the body (such as the abdomen or leg)
- **Systemic** – gross anatomy of the body studied by system
- **Surface** – study of internal structures as they relate to the overlying skin
Microscopic Anatomy

- **Cytology** – study of the cell
- **Histology** – study of tissues
Developmental Anatomy

- Traces structural changes throughout life
- Embryology – study of developmental changes of the body before birth
Specialized Branches of Anatomy

- **Pathological anatomy** – study of structural changes caused by disease
- **Radiographic anatomy** – study of internal structures visualized by specialized scanning procedures such as X-ray, MRI, and CT scans
- **Molecular biology** – study of anatomical structures at a subcellular level
Physiology – the study of the function of the body’s structural machinery

- Physiology is defined as the study of function – so human physiology attempts to explain how and why humans function.
- Physiology is where we figure out how stuff works.
  - How do muscles contract?
  - How do we run?
  - How does our heart beat?

- 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
Physiology

- Understanding physiology also requires a knowledge of physics, which explains
  - electrical currents
  - blood pressure
  - the way muscle uses bone for movement
Principle of Complementarity

- Function always reflects structure
- What a structure can do depends on its specific form

Principle of Complementarity of Structure and Function

- The form of each body structure allows that structure to carry out its specific task
  - Function follows form, and form follows function
    - Function always reflects structure
    - What a structure can do depends on its specific form

COMPLEMENTARITY OF STRUCTURE AND FUNCTION

- Function always reflects structure
- What a structure can do depends on its specific form

- hard mineral deposits → bone → support body
- valves in the heart → prevent blood backflow → one direction blood flow

Think about more examples in your body.....
Can Anatomy & Physiology Be Separated?

- NOOOOOOOO!!!!  Absolutely not!
- Structure and function are undeniably connected. We cannot divorce them.
- What do we mean by this?
  - Can you eat soup with a fork?
  - Find 2 everyday items and determine whether/how their structure (anatomy) relates to their function (physiology)

When you consider the structure of an organ, cell, or anything for that matter you must also consider its function!
Body System
Integumentary System

- Forms the external body covering
- Composed of the skin, sweat glands, oil glands, hair, and nails
- Protects deep tissues from injury and synthesizes vitamin D
Skeletal System

- Composed of bone, cartilage, and ligaments
- Protects and supports body organs
- Provides the framework for muscles
- Site of blood cell formation
- Stores minerals
Muscular System

- Composed of muscles and tendons
- Allows manipulation of the environment, locomotion, and facial expression
- Maintains posture
- Produces heat
Nervous System

- Composed of the brain, spinal column, and nerves
- Is the fast-acting control system of the body
- Responds to stimuli by activating muscles and glands
Cardiovascular System

- Composed of the heart and blood vessels
- The heart pumps blood
- The blood vessels transport blood throughout the body
Lymphatic System

- Composed of red bone marrow, thymus, spleen, lymph nodes, and lymphatic vessels
- Picks up fluid leaked from blood vessels and returns it to blood
- Disposes of debris in the lymphatic stream
- Houses white blood cells involved with immunity
Hematological system / hematopoietic system

- include the blood, blood vessels, and blood-forming organs (bone marrow, spleen, liver, lymph nodes, and thymus gland).
- The hematologic system also plays an important role in hormone transport, the inflammatory and immune responses, temperature regulation, fluid-electrolyte balance, and acid-base balance.
Respiratory System

- Composed of the nasal cavity, pharynx, trachea, bronchi, and lungs
- Keeps blood supplied with oxygen and removes carbon dioxide
Digestive System

- Composed of the oral cavity, esophagus, stomach, small intestine, large intestine, rectum, anus, and liver
- Breaks down food into absorbable units that enter the blood
- Eliminates indigestible foodstuffs as feces
Urinary System

- Composed of kidneys, ureters, urinary bladder, and urethra
- Eliminates nitrogenous wastes from the body
- Regulates water, electrolyte, and pH balance of the blood
Male Reproductive System

- Composed of prostate gland, penis, testes, scrotum, and ductus deferens
- Main function is the production of offspring
- Testes produce sperm and male sex hormones
- Ducts and glands deliver sperm to the female reproductive tract
Female Reproductive System

- Composed of mammary glands, ovaries, uterine tubes, uterus, and vagina
- Main function is the production of offspring
- Ovaries produce eggs and female sex hormones
- Remaining structures serve as sites for fertilization and development of the fetus
- Mammary glands produce milk to nourish the newborn
Organ Systems Interrelationships

- The integumentary system protects the body from the external environment.
- Digestive and respiratory systems, in contact with the external environment, take in nutrients and oxygen.
- Nutrients and oxygen are distributed by the blood.
- Metabolic wastes are eliminated by the urinary and respiratory systems.
Necessary Life Functions

- **Maintaining boundaries** – the internal environment remains distinct from the external environment
  - **Cellular level** – accomplished by plasma membranes
  - **Organismal level** – accomplished by the skin
- **Movement** – locomotion, propulsion (peristalsis), and contractility
- **Responsiveness** – ability to sense changes in the environment and respond to them
- **Digestion** – breakdown of ingested foodstuffs
- **Metabolism** – all the chemical reactions that occur in the body
- **Excretion** – removal of wastes from the body
- **Reproduction** – cellular and organismal levels
  - **Cellular** – an original cell divides and produces two identical daughter cells
  - **Organismal** – sperm and egg unite to make a whole new person
- **Growth** – increase in size of a body part or of the organism
Survival Needs

- **Nutrients** – needed for energy and cell building
- **Oxygen** – necessary for metabolic reactions
- **Water** – provides the necessary environment for chemical reactions
- **Normal body temperature** – necessary for chemical reactions to occur at life-sustaining rates
- **Atmospheric pressure** – required for proper breathing and gas exchange in the lungs
Abdominopelvic Regions

Figure 1.11a

Liver
Gallbladder
Ascending colon of large intestine
Small intestine
Cecum
Appendix
Diaphragm
Stomach
Transverse colon of large intestine
Descending colon of large intestine
Initial part of sigmoid colon
Urinary bladder

Right hypochondriac region
Right lumbar region
Right iliac (inguinal) region
Epigastric region
Umbilical region
Hypogastric (pubic) region
Left hypochondriac region
Left lumbar region
Left iliac (inguinal) region
Abdominopelvic Quadrants

- Right upper
- Left upper
- Right lower
- Left lower
# Abdominal quadrants

<table>
<thead>
<tr>
<th>Right upper quadrant</th>
<th>Left upper quadrant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liver right lobe</td>
<td>Liver left lobe</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Right lower quadrant</th>
<th>Left lower quadrant</th>
</tr>
</thead>
</table>
Homeostasis

Relative constancy near a setpoint
- Dynamic
  - Energy-consuming
- Negative feedback loops
- Stability of variable is vital to survival
- Interdependence of variables (pyramid)
Homeostasis

- **Homeostasis** – ability to maintain a relatively stable internal environment in an ever-changing outside world
- The internal environment of the body is in a dynamic state of equilibrium
- Chemical, thermal, and neural factors interact to maintain homeostasis
Homeostatic Control Mechanisms

- Variables produce a change in the body
- The three interdependent components of control mechanisms:
  - Receptor – monitors the environment and responds to changes (stimuli)
  - Control center – determines the set point at which the variable is maintained
  - Effector – provides the means to respond to stimuli
Homeostatic Control Mechanisms

1. **Stimulus**: Produces change in variable
2. **Change detected by receptor**
3. **Input**: Information sent along afferent pathway to the control center
4. **Output**: Information sent along efferent pathway to the effector
5. **Response of effector feeds back to influence magnitude of stimulus and returns variable to homeostasis**

**Figure 1.4**
Negative Feedback

- In negative feedback systems, the output shuts off the original stimulus
- Example: Regulation of room temperature
Figure 1.5

Signal wire turns heater on
Response; temperature rises

Stimulus: rising room temperature

Balance

Effector (heater)
Set point

Receptor-sensor (thermometer in Thermostat)

Signal wire turns heater off
Response; temperature drops

Stimulus: dropping room temperature

Control center (thermostat)

Set point

Heater off

Heater on
Positive Feedback in Childbirth

- Baby drops lower in uterus to initiate labor
- Cervical stretch stimulates Oxytocin release
- Oxytocin release causes uterine contractions
- Uterine contractions push baby against cervix
- Delivery of baby stops the cycle
Positive Feedback

- In positive feedback systems, the output enhances or exaggerates the original stimulus
- Example: Regulation of blood clotting

Figure 1.6
Homeostatic Imbalance

- Disturbance of homeostasis or the body’s normal equilibrium
- Overwhelming the usual negative feedback mechanisms allows destructive positive feedback mechanisms to take over
Dangerous Positive Feedback

- Rise in body temperature
- Increase in body heat production
- Increase in body metabolism
Thermoreceptors in hypothalamus
(detect blood temperature)

Thermoreceptors in skin
(detect external temperature)

Thermoregulatory Centre in Hypothalamus

- smooth muscle in arterioles
  - vasodilation and constriction
- sweat glands
  - sweat
- erector pili muscles in skin
  - skin hairs stand up
- skeletal muscles
  - shivering
- Adrenal and thyroid glands
  - metabolic rate
Figure 1.5 Regulation of body temperature by a negative feedback mechanism.

Stimulus
Body temperature rises

Response
Body temperature rises; stimulus ends

Stimulus
Body temperature falls

Response
Body temperature falls; stimulus ends

Receptors
Temperature-sensitive cells in skin and brain

Effectors
Sweat glands

Effectors
Skeletal muscles

Control Center
(thermoregulatory center in brain)

Information sent along the afferent pathway to control center

Information sent along the efferent pathway to effectors
Figure 1.6 Summary of the positive feedback mechanism regulating formation of a platelet plug.

1. Break or tear occurs in blood vessel wall.
2. Platelets adhere to site and release chemicals.
3. Released chemicals attract more platelets.
4. Platelet plug forms.

Positive feedback cycle is initiated.

Feedback cycle ends when plug is formed.
Nutrient-related signals (e.g., FFA) → Glucose production → Energy balance:
  - Food intake
  - Energy expenditure

Glucose production → Nutrient availability → Circulating nutrients

Circulating nutrients

Nutrient availability → Body fat mass

Adiposity-related signals (leptin, insulin) → Glucose production

Glucose production → Nutrient-related signals (e.g., FFA)
<table>
<thead>
<tr>
<th>Effector</th>
<th>Response to low temperature</th>
<th>Response to high temperature</th>
</tr>
</thead>
</table>
| Smooth muscles in peripheral arterioles in the skin.  | • Muscles contract causing vasoconstriction.  
• Less heat is carried from the core to the surface of the body, maintaining core temperature.  
• Extremities can turn blue and feel cold and can even be damaged (frostbite). | • Muscles relax causing vasodilation.  
• More heat is carried from the core to the surface, where it is lost by convection and radiation.  
• Skin turns red. |
| Sweat glands                                           | • No sweat produced.                                                                         |                                                                                             |
| Erector pili muscles in skin (attached to skin hairs) | • Muscles contract, raising skin hairs and trapping an insulating layer of still, warm air next to the skin.  
• Not very effective in humans, just causing “goosebumps”.
| Skeletal muscles                                       | • Muscles contract and relax repeatedly, generating heat by friction and from metabolic reactions. | • No shivering.                                                                          |
| Adrenal and thyroid glands                             | • Glands secrete adrenaline and thyroxine respectively, which increase the metabolic rate in different tissues, especially the liver, so generating heat. | • Glands stop releasing adrenaline and thyroxine.                                           |
| Behaviour                                              | • Curling up, huddling, finding shelter, putting on more clothes.                           | • Stretching out, finding shade, swimming, removing clothes.                               |
Another feedback

Diagram showing the glucose metabolism pathways involving glucagon and insulin stimulation.
Excretion means the removal of waste products from cells. There are five important excretory organs in humans:

- **Skin** excretes sweat, containing water, ions and urea
- **Lungs** excrete carbon dioxide and water
- **Liver** excretes bile, containing bile pigments, cholesterol and mineral ions
- **Gut** excretes mucosa cells, water and bile in faeces. (The bulk of faeces comprises plant fibre and bacterial cells, which have never been absorbed into the body, so are not excreted but egested.)
- **Kidneys** excrete urine, containing urea, mineral ions, water and other “foreign” chemicals from the blood.