Lecture Outline: Overview of Anatomy and Physiology

I. **Course Introduction and Overview**

A. **Lecture Slides**

1. Mostly pictures from textbook, minimal text to encourage active listening.
2. Red slide numbers mentioned to aid in listening to recordings.
3. Recommendation to label notes by slide and refine them later.

B. **Defining Anatomy and Physiology**

1. **Anatomy**: The study of the **structure** and shape of the body and its parts and their relationships to one another.
2. **Physiology**: The study of **function**; how those structures perform their jobs.
3. **Relationship**: Anatomy and physiology are highly related; form fits function due to natural selection and evolution.

C. **Levels of Anatomical Organization**

1. **Gross Anatomy (Macroscopic)**: Study of coarse, large structures visible to the naked eye, such as major organs (e.g., small and large intestine).
2. **Microscopic Anatomy**: Study of finer details, beyond what is visible to the human eye, such as tissues and cells.
3. **Cellular Anatomy**: Study of the structures within a single cell, including organelles.

D. **The Cell: Functional Unit of Life**

1. Strict requirement for being an organism: Must have at least one cell.
2. Most individual organisms (e.g., bacteria) are **unicellular**.
3. Humans are **multicellular** organisms, possessing 10 to 100 trillion of their own cells.

4. The space we call "our body" is mostly occupied by other cells, primarily bacteria (10-100 bacteria for every human cell), which are much smaller.
5. **Viruses** are not considered living organisms because they lack cells and do not metabolize.

E. **Metabolism: The Essence of Life**

1. **Definition**: The sum of all chemical reactions occurring within an organism (quadrillions of reactions at any given moment).
2. Life is defined by metabolism.
3. A cell acts as a "tiny test tube" to sequester these chemical reactions from the external environment.
4. **Example**: Pepsinogen (a pro-enzyme) is converted to pepsin (an active digestive enzyme) with the help of hydrochloric acid (HCl) in the stomach. Pepsin then breaks down proteins.

F. **Hierarchy of Biological Organization (from Smallest to Largest)**

1. **Chemical Level**: Atoms and molecules.
    a. Atoms combine to form molecules.
    b. **Emergent Properties**: New properties arise at higher levels that are not present at lower levels (e.g., water molecules are watery, but individual hydrogen or oxygen atoms are not).
2. **Cellular Level**: Molecules make up cells; cells are the functional unit of life and possess properties not found in individual molecules.
    a. Human cells differentiate from an initial zygote into various types (e.g., kidney, liver cells).
3. **Tissue Level**: Collections of specialized cells working together for a common function.
    a. Humans have four main tissue types:
        (1) Epithelial tissue (e.g., skin, linings)
        (2) Nervous tissue (e.g., brain, nerves)
        (3) Muscular tissue (e.g., muscles for movement)
        (4) Connective tissue (e.g., blood, bone, cartilage)

4. **Organ Level**: Different types of tissues organize to form structures with specific functions (e.g., heart, lungs, skin, eyes).
5. **Organ System Level**: Multiple organs work together to perform a set of specific functions (e.g., digestive system).
    a. Humans have **11 organ systems**.
6. **Organism Level**: All 11 organ systems collectively form an individual human.

II. **The 11 Human Organ Systems**

A. **Integumentary System**

1. **Definition**: The body's covering (integument means covering).
2. **Components**: Skin, hair (produced only by mammals), and nails.
3. **Functions**:
    a. Aesthetic and cosmetic importance.
    b. Critical for health: protects against desiccation (drying out) and infection.
    c. Temperature maintenance (e.g., blood flow to surface, sweating).

B. **Skeletal System**

1. **Components**: Bones, cartilages, and ligaments.
2. **Functions**:
    a. Provides a **rigid framework** (endoskeleton).
    b. Serves as attachment points for muscles to pull on, enabling movement.
    c. Functions as a large **storage repository for calcium**, vital for cell operations (especially nervous and muscular systems).

C. **Muscular System**

1. **Components**: Primarily **skeletal muscles** (muscles that connect to bone) and tendons.
    a. Cardiac muscle (heart) and smooth muscle (internal organs) are part of other systems.
2. **Functions**:
    a. Enables coordinated body movement (muscles can only pull/

shorten).

b. Important for **heat maintenance** (e.g., shivering is uncoordinated muscle contraction to generate heat).

D. **Nervous System**

1. **Importance**: Defines our existence and mind (the brain is central to "self"). Brain death is considered death.
2. **Control System**: One of two major control systems (along with the endocrine system) that regulate all other organ systems and each other.
3. **Signals**: Transmits **electrochemical signals** (action potentials) rapidly along specialized cells called neurons, enabling fast-acting control (e.g., reflexes).
4. **Hierarchy**:
   a. **Central Nervous System (CNS)**: Brain and spinal cord.
   b. **Peripheral Nervous System (PNS)**: Nerves that connect to the CNS.

E. **Endocrine System**

1. **Control System**: The second major control system.
2. **Components**: Diverse set of glands spread throughout the body.
3. **Signals**: Produces and secretes **chemical signals called hormones** into the bloodstream, broadcasting them throughout the body.
4. **Action**: Hormones bind to specific receptors on target cells, leading to slower but longer-lasting responses compared to the nervous system.

F. **Circulatory System (formerly Cardiovascular System)**

1. **Nomenclature Clarification**:
   a. "Cardiovascular system" refers only to the heart and blood vessels.
   b. The complete organ system, including the blood, is correctly termed the **circulatory system**.
2. **Components**: Heart (pump), blood vessels (tubes), and blood.
3. **Primary Function**: **Transporting substances** throughout the body, especially in large organisms like humans.

a. Carries oxygen to cells, carbon dioxide away from cells.
b. Transports nutrients from the digestive system.
c. Removes toxins and waste products to other systems.
d. Distributes heat throughout the body.

4. The circulatory system is partially leaky, allowing fluids and hormones to exit vessels to reach tissues.

G. **Lymphatic System**

1. **Components**: Lymphatic vessels (parallel to blood vessels) and lymph (fluid leaked from blood).
2. **Functions**:
   a. **Reclaims lymph**: Collects fluid leaked from the circulatory system and returns it to the bloodstream, preventing swelling (edema).
   b. Crucial for **immunity**: Many immune functions are carried out by structures within this system.
3. The "immune system" is not a distinct organ system but a functional collective of various systems.

H. **Respiratory System (Ventilatory System)**

1. **Components**: Primarily the lungs (site of gas exchange) and associated "plumbing" for air movement.
2. **Function (Ventilation)**: Inhaling air to obtain oxygen and exhaling carbon dioxide.
3. **Why Oxygen is Needed**: Oxygen acts as the final electron acceptor in cellular energy production, combining with hydrogen atoms (from food) to form water. This prevents a backup in the electron transport chain.
4. **Why Carbon Dioxide is Exhaled**: It is the waste product remaining after food molecules have been completely dismantled for energy.

I. **Digestive System**

1. **Components**: Mostly the continuous **alimentary canal** (mouth to anus), plus accessory organs like the liver (food does not pass through).
2. **Functions**:

a. **Digestion**: Breaking down large food molecules into smaller ones.

b. **Absorption**: The primary and most important function; taking digested nutrients into the body cells, primarily through the small intestine lining.

3. Digestion fundamentally occurs "outside the body" in the lumen of the alimentary canal, which is continuous with the external environment.

J. **Urinary System**

1. **Components**: Kidneys (most important, form urine), ureters, urinary bladder, and urethra.
2. **Function**: Kidneys continuously **filter blood to produce urine** (filtered blood), regulating blood composition.
3. Urine production is primarily for the sake of filtering the blood.

K. **Reproductive System(s)**

1. **Uniqueness**:

a. Exists in two distinct versions (male and female).

b. Its primary purpose (reproduction) is not indispensable for the individual's survival, unlike other systems.

III. **Body Organization and Orientation**

A. **Body Compartmentalization**

1. The body consists of various compartments; structures like the alimentary canal, lungs, and urinary bladder are considered continuous with the outside environment until absorption or exchange occurs at the cellular level.
2. Blood within blood vessels is also in its own compartment, separate from other cells, yet continuously exchanges substances with them.

B. **Anatomical Position**

1. The standardized reference position for the human body: standing erect, naked, with palms facing anteriorly.
2. All directional terms are applied as if the body is in this position, regardless of its actual orientation.

C. **Body Regions (Superficial Anatomy)**

1. **Trunk/Torso**: Thorax (chest) and Abdominopelvic area (abdomen and pelvic regions combined).
2. **Appendages**: Limbs attached to the torso.
3. **Specific Regional Terminology (Examples)**:
    a. Cephalic (Head): Frontal (forehead), Orbital (eye sockets), Nasal (nose), Buccal (cheeks), Oral (mouth), Mental (jaw/chin).
    b. Cervical (Neck): A narrowing (cervix).
    c. Thoracic (Chest): Sternal (breastbone area), Axillary (armpit), Pectoral (chest muscle area).
    d. Abdominal: Umbilical (navel area).
    e. Pelvic: Inguinal (groin), Pubic (pubis bone area).
    f. Upper Limb: Brachium (anatomical arm, shoulder to elbow), Antebrachium (forearm), Acromial (shoulder, highest part of scapula), Deltoid (shoulder muscle area), Antecubital (anterior elbow), Manus (hand), Carpus (wrist, part of the hand), Digital (fingers).
    g. Lower Limb: Femoral (thigh, named for femur), Patellar (kneecap), Crural (anatomical leg, knee to ankle), Fibular (lateral leg), Pedis (foot), Tarsus (ankle, part of the foot), Calcaneal (heel bone).
    h. Posterior Regions: Olecranal (posterior elbow), Popliteal (posterior knee), Sural (calf), Occipital (back of skull), Scapular (shoulder blade), Vertebral (spinal column), Lumbar (lower back), Sacral (sacrum bone), Gluteal (buttocks).

D. **Directional Terms (Mostly Comparative and Antonymous Pairs)**

1. **Superior (Cranial/Cephalic)**: Toward the head or upper part of a structure.
2. **Inferior (Caudal)**: Away from the head or toward the lower part of a structure.
3. **Anterior (Ventral)**: Toward the front of the body.
4. **Posterior (Dorsal)**: Toward the back of the body.
5. **Medial**: Closer to the midline of the body.
6. **Lateral**: Away from the midline of the body.

7. **Intermediate**: Between a more medial and a more lateral structure.
8. **Proximal**: Closer to the origin of the body part or the point of attachment of a limb to the body trunk (also used for internal flow).
9. **Distal**: Farther from the origin of a body part or the point of attachment of a limb to the body trunk (also used for internal flow).
10. **Superficial**: Toward or at the body surface.
11. **Deep**: Away from the body surface; more internal.

E. **Planes of Dissection (Mutually Orthogonal Imaginary Planes)**

1. **Sagittal Plane**: A vertical plane that divides the body into left and right parts.
    a. **Median Plane (Midsagittal Plane)**: The single sagittal plane that passes directly through the midline, dividing the body into equal left and right halves.
2. **Frontal Plane (Coronal Plane)**: A vertical plane that divides the body into anterior (front) and posterior (back) parts. It is at right angles to sagittal planes.
3. **Transverse Plane (Horizontal or Cross-Sectional Plane)**: A horizontal plane that divides the body into superior (upper) and inferior (lower) parts. It is at right angles to both sagittal and frontal planes.
4. **Oblique Plane**: Any plane that is at an angle other than 90 degrees to the sagittal, frontal, or transverse planes.

F. **Body Cavities (within the Trunk)**

1. **Dorsal Body Cavity**:
    a. **Cranial Cavity**: Encloses the brain.
    b. **Spinal Cavity (Vertebral Canal)**: Encloses the spinal cord; continuous with the cranial cavity.
2. **Ventral Body Cavity**:
    a. **Thoracic Cavity** (Chest):
        (1) Two pleural cavities (each enclosing a lung).
        (2) Mediastinum (central compartment between the lungs, containing the heart, trachea, esophagus, etc.).

d. **Abdominopelvic Cavity**: Often combined but considered distinct.

(1) **Abdominal Cavity**: Superior portion.

1. Can be subdivided into **four quadrants**: Right Upper, Left Upper, Right Lower, Left Lower.
2. Can be subdivided into **nine regions**: Hypochondriac (right/left), Epigastric, Umbilical, Lumbar (right/left), Iliac (right/left), Hypogastric.

(2) **Pelvic Cavity**: Inferior portion.

IV. **Homeostasis and Feedback Mechanisms**

A. **Homeostasis**: The fundamental physiological principle of maintaining a **relatively stable internal environment** in an organism within tolerable limits. Deviation from these limits can lead to death.

B. **Variables**: Internal conditions that fluctuate and need to be controlled (e.g., body temperature, pH).

C. **Set Point**: The desired or ideal value for a given variable.

D. **Error**: The difference between the actual value of a variable and its set point.

E. **Feedback Mechanisms**: Processes organisms use to control variables and maintain homeostasis.

1. **Negative Feedback Mechanisms**:

a. **Function**: They **negate (reduce or eliminate) the error**, bringing the variable back toward the set point, whether it is too high or too low.

b. **Role in Homeostasis**: These mechanisms are essential for **maintaining homeostasis**; almost all body feedback loops are negative.

c. **Example**: Body temperature regulation. If too hot, sweating cools; if too cold, shivering warms, both returning temperature to set point.

2. **Positive Feedback Mechanisms**:

a. **Function**: They **amplify the error**, driving the variable even farther away from the set point.

b. **Role in Homeostasis**: They never lead to homeostasis.

c. **Characteristics**: Positive feedback loops are always **temporary events** and must eventually be terminated by other mechanisms (usually negative feedback) to restore homeostasis.
d. **Example**: Parturition (childbirth). Uterine stretching leads to oxytocin release, causing stronger contractions, which further stretches the uterus, creating a reinforcing cycle until birth occurs.