PHYSIOLOGY

Skeletal System

Optional review: *"Bone Structure" section, p.1 of* ***QuickStudy®*** **Anatomy** *guide.*

Functions

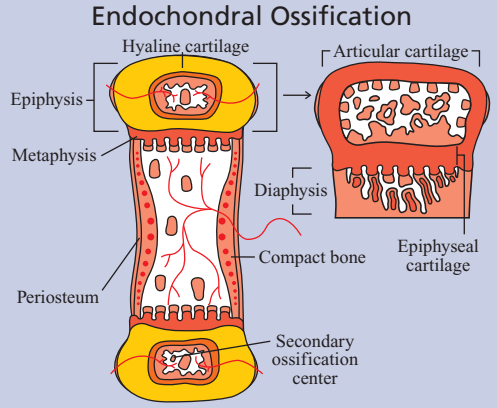
1. **Support:** Framework for body.
2. **Movement:** Muscular attachment.
3. **Protection:** Brain, spinal cord, thorax, etc.
4. **Mineral & lipid storage:** Ca, P, etc., and lipids in yellow marrow.
5. **Hemopoiesis:** Blood cell formation in red marrow.

Skeletal Development & Growth

Skeleton develops by transformation of embryonic mesodermal connective tissue into cartilage and/or bone (i.e., ossification).

Two major types exist:

1. **Intramembranous ossification:** Undifferentiated mesoderm (mesenchyme) transformed to bone. *Examples*: Dermal bones (flat skull bones, mandible and clavicle).
   a. **Osteoprogenitor stem cells** (to become bone-forming cells) cluster and form organic matrix with collagen fibers.
   b. Cells enlarge, compress and calcify matrix, forming spicules around collagen fibers. These cells, or **osteoblasts**, form an ossification center.
   c. As more bony spicules develop and coalesce, osteoblasts are trapped in bony chambers (**lacunae**) and become mature, bone-producing **osteocytes**.
   d. **Osteoclasts** reabsorb bone and allow for shaping and remodeling to final form of bone structure (e.g., spongy vs. compact bone, or final shape of entire bone).
2. **Endochondral ossification:** Bone converted from a **hyaline cartilage** model resembling shape of future bone. *Examples*: Most bones of appendicular and axial skeleton.
   a. **Chondrocytes** deep within the **diaphysis** enlarge (**hypertrophy**), compressing and calcifying the cartilage into spicules.
   b. Calcification of cartilage prevents diffusion of nutrients from **perichondrium** to chondrocytes, killing these cells and leaving empty lacunae.
   c. Osteoblasts form inside the perichondrium of the cartilage model, forming a **periosteum** or bony collar.
   d. Blood vessels grow into spaces created by dead chondrocytes and decaying cartilage.
   e. **Osteoblasts** from periosteum move in via the blood and form a **primary ossification center** around remaining cartilage matrix (occurring in three-month fetus).
   f. Osteoclasts move into **diaphysis** via the blood to reabsorb spongy bone to create **yellow marrow cavity**.
   g. Steps "a - d" occur in **epiphyses** (ends of long bones), creating **secondary ossification centers** (often occur shortly after birth). Although no cavity is created and spongy bone remains, the epiphyses of large bones serve as primary sites of **red marrow**.
   h. Where primary and secondary ossification centers meet (metaphysis), a thin layer of cartilage, **epiphyseal plate**, remains until adulthood, allowing for increases in bone length. In adults, the cartilage is converted to bone, creating an **epiphyseal line** - bone lengthening is no longer possible at this point.



Factors Affecting Bone Development

1. **Stress: Gravitational** and **functional** (muscle contraction) forces increase bone development. Absence or reduction of these forces (e.g., space flight) can cause abnormal growth.
2. **Hormones:** Sex hormones (**estrogens** and **androgens**), **growth hormone**, **thyroxine**, **calcitonin**, and **calcitriol** stimulate bone growth. **Parathormone** inhibits bone growth.
3. **Nutrition: Vitamin D** is required for calcitriol formation, which aids in absorption of calcium and phosphate. **Vitamin C** is involved in collagen synthesis. **Vitamin A** stimulates osteoblasts.

Muscular System

Muscle Types

1. **Skeletal muscle:** Moves bones directly or indirectly; voluntarily (conscious) controlled; striated (banded).
2. **Cardiac muscle:** Pumps blood through body; involuntarily controlled; striated.
3. **Smooth muscle:** Moves materials through structures; involuntarily controlled; no striations

Functions of Skeletal Muscle

1. **Movement:** Moves body parts and materials.
2. **Posture:** Maintenance of body positions.
3. **Temperature homeostasis:** Heat production.

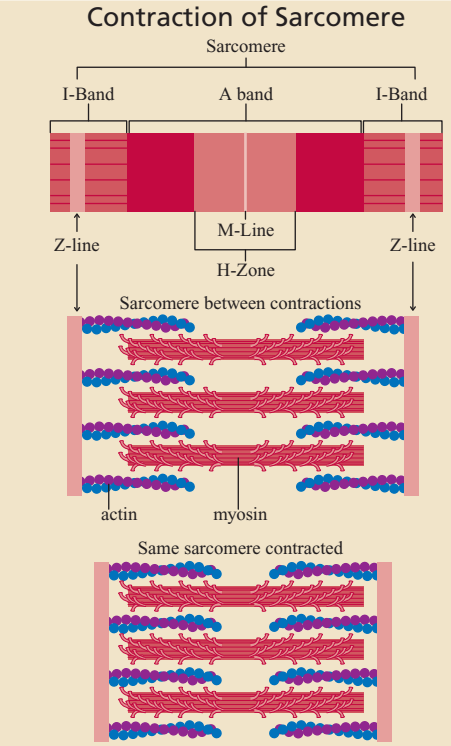
Skeletal Muscle Anatomy

Knowledge of skeletal muscle fiber microanatomy is necessary to understand contraction mechanism.

1. **Muscle fiber**: Contractile cells.
2. **Sarcolemma**: Plasma membrane of muscle fiber.
3. **Myofibrils**: Small fibers packed within muscle fiber; composition varies along length creating banding appearance.
4. **A band**: Dark area on myofibrils.
5. **I band**: Light area on myofibrils.
6. **Z line**(disc):Middle of I band.
7. **Sarcomere**: Between two Z lines, unit of contraction.
8. **H zone**: Light area in A band.
9. **M line**: Middle of H zone.
10. **Myofilaments**: Fibers found in myofibrils.
11. **Thick filaments**: **Myosin** protein; forms A band; bound at M Line.
12. **Thin filaments**: **Actin**, **tropomyosin**, and **troponin** proteins; form I band; bound at Z line.

Contraction of Skeletal Muscle

1. A nerve signal triggers the release of **acetylcholine** into neuromuscular synapse.
2. Receptors in sarcolemma combine with acetylcholine, triggering a **propagated action potential (PAP)** that spreads across membrane and deep into muscle fiber via **transverse tubules**.

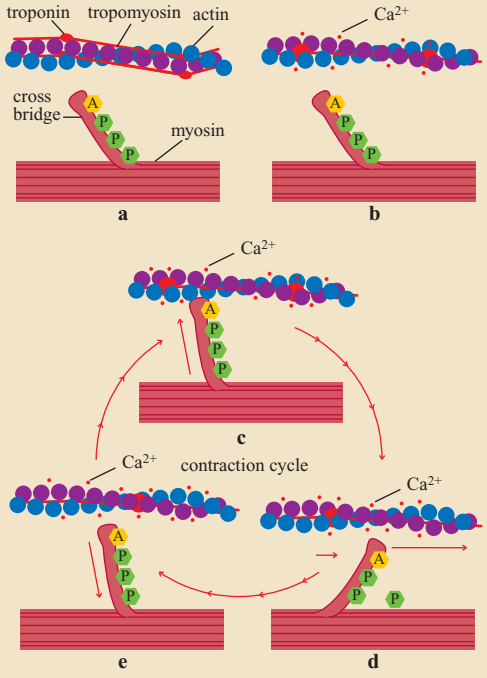


3. **Lateral sacs** (**terminal cisternae**) of **sarcoplasmic reticulum** are stimulated by PAP to release **calcium ions**.
4. The thick filaments, **myosin**, have specialized heads binding to special sites on **actin**.
5. However, a muscle fiber at rest has its myosin binding sites blocked by **tropomyosin**.

When calcium ions (Ca^{+2}) combine with **troponin**, this triggers a shift in the position of **tropomyosin**, allowing the myosin heads to bind with actin forming cross-bridges.

6. **ATP** hydrolysis energizes the myosin head, causing it to attach to actin and swivel, pulling on the thin filament. A new ATP molecule is necessary for myosin to detach from the thin filament and return the head to its original position.
7. The myosin head now can reattach to a new segment of the filament. As long as calcium ions and ATP are available, this cycle can continue.

Role of Microfilaments & ATP During Contractions



Types of Skeletal Muscle Fiber

1. **Red muscle fibers**
   a. **Slow twitch, fatigue resistant**
   - Splits ATP slowly; rich blood supply; large stores of myoglobin; many mitochondria for aerobic metabolism.
   - *Examples*: Postural muscles of neck, back.

   b. **Fast twitch, fatigue resistant**
   - Splits ATP rapidly; otherwise, same as (1a).
   - *Example*: Leg muscles.
2. **White muscle fibers**
   a. **Fast twitch, fatigable**
   - Splits ATP rapidly; few blood vessels; little myoglobin; large glycogen stores for anaerobic metabolism.
   - *Example*: Arm muscles.
3. Most skeletal muscles in the body have a mixture of all three fiber types in various proportions depending on the muscle function.

Contraction of Cardiac & Smooth Muscle

Although significant differences exist, the basic mechanism in both muscle types involves interactions between **actin** and **myosin** similar to those in skeletal fibers.

Nervous System

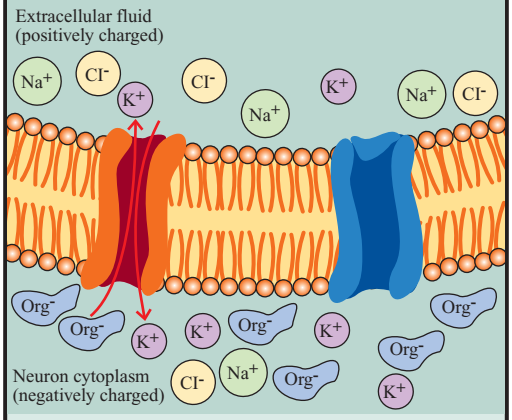
Functions

1. **Sensory:** Detects changes in environment.
2. **Integration:** Decides on a course of action.
3. **Motor:** Responds to change.

Neurophysiology

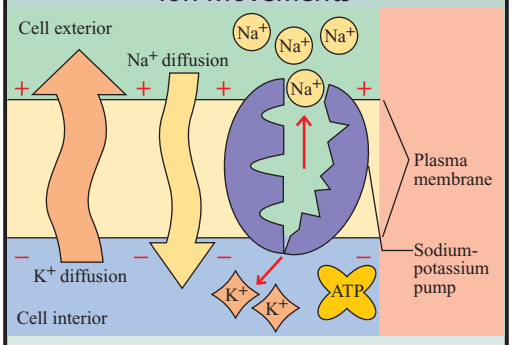
1. **Membrane potentials**
   Living body cells are electrically polarized, with the inside (cytoplasm) more negative than the outside (interstitial fluid). This electrical charge difference is called the **membrane potential**.

Ion Positions & Resting Membrane Potential



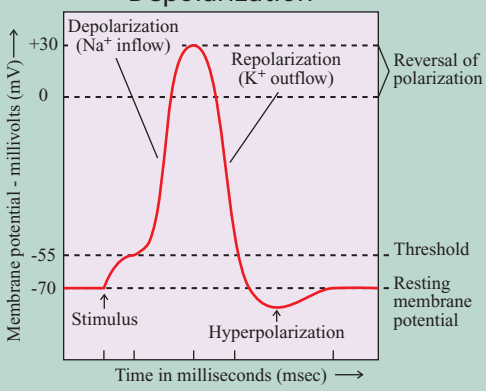
a. **Resting membrane potential (RMP):**
Typically -70 millivolts (mV)
- Distribution of key ions
  - K^+ higher inside cell
  - Na^+ and Cl^- higher outside cell
  - Organic ions higher inside
- Distribution and RMP caused by:
  - **Membrane pumps**
    - *Example*: Na/K pump takes Na^+ out while bringing in K^+.
  - **Membrane permeability**
    - K^+ leaks more easily through membrane than Na^+.
  - **Negatively-charged organic ions**
    - Proteins prevent many K^+ ions from escaping.

Ion Movements



b. **Graded (local) and action potentials**
- **Voltage-gated channels:** Open to ions in response to change in RMP.
  - *Examples*: Na^+ and K^+ channels.
- Opening Na^+ channels causes a **depolarization** as Na^+ rushes inside and the **cytoplasm** becomes more positive (i.e., approaches zero from -70 mV).
- Small changes in RMP will remain localized and graded (dependent on strength of stimulus) as channels open and K+ flows out of the cell to quickly halt the depolarization.
- However, if a stimulus reaches a critical point or **threshold**, the membrane goes through a full-scale **depolarization**, reversing the polarity with the inside becoming positive and the outside negative.
- This is an **action potential** and an **all-or-nothing response** as stimulus strengths greater than the threshold will trigger the same response.

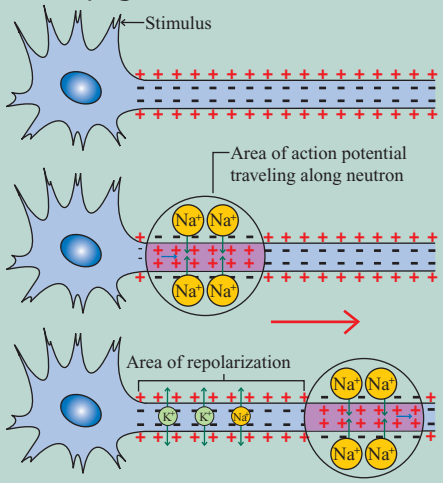
Depolarization



- **Absolute refractory period:** Time during which no new action potential can occur regardless of stimulus strength. Occurs during **main spike**.
- **Relative refractory period:** Time during which a new action potential can be initiated - requires a stronger than normal stimulus. Occurs during **hyperpolarized** state.

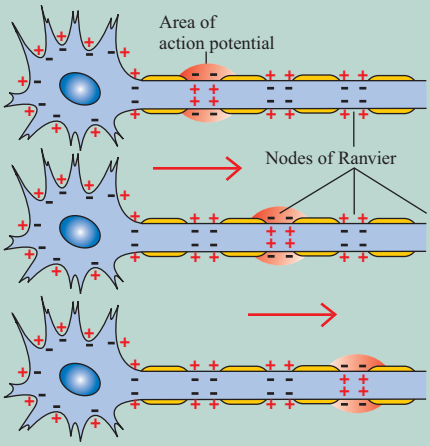
c. **Propagated Action Potential (PAP) "The Nerve Impulse"**
Initial action potential generates action potentials nearby; PAPs move along membrane of neuron.

Propagated Action Potential



d. **Saltatory conduction:** Myelinated axons transmit PAP much faster (up to 50 times faster) as impulse jumps from areas lacking myelin **(Nodes of Ranvier)**. It also saves energy as much less ion pumping is required to restore RMP.

Saltatory Conduction Along an Axon



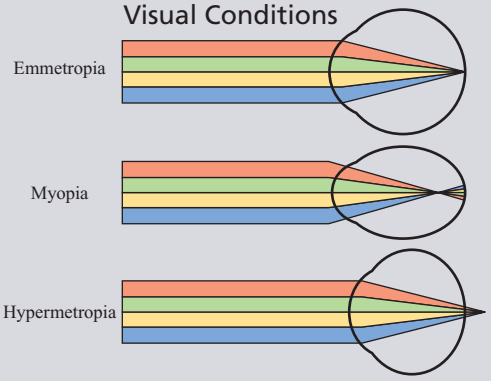
2. **Synapses**
Transfer information (nerve impulses) from one cell (**presynaptic neuron**) to another (**postsynaptic neuron**).
Two major types exist:
a. **Electrical synapses:** Cells are in direct contact. May allow for faster communication between cells and synchronization of certain stereotyped responses. Rare in the nervous system.
b. **Chemical synapses:** Cells are separated by a **synaptic cleft**. **Neurotransmitters** (e.g., acetylcholine, norepinephrine, serotonin) released from the **presynaptic neuron** can trigger different responses by the postsynaptic neuron. Most abundant synapse type in nervous system.
- **Excitatory PostSynaptic Potential (EPSP)**: Response by cell that triggers **depolarization,** making PAP more likely.
- **Inhibitory PostSynaptic Potential (IPSP)**: Response by cell that triggers **hyperpolarization**, making PAP less likely.
- **Synaptic delay:** Time required for signal to cross synapse - 0.5—1 msec.
- **Neuromodulators**: Chemicals that alter neuronal activity by influencing the release of neurotransmitters or the response of the postsynaptic cell to a neurotransmitter.
  • *Examples*: **Endorphins** and **enkephalins** which relieve pain by preventing the release of the neurotransmitter **substance P**.

Physiology of Vision

Optional review: *"Eye" section, p.6 of* **Anatomy** *guide.*

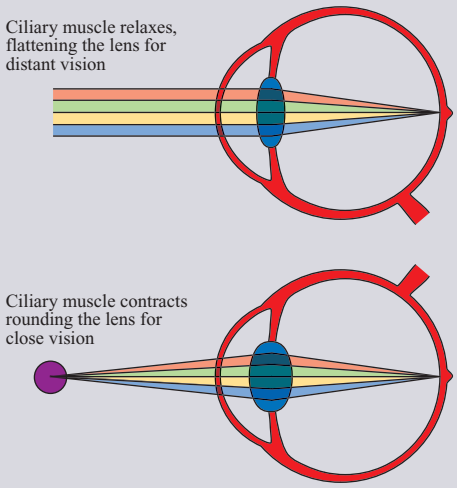
1. **Optics:** Light travels in a straight line until a new medium is encountered - it may then bend or be **refracted**.
a. The refractive tissues of the eye form a convex surface.
b. The distance at which the bent light converges to a focal point creates three conditions:
- **Emmetropia:** Focal point hits retina.
- **Myopia:** Focal point is in front of retina creating nearsightedness. Corrective lenses or surgery may correct refractive abnormalities.
- **Hypermetropia:** Focal point is behind retina, creating farsightedness.

Visual Conditions



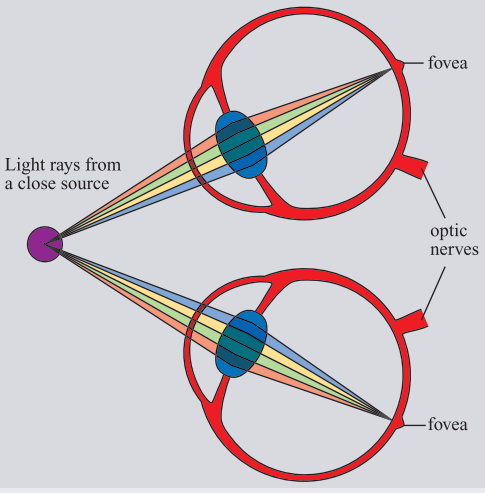
2. **Accommodation:** Objects closer than six meters (20 ft.) generally have light rays that must be refracted greatly, thus requiring the eye to accommodate or adjust. Involves three major actions:
a. **Lens shape**: Ciliary muscle contraction regulates the shape of the lens. **Presbyopia** occurs when lens loses elasticity with age, which decreases ability to accommodate.

Visual Accommodation



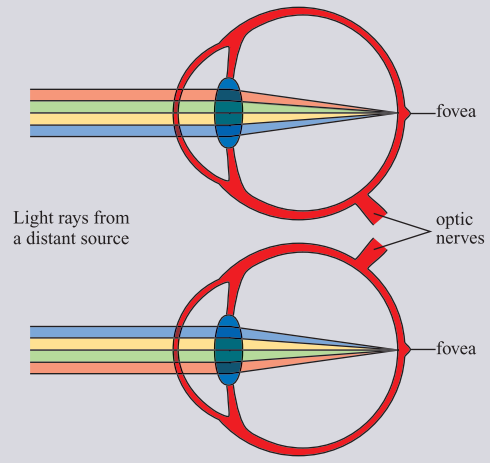
b. **Pupil size:** Pupillary dilator muscles relax while pupillary constrictors contract to eliminate divergent light rays, making refraction easier to accomplish.
c. **Eye convergence:** Eyes turn medially to focus light on the **fovea** or area of greatest visual acuity.

Eye Convergence



- **Near point:** Minimum distance from eye that object can be focused using accommodation.
- **Far point:** Distance from eye that does not require accommodation; generally six meters (20 ft.)
  • 20/20 vision is normal focusing at 20 ft.
  • 20/40 is only focusing objects at 20 ft. that a normal eye can focus at 40 ft.
  • 20/10 is focusing objects that a normal eye could only focus at 10 ft.

Visual Far Point



3. **Photoreceptors of the retina**
a. **Rods:** Respond to light levels, but not color; low threshold; good in dim light (i.e., night); common in peripheral areas of retina.
b. **Cones:** Respond to light levels and color (red, green, blue); high threshold; good in bright light conditions (e.g., day); common in fovea for visual acuity.

Physiology of Hearing & Equilibrium

Optional review: *"Ear" and "Ear Interior" sections, p.6 of* **Anatomy** *guide.*

Hearing

1. **Sound waves:** Produced by alternately compressing air and then relaxing the compression.
↑ Amplitude → ↑ Intensity (= Loudness)
↑ Frequency → ↑ Pitch
2. **Transmission of sound waves to inner ear:** Sound waves are directed by **pinna** (ear lobes) into **external auditory meatus** and eventually **tympanic membrane** (ear drum).
- Vibrations transferred to **malleus→incus→stapes**.
3. **Function of cochlea:** Stapes vibrates **oval window**, which pushes fluid in the **vestibular canal**.
- Depending on the frequency of the sound wave, an area of the **basilar membrane** vibrates, triggering **propagated action potentials** that travel via the **auditory nerve** to the brain.

Equilibrium

1. **Static equilibrium:** Maintaining body (head) position relative to gravity.
2. **Dynamic equilibrium:** Maintaining body (head) position in response to sudden movements.
- **Vestibular complex** is the sensory structure for equilibrium and consists of the **vestibule** and **semicircular canals**.

Endocrine System

Functions

Regulate cellular activity for:

1. **Metabolism**
2. **Growth**
3. **Development**
4. **Homeostasis**
5. **Reproduction**

Hormones

Chemicals derived from amino acids, lipids (e.g., steroids) and peptides are produced by and released from cells and trigger a response in same or other cells by binding to receptors (located inside or outside of cell).

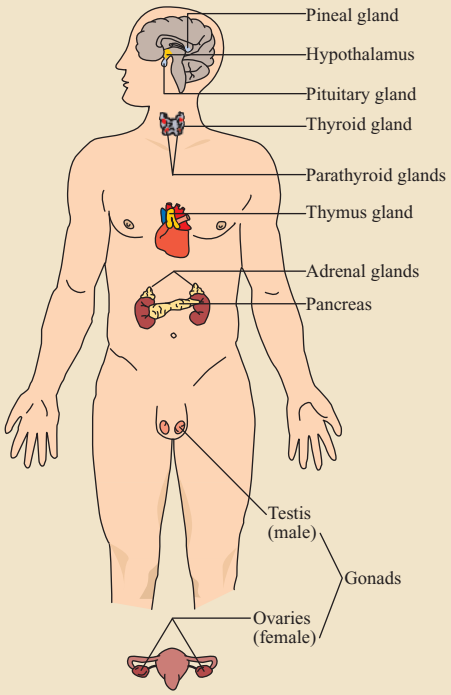
Three major types:

1. **Local hormones (cytokines):** Released into interstitial fluid (e.g., prostaglandins, histamines, growth factors).
   a. **Autocrine:** Same cell is affected.
   b. **Paracrine:** Neighboring cells affected.
2. **Neurotransmitters** (see *Chemical Synapses* section of this guide).
3. **Circulating hormones**: Released into blood and transported to cells throughout body.

Endocrine glands

Although every cell may release hormones, certain areas of the body serve as principal endocrine glands that release circulating hormones, resulting in numerous, complex responses by target cells. Hormone actions in general are regulated by **negative feedback systems**.

Major Endocrine Glands



Cardiovascular System

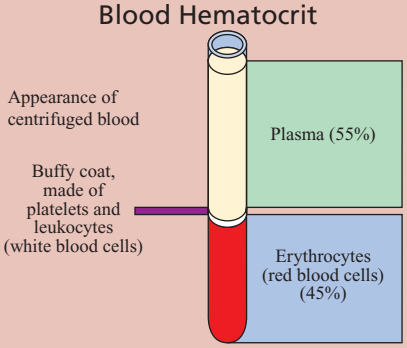
Blood Functions

1. **Transport:** O_2, CO_2, food, wastes, hormones.
2. **Homeostasis:** pH, temperature, defense, clotting, ion and fluid balance.

Composition

1. Water solution and cells; ratio is called **hematocrit.**

Blood Hematocrit



2. **Plasma:** Mostly H_2O, proteins (e.g., albumins, globulins, fibrinogen) and other solutes (e.g., electrolytes, nutrients, gases, enzymes, vitamins, wastes).
3. **Formed elements:** Cells produced in bone marrow by **hemopoiesis**.
   a. **Erythrocytes:** Red blood cells; composed of **hemoglobin**, used for gas transport; formation stimulated by **erythropoietin** from kidney; recycled in spleen.
   b. **Leukocytes:** White blood cells; most involved in defense.
      - **Granulocytes:**
        • Neutrophils
        • Eosinophils
        • Basophils
      - **Agranulocytes**
        • Monocytes
        • Lymphocytes (B and T cells)
   c. **Platelets:** Thrombocytes; involved in clotting.

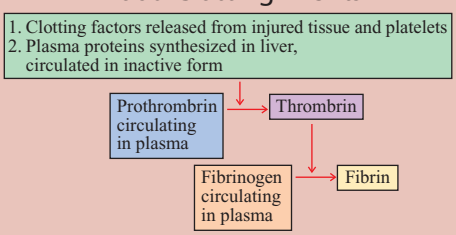
Hemostasis

Prevention of blood loss.

Three phases involved:

1. **Vascular constriction:** Walls of vessels may narrow at injury site to temporarily halt blood loss until next hemostatic phase. ↑pressure → ↑constriction; thus, applying pressure to a wound can increase this response.
2. **Platelet plug formation.**
3. **Coagulation:** Blood clotting.

Blood Clotting Events

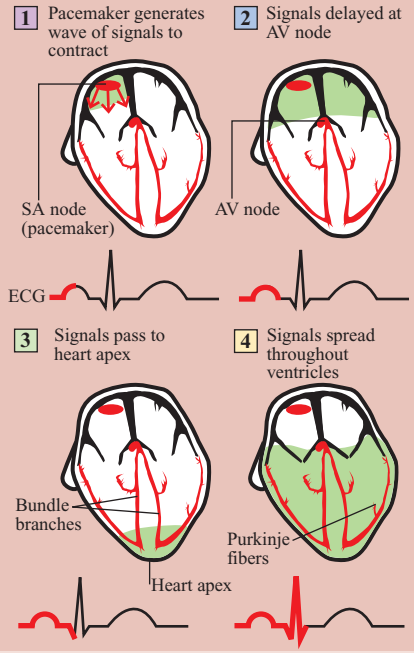


Heart & Circulation

Optional review: *"Heart" and "Blood Circuit" sections, p.3 of* **Anatomy** *guide and* **Heart** *and* **Circulatory System** *guides.*

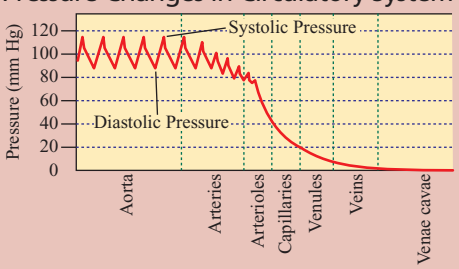
1. **Function:** Muscular organ contracts rhythmically, forcing blood through the body.
2. **PAPs in the heart**
   a. **P**ropagated **A**ction **P**otentials occur when the **Sinoatrial (SA) Node** depolarizes spontaneously 70-80 time/min.
   b. These rhythmic excitations spread via a conduction system through the heart, creating **systole** and **diastole** phases.
   c. An **electrocardiogram (ECG or EKG)** is a recording of these electrical changes.

Electrical Signals Regulating Heartbeat



3. **Cardiac output:**
   a. The volume of blood pumped by the heart every minute is related to the number of ventricular contractions (**heart rate**) and the amount of blood pumped per contraction (**stroke volume**).
   b. Numerous factors influence cardiac output.
   c. Total blood volume in body (4-6 L) is pumped every minute at rest.
   d. During exercise, total blood volume may circulate through body every 10 seconds (5-6 times per min).
4. **Blood pressure:**
   a. Arteries have highest pressure, which fluctuates between **systole** and **diastole**.
   b. Pressure drops off quickly in arterioles and is very low in the veins.
   c. At any given moment, most blood is found in the venous portion.
   d. Breathing and movement help push blood back to the heart by contracting muscles, which in turn compress veins.

Pressure Changes in Circulatory System



Lymphatic System

Optional review: *"Lymphatic Network" section, p.2 of* **Anatomy** *guide.*

Functions

1. **Fluid homeostasis:** Returns excess fluids that leak from blood capillaries to bloodstream.
2. **Transport:** Lipids from intestine delivered to bloodstream.
3. **Protection:** Part of immune response; involves lymph nodes, thymus, spleen.

Immune System

Nonspecific Immunity

Ability to protect against many different organisms, defective body cells and chemicals by using the same generalized responses.

Major components:

1. **Barriers:** Skin and mucous membranes cover and protect the body.
2. **Phagocytosis: Microphages** (neutrophils and eosinophils) and **macrophages** (mostly from monocytes) consume debris and foreign cells.
3. **Natural Killer (NK) cells:** Engage in **immune surveillance** or monitoring body for abnormal cells. May involve **interferon** cytokines.
4. **Inflammation:** Damaged tissues release **histamines** and other cytokines that trigger swelling, redness, heat and pain as **phagocytes** are activated. May activate **complement system** to enhance response.
5. **Fever:** Higher (within limits) body temperature speeds up body's response and may inhibit bacterial/viral replication.

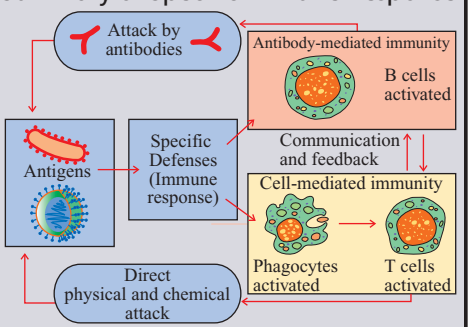
Specific Immunity

Protection based on individualized responses by recognition of "nonself" **antigens**.

Two major components:

1. **Cell-mediated response: Cytotoxic (killer) T cells** attack foreign cells directly.
2. **Humoral (antibody) response: B cells** produce immunoglobulin antibodies (IgG, IgE, IgD, IgM, or IgA) that are specific for antigens.
   - **Helper T cells** enhance this response; **suppressor T cells** inhibit.
   - Phagocytosis, complement system, inflammation may assist in attack.

Summary of Specific Immune Response



Respiratory System

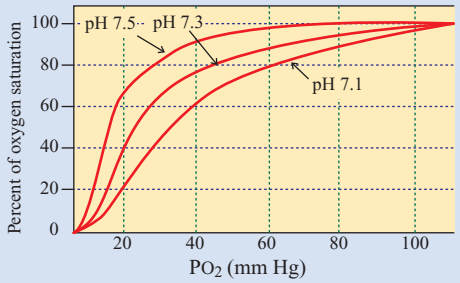
Optional review: *"Respiratory System" section, p.2 of* **Anatomy** *guide and* **Respiratory System** *guide.*

1. **Function:** Exchange O_2 and CO_2.
2. **Mechanics of breathing:** Ventilation of the lungs occurs by muscular **contractions/relaxations** that alter pressure within the thoracic cavity.

Gas Exchange

1. **Dalton's Law:** The pressure of a gas mixture is equal to the sum of the separate or partial pressures (e.g., Air = 1 atmosphere or 760mm Hg: pN_2 = 78% or 593mm Hg; pO_2 = 21% or 160mm Hg).
2. **Henry's Law:** Each gas in a mixture will dissolve proportionally to its partial pressure.
3. **Alveolar air:** The composition of air reaching the alveoli helps determine the dynamics of gas exchange with the blood.
4. **O_2 transport in blood:** Only 3% can dissolve in plasma; 97% of O_2 is transported by hemoglobin.
   - The binding of O_2 to hemoglobin is influenced by several factors:
     - pO_2, pH (**Bohr effect**), pCO_2, temperature.
     - **Active tissues** have low pO_2, low pH, high pCO_2 and high temperatures, all of which increase oxygen delivery.

Oxygen/Hemoglobin Dissociation Curves: Bohr Effect



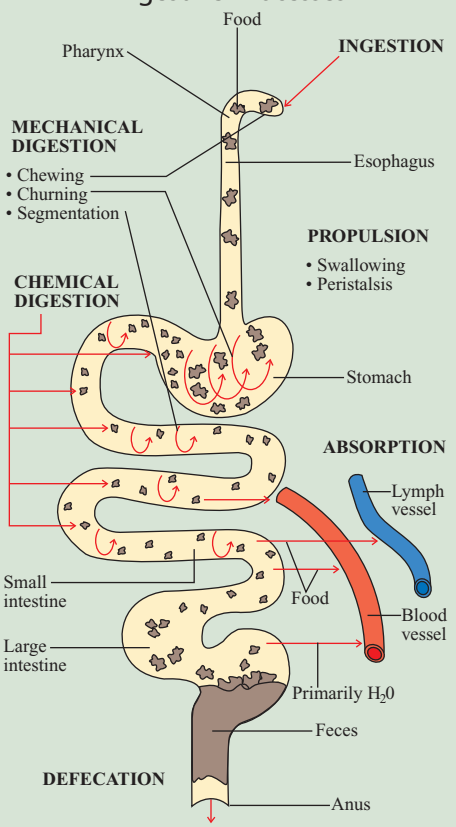
5. **CO_2 transport in blood:** Only 7% can dissolve in plasma; 23% binds to hemoglobin; 70% transported as HCO_3^-.

Digestive System

Optional review: *"Digestive System & Viscera" section, p.2 of* **Anatomy** *guide and* **Digestive System** *guide.*

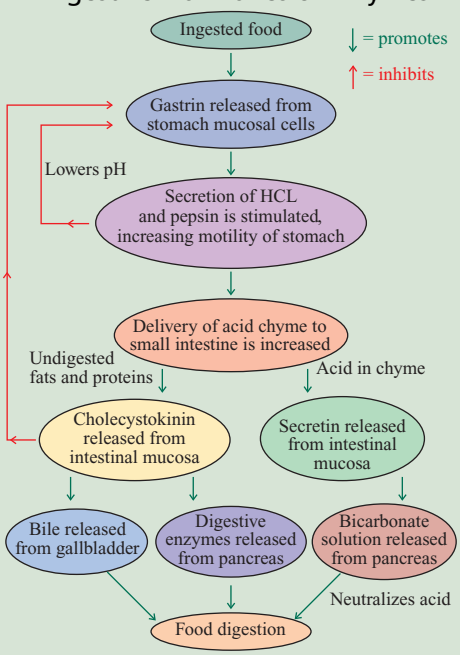
1. **Function:** Break down food so cells can be nourished.
2. **Mechanical digestion:** Various activities aid in presenting foods to the GI tract for absorption.
   a. **Mastication (chewing):** Breaks down large particles, mixing them with saliva.
   b. **Deglutition (swallowing):** Moves (via **peristalsis**) materials from mouth, to the pharynx, on to stomach.
   c. **Gastric/intestinal motility:** Peristalsis and mixing movements (**segmentation**) facilitate formation of small particles for absorption (requires chemical digestion, too).
3. **Chemical digestion:** Digestive enzymes break down large **macromolecules** (proteins, lipids, carbohydrates) into their constituent parts.
4. **Absorption:** Most food molecules are absorbed in the **small intestine**.
   - Some absorption occurs in large intestine (e.g., ions, water).
   - Undigested materials (**feces**) are expelled (**defecation**) via the rectum.

Digestive Processes



5. **Control of digestive processes:** Complex interactions involving **hormones** and **neural reflexes** highly coordinate mechanical and chemical digestion to facilitate absorption.

Digestive Hormones & Enzymes

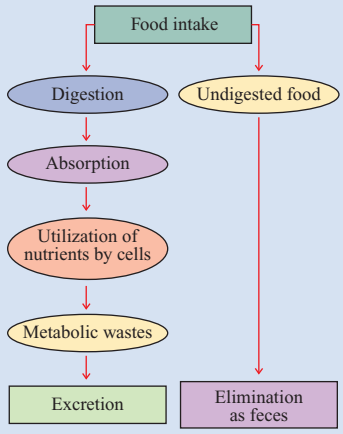


Urinary System

Optional review: *"Urinary System" section, p.2 of* **Anatomy** *guide.*

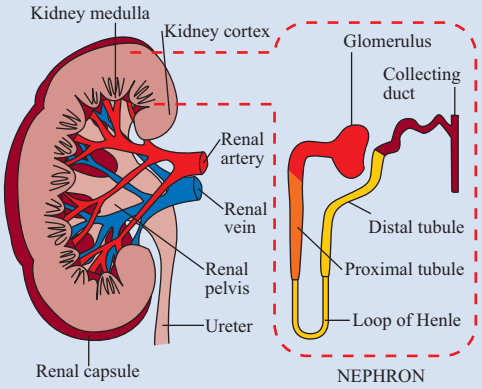
1. **Function:** Maintain **blood homeostasis**: i.e., pressure, pH, ionic balance and conserve nutrients while eliminating wastes.

Excretion vs. Digestion



2. **Nephron:** Functional unit of kidney found in cortex/medula.
   Two major portions:
   a. **Renal corpuscle:** Blood enters **Bowman's capsule** via **glomerulus** where a filtrate is formed.
   b. **Renal tubules:** Glomerular filtrate enters **proximal convoluted tubule** → **loop of Henle** → **distal convoluted tubule** → **collecting duct** where it is now urine.

Kidney & Nephron Structure



3. **Tubular secretion and reabsorption:**
   a. Glomerular filtrate entering **renal tubules** consists mostly of plasma minus proteins.
   b. 180 L (47 gallons) of filtrate are produced per day.
   c. Nearly all the plasma (and nutrients) must be reabsorbed by capillaries that follow the renal tubules.
   d. The **loop of Henle** dips deep into the medulla of the kidney, which has an **interstitial fluid** laden with solutes to help the blood vessels reabsorb water.
   e. **Electrolytes** may be actively and passively removed from the filtrate to help maintain ion balance of the blood and interstitial fluid of the kidney.
   f. Collecting tubule's permeability to water can be increased by **antidiuretic hormone** (ADH), which allows for more water reabsorption and more concentrated urine.

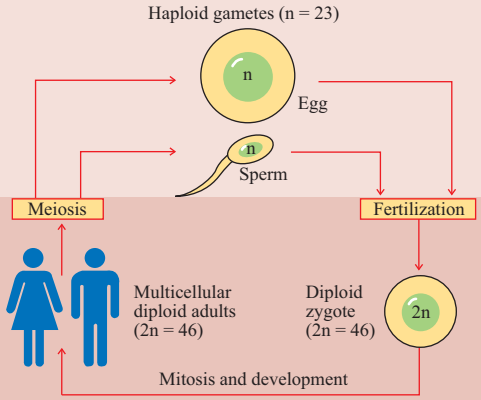
Reproductive System

Optional review: *"Male and Female Reproduction" sections, p.2 of* **Anatomy** *guide and* **Reproductive System** *guide.*

Functions

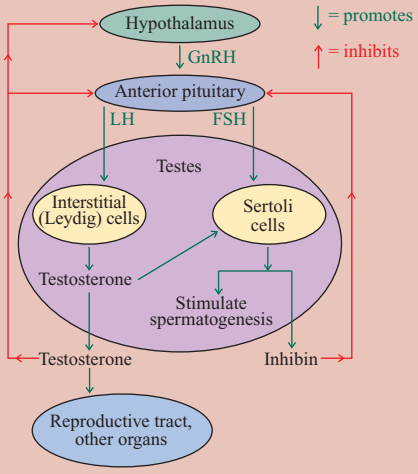
1. Perpetuate the species.
2. Maintain sexual characteristics.
3. **Human Life Cycle: Haploid** gametes (**sperm**, **eggs**) produced through **meiosis**, which also scrambles the DNA, creating unique cells. At fertilization, gametes fuse forming a **diploid zygote** and development occurs via **mitosis**.

Gametogenesis & Fertilization



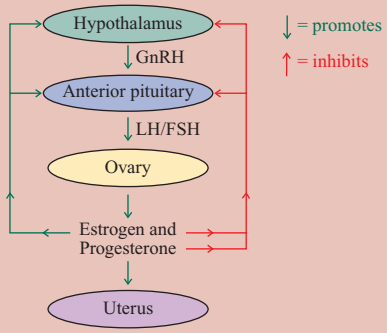
4. **Spermatogenesis**: At puberty, the brain releases **Gonadotropin-releasing hormone (GnRH)**, triggering a complex set of responses ultimately ending in the production of **sperm**.
   - Normal sperm development requires slightly lower temperature; thus, testes descend from body in **scrotum**.

Hormones & Spermatogenesis



5. **Oogenesis**: A female is born with her total supply of eggs.
   - At puberty, **GnRH** release triggers a cascade of events (the ovarian cycle), where each month one (usually) **oocyte** is released (**ovulation**) from the ovary into a **fallopian tube** where fertilization can occur.
6. **Ovarian cycle**: A complex, hormonally-controlled system where growing **oocytes** surrounded by cells (follicles) compete for ovulation.
   - **Estrogen effect:** Simultaneously thickens the **endometrium** (lining of uterus) for possible **implantation** after fertilization.

Hormones & Oogenesis



   a. The ovulated **primary follicle** leaves behind a **corpus luteum**, which prevents other oocytes from developing and being released (**progesterone-estrogen** effect).
   b. If fertilization and implantation occur, fetus will temporarily keep corpus luteum functioning by releasing **human chorionic gonadotropin**, or **HCG** (detected in pregnancy test kits).
   c. If fertilization does not occur, endometrium partially sloughs off (**menses**) and cycle occurs again monthly until **menopause**.
7. **Male sexual response**: The **penis** must become erect to facilitate fertilization by penetrating the **vagina**.
   a. Ejaculation activates sperm that are expelled via semen into the vagina.
   b. Ejaculation is usually accompanied by a pleasurable sensation called **orgasm**.
8. **Female sexual response**: Analogous engorgement of **clitoris** and associated vaginal tissues may occur leading to orgasm, but this response is not necessary for fertilization.
9. **Fertilization**: A high **sperm count** (i.e., multiple sperm) is necessary, as small quantities of enzymes are released from sperm and collectively break down barriers surrounding **egg**.
   a. Once a single sperm enters the egg, a series of events prevents other nearby sperm from entering.
   b. Normal fertilization occurs in the **fallopian tubes**, after which the embryo moves into the **uterus**, where it implants on the **endometrium** and forms a placental connection with the mother.
10. **Development**: At 10 weeks, the embryo has the basic human body plan and is called a **fetus**.
    - Developmental changes occur before and after birth (**parturition**).

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