UNIT 2

Integumentary System

The **integumentary system** is the outer covering of the body that protects the internal organs from the external environment. It also aids in **sensation**, **temperature regulation**, **excretion**, **vitamin D synthesis**, and **immunity**.

Components of the Integumentary System

1. **Skin**
2. **Hair**
3. **Nails**
4. **Sweat glands**
5. **Sebaceous (oil) glands**
6. **Sensory receptors**

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1. Skin *(Briefly)*

The **skin** is the **largest organ** of the body and has **three layers**:

- **Epidermis** – outermost layer, protective and avascular
- **Dermis** – middle connective tissue layer, vascular, contains glands, nerves, hair follicles
- **Hypodermis** – subcutaneous layer with fat and connective tissue for cushioning and insulation

Main functions: **protection**, **temperature regulation**, **sensation**, **vitamin D production**, and **excretion**.

(Detailed structure of skin is covered separately.)

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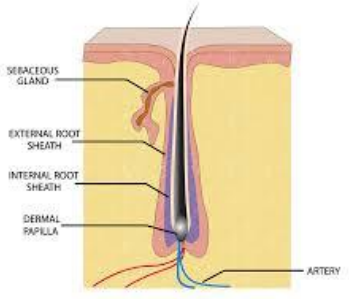
2. Hair

- **Hair** is a filament of **keratinized cells** growing from a follicle in the dermis.
- Composed of:
    - **Shaft** – visible part above skin
    - **Root** – below the skin
    - **Hair bulb** – base where cells divide
    - **Hair papilla** – contains blood vessels and nerves



Hair Follicle

A sheath surrounding the root and bulb, with associated **sebaceous glands** and **arrector pili muscle** (causes goosebumps).

Functions of Hair

- **Protection**: scalp from sun, eyes from dust (eyelashes)
- **Sensory**: detects light touch through follicle receptors
- **Thermoregulation**: traps heat in cold conditions

3. Nails

- **Nails** are hard **keratinized plates** at the tips of fingers and toes.
- Made of:
    - **Nail plate** – visible part
    - **Nail bed** – skin under the nail
    - **Nail root** – embedded in the skin
    - **Lunula** – white crescent-shaped base
    - **Cuticle** – fold of skin protecting the nail matrix

Functions of Nails

- Protect distal phalanges
- Aid in precise movements and grip
- Enhance sensation by counter-pressure on fingertips

4. Sebaceous (Oil) Glands

- Found in **dermis**, mostly attached to **hair follicles**
- Secrete **sebum**: an oily substance rich in lipids
- Sebum keeps skin and hair **moist, soft, and waterproof**
- Also has **antimicrobial properties**

Location

- Present all over the body except palms and soles
- Abundant on face, scalp, chest, and back

5. Sweat (Sudoriferous) Glands

Two main types:

a) Eccrine Glands

- Widely distributed; especially on **palms, soles, forehead**

- Secrete **watery sweat** directly to skin surface
- Function: **cooling** via evaporation and **excretion of salts and urea**

b) Apocrine Glands

- Located in **axillae, groin, nipples**
- Secrete **viscous sweat** into **hair follicles**
- Active after **puberty**; may produce body odor when broken down by bacteria

6. Sensory Receptors in Skin

- Specialized nerve endings detect stimuli:
    - **Meissner's corpuscles** – light touch
    - **Pacinian corpuscles** – deep pressure and vibration
    - **Merkel discs** – texture and steady pressure
    - **Ruffini endings** – skin stretch
    - **Free nerve endings** – pain and temperature

These receptors are located in the **epidermis and dermis**, allowing the skin to act as a **sensory interface**.

Functions of the Integumentary System

1. **Protection** – Barrier against physical injury, microbes, UV rays, and dehydration
2. **Temperature regulation** – Sweat glands and blood flow adjustments
3. **Sensation** – Touch, pressure, pain, and temperature
4. **Excretion** – Removal of urea, salts, and water via sweat
5. **Synthesis of vitamin D** – UV rays convert 7-dehydrocholesterol into vitamin D3
6. **Immunity** – Langerhans cells in epidermis help in immune defense
7. **Storage** – Fat in hypodermis stores energy and provides insulation

SKIN

Introduction

The skin is the **largest organ** of the human body. It forms the external covering and serves as a **protective interface** between the body and the external environment. It constitutes around **16% of total body weight** and plays a vital role in **protection, sensation, temperature regulation, excretion, immunity**, and **vitamin D synthesis**.

Major Layers of the Skin

The skin has **three primary layers**:

1. Epidermis

The epidermis is the **outermost layer** of the skin. It is composed of **stratified squamous keratinized epithelium** and is **avascular** (lacks blood supply). The nutrition comes from diffusion through capillaries in the dermis.

Layers of the Epidermis (from deep to superficial)

Stratum basale – Also known as stratum germinativum. This single layer of cuboidal or columnar cells is attached to the basement membrane. It contains mitotically active keratinocytes, melanocytes, and Merkel cells.

Stratum spinosum – Composed of several layers of polygonal keratinocytes held together by desmosomes, giving a spiny appearance.

Stratum granulosum – Contains 3–5 layers of flattened cells with keratohyalin granules and lamellar bodies. It marks the beginning of keratinization.

Stratum lucidum – Thin, translucent layer found only in thick skin (palms and soles). Consists of dead keratinocytes.

Stratum corneum – Outermost layer with 20–30 layers of dead, flattened, anucleated keratinized cells. Forms a protective barrier.

Cells in the Epidermis

Keratinocytes – 90% of epidermal cells; produce keratin, which gives toughness and waterproofing.

Melanocytes – Produce melanin pigment that protects against ultraviolet radiation. Located in the stratum basale.

Langerhans cells – Dendritic immune cells responsible for antigen presentation. Found in the stratum spinosum.

Merkel cells – Sensory receptor cells associated with nerve endings, responsible for touch perception. Found in stratum basale.

2. Dermis

The dermis lies below the epidermis. It is made of **connective tissue** and contains **blood vessels, lymphatic vessels, nerves, hair follicles, sebaceous glands, sweat glands,** and **sensory receptors**. It is divided into two layers:

Papillary layer – The superficial layer made of loose areolar connective tissue. It has dermal papillae that interlock with epidermal ridges and contain capillaries and Meissner's corpuscles (touch receptors).

Reticular layer – The deeper layer consisting of dense irregular connective tissue. It provides strength and elasticity to skin and houses the larger blood vessels, sweat and sebaceous glands, Pacinian corpuscles (pressure receptors), and hair follicles.

3. Hypodermis (Subcutaneous Layer)

Located beneath the dermis, this layer is made of **loose areolar connective tissue** and **adipose tissue**. It anchors the skin to underlying muscles and bones.

Functions of hypodermis:

- Insulation
- Energy storage
- Shock absorption
- Allows movement of skin over underlying tissues

Functions of the Skin

Protection – Acts as a barrier against mechanical injury, pathogens, chemical substances, and UV radiation.

Thermoregulation – Maintains body temperature through sweating and vasodilation/vasoconstriction.

Sensation – Contains sensory receptors that detect touch, pressure, pain, heat, and cold.

Excretion – Removes urea, ammonia, salts, and water through sweat.

Vitamin D synthesis – UV rays convert 7-dehydrocholesterol in the skin into cholecalciferol (vitamin D3).

Immune defense – Langerhans cells detect pathogens and initiate immune response.

Storage – Stores lipids and water in the dermis and hypodermis.

Skin Appendages (Derived from Epidermis)

Hair

Hair is composed of keratinized cells and grows from hair follicles in the dermis. Each hair consists of a shaft (visible part), root (embedded in skin), and bulb (base of follicle). Hair follicle contains dermal papilla with blood supply and matrix cells for growth.

Functions:

- Protection of scalp and eyes (eyelashes)
- Sensory function through follicle receptors
- Thermoregulation by trapping air

Nails

Nails are made of hard keratin. They protect the fingertips and enhance grip.

Parts:

- Nail plate – visible part
- Nail bed – skin under the nail
- Nail root – embedded in skin

- Lunula – white crescent
- Nail matrix – produces new cells
- Cuticle – skin fold protecting matrix

Sebaceous Glands

These are oil glands associated with hair follicles. They secrete **sebum**, a lipid-rich secretion that lubricates the skin and hair and provides antibacterial properties. Found all over the body except palms and soles.

Sweat Glands

Two main types:

Eccrine glands – Widely distributed, open directly onto the skin. Secrete watery sweat for thermoregulation and excretion.

Apocrine glands – Found in axillae, areola, and genital areas. Open into hair follicles. Active after puberty. Secretion is milky and may cause body odor when broken down by bacteria.

Sensory Receptors

The skin contains specialized nerve endings:

- Meissner's corpuscles – light touch (papillary dermis)
- Pacinian corpuscles – deep pressure and vibration (reticular dermis)
- Merkel cells – light touch (epidermis)
- Ruffini endings – stretch
- Free nerve endings – pain and temperature

Skin Color

Skin color is determined by:

Melanin – Brown-black pigment from melanocytes. Protects DNA from UV damage.

Carotene – Yellow-orange pigment from diet (carrots, sweet potatoes).

Hemoglobin – Red color from oxygenated blood in capillaries. Gives a pink tone in light-skinned individuals.

Clinical Conditions Related to Skin

Albinism – Genetic absence of melanin due to lack of tyrosinase enzyme.

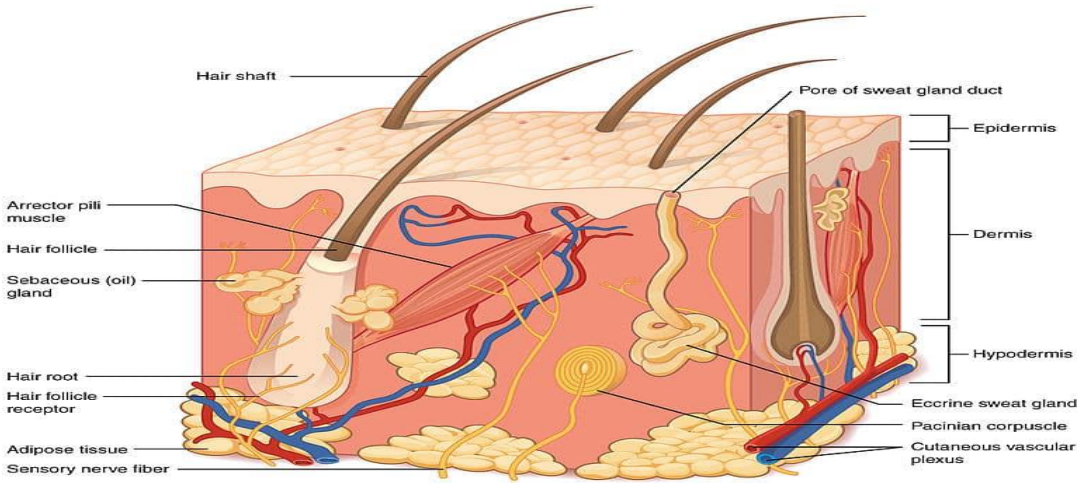
Vitiligo – Autoimmune destruction of melanocytes causing white patches.

Jaundice – Yellowing due to excess bilirubin, indicating liver dysfunction.

Cyanosis – Bluish discoloration due to low oxygen levels in blood.

Callus – Thickened area due to excessive friction.

Burns – Damage due to heat, chemicals, or radiation.



Skeletal System

Introduction

The skeletal system forms the **framework of the human body**, providing **shape, protection, movement, and support**. It also plays a role in **mineral storage (like calcium and phosphorus)**, **blood cell production** (hematopoiesis), and **fat storage**.

An **adult human skeleton** typically contains **206 bones**.

Divisions of the Skeletal System

The skeleton is divided into two main parts:

1. Axial Skeleton

It consists of **80 bones** that lie along the **central axis** of the body. Functions mainly for **support and protection** of organs in the head, neck, and trunk.

Components:

- **Skull (22 bones)**
  Includes cranial bones (8) and facial bones (14)
- **Hyoid bone (1 bone)**
  U-shaped bone in the neck, supports the tongue
- **Auditory ossicles (6 bones)**
  Small bones in the middle ear (malleus, incus, stapes)
- **Vertebral column (26 bones)**
  - Cervical – 7
  - Thoracic – 12

    - Lumbar – 5
    - Sacrum – 1 (fused)
    - Coccyx – 1 (fused)
- **Thoracic cage (25 bones)**
    - Sternum – 1
    - Ribs – 24 (12 pairs)

2. Appendicular Skeleton

It consists of **126 bones** that include the limbs and girdles, enabling **movement and locomotion**.

Components:

- **Pectoral (Shoulder) girdle (4 bones)**
    - Clavicles (2)
    - Scapulae (2)
- **Upper limbs (60 bones)**
    - Humerus – 2
    - Radius – 2
    - Ulna – 2
    - Carpals (wrist bones) – 16
    - Metacarpals – 10
    - Phalanges (fingers) – 28
- **Pelvic girdle (2 bones)**
    - Hip bones (2), each formed by fusion of ilium, ischium, and pubis
- **Lower limbs (60 bones)**
    - Femur – 2
    - Patella – 2
    - Tibia – 2
    - Fibula – 2
    - Tarsals (ankle bones) – 14
    - Metatarsals – 10
    - Phalanges (toes) – 28

Types of Bone (Based on Shape)

Bones are classified into **five major types** based on their shape and structure:

1. Long Bones

- Greater in length than width
- Mostly found in limbs
- Have a shaft (diaphysis) and two ends (epiphyses)

Examples:
Humerus, femur, tibia, fibula, radius, ulna, metacarpals, metatarsals, phalanges

2. Short Bones

- Nearly equal in length, width, and thickness
- Cube-shaped and provide support with little movement

Examples:
Carpals (wrist bones), tarsals (ankle bones)

3. Flat Bones

- Thin, flattened, and often curved
- Provide protection and surfaces for muscle attachment

Examples:
Cranial bones (frontal, parietal), sternum, ribs, scapula

4. Irregular Bones

- Complex shapes that don't fit into other categories
- Vary in shape and function

Examples:
Vertebrae, pelvic bones, sphenoid, ethmoid

5. Sesamoid Bones

- Small, round bones embedded in tendons
- Protect tendons from wear and stress

Examples:
Patella (kneecap), small sesamoids in hands and feet

Salient Features and Functions of Bones of Axial and Appendicular Skeleton

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Axial Skeleton – 80 Bones

The axial skeleton forms the **central axis of the body** and is primarily involved in **protection**, **support**, and **attachment of muscles**.

1. Skull (22 Bones)

- **Cranial bones (8):** Frontal, parietal (2), temporal (2), occipital, sphenoid, ethmoid
    - Protects the brain
    - Provides attachment for head and neck muscles
- **Facial bones (14):** Maxillae (2), zygomatic (2), nasal (2), lacrimal (2), palatine (2), inferior nasal conchae (2), vomer, mandible
    - Framework of the face
    - Support for sense organs (smell, vision, taste)
    - Openings for air and food passage
    - Secure teeth and provide anchor for facial muscles

2. Hyoid Bone (1)

- U-shaped bone in the anterior neck
- Suspended by ligaments and muscles
- **Supports the tongue** and **serves as an attachment point for muscles of the neck and pharynx**
- Does **not articulate with any other bone**

3. Auditory Ossicles (6)

- **Malleus, incus, stapes (3 in each ear)**
- Located in the middle ear cavity
- **Transmit sound vibrations** from the eardrum to the inner ear

4. Vertebral Column (26 Bones)

- **Cervical (7), Thoracic (12), Lumbar (5), Sacrum (1 fused), Coccyx (1 fused)**
- Forms the **backbone**
- **Protects the spinal cord**
- Supports head and trunk
- Allows **flexibility and movement**
- Attachment for ribs and back muscles

5. Thoracic Cage (25 Bones)

- **Ribs (24)** – 12 pairs
    - 7 pairs true ribs (attached directly to sternum)
    - 5 pairs false ribs (including 2 floating ribs)
- **Sternum (1)** – Manubrium, body, xiphoid process
- **Protects vital organs** like heart and lungs
- Supports shoulder girdles and upper limbs
- Aids in **breathing** by expanding and contracting during respiration

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Appendicular Skeleton – 126 Bones

The appendicular skeleton includes bones of the **limbs and girdles** and is primarily involved in **movement and locomotion**.

1. Pectoral Girdle (4 Bones)

- **Clavicle (2)** – S-shaped bones that connect sternum to scapula
    - Acts as a strut to keep the arm away from the thorax
- **Scapula (2)** – Flat triangular bones
    - Attachment site for arm and shoulder muscles
    - Allows wide range of shoulder movement

2. Upper Limbs (60 Bones)

- **Humerus (2)** – Long bone of the upper arm
    - Forms shoulder and elbow joints
- **Radius (2)** and **Ulna (2)** – Forearm bones
    - Radius is lateral, ulna is medial
    - Allow rotation (pronation/supination)
- **Carpals (16)** – 8 bones in each wrist
    - Allow wrist flexibility
- **Metacarpals (10)** – Form palm
    - Support palm and hand movements
- **Phalanges (28)** – Finger bones
    - 3 in each finger, 2 in thumbs
    - Fine motor functions and grip

3. Pelvic Girdle (2 Bones)

- **Hip bones (coxal bones)** – Each formed by fusion of ilium, ischium, and pubis
    - Strong and heavy to support body weight
    - Articulates with sacrum at sacroiliac joint
    - Supports pelvic organs and transmits weight from upper to lower limbs

4. Lower Limbs (60 Bones)

- **Femur (2)** – Thigh bone, longest and strongest bone
    - Supports body weight during walking and standing
- **Patella (2)** – Kneecap
    - Protects knee joint and improves leverage of thigh muscles
- **Tibia (2)** and **Fibula (2)** – Leg bones
    - Tibia bears most weight; fibula stabilizes ankle
- **Tarsals (14)** – 7 bones in each ankle
    - Talus, calcaneus (heel), navicular, cuboid, and cuneiforms
    - Provide stability and shock absorption
- **Metatarsals (10)** – Foot arch support
- **Phalanges (28)** – Toe bones
    - Important for balance and walking

Summary of Major Functions of Skeletal System

- Provides **structural support** and body shape
- Protects internal organs (e.g., brain, heart, lungs)
- Facilitates **movement** by serving as levers for muscles
- Stores **minerals** like calcium and phosphorus
- Houses **bone marrow** for hematopoiesis
- Acts as a **reservoir for fat** in yellow marrow

Organization of Skeletal Muscle

1. Skeletal Muscle Overview

Skeletal muscle is a type of **striated, voluntary muscle tissue** attached to bones, facilitating **movement** through contraction.

2. Structural Hierarchy

Skeletal muscle is organized in **a multi-layered connective tissue framework**:

a) Muscle Fiber (Cell)

- Long, cylindrical, multinucleated cell
- Contains **myofibrils** (contractile units)

b) Myofibrils

- Composed of repeating units called **sarcomeres**
- Contain **actin (thin)** and **myosin (thick)** filaments
- Responsible for striations and contraction

c) Sarcomere

- The **functional unit** of muscle contraction
- Runs from one **Z-line to the next Z-line**
- Contains:
    - **A-band** (dark, myosin region)
    - **I-band** (light, actin region)
    - **H-zone** (center of A-band, only myosin)
    - **M-line** (midline proteins holding myosin)

d) Sarcolemma

- The **plasma membrane** of the muscle fiber
- Conducts **action potentials**

e) Sarcoplasmic Reticulum (SR)

- Specialized endoplasmic reticulum storing **calcium ions (Ca^{2+})**
- Releases Ca^{2+} during stimulation

f) T-tubules

- Invaginations of sarcolemma into the cell
- Conduct impulses deep into muscle fiber
- Coordinate Ca^{2+} release from SR

g) Connective Tissue Coverings

- **Endomysium**: Around individual muscle fibers
- **Perimysium**: Around fascicles (bundles of fibers)
- **Epimysium**: Around entire muscle

Physiology of Muscle Contraction

1. Neuromuscular Junction (NMJ)

- The point of contact between **motor neuron** and **muscle fiber**
- Neurotransmitter: **Acetylcholine (ACh)**
- ACh binds to receptors on sarcolemma → generates **action potential**

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2. Excitation-Contraction Coupling

1. **Action potential** travels along sarcolemma and enters through **T-tubules**
2. Stimulates **Sarcoplasmic Reticulum** to release **Ca^{2+}**
3. Ca^{2+} binds to **troponin**, causing **tropomyosin** to move and expose binding sites on actin
4. **Myosin heads** bind to actin → form **cross-bridges**

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3. Sliding Filament Theory

The theory explains how **actin and myosin filaments slide over each other**, causing shortening of sarcomeres and thus muscle contraction.

Steps:

1. **Cross-bridge formation**
   Myosin head binds to actin
2. **Power stroke**
   Myosin head pulls actin filament → ADP + Pi are released
3. **Detachment**
   New ATP binds to myosin → myosin detaches from actin
4. **Reactivation**
   ATP is hydrolyzed → myosin head returns to original position

This cycle continues as long as **Ca^{2+} and ATP** are available.

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4. Relaxation of Muscle

- **ACh is broken down** by **acetylcholinesterase**
- Ca^{2+} is **reabsorbed** by SR
- **Troponin-tropomyosin complex** returns to resting state
- Actin-myosin interaction stops → muscle **relaxes**

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5. Energy for Muscle Contraction

- **Immediate:** ATP (few seconds only)
- **Short-term:** Creatine phosphate system
- **Mid-term:** Anaerobic glycolysis (produces lactic acid)
- **Long-term:** Aerobic respiration (glucose, fatty acids, oxygen)

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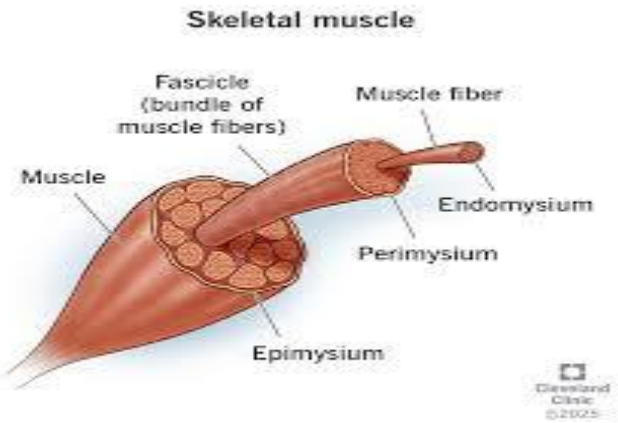
6. Clinical Insight

- **Myasthenia Gravis**: Autoimmune disorder at NMJ causing muscle weakness
- **Muscle fatigue**: Due to accumulation of lactic acid and depletion of ATP



Neuromuscular Junction (NMJ)

Definition

The **neuromuscular junction** is a specialized **synapse** where a **motor neuron communicates with a skeletal muscle fiber**, leading to **muscle contraction**. It is also called the **myoneural junction**.

Structure of Neuromuscular Junction

The NMJ consists of three key components:

1. **Presynaptic Terminal (Motor Neuron Ending)**
    - Contains **synaptic vesicles** filled with the neurotransmitter **acetylcholine (ACh)**
    - Has **voltage-gated calcium channels**
2. **Synaptic Cleft**
    - A narrow **space (20–30 nm)** between the neuron and muscle fiber
    - Filled with **extracellular fluid and acetylcholinesterase (AChE)**

3. **Postsynaptic Membrane (Motor End Plate)**
    - The **sarcolemma** of the muscle fiber at the junction
    - Contains **ACh receptors (nicotinic receptors)**
    - These receptors are **ligand-gated sodium channels**

Steps in Neuromuscular Transmission

1. **Nerve Impulse Arrives**
    - An action potential reaches the axon terminal of the motor neuron
2. **Calcium Influx**
    - Voltage-gated **Ca^{2+} channels open**, and **Ca^{2+} enters** the presynaptic terminal
3. **ACh Release**
    - Synaptic vesicles fuse with the membrane and **release ACh into the synaptic cleft** via exocytosis
4. **ACh Binding**
    - ACh diffuses across the cleft and **binds to ACh receptors** on the motor end plate
5. **Generation of Action Potential**
    - Binding opens **Na^{+} channels**, causing **influx of sodium ions** into the muscle fiber
    - Leads to **depolarization** of sarcolemma → **action potential** generated
6. **Propagation**
    - Action potential travels along the sarcolemma and into the **T-tubules** to trigger **muscle contraction**
7. **Termination of Signal**
    - ACh is rapidly broken down by **acetylcholinesterase** into **acetate and choline**
    - Prevents continuous stimulation of the muscle fiber
    - Choline is **reabsorbed** by the neuron to **synthesize new ACh**

Significance of NMJ

- Ensures **precise communication** between the nervous system and muscle
- Converts **electrical signals** into **mechanical contraction**
- Controls **voluntary muscle movement**

Clinical Correlations

1. **Myasthenia Gravis**
    - Autoimmune disease where antibodies **block or destroy ACh receptors**
    - Causes **muscle weakness and fatigue**
2. **Botulism**
    - Caused by **Clostridium botulinum toxin**
    - **Prevents ACh release** → leads to **flaccid paralysis**
3. **Curare Poisoning**
    - Curare **blocks ACh receptors** at NMJ
    - Results in muscle paralysis
4. **Organophosphate Poisoning**
    - Inhibits **acetylcholinesterase** → excess ACh accumulation
    - Leads to continuous stimulation, spasms, or paralysis

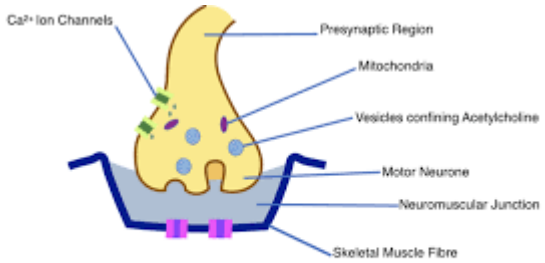


Fig 2. Structure of a Neuromuscular Junction.

Joints (Articulations)

A **joint** is a point where **two or more bones meet**, allowing for **movement** or **providing stability**. Joints are vital for body mobility and flexibility.

Classification of Joints

Joints can be classified based on:

1. **Structure** – Based on the type of connective tissue and presence/absence of synovial cavity
2. **Function** – Based on the **degree of movement** permitted

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1. Structural Classification of Joints

There are **three structural types**:

a) Fibrous Joints

- **Bones are joined by dense fibrous connective tissue**

- **No synovial cavity**
- **Immovable or slightly movable (synarthrosis or amphiarthrosis)**

Examples:

- **Sutures** (skull bones) – immovable
- **Syndesmoses** (distal tibiofibular joint) – slightly movable
- **Gomphosis** (teeth in sockets) – immovable

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b) Cartilaginous Joints

- **Bones are connected by cartilage (hyaline or fibrocartilage)**
- **No synovial cavity**
- **Slightly movable (amphiarthrosis)**

Types:

- **Synchondrosis** – hyaline cartilage (e.g., epiphyseal plate in growing bone)
- **Symphysis** – fibrocartilage (e.g., pubic symphysis, intervertebral discs)

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c) Synovial Joints

- **Bones are separated by a fluid-filled synovial cavity**
- **Freely movable (diarthrosis)**
- Most common joint type in the body

Features:

- Articular cartilage (hyaline)
- Synovial cavity filled with synovial fluid
- Articular capsule (fibrous + synovial membrane)
- Accessory ligaments and sometimes menisci or bursae

Examples: Shoulder, knee, hip, elbow, wrist

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2. Functional Classification of Joints

This classification is based on **how much movement** the joint allows:

a) Synarthrosis (Immovable joints)

- Provide stability and protection
- **Examples:** Skull sutures, gomphosis

b) Amphiarthrosis (Slightly movable joints)

- Provide limited mobility with strength
- **Examples:** Intervertebral discs, pubic symphysis

c) Diarthrosis (Freely movable joints)

- Provide a wide range of motion
- All **synovial joints** fall under this category
- Subtypes based on movement axes (see below)

Types of Synovial (Diarthrosis) Joints Based on Movement

Type of Synovial Joint	Description	Example
Plane (gliding)	Flat surfaces, side-to-side movement	Intercarpal joints
Hinge	Flexion and extension	Elbow, knee
Pivot	Rotation around axis	Atlantoaxial joint (C1–C2), radioulnar joint
Condyloid (ellipsoidal)	Flexion, extension, abduction, adduction	Wrist joint
Saddle	Like condyloid, but more freedom	Thumb joint (carpometacarpal)
Ball-and-socket	Multiaxial movement	Shoulder, hip

Summary Table

Classification	Subtypes	Mobility	Example
Fibrous	Sutures, syndesmoses, gomphoses	Immovable or slightly movable	Skull, tibiofibular joint
Cartilaginous	Synchondrosis, symphysis	Slightly movable	Epiphyseal plate, pubic symphysis
Synovial	Plane, hinge, pivot, etc.	Freely movable	Shoulder, knee

Types of Joint Movements and Their Articulations

🔹 What is Joint Movement?

Joint movement refers to the **specific types of motions** permitted at a joint based on its **structure and articulation**. Only **synovial joints** allow **free movement** (diarthrosis), while fibrous and cartilaginous joints have limited or no movement.

🔹 Types of Movements at Synovial Joints

Movements are classified into the following **major types**:

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1. Gliding Movement

- **Definition:** Sliding motion between flat bone surfaces
- **Occurs in:** Plane joints
- **Example:** Intercarpal joints (wrist), intertarsal joints (foot)

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2. Angular Movements

These involve changes in the **angle between two bones**.

a) Flexion

- Decreases the angle between bones
- Example: Bending elbow, knee, or neck forward

b) Extension

- Increases the angle between bones
- Example: Straightening elbow or knee

c) Hyperextension

- Extension beyond the anatomical position
- Example: Looking upward (neck hyperextension)

d) Abduction

- Movement away from the midline
- Example: Raising arm sideways

e) Adduction

- Movement toward the midline

- Example: Bringing arm down to side

f) Circumduction

- Circular motion combining flexion, extension, abduction, and adduction
- Example: Shoulder and hip joints

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3. Rotational Movements

Rotation around the **longitudinal axis** of a bone

a) Medial (Internal) Rotation

- Rotation toward the midline
- Example: Rotating the thigh inward

b) Lateral (External) Rotation

- Rotation away from the midline
- Example: Turning the head side to side

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4. Special Movements

These are movements unique to **certain joints**:

Movement	**Definition**	**Example**
Elevation	Upward movement	Closing the mouth, shrugging shoulders
Depression	Downward movement	Opening the mouth
Protraction	Moving body part forward	Pushing jaw forward
Retraction	Moving body part backward	Pulling jaw backward
Inversion	Turning sole of foot inward	Ankle joint
Eversion	Turning sole of foot outward	Ankle joint
Dorsiflexion	Bending foot upward (toes to shin)	Ankle joint
Plantar flexion	Pointing foot downward	Ankle joint
Supination	Turning palm upward (anatomical position)	Forearm
Pronation	Turning palm downward	Forearm
Opposition	Touching thumb to fingers	Thumb joint (saddle joint)

Articulations and Movement Types

Each **synovial joint type** allows specific types of movement:

Type of Synovial Joint	Articulating Bones	Permitted Movements	Example
Plane (Gliding)	Flat/slightly curved surfaces	Gliding	Intercarpal joints
Hinge	Convex + concave surfaces	Flexion, extension	Elbow, knee
Pivot	Rounded surface + ring	Rotation	Atlantoaxial joint, radioulnar joint
Condyloid (Ellipsoidal)	Oval convex + concave surface	Flexion, extension, abduction, adduction, circumduction	Wrist joint
Saddle	Saddle-shaped bones	Similar to condyloid but more freedom	Carpometacarpal joint of thumb
Ball-and-socket	Ball-like head + socket	All movements (multiaxial)	Shoulder, hip