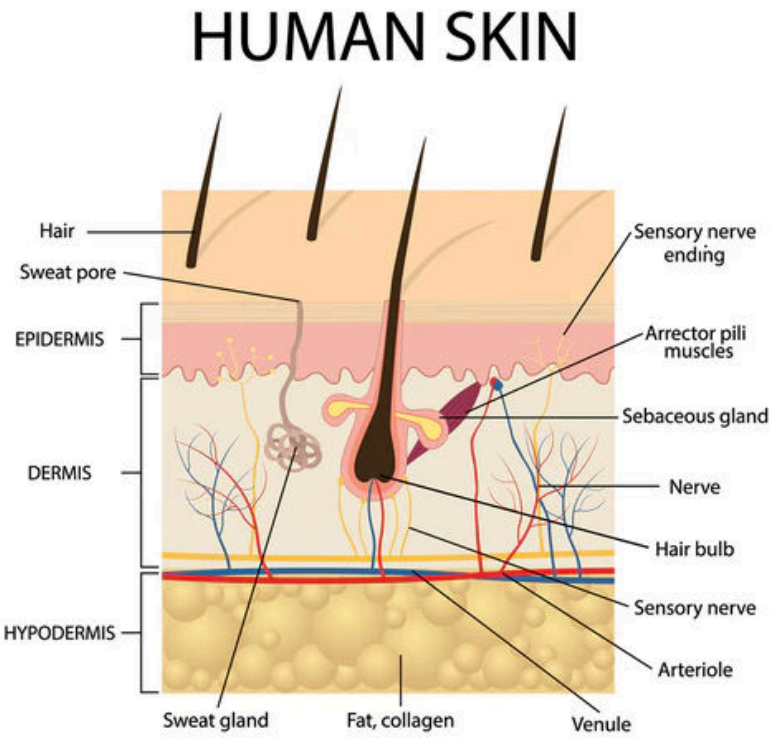
The Integumentary system

- **Why Is Skin an Organ?**



1. Made of Multiple Tissues

- An organ is defined as a structure made up of two or more types of tissues working together to perform specific functions.

- **Skin contains:**

    - **Epithelial tissue (epidermis)**

- **Connective tissue (dermis)**
- **Nervous tissue (sensory receptors)**
- **Muscle tissue (arrector pili muscles)**

2. Performs Vital Functions

Skin carries out several essential functions, just like other organs:

Function	Description
Protection	Acts as a barrier against microbes, UV rays, and dehydration
Sensation	Contains receptors for touch, pain, temperature
Temperature Regulation	Through sweating and blood vessel dilation/constriction
Excretion	Removes waste like urea and salts through sweat
Vitamin D Synthesis	Helps produce vitamin D in response to UV light
Water Balance	Prevents excessive water loss from body

3. Highly Organized Structure:

- Skin has three layers with specialized cells and structures:
    - Epidermis, Dermis, and Hypodermis (subcutaneous)
- Works in coordination, just like other organs (e.g., heart, liver).

☐ What types of tissues make up the skin?

The skin is made up of **all four types of animal tissue**, but the main ones are:

🧫 1. Epithelial Tissue

Main tissue of the outer layer of skin (epidermis)

- Specifically: **Stratified squamous epithelium** (keratinized)
- Function: Protection from abrasion, pathogens, and water loss
- Contains cells like **keratinocytes**, **melanocytes**, and **Langerhans cells**

🧵 2. Connective Tissue:

Found mainly in the dermis (middle layer)

- Includes **loose connective tissue**, **dense irregular connective tissue**, **collagen**, and **elastin fibers**
- Contains **blood vessels**, **nerves**, and **immune cells**
- Provides **strength, elasticity, and support**

🧠 3. Nervous Tissue

- Found throughout the **dermis**

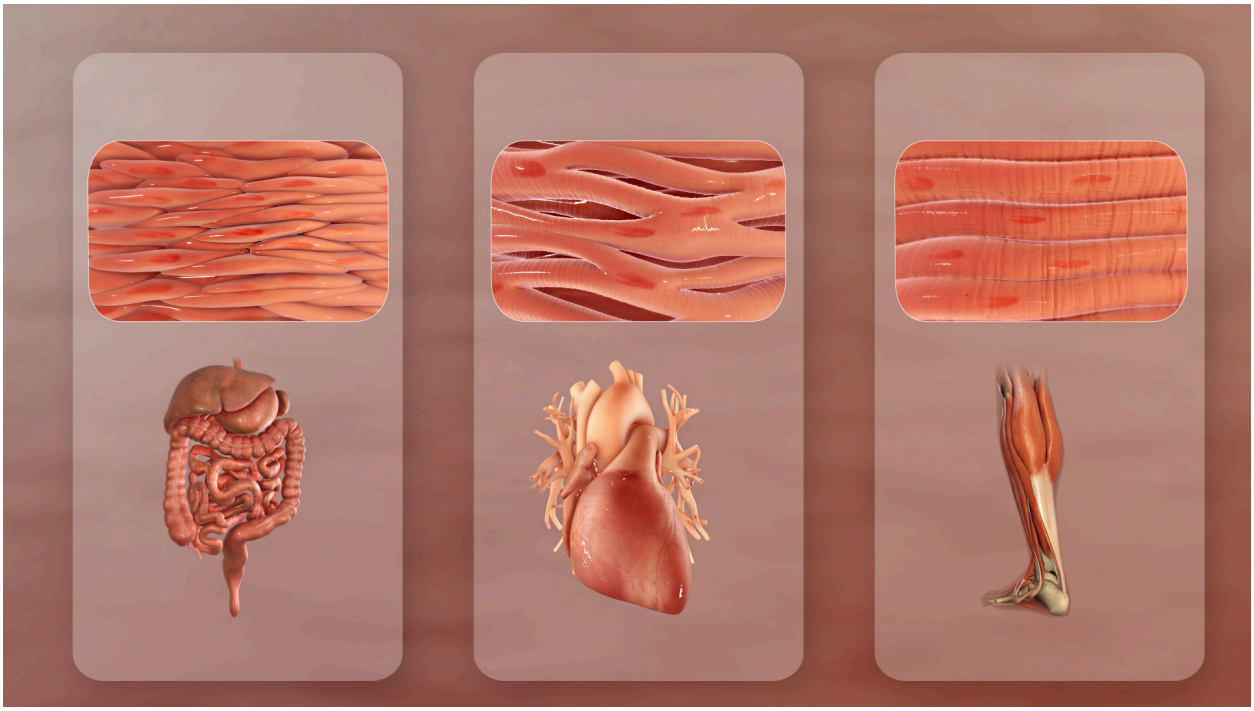
- Includes **sensory receptors** for touch, temperature, and pain
- Connected to **nerve endings** that transmit signals to the brain

💪 4. Muscle Tissue

- Found in small amounts in the skin (e.g., **arrector pili muscles**)
- Type: **Smooth muscle**
- Function: Raises hairs during cold or fear ("goosebumps")

TYPES OF MUSCLE

The human body contains over 600 muscles, which are classified into **three main types** based on their structure, control mechanism, and function:



Smooth muscle **Cardiac muscle** **Skeletal muscle**

1. Skeletal Muscle

Structure:

- **Striated** (has a striped appearance under a microscope due to the arrangement of actin and myosin filaments)
- **Multinucleated** (each cell/fiber has multiple nuclei)
- **Long cylindrical fibers**
- **Voluntary control** (controlled consciously)

Function:

- Responsible for **movement** of the skeleton (e.g., walking, lifting)
- Maintains **posture** and **body position**
- Produces **heat** (through contraction—helps in thermoregulation)

Location/Examples:

- Attached to bones via tendons
    - **Biceps brachii** – bends the elbow
    - **Quadriceps** – extends the knee
    - **Diaphragm** – aids in breathing (note: although skeletal, it is partly involuntary)

2. Cardiac Muscle

Structure:

- **Striated** (like skeletal muscle)
- **Uninucleated** (usually one nucleus per cell)
- **Branched fibers**
- Contains **intercalated discs** (special connections between cells that allow synchronized contraction)
- **Involuntary control**

Function:

- Pumps **blood** throughout the body by contracting the heart chambers rhythmically
- Coordinates **heartbeats** without conscious control (myogenic origin—can initiate its own contraction)

Location:

- Found **only in the heart**

3. Smooth Muscle

Structure:

- **Non-striated** (smooth under a microscope)
- **Spindle-shaped** cells
- **Uninucleated**
- **Involuntary control**

Function:

- Controls **slow, involuntary movements** such as:
    - Moving food through the digestive tract (peristalsis)
    - Controlling blood flow by adjusting vessel diameter
    - Regulating airflow in respiratory passages

Location/Examples:

- **Walls of hollow internal organs**, such as:
    - **Stomach**, intestines (digestive system)
    - **Blood vessels** (circulatory system)
    - **Bladder** (urinary system)
    - **Uterus** (reproductive system)
    - **Iris of the eye**

Comparison Table:

Feature	Skeletal Muscle	Cardiac Muscle	Smooth Muscle
Appearance	Striated	Striated	Non-striated
Nuclei	Multinucleated	Uninucleated	Uninucleated
Cell Shape	Long and cylindrical	Branched and cylindrical	Spindle-shaped
Control	Voluntary	Involuntary	Involuntary
Location	Attached to bones	Heart	Walls of organs
Function	Movement, posture	Pumping blood	Movement of substances
Special Features	Quick, powerful contractions	Intercalated discs, rhythmic contraction	Slow, sustained contractions

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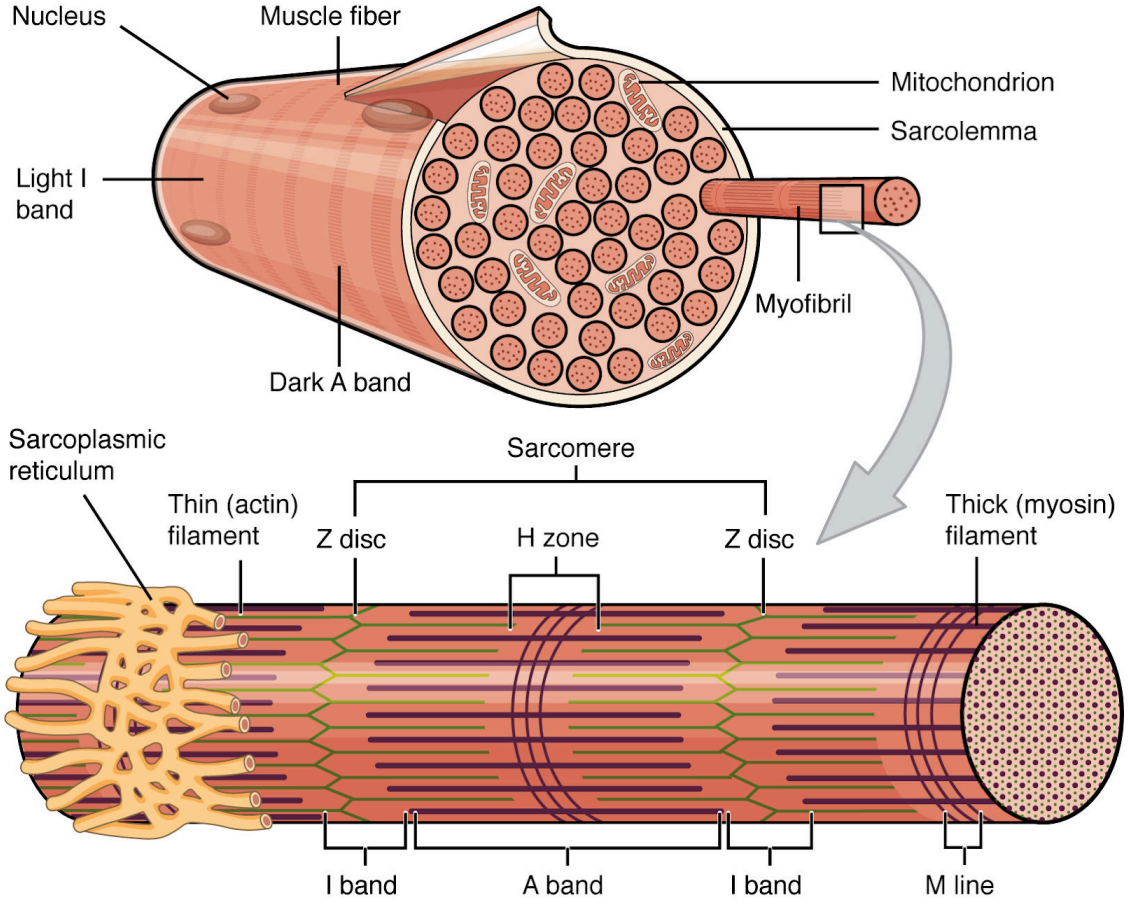
Interesting Facts:

- Skeletal muscles can contract rapidly but fatigue quickly.
- Cardiac muscle has a **built-in pacemaker** (the sinoatrial node).
- Smooth muscle contractions are **slower but more sustained** than skeletal muscle.

🧬 Sliding Filament Model of Muscle Contraction



🔍 What is it?

The **Sliding Filament Model** explains **how muscle fibers contract** by describing how **actin (thin filaments)** and **myosin (thick filaments)** slide past each other to shorten the **sarcomere**, the basic unit of a muscle.

> 💡 The muscle does **not** shorten by compressing the filaments—it shortens because the filaments **slide past each other**, like the teeth of two combs sliding into one another.

🧱 Structure Involved in Muscle Contraction

1. Sarcomere

- The **functional unit** of a muscle fiber (from Z-line to Z-line)
- Contains:
    - **Actin** (thin filaments)
    - **Myosin** (thick filaments)
    - **Tropomyosin and troponin** (regulatory proteins on actin)
- Appears striated due to the alignment of sarcomeres

2. Myosin (Thick Filament)

- Has **heads** that form **cross-bridges** with actin
- ATP is used by myosin heads to generate force

3. Actin (Thin Filament)

- Contains **binding sites** for myosin
- In resting state, these sites are blocked by **tropomyosin**

⚙️ Steps in the Sliding Filament Mechanism

1. Muscle Activation

- A **nerve impulse** (action potential) reaches the neuromuscular junction

- Triggers the release of **calcium ions (Ca^{2+})** from the **sarcoplasmic reticulum**

2. Exposure of Binding Sites

- Ca^{2+} binds to **troponin**, causing **tropomyosin** to move and expose the **myosin-binding sites** on actin

3. Cross-Bridge Formation

- Myosin heads (with ADP + Pi attached) bind to actin to form a **cross-bridge**

4. Power Stroke

- ADP and Pi are released
- The myosin head **pivots**, pulling the actin filament inward → **sarcomere shortens**
- This is the **power stroke**

5. Detachment

- A **new ATP molecule binds** to the myosin head, causing it to **detach** from actin

6. Reactivation of Myosin Head

- ATP is **hydrolyzed** (broken down) into ADP + Pi
- This **re-cocks** the myosin head to its original position, ready to bind again

🔁 This cycle repeats as long as **Ca^{2+} and ATP are available**

🔄 Summary of the Cycle:

1. **Calcium binds** to troponin → binding sites exposed
2. **Myosin binds** to actin (cross-bridge)
3. **Power stroke** pulls actin → sarcomere shortens
4. **ATP binds** to myosin → myosin detaches
5. **ATP hydrolyzed** → myosin resets
6. **Cycle continues** until nerve signal stops

🧠 After Contraction: Relaxation

- When the nerve impulse **stops**, Ca^{2+} is **actively pumped** back into the sarcoplasmic reticulum
- **Tropomyosin covers** the binding sites again
- Myosin can no longer bind → **muscle relaxes**

💡 Key Points to Remember

Term	Explanation
Sarcomere	Functional unit of muscle contraction
Myosin	Thick filament with heads that bind to actin

Actin	Thin filament with myosin-binding sites
Tropomyosin	Blocks binding sites in relaxed muscle
Troponin	Binds calcium, moves tropomyosin
ATP	Required for both contraction and relaxation
Ca^{2+}	Triggers binding site exposure on actin