Muscle Tissue

Muscle Tissue Types

Muscle tissue is characterized by properties that allow movement. Muscle cells are excitable meaning that they can respond to a stimulus. They are also contractile, meaning they can shorten and generate a force. When attached between two movable objects (bones) muscle contractions cause the bones to move. Some muscle movement is voluntary, which means it is under conscious control. For example, when a person uses their arm to open a book and read a chapter on anatomy. Other movements are involuntary, meaning they are not under conscious control, such as the change in the diameter of your pupil in response to bright light. Muscle tissue is classified into three types according to structure and function: skeletal, cardiac, and smooth (Table 4.1 Figure 4.2).

Table 4.1 Muscle Tissue Types

Tissue	Cell Structure	Major Function	Location
Skeletal	Long cylindrical fiber, striated, many peripherally located nuclei	Voluntary movement, produces heat, protects organs	Attached to bones and around entrance points to body
Cardiac	Short, branched, striated, single central nucleus	Contracts to move blood in the heart	Heart
Smooth	Short, spindle-shaped, single nucleus in each fiber	Involuntary movement of many materials including food, air during respiration, secretions, and the flow of blood through blood vessels	Walls of major organs and passageways

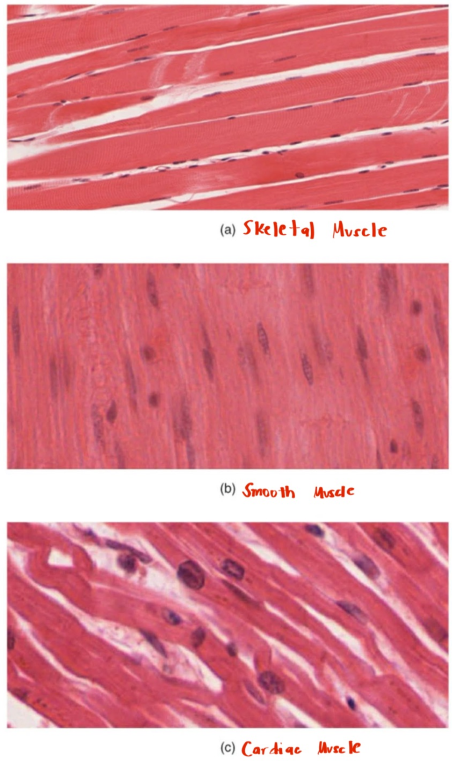

Figure 4.2 Muscle Tissue (a) Skeletal muscle (b) Smooth muscle (c) Cardiac muscle. All images are LM × 1600 (Micrographs provided by the Regents of University of Michigan Medical School © 2012)

Skeletal muscle is attached to bones and its contraction makes possible locomotion, facial expressions, posture, and other voluntary movements of the body. Forty percent of your body mass is made up of skeletal muscle. Another function of skeletal muscle is to generate heat as a byproduct of their contraction and thus participate in thermal homeostasis. Shivering is an involuntary contraction of skeletal muscles in response to perceived lower than normal body temperature. Under a light microscope, muscle cells appear striated with many nuclei squeezed along the membranes. The striation is due to the regular alternation of the contractile proteins actin and myosin, along with the structural proteins that couple the contractile proteins to connective tissues. The cells are multinucleated as a result of the fusion of the many myoblasts that fuse to form each long muscle fiber. The gross anatomy of skeletal muscle is considered further below.

Cardiac muscle forms the contractile walls of the heart. The cells of cardiac muscle, known as cardiomyocytes, also appear striated under the microscope. Unlike skeletal muscle fibers, cardiomyocytes are single, branched cells typically with a single centrally located nucleus. Cardiomyocytes attach to one another with specialized cell junctions called intercalated discs which have both anchoring junctions and gap junctions. Attached cells form long, branching cardiac muscle fibers that are, essentially, a mechanical and electrochemical syncytium allowing the cells to synchronize their actions.

Smooth muscle tissue contraction is responsible for involuntary movements in the internal organs. It forms the contractile component of the digestive, urinary, and reproductive systems as well as the airways and arteries. Each cell is small, spindle-shaped, has a single nucleus, and no visible striations.

Types Of Tissues

Skeletal Muscle Anatomy

Gross Anatomy & Connective Tissue Layers

Each skeletal muscle is an organ that consists of various integrated tissues. These tissues include skeletal muscle cells (called muscle fibers), blood vessels, nerve fibers, and connective tissue. Each skeletal muscle has three layers of connective tissue that enclose it, provide structure to the muscle as a whole, and also compartmentalize the muscle fibers within and around other muscles (Figure 4.3). Each muscle is wrapped in a sheath of dense, irregular connective tissue called the epimysium, which allows a muscle to contract and move powerfully while maintaining its structural integrity independent of surrounding structures.

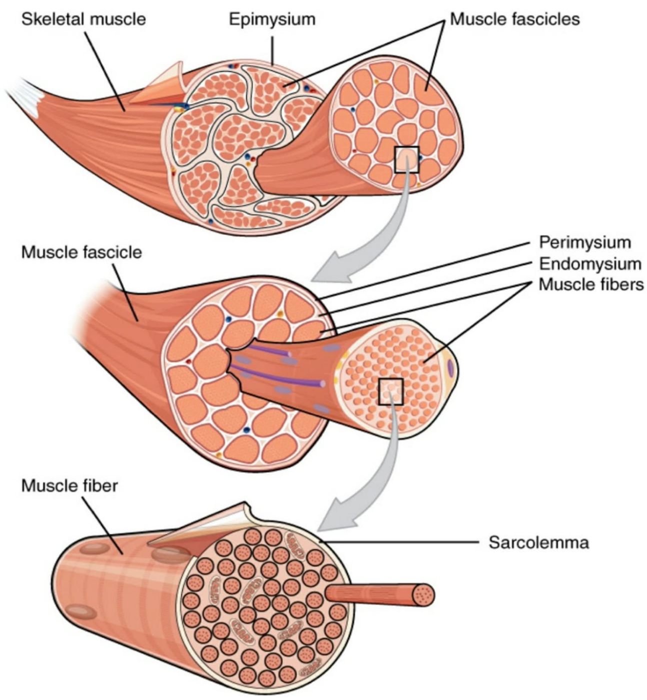

Figure 4.3 Connective Tissue Layers of Skeletal Muscle.

Inside each skeletal muscle, muscle fibers are organized into individual bundles, each called a fascicle, by a middle layer of connective tissue called the perimysium. This fascicular organization is common in muscles of the limbs; it allows the nervous system to trigger a specific movement of a muscle by activating a subset of muscle fibers within a fascicle of the muscle. Inside each fascicle, each muscle fiber is encased in a thin connective tissue layer of collagen and reticular fibers called the endomysium. The endomysium contains the extracellular fluid, nutrients, blood vessels, and nerves needed to support the muscle fiber.

In skeletal muscles that work with tendons to pull on bones, the collagen in the three tissue layers intertwines with the collagen of a tendon. At the other end of the tendon, it fuses with the periosteum coating the bone. The tension created by contraction of the muscle fibers is then transferred though connective tissue layers to the tendon, and then to the periosteum to pull on the bone for movement of the skeleton. In other places, the connective tissue layers may fuse with a broad, tendon-like sheet called an aponeurosis, or to fascia, the connective tissue between skin and bones.

Fascicle Organization Patterns

Based on the patterns of fascicle arrangement, skeletal muscles can be classified in several ways which are described in Table 4.2 and shown in Figure 4.4.

Table 4.2 Muscle Shapes

Muscle Shape	Description	Example
Parallel (fusiform)	Fibers are arranged in the same direction along the long axis of the muscle. Spindle-shaped with a central, large belly.	Biceps brachii
Parallel (non-fusiform)	Fibers are arranged in the same direction along the long axis of the muscle with no belly.	Sartorius
Circular	Also called sphincters. Surrounds an opening to control the size of the opening.	Orbicularis oculi
Convergent	Widespread muscle fibers come to a single, slender attachment point.	Pectoralis major
Unipennate	Tendon runs through the central region of the muscle with muscle fibers located on one side of the tendon.	Extensor digitorum
Bipennate	Tendon runs through the central region of the muscle with muscle fibers located on both sides of the tendon.	Rectus femoris
Multipennate	Tendon runs through the central region of the muscle with muscle fibers wrapping the tendon on all sides to form separate fascicles.	Deltoid

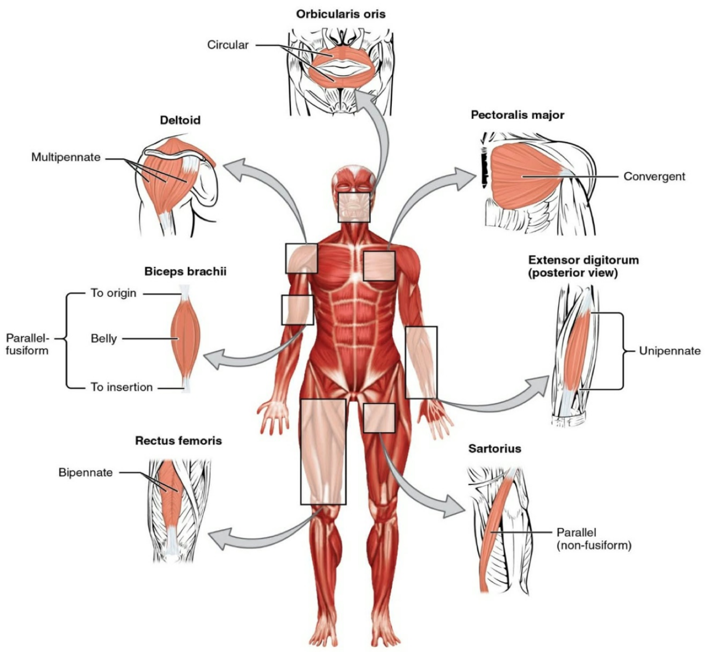

Figure 4.4 Muscle Shapes and Fiber Alignment. Skeletal muscles of the body typically come in seven different general shapes.

Skeletal Muscles and Body Movement

To move the skeleton a skeletal muscle must be attached to a fixed part of the skeleton. The movable end of the muscle that attaches to the bone being pulled is called the muscle's insertion, and the end of the muscle attached to a fixed (stabilized) bone is called the origin. In many cases the origin is the proximal attachment point while the insertion is the distal attachment point.

Although a number of muscles may be involved in an action, the principal muscle involved is called the prime mover, or agonist. To lift a cup, a muscle called the biceps brachii is the prime mover; however, because it can be assisted by the brachialis, the brachialis is called a synergist in this action. A synergist can also be classified as a fixator if that muscle's action stabilizes the bone that is the attachment for the prime mover's origin.

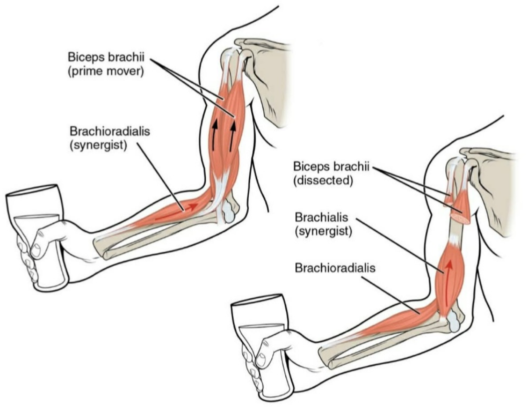

Figure 4.5 Prime Movers and Synergists. The biceps brachii flex the lower arm. The brachoradialis, in the forearm, and brachialis, located deep to the biceps in the upper arm, are both synergists that aid in this motion.

Nervous Tissue

Nervous tissue is organized into two major regions: the central and peripheral nervous systems. The central nervous system (CNS) is the brain and spinal cord, and the peripheral nervous system (PNS) is everything else (Figure 4.6). The brain is contained within the cranial cavity of the skull, and the spinal cord is contained within the vertebral cavity of the vertebral column. It is a bit of an oversimplification to say that the CNS is what is inside these two cavities and the peripheral nervous system is outside of them, but that is one way to start to think about it. In actuality, there are some elements of the peripheral nervous system that are within the cranial or vertebral cavities. The peripheral nervous system is so named because it is on the periphery—meaning beyond the brain and spinal cord. Depending on different aspects of the nervous system, the dividing line between central and peripheral is not necessarily universal.

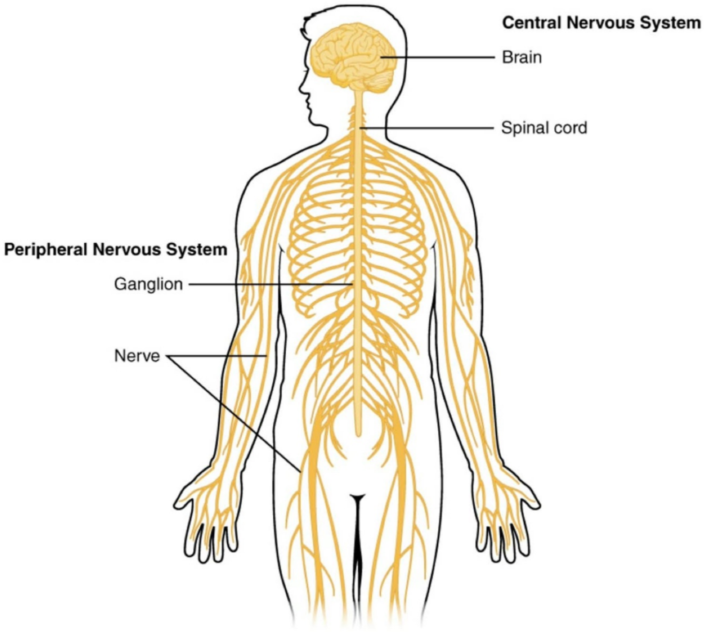

Figure 4.6 Central and Peripheral Nervous Systems

Nervous tissue, present in both the CNS and PNS, contains two basic types of cells: neurons and glial cells. Neurons are the primary type of cell that most anyone associates with the nervous system. They are responsible for the computation and communication that the nervous system provides. They are electrically active and release chemical signals to target cells. Glial cells, or glia, are known to play a supporting role for nervous tissue. Ongoing research pursues an expanded role that glial cells might play in signaling, but neurons are still considered the basis of this function. Neurons are important, but without glial support they would not be able to perform their function.

To describe the functional divisions of the nervous system, it is important to understand the structure of a neuron. Neurons are cells and therefore have a soma, or cell body, but they also have extensions of the cell; each extension is generally referred to as a process. There is one important process that every neuron has called an axon, which is the fiber that connects a neuron with its target. Another type of process that branches off from the soma is the dendrite. Dendrites are responsible for receiving most of the input from other neurons. Looking at nervous tissue, there are regions that predominantly contain cell bodies and regions that are largely composed of just axons. These two regions within nervous system structures are often referred to as gray matter (the regions with many cell bodies and dendrites) or white matter (the regions with many axons). The colors ascribed to these regions are what would be seen in "fresh," or unstained, nervous tissue. Gray matter is not necessarily gray. It can be pinkish because of blood content, or even slightly tan, depending on how long the tissue has been preserved. But white matter is white because axons are insulated by a lipid-rich substance called myelin.

Cell bodies of neurons or bundles of axons can be identified as discrete anatomical structures and, therefore, can be named. Those names are specific to whether the structure is central or peripheral. A localized collection of neuron cell bodies in the CNS is referred to as a nucleus. In the PNS, a cluster of neuron cell bodies is referred to as a ganglion. A bundle of axons, or fibers, found in the CNS is called a tract whereas the same thing in the PNS would be called a nerve. There is an important point to make about these terms, which is that they can both be used to refer to the same bundle of axons. When those axons are in the PNS, the term is nerve, but if they are CNS, the term is tract. The most obvious example of this is the axons that project from the retina into the brain. Those axons are called the optic nerve as they leave the eye, but when they are inside the cranium, they are referred to as the optic tract. There is a specific place where the name changes, which is the optic chiasm, but they are still the same axons from the same neurons.

Nerves

Nerves in the periphery are different than the central counterpart, tracts. Nerves are composed of more than just nervous tissue. They have connective tissues included in their structure, as well as blood vessels supplying the tissues with nourishment, very similar to what was described for skeletal muscle tissue. The outer surface of a nerve is a surrounding layer of fibrous connective tissue called the epineurium. Within the nerve, axons are further bundled into fascicles, which are each surrounded by their own layer of fibrous connective tissue called perineurium. Finally, individual axons are surrounded by loose connective tissue called the endoneurium (Figure 4.7, 4.8). Nerves are associated with the region of the CNS to which they are connected, either as cranial nerves connected to the brain or spinal nerves connected to the spinal cord.

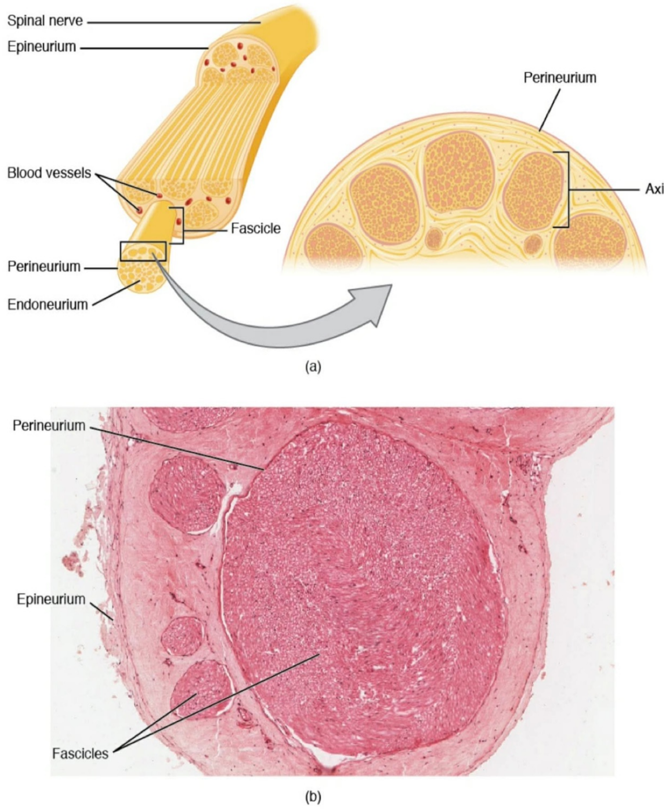

Figure 4.7 Nerve Structure. The structure of a nerve is organized by the layers of connective tissue on the outside, around each fascicle, and surrounding the individual nerve fibers (tissue source: simian). LM × 40. (Micrograph provided by the Regents of University of Michigan Medical School © 2012)

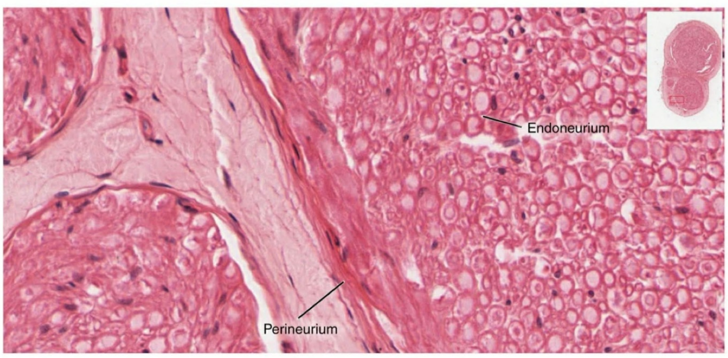

Figure 4.8 Close-Up of Nerve Trunk. Shows the endoneurium and perineurium in greater detail (tissue source: simian). LM × 1600.

Neurons

Neurons are the cells considered to be the basis of nervous tissue. They are responsible for the electrical signals that communicate information about sensations, and that produce movements in response to those stimuli, along with inducing thought processes within the brain. An important part of the function of neurons is in their structure, or shape. The three-dimensional shape of these cells makes the immense numbers of connections within the nervous system possible.

Neuron Anatomy

As you learned above, the main part of a neuron is the cell body, which is also known as the soma (soma = "body"). The cell body contains the nucleus and most of the major organelles. But what makes neurons special is that they have many extensions of their cell membranes, which are generally referred to as processes. Neurons are usually described as having one, and only one, axon—a fiber that emerges from the cell body and projects to target cells. That single axon can branch repeatedly to communicate with many target cells. It is the axon that propagates the nerve impulse, which is communicated to one or more cells. The other processes of the neuron are dendrites, which receive information from other neurons at specialized areas of contact called synapses. The dendrites are usually highly branched processes, providing locations for other neurons to communicate with the cell body. Information flows through a neuron from the dendrites, across the cell body, and down the axon. This gives the neuron a polarity—meaning that information flows in this one direction. Figure 4.9 shows the relationship of these parts to one another.

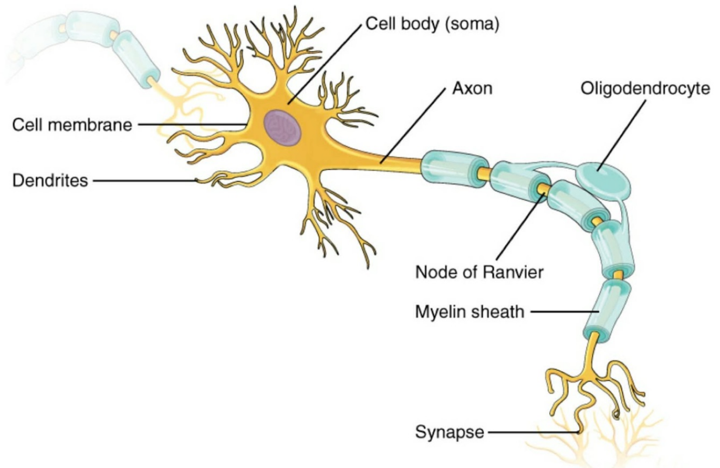

Figure 4.9 Neuron anatomy for a generic multipolar neuron from the CNS.

Where the axon emerges from the cell body, there is a special region referred to as the axon hillock. This is a tapering of the cell body toward the axon fiber. Many axons are wrapped by an insulating substance called myelin, which is made up of glial cells. Myelin acts as insulation much like the plastic or rubber that is used to insulate electrical wires. At the end of the axon is the axon terminal, where there are usually several branches extending toward the target cell, each of which ends in an enlargement called a synaptic end bulb. These bulbs are what make the connection with the target cell at the synapse.

Neurons Classification

There are trillions of neurons in the nervous system that can be classified by many different criteria. The first way to classify them is structurally by the number of processes attached to the cell body. Using the standard model of neurons, one of these processes is the axon, and the rest are dendrites. Because information flows through the neuron from dendrites or cell bodies toward the axon, these names are based on the neuron's polarity (Figure 4.10).

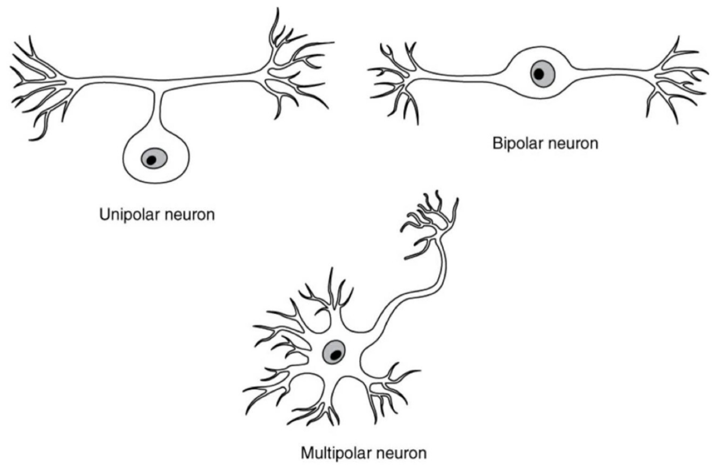

Figure 4.10 Structural classification of neurons. Unipolar cells have one process that includes both the axon and dendrite. Bipolar cells have two processes, the axon and a dendrite. Multipolar cells have more than two processes, the axon and two or more dendrites.

Unipolar cells have only one process emerging from the cell. True unipolar cells are only found in invertebrate animals, so the unipolar cells in humans are more appropriately called "pseudo-unipolar" cells. Invertebrate unipolar cells do not have dendrites. Human unipolar cells have an axon that emerges from the cell body, but it splits so that the axon can extend along a very long distance. At one end of the axon are dendrites, and at the other end, the axon forms synaptic connections with a target. Unipolar cells are exclusively sensory neurons and have two unique characteristics. First, their dendrites are receiving sensory information, sometimes directly from the stimulus itself. Secondly, the cell bodies of unipolar neurons are always found in ganglia. Sensory reception is a peripheral function (those dendrites are in the periphery, perhaps in the skin) so the cell body is in the periphery, though closer to the CNS in a ganglion. The axon projects from the dendrite endings, past the cell body in a ganglion, and into the central nervous system.

Bipolar cells have two processes, which extend from each end of the cell body, opposite to each other. One is the axon and one the dendrite. Bipolar cells are not very common. They are found mainly in the olfactory epithelium (where smell stimuli are sensed), and as part of the retina.

Multipolar neurons are all of the neurons that are not unipolar or bipolar. They have one axon and two or more dendrites (usually many more). With the exception of the unipolar sensory ganglion cells, and the two specific bipolar cells mentioned above, all other neurons are multipolar.

Neurons can also be functionally classified on the basis of the role they play in the nervous system. Sensory, or afferent, neurons carry information about the environment towards the central nervous system. Interneurons are found exclusively within the central nervous system and receive information either from sensory neurons or other interneurons. Motor, or efferent, neurons receive information from interneurons or directly from sensory neurons in order stimulate responses in tissues throughout the body.

Source Material

- **Cutaneous membrane** – exposed area of the skin.
- **Covering** – also called the **integument**.
- **Dermatology** – branch of science that studies the skin.
- **Dermatologist** – a professional who studies and treats the skin.

Functions of the Skin

1. **Protection**
    - Controls water loss (prevents dehydration)
    - Shields internal organs from external damage
2. **Cutaneous Sensation**
    - Skin can detect all senses because it is richly **innervated** with nerves
3. **Thermal Regulation**
    - Maintains internal body temperature
4. **Vitamin D Production**
    - UV radiation from sunlight converts precursors in skin into Vitamin D
    - Vitamin D aids calcium absorption for bones
5. **Excretion**
    - Excretes urea and other toxins
    - More urea is lost in urine than in sweat
6. **Wound Healing**
    - Skin cells divide rapidly to repair damage
    - Skin sheds ~20,000 dead cells daily
    - **Mitosis** is essential for repair

Easy Way to Remember What Skin Does

"Please Cut The Very Extra Watermelon"

- **P** – Protection
- **C** – Feeling (Cutaneous sensation)
- **T** – Temperature control
- **V** – Vitamin D
- **E** – Excretion
- **W** – Wound healing

Additional: **epidermis** - wave-like structure. it has no capillaries, highly avascular

produces an expected cell: **keratinocytes**

also consist of **melanocytes**, once it matures and forms a melanin. (uv rays protector and gives color to skin)

Layers of the Skin

1. Epidermis (Top Layer)

- Outer layer you can see
- **No blood vessels** – gets nutrients from layer below
- **Main cells:**
    - **Keratinocytes** – make skin strong
    - **Melanocytes** – give color and protect from sun
    - **Langerhans cells** – fight germs and the adaptive immune response. it also has a photographic memory to promote inflammatory response.
    - **Merkel cells** – help you feel touch or receptor for touch.

2. Dermis (Middle Layer)

- Thicker, stretchy layer under epidermis
- **Has:** blood vessels, nerves, hair roots, sweat glands, oil glands
- **Function:** feeds and supports the top layer, gives strength

3. Hypodermis (Bottom Layer)

- Fatty layer under dermis
- **Function:** cushions, stores energy, keeps body warm

Stratum Basale/Germativum
- has simple cuboidal cells/tissue
- produce keratinocytes & melanocytes
- where mitosis occurs
- has merkel cells
- basale means base
- this is the last and vv base type of process na mag produce

Stratum Spinosum
- has 8-10 layers (this is thicc and has matured keratinocytes)
- it highly contains collagen and has elastic fibers
- synthesized keratin and glycolipids
- it has langerhans cells
- having glycolipids means it can undergo a cellular recognition cuz it is a major or composed of glyco (glycogen) and lipids which is fats
- flexibility (flexible) & strength

Stratum Granulosum
- has 3-5 layers
- granules containing lipids
- it has desmosomes in which it is the threads in the granulosum and is vv bulky
- this is prone to mechanical stress
- it forms a waterproof barrier
- accumulates a large amount of keratin
- has a desmossinal connections

Stratum Lucidum
- has a clear or transparent layer (colorless)
- thin layer
- reduces friction
- this is present in thicker skin
- in between or junction between the granulosum and corneum

Stratum Corneum
- has 15-30 layers
- is in the outermost epidermal layer
- it consists of layer of dead keratinocytes (matured keratin)
- desquamination process (like it undergoes a shedding process. desquamate means shed off man)

Mnemonic from Top to Bottom: Come, **L**et's **G**et **S**un **B**urn
Mnemonic from Bottom to Top: Bro, **S**tudents **G**ot **L**owkey **C**ooked **:'))**

Dermis

- The dermis is the middle layer of the skin, right under the epidermis. It gives skin strength, flexibility, and nourishment.
- The **papillary layer** (pappillac) is the top part of the dermis. It has a **wavy shape or wavelike structure** that connects to the epidermis. Think of it like a **transition** bridge between the outer and inner skin layers. It has:
    - ***Loose areolar tissue to give flexibility***

- ***Collagen and elastic fibers** that make skin strong and stretchy*
- ***Small blood vessels (arterioles)** that help control body heat by widening (vasodilation) or narrowing (vasoconstriction)*
- ***Sensory receptors** that let you feel touch, pressure, and pain*

- The reticular layer is deeper in the dermis. It has dense, **fibrous/irregular connective tissue,** meaning fibers go in different directions for strength.

Other important cells in the dermis:

- Adipocytes – fat cells that cushion and store energy
- Phagocytes – white blood cells that protect against germs or it's like the T-cell vro
- The dermis also has capillaries, tiny blood vessels that supply nutrients and oxygen to the skin.

Vasodilation and Vasoconstriction

These happen in the **small blood vessels (arterioles) in the dermis** to help control body temperature.

1. **Vasodilation** – blood vessels **get wider**
    - More blood flows near the skin surface
    - Heat from the blood **escapes**, cooling the body
    - Happens when you're **hot or exercising**
2. **Vasoconstriction** – blood vessels **get narrower**
    - Less blood flows near the skin surface
    - Body **keeps heat inside**, staying warm
    - Happens when you're **cold**

Skin Sensory Receptors

- Sensory receptors in the skin detect touch, pressure, vibration, pain, and temperature. They can be free (uncovered) or encapsulated (covered by tissue).

Free (Unencapsulated)

- **Root hair plexus –** wraps around hair follicles; detects **hair movement**
- **Free nerve endings –** detect **pain and temperature**
- **Pacinian corpuscles –** detect **vibration**
- **Ruffini endings –** detect **heat** and skin stretch

Encapsulated (Closed) Receptors

- **Meissner corpuscles –** detect light **touch** (especially fingertips)
- **Merkel disks –** detect **pressure** and texture

Hypodermis (Subcutaneous Layer)

- Also called superficial fascia
- Made of areolar tissue and adipose tissue (fat storage)
- Cushions organs, insulates the body, and stores energy
- Connects skin to underlying muscles and bones

Hair, also known as **Pili**.

- Hair grows from the deepest part of the skin
- We have **thousands of hairs**, except in certain areas:
  - **No hair**: palms, soles, lips, nails, and genitalia
  - **Hair present**: eyebrows, nose, armpits, scalp, and outer genital area

Hair Structure

1. **Hair bulb** – base of the hair, where growth starts
   - Contains hair matrix
     - Blood vessels supply nutrients
     - Site of mitosis for hair growth
     - Contains keratinocytes (make hair strong) and melanocytes (give hair color)
2. **Arrector pili** – tiny smooth muscle attached to hair
   - Contracts to make hair stand up (goosebumps)

Skin Glands

1. **Sebaceous glands** – produce sebum (oil) to lubricate hair and skin
2. **Sudoriferous** (**sweat**) **glands** – help with cooling
   - ***Eccrine glands*** – surface-level; found all over body; produce watery sweat
   - ***Apocrine glands*** – deep; found in armpits and genital area; produce thicker sweat
3. **Ceruminous glands** – found in ear canal; produce earwax to protect and keep ear moist. it is vv sticky.

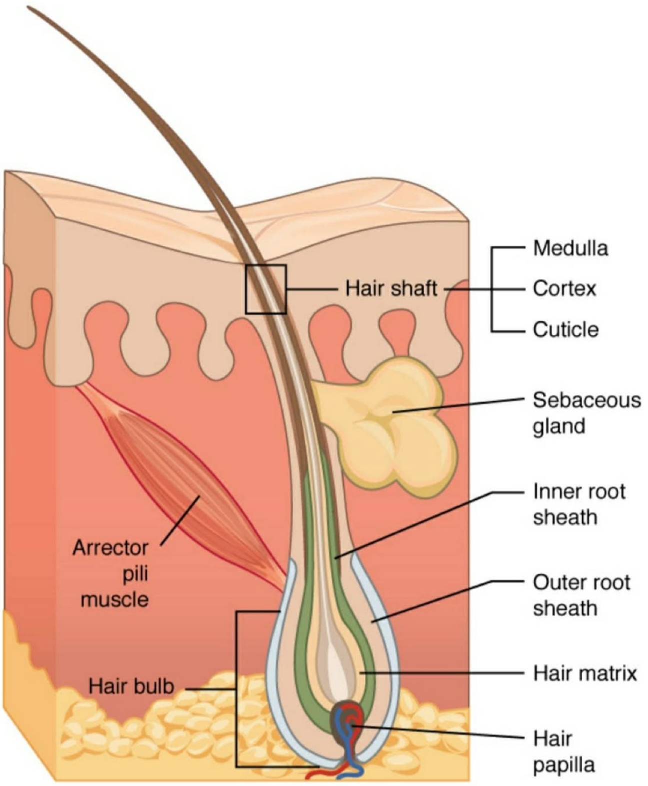

Figure 5.4 The structure of a hair and a hair follicle.