WHAT IS ANATOMY AND PHYSIOLOGY?

Anatomy and physiology are two related biology disciplines that study the structure and function of body parts and the body as a whole. Anatomy is the study of the structure and relationship between body parts, their organization, and their identity. Physiology is the study of the function of body parts and their interactions within a living system.

Subdivision of Anatomy

Surface Anatomy	the study of form and markings of the body structure explored through visualization without any cutting.
Gross Anatomy	the study of the anatomical structures visible to unaided eye. The gross dissection proceeds through cutting after making surface marking.
Develo-pmental Anatomy	the study of the fertilized egg developing into its adult form.
Cytology	the study of cells
Histology	the study of tissues
Pathology	the study of anatomical changes due to disease

LEVELS OF ORGANIZATION

Cell	basic unit of structure and function in all living things.
Tissues	group of similar cells carrying out similar or related functions.
Organ	collections of tissues grouped together performing a common functions.
Organ System	group of organ working together to perform a specific function for the organism.
Organism	any living thing.

Single-celled organism	an organism made up of only one cell; organelles carry out life functions. Ex. Amoeba
Multi-cellular organism	made up of many different types of cells; organ system carry out life functions. Ex. Human

Life

is the sum total of all bodily activities of an organism

Life (cont)

is a characteristic that distinguishes physical entities that have biological processes from those that do not have.

Characteristics of Life

1.Respons-iveness	ability of sense change and react
2. Movement	change in position of an organism
3. Reprod-uction	process of making a new organism
4. Respir-ation	the process of getting oxygen
5. Growth	an increase in body size
6. Digestion	complex material changes
7. Absorption	the passage of a substance through a membrane
8. Assimi-lation	putting molecules together to make a more complex substances
9. Circul-ation	movement of material
10. Excretion	getting rid of material

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Major Needs of Organism

1. Water	Most abundant substance in the body
2. Food	Provides energy for body
3. Oxygen	Makes up 20% of atmospheric air we breath 78% is nitrogen 2% other gases
4. Heat	we get heat from muscle activity Normal temp-98.6 °F or 37 °C
5. Pressure	a. Hydrostatic pressure- example would be the blood moving under the pressure of the heart 120/80 is normal
	b. Atmospheric pressure- comes from the air around us and allows us to breath

Body Systems

Integumentary system	skin and anything in skin protects. The skin is your largest organ.
Skeletal system	bones support, protect and make blood cells.
Muscular system	move the body and produces heat
Nervous system	brain, spinal cord, and nerves-…helps you to communicate

Body Systems (cont)

Endocrine system	made up of hormones and glands-hormones affect target cell Example of endocrine glands are pancreas, thyroid, and adrenalin gland
Digestive system	breaks down food stomach, intestine, liver and gall bladder
Respiratory system	intake and output of gases…-lungs
Circulatory system	transports gases, nutrients, and other things…heart and blood vessels
Lymphatic system	cleans up lymph fluid…spleen and lymph nodes
Urinary system	gets rid of waste kidney, ureters, and urethra
Reproductive system	produces offspring testes and uterus

Anatomical Terms

Superior	above
Inferior	below
Anterior	toward the front
Posterior	toward the back
Medial	close to the midline of body
Lateral	toward sides of body

Anatomical Terms (cont)

Proximal	closer to the point of attachment
Distal	further away from the point of attachment
Superficial	near the surface
Deep	internal

Vertebral Cavity

Vertebral cavity contains three cavities	1. Thoracic cavity- which is the chest cavity contains heart and lungs (Diaphragm separates thoracic and abdominal)
	2. Abdominal cavity- contains stomach, liver, pancreas, intestines, gall bladder, and spleen
	3. Pelvic cavity- contains bladder and uterus

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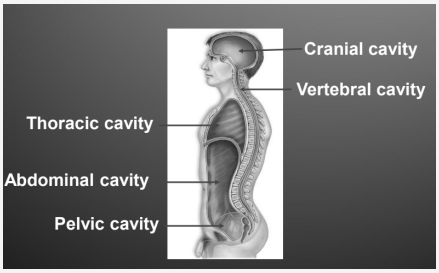
Dorsal Cavities

Dorsal cavity contains two cavities	1.Cranial (skull)-brain
	2.Vertebral (spinal)-spinal cord

Body Cavities



Tissue

A tissue is defined as a group of cells, organized to perform a specific function.

Types of Tissues	1. Epithelial Tissue
	2. Connective Tissue
	3. Muscle Tissue
	4. Nerve Tissue

Connective Tissue

binds and supports body parts

Three Components of Connective Tissue	Specialized Cells
	Protein Fibers: elastin & collagen
	Ground Substance: non-cellular material separating cells

Types of Connective Tissue

1. Loose Fibrous Connective Tissue	✔ contains fibroblast
	✔ Matrix: ground substance + fibers
	✔ Protective covering for muscles, blood vessels, nerves
2. Dense Fibrous Connective Tissue	✔ collagen fibers packed together
	✔ Tendons: connect muscle to bone
	✔ Ligaments: connect bone to bone
3. Fibrous Connective Tissue	✔ Adipose Tissue- cells stores fat
	✔ Found under the skin, around kidneys and heart
4. Supportive Connective Tissue	
Cartilage	
	✔ solid and flexible
	✔ cells located in chambers--lacunae
Types of Cartilage	a. Elastic cartilage- elastin fibers, more flexible and located in the outer ear
	b. Hyaline cartilage- most common and contains fine collagen fibers. It is located in the nose, ends of long bones and ribs, walls of respiratory passages.
	c. Fibrocartilage- strong collagen fibers located in between vertebrae and in knee joint.
Bone	
	✔ solid, rigid matrix of calcium salts arond collagen fibers

Connective Tissue (cont)

	✔ in compact bone, cells are located in spaces between rings of matrix
Types of Bone	a. Compact bone
	c. Spongy bone
5. Fluid Connective Tissue	
Liquid matrix-=plasma	✔ dissolved substances, eg. gases and ions
	✔ suspended substances, eg. proteins
Formed elements: cells and cell fragments	✔ Red blood cells - transport oxygen
	✔ White blood cells - fight infection
	✔ Platelets - cell fragments that aid in blood clotting
Liquid matrix-=lymphatic fluid	contains white blood cells

Hemapoietic

Blood making

Hematopoietic refers to the formation of blood cells. Hematopoiesis is the process through which the body manufactures blood cells. It occurs within the hematopoietic system, which includes organs and tissues such as the bone marrow, liver, and spleen.

Epithelial Tissue

Epithelial tissue is a thin tissue that covers all the exposed surfaces of the body. It has different functions, such as protection, absorption, secretion and movement of substances.

The cells making up epithelia are often closely bound to one another through specialized structures called tight junctions.

Classification of Epithelial Tissue

Squamous	flattened cells
Simple	one layer
Pseudostratified	appears as multiple layers
Stratified	multiple layers
Cuboidal	cube-shaped cells
Columnar	elongated cells

Muscular Tissue

Cells are called *muscle fibers*

Cells contain protein filaments called *actin* and *myosin*

Types of Muscular Tissue

a. Skeletal Muscle	✔ voluntary
	✔ striation and nucleus
b. Smooth Muscle	✔ Involuntary
	✔ cell and nucleus
c. Cardiac Muscle	✔ Involuntary
	✔ nucleus

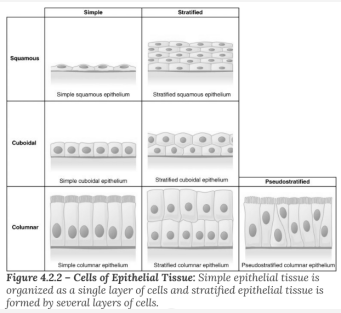
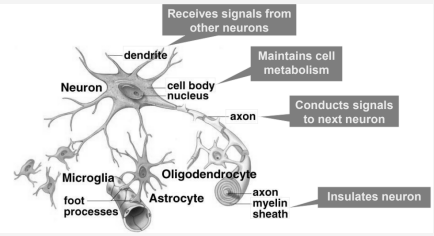


Figure 4.2.2 – Cells of Epithelial Tissue: *Simple epithelial tissue is organized as a single layer of cells and stratified epithelial tissue is formed by several layers of cells.*

Nerve Tissue

Neurons	conduct nerve impulses
Neuroglia	support and nourish neurons



Integumentary System

The integumentary system, which includes the skin, hair, and nails, provides protection, sensations, thermoregulation, and allows sunlight for vitamin D synthesis.

Epidermis is the outermost and thinnest layer of the skin. It protects the body from harm, keeps the body hydrated, produces new skin cells and contains melanin, which determines the color of the skin.

Integumentary System (cont)

The Four Layers of Epidermis	✔ *stratum basale* - the deepest layer of your epidermis. New skin cells develop in this layer. It also contains the keratinocyte stem cells, which produce the protein keratin. It also contains melanocytes, which are responsible for producing melanin, which provides the pigment of your epidermis.
	✔ *stratum spinosum* - This layer mostly consists of keratinocytes held together by sticky proteins called desmosomes. The stratum spinosum helps make the skin flexible and strong.
	✔ *stratum granulosum* - Keratinocytes have granules within them, which are visible under a microscope in this layer.

Integumentary System (cont)

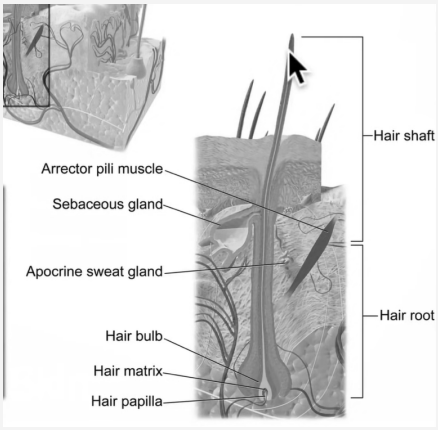
✔ *stratum lucidum* - It's a thin, transparent layer of keratinocytes that are becoming less round and have a flatter shape.

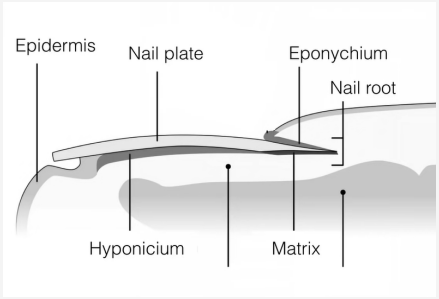
✔ *stratum corneum* - the top layer of the epidermis. This is where keratinocytes become corneocytes. Corneocytes are strong, dead keratinocytes that protect you from harm, including abrasions, light, heat and pathogens.

Dermis is a vital layer containing blood vessels, sweat glands, sebaceous glands, and various receptors that allow us to sense touch, pain, and light.

Hypodermis, or subcutaneous layer, provides insulation and padding with its abundance of connective tissue and fat cells.

Accessory Structures





Skeletal System

Functions of the Skeletal System

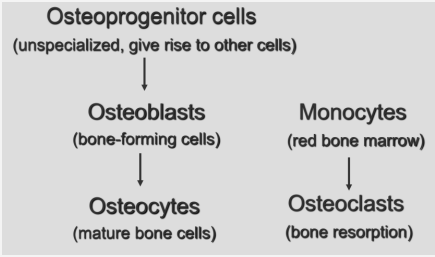
- ✔ Supports the body
- ✔ Protects soft body parts
- ✔ Produces blood cells
- ✔ Stores minerals and fat
- ✔ Permits flexible body movement

Tissues of the Skeletal System

Skeletal System (cont)

Bone cells= osteocytes	*compact bone* - dense matrix of salts (calcium phosphate)
	spongy bone - thin plates with open spaces
	bone marrow - red: produces blood cells, yellow: stores fat
Cartilage cells=chondrocytes	*hyaline* - firm yet flexible. At ends of long bones, ribs, in nose
	fibrocartilage - strong for support. Found in knee and disks between vertebrae
	elastic cartilage - most flexible and found in ear flaps
Fibrous connective tissue	*periosteum* - covers long bones. It contains blood and lymphatic vessels, nerves
	ligaments - connect bone to bone
	tendons - connect muscles to bones at joints

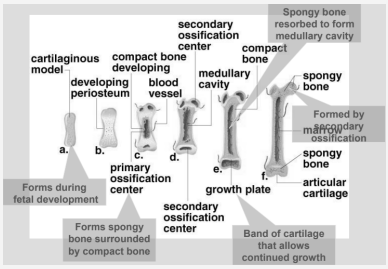
Cells Involved in Bone Growth and Repair



Bone Development and Growth

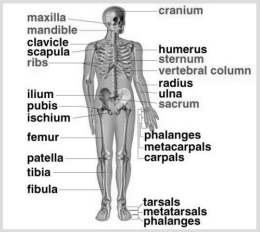
Bone formation =	ossification
✔ Bones of the skull form by Intramembranous ossification	Bones develop between sheets of fibrous tissue
✔Most bones form by Endochondral ossification	Cartilage models are formed first
	At ossification centers, cartilage is gradually replaced by bone

Endochondral Ossification

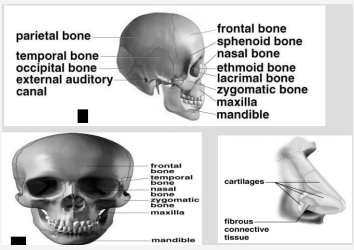


Axial Skeleton: Midline of the Body

- Skull
- Hyoid bone
- Vertebral column
- Rib cage/bony thorax

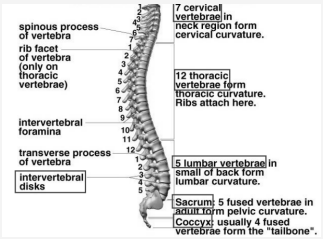


Bones of the Skull



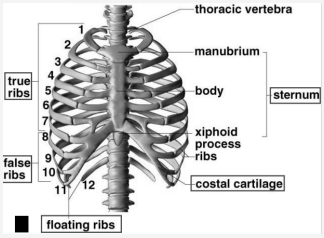
The skull is divided into cranial and facial bones, with sutures connecting them. It also contains foramina for nerves and vessels, as well as ear and nasal cavities and orbits for the eyes.

The Vertebral Column



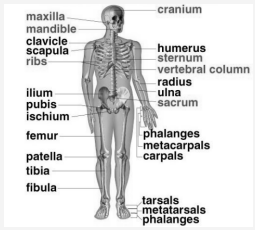
The vertebral column is a flexible structure supporting the skull to the pelvis. It consists of cervical, thoracic, lumbar, sacrum, and coccyx vertebrae, with intervertebral discs acting as shock absorbers.

The Rib Cage



The thoracic cage, made up of the sternum and ribs, protects the organs in the chest and supports respiration.

Appendicular Skeleton

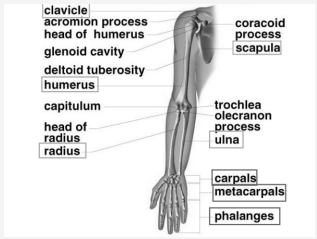


Pectoral and Pelvic Girdles and the Limbs

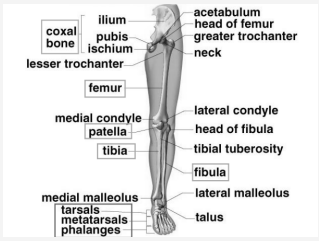
It consists of the bones of the limbs (or appendages), and the bones that attach the limbs to the rest of the body. It includes a total of 126 bones, including those in the arms, legs, and shoulder and pelvic girdle bones.

The pectoral and pelvic girdles attach the upper and lower limbs to the axial skeleton. The pectoral girdle has the clavicle and scapula, while the pelvic girdle consists of the hip bones.

Bones of Pectoral Girdle, Arm, Hand

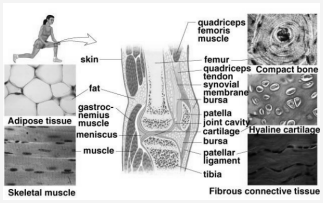


Bones of Pelvic Girdle, Leg, Foot



The bones in the lower limb are thicker and sturdier, allowing for effective running and jumping. The foot has tarsals, metatarsals, and phalanges similar to the hand.

Knee Joint

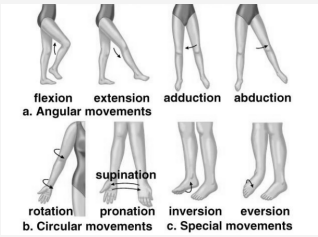


Joints play a crucial role in the movement and stability of the skeleton. Ligaments and intervertebral discs help connect and support the bones in the spine.

Joints: Articulations between Bones

Fibrous joints: immovable	
Cartil-aginous joints	✔ connected by hyaline or fibrocartilage cartilage
	✔ slightly movable
Synovial joints	✔ separate the bones by a cavity
	✔ freely movable
	✔ Hinge
	✔ Ball-and-socket

Movements Permitted by Synovial Joints



Disorders of Muscular and Skeletal System

Arthritis	is a broad term for joint inflammation, with various forms like osteoarthritis and rheumatoid arthritis. It causes constant joint pain and damage.

Disorders of Muscular and Skeletal System (cont)

Gout	is characterized by the deposition of uric acid crystals in joints, leading to swelling, loss of function, and severe pain.
Myasthenia gravis	is an autoimmune disease that affects muscle strength and causes fatigue. It primarily affects eye muscles and may lead to difficulty swallowing and slurred speech.
Muscular dystrophy	refers to a group of genetic disorders that progressively weaken muscles, impairing locomotion. It primarily affects skeletal muscles.
Tetany	is the involuntary contraction of muscles due to low calcium levels. Muscle cramps and spasms are long-lasting and painful.

Disorders of Muscular and Skeletal System (cont)

Osteo porosis	is a condition where bone mineral density decreases, resulting in fragile bones and an increased risk of fractures, especially in postmenopausal women.

✔ Aging, lack of exercise, and family history are significant risk factors for these disorders. Early diagnosis and appropriate management are crucial.

✔ These conditions lead to joint inflammation, muscle weakness, decreased mobility, and increased fracture risk.

Muscular System

The muscular system is an organ system consisting of skeletal, smooth, and cardiac muscle.

Skeletal muscle - the only organ of the muscular system

Skeletal muscle is composed of skeletal muscle tissue and also contains nervous tissue, blood vessels and connective tissue

Half of the body's weight is muscle tissue	– Skeletal muscle = 40% in males
	– 32% in females
	– Cardiac muscle = 10%

Muscular System (cont)

Muscles are excitable, contractable, extensible, and elastic. They can adapt and change based on usage.

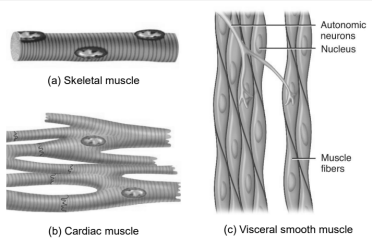
There are five types of muscle movements: adduction, abduction, flexion, extension, and rotation.

The muscular system consists of over 600 muscles with various functions and properties.

Functions of the Muscular System

- ✔ Supports the body
- ✔ Makes the bones move
- ✔ Helps maintain constant body temperature
- ✔ Assists movement in cardiovascular and lymphatic vessels
- ✔ Helps protect internal organs and stabilize joints

Three Types of Muscular Tissue



	Location	Function	Appearance	Control
Skeletal	skeleton	movement, heat, posture	striated, multi-nucleated (eccentric), fibers parallel	voluntary
Cardiac	heart	pump blood continuously	striated, one central nucleus	involuntary
Visceral (smooth muscle)	G.I. tract, uterus, eye, blood vessels	Peristalsis, blood pressure, pupil size, erects hairs	no striations, one central nucleus	involuntary

Characteristics of Skeletal Muscle

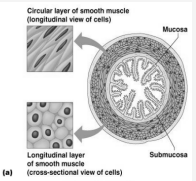
- ✔ Most are attached by tendons to bones
- ✔ Cells are multinucleate
- ✔ Striated – have visible banding
- ✔ Voluntary – subject to conscious control
- ✔ Cells are surrounded and bundled by connective tissue
- ✔ Allow for movement, facial expressions, breathing, swallowing, writing, talking and singing, posture, heat production, joint stability

Skeletal Muscle Attachments

✔ Epimysium blends into a connective tissue attachment	Tendon – cord-like structure
	Aponeuroses – sheet-like structure
✔ Sites of muscle attachment	Bones
	Cartilages
	Connective tissue coverings

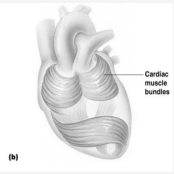
Characteristics of Smooth Muscle

- Has no striations
- Spindle-shaped cells
- Single nucleus
- Involuntary – no conscious control
- Found mainly in the walls of hollow organs



Cardiac Muscle Characteristics

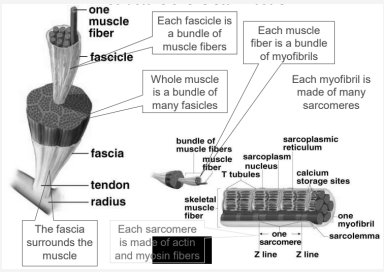
- Found only in the heart
- Involuntary (not under the control of the will)
- Has striations
- Usually has a single nucleus
- Joined to another muscle cell at an intercalated disc



Muscle Cell Type

1. skeletal (or voluntary/striated) muscle	the most abundant tissue in the human body, producing movement.
2. smooth (or visceral) muscle	forming the muscle layers in the walls of the digestive tract, bladder, various ducts, arteries and veins, and other internal organs.
3. cardiac (or heart) muscle	a cross between the smooth and striated muscles, comprising the heart tissue.

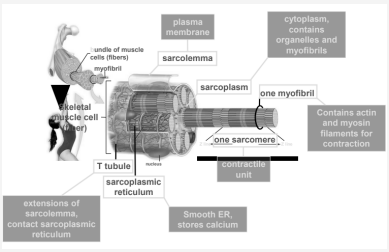
Structure of Skeletal Muscle



Four Different Connective Tissue Coverings

1. Deep fascia	Surrounds entire skeletal muscle and extends beyond its length
2. Perimysium	Surrounds each fascicle
3. Epimysium	Closely surrounds skeletal muscle, binds fascicles together
4. Endomysium	Surrounds each muscle fiber (cell)

Fascicles are arranged bundles of skeletal muscle fibers (cells). Fascicles are bound by connective tissue.



Specialized Organelles of Skeletal Muscle

Sarcoplasmic Reticulum (SR)	✔ a type of ER.
	✔ Surrounds each myofibril, running parallel to it.
	✔ Stores calcium, when stimulated, calcium diffuses into sarcoplasm.
Transverse Tubules (TT)	✔ Extends into sarcoplasm as invaginations continuous with sarcolemma
	✔ T tubules run between cisternae of SR
	✔ Filled with extracellular fluid
	✔ Cisternae of SR and TT form a triad near where thick and thin filaments overlap

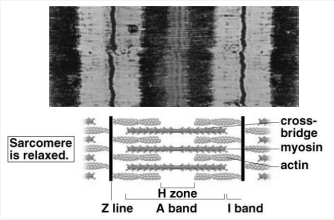
Skeletal Muscle Contraction

Motor Neuron	Nerve cell that innervates skeletal muscle tissue
Dendrite	Receives information
Axon	Transmits information
	Has vesicles containing neurotransmitter that will stimulate or inhibit muscle contraction
Neuromuscular Junction	Site where branch of motor neuron (motor nerve ending) comes in contact with sarcolemma of skeletal muscle fiber
	A type of synapse

Skeletal Muscle Contraction (cont)

Muscle contraction occurs through a complex process involving sarcomeres, action potentials, and the neuromuscular junction. The sliding filament model of contraction explains how myosin and actin interact to produce muscle movement. The process is initiated by a signal from the nervous system, which triggers the release of acetylcholine at the neuromuscular junction. This leads to depolarization and the generation of an action potential, causing calcium ions to be released and allowing for the interaction of myofilaments. The myosin heads bind to actin, resulting in the sliding of filaments and muscle contraction. Once calcium levels deplete, the muscle fiber relaxes. Understanding these basic concepts is important before delving into more detailed aspects of muscle contraction.

Structure of the Sarcomere



Muscle has light and dark bands (striations) corresponding to the placement of myofilaments in the sarcomere.

Sarcomere exists from Z-line to Z-line

• A-Band is dark middle band

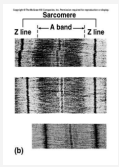
– Overlapping think and thin filaments

• I-Band – ends of A-Band, thin filaments only

• Z-line is in the middle if the I-Band

• Myosin filaments are held to the Z-line by titin proteins

Contraction in the Sarcomere



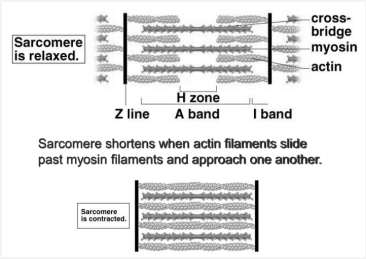
• A band stays the same

• I band gets smaller

• H zone gets smaller

• Sarcomere shortens

Sliding Filament Theory of Muscle Contraction



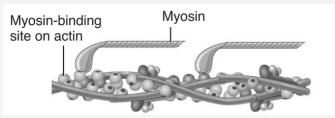
Sliding Filament Theory

• Sarcomere is the functional unit of skeletal muscle

• When a skeletal muscle contracts, sarcomeres shorten

• This is described by the sliding filament theory

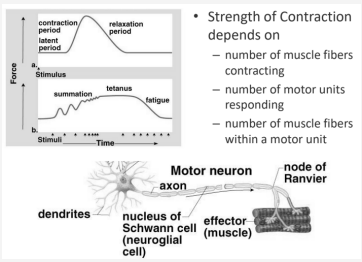
Sliding Filament Theory



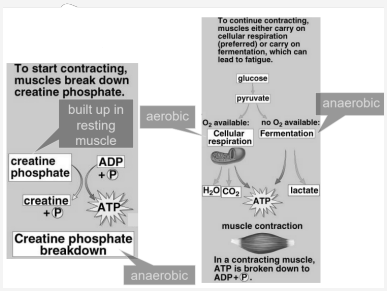
• Sarcomeres shorten because thick and thin filaments slide past one another

• Thin filaments move towards the center of the sarcomere from both ends

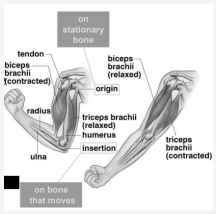
Whole Muscle Contraction



Energy for Muscle Contraction



Skeletal Muscles Work in Pairs



• Muscles contract (shorten) or relax

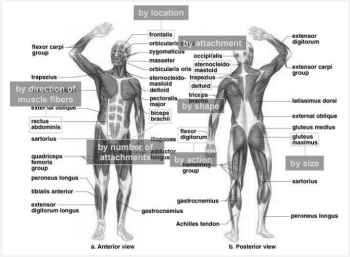
• Muscle contraction pulls on an attached bone

• Prime mover = muscle doing the most work

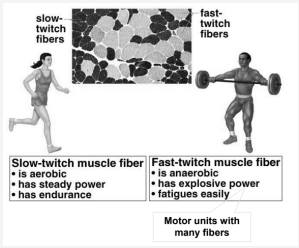
• Synergists = muscles assisting prime mover

• Antagonist = muscle with action opposite to prime mover

Ways to Name Muscles



Slow-and-Fast Twitch Muscle Fibers



Nervous System

Functions of Nervous System

✔ Transmission of signals for communication, regulation and coordination of body systems

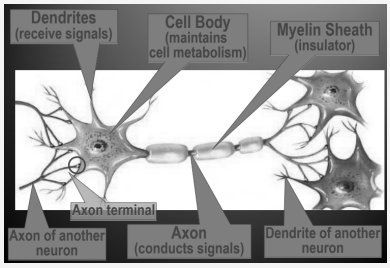
✔ Sensing the world (vision, hearing, taste, smell, and touch

Neurons - The functional unit of the nervous system is the nerve cell

They send electrochemical messages around the body

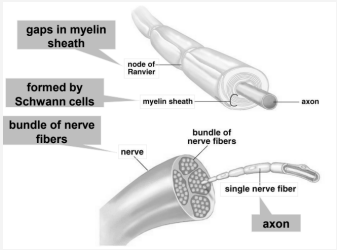
Glial cells provide support and protection for neurons

Structure of a Neuron

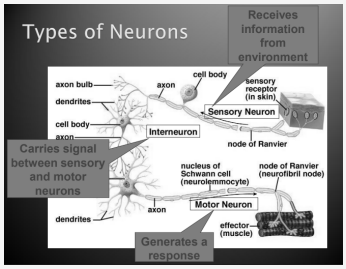


Parts of Nerve Cell

Dendrites	receive chemical signals from neighboring cells.
Cell Body	contains the nucleus & organelles
Axon	long extension that carries electrical messages away from the body to the terminal axons
Terminal Axons	passes the signal to the next cell.
Myelin sheath	Protective covering for axon



Types of Neurons



3 main types of neurons:

☐Sensory neuron = detect stimuli

☐Interneurons = relay sensory signals to brain then return message back to motor neurons.

☐Motor neuron = pass message from brain to rest of body for muscle response

☐ This coordinated pathway is known as the REFLEX ARC

Reflex Arc

"What happens when you step on a nail?"

✔ Reflexes are automatic

✔ The Stimulus (nail) is received by the sensory neurons in the foot

✔ This info travels to the spine, where the interneuron is triggered

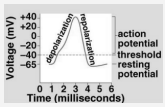
✔ The interneuron transmits signal to brain (through the spinal cord)and carries message back and stimulates the motor neuron, to move the foot

Nerve Impulse

A progressive wave of electric and chemical activity along a nerve fiber that stimulates or inhibits the action of a muscle, gland, or other nerve cell

This is how the information moves from sensory neurons to interneuron to motor neurons

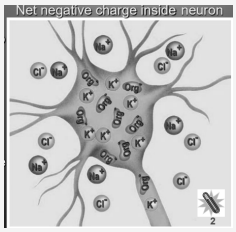
Transmission of Nerve Impulse Along a Neuron



↕ Involves a change in charge across the neuron's membrane, caused by the movement of ions

↕ Action Potential = rapid depolarization and repolarization of membrane

Resting Potential Depends on Ionic Gradients



Inside:

• Potassium ions are pumped into cell

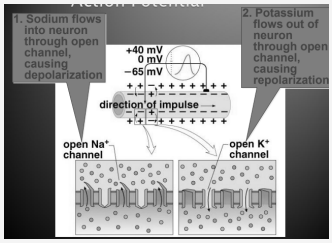
• Large organic molecules cannot pass through membrane

Outside:

•Sodium ions are pumped out

•Chloride ions found in extra-cellular fluid

Action Potential



Transmission of Nerve Impulses Between Neurons

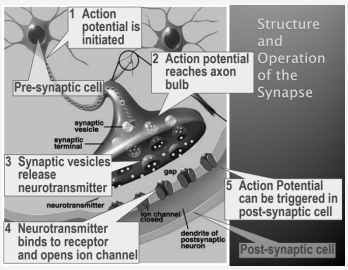
Signal is carried by neurotransmitters that diffuse across the space between neurons.

Synapse: junction between neurons

Synaptic cleft: space between neurons

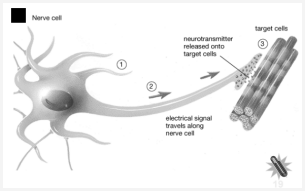
Neurotransmitters bind to receptors on next neuron, opening ion channels

Structure and Operation of the Synapse



Transmission Between Neurons

Neurotransmitters can be	✔ Excitatory: initiate action potential - Acetylcholine
	✔ Inhibitory: prevent action potential - Dopamine
After acting on the post-synaptic neuron, neurotransmitters are removed from the synaptic cleft	Acetylcholinesterase breaks down acetylcholine



Neurotransmitters carry signals to muscle cells to stimulate contraction.

Disorders of the Nervous System

✔ **Multiple Sclerosis**	Autoimmune disease leading to breakdown of neuron myelin sheaths
✔ **Parkinson's Disease**	Degeneration of neurons that produce dopamine

Disorders of the Nervous System (cont)

✔ **Alzheimer's Disease**	Extensive death of neurons and loss of brain tissue

Neurons, the main cells in the nervous system, have an incredible amount of branching within each cell, allowing them to respond to stimuli and transmit electrical impulses over long distances. They are amitotic and can live for a hundred years or more.

Neuroglia, or glial cells, are supporting cells in the nervous system that wrap around delicate parts of neurons to provide protection. They do not transmit electrical impulses like neurons but play a crucial role in maintaining the health and functioning of neurons.

Neurons can be classified by their structure or function. Structurally, they can be **unipolar, bipolar, or multipolar**, depending on the number of processes extending from the cell body. Functionally, they can be **sensory, motor, or interneurons**, depending on the direction of signal transmission.

(cont)

Neurons have distinct regions: the **receptive region** where stimuli are received, the **trigger zone** where electrical signals are initiated, the **conducting region** where signals travel along the axon, and the **secretory region** where neurotransmitters are released at the axon terminals.

The generation of electrical impulses in neurons is dependent on changes in membrane potential and the opening of ion channels. Different types of ion channels, such as **chemically-gated** and **voltage-gated channels**, allow specific ions to flow in and out of the cell, generating electrical currents.

The nervous system is composed of the **central nervous system (CNS)**, which includes the brain and spinal cord, and the **peripheral nervous system (PNS)**, which consists of nerves that extend throughout the body. The CNS is the control center where sensory information is integrated and motor outputs are determined and implemented.

(cont)

The PNS is divided into the **sensory (afferent)** division, which sends signals from receptors to the CNS, and the **motor (efferent)** division, which sends signals from the CNS to muscles and glands. The motor division is further divided into the **somatic nervous system (voluntary control)** and the **autonomic nervous system (involuntary control)**, which includes the sympathetic and parasympathetic divisions that often have opposing functions.