

Functions of Muscular Tissue

- Muscles make up a large percentage of the body's weight
 - Nearly half
- Their main functions are to:
 - Create motion
- Muscles work with nerves, bones, and joints to produce body movements
 - Stabilize body positions and maintain posture
- Sustained contractions of your neck muscles keep your head upright while you are paying attention in lecture!!!
 - Store substances within organs using sphincters
- Sphincters in your bladder keep you from micturating all over yourself
 - Move substances throughout the body by peristaltic contractions
- Moving food down your esophagus or through the intestines.
 - Generate heat through thermogenesis
- Shivering is involuntary contractions of skeletal muscle to increase the rate of heat production

Types of Muscle

- Myo, mys, and sarco
 - prefixes for muscle
- Three main types of muscle in the human body
 - Skeletal
 - Cardiac
 - Smooth

Organization of Skeletal Muscle Tissue

- Each muscle served by one artery, one nerve, and one or more veins
 - Enter/exit near central part and branch through connective tissue sheaths
 - Every skeletal muscle fiber supplied by neuron ending that controls its activity
 - High metabolic rate when contracting
- Uses large amounts of ATP
- Huge nutrient and oxygen need
- Generates large amount of waste

Organization of Skeletal Muscle Tissue

- In groups of muscles, the epimysium continues to become thicker forming a fascia which covers many muscles
 - This graphic shows the fascia lata enveloping the entire group of quadriceps and hamstring muscles

Organization of Skeletal Muscle Cell

- Beneath the connective tissue of the endomysium is the plasma membrane (sarcolemma) of an individual muscle cell
- The cytoplasm (sarcolemma) of a skeletal muscle fiber is chocked full of contractile proteins arranged in contractile bands called myofibrils
 - These are the sites that physically shorten in order to produce muscle tension

Muscle Fiber Structures

- Myofibril
 - Densely packed, rod-like elements
 - ~80% of cell volume
 - Contain sarcomeres
 - contractile units
 - Sarcomeres contain myofilaments (contractile proteins of muscle)
 - Exhibit striations
 - perfectly aligned repeating series of dark A bands and light I bands
 - Transverse (T)-Tubules
 - Tunnels of sarcolemma that run from the surface of the muscle cell to the inner regions
 - Open to the outside of the fiber and are filled with interstitial fluid
 - Muscle AP's travel along sarcolemma and down into the T-tubules
 - Allows for quick spreading of AP throughout the muscle fiber and almost equal instantaneous excitation

Myofibril Banding Pattern

- Orderly arrangement of actin and myosin myofilaments within sarcomere
 - Actin myofilaments = thin filaments
 - Extend across I band and partway in A band
 - Anchored to Z discs
 - Myosin myofilaments = thick filaments
 - Extend length of A band
 - Connected at M line

Other Important Sarcomere Proteins

- Elastic filaments
 - Composed of protein titin
 - Holds thick filaments in place; helps filaments recoil after stretch
- Also resists excessive stretching
- Dystrophin
 - Links thin filaments to proteins of sarcolemma
- Nebulin, myomesin, C proteins bind filaments or sarcomeres together
 - Important in maintenance of alignment

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Properties of Muscular Tissue

- Like nervous tissue, muscles are excitable, or "irritable"
 - they have the ability to respond to a stimulus
- Unlike nerves, however, muscles are also:
 - Contractible
 - Extensible
 - Elastic

Types of Muscle

- Skeletal muscles
 - Organs attached to bones and skin
 - Elongated cells called muscle fibers
- Skeletal muscle fiber and skeletal muscle cell are the same thing
- Some are quite long
 - The Sartorius muscle contains single fibers that are at least 30 cm long
 - Striated (striped)
- Microscopic arrangement of contractile units give striated appearance
 - Multinucleate
 - Voluntary (i.e., conscious control)
 - Require nervous system stimulation for contraction

Organization of Skeletal Muscle Tissue

- The epimysium, perimysium, and endomysium all are continuous with the connective tissues that form tendons, ligaments, and muscle fascia (connect muscles to other muscles to form groups of muscles)
- Connective tissue sheaths of skeletal muscle

Organization of Skeletal Muscle Tissue (cont)

- Support cells; reinforce whole muscle
- External to internal
 - Epimysium: dense irregular connective tissue surrounding entire muscle; may blend with fascia
 - Perimysium: fibrous connective tissue surrounding fascicles (groups of 10-100 muscle fibers)
 - »Fascicles form the "grain" in meat
 - Endomysium: fine areolar connective tissue surrounding each individual muscle fiber

Organization of Skeletal Muscle Tissue

- Many large muscle groups are encased in both a superficial and deep fascia

Organization of Skeletal Muscle Cell

- You will need to learn the names of the internal structures of the muscle fiber
 - Sarcolemma
 - Sarcoplasm
 - Myofibril
 - T-tubules
 - Triad
 - Terminal cisterns
 - Sarcoplasmic reticulum
 - Sarcomere

Muscle Fiber Structures

- Sarcoplasmic Reticulum
 - Similar to the smooth edoplasmic reticulum of the typical cell
 - Stores and releases calcium ions, amongst many other functions
- Terminal Cisternae
 - Dilated end sacks of the sarcoplasmic reticulum that butt against the T-tubules
 - Allow for quick release of Ca²⁺ from SR into sarcoplasm when stimulated
- Triad
 - Formed from a T-tubule and two terminal cisterns

Thin Filaments

- Twisted double strand of fibrous protein F actin
- F actin consists of G (globular) actin subunits
- G actin bears active sites for myosin head attachment during contraction
- Tropomyosin and troponin
 - regulatory proteins bound to actin

Properties of Muscular Tissue

- Electrical excitability
 - Respond to certain stimuli by producing electrical signals called action potentials (APs)
- Contractility
 - Muscle tissue contracts forcefully when stimulated by action potential
 - Muscle contraction generates tension (force of contraction) while pulling on it's attachment points
 - ATP used to power contraction
- Extensibility
 - Muscle tissue is able to stretch, to a certain point, without being damaged.
- Elasticity
 - Muscle is able to return to it's normal length after being stretched or shortened (contracted).

Types of Muscle

- Cardiac muscle
 - Only in heart; bulk of heart walls
 - Branched short cells
 - Striated–Uni or binucleate
 - Can contract without nervous system stimulation
 - Involuntary (not under conscious control)
 - More detail in Chapter 18
- Smooth muscle
 - In walls of hollow organs, e.g., stomach, urinary bladder, and airways
 - Non-striated
 - Uninucleate
 - Can contract with or without nervous system stimulation
 - Involuntary

Organization of Skeletal Muscle Tissue

- Skeletal muscles attach in at least two places
 - Insertion
 - movable bone
 - Origin
 - immovable (less movable) bone
- Attachments can be direct or indirect
 - Direct
 - epimysium fused to periosteum of bone or perichondrium of cartilage
 - Indirect
 - connective tissue wrappings extend beyond muscle as rope like tendon or sheetlike aponeurosis

Organization of Skeletal Muscle Tissue

- An aponeurosis is essentially a thick, flat fascia that connects two muscle bellies.
 - The epicranial aponeurosis connects the muscle bellies of the occipitalis and the frontalis to form “one” muscle: The occipitofrontalis

Skeletal Muscle Fiber Structures

- Sarcolemma
 - The plasma membrane of the muscle cell
- Sarcoplasm
 - The cytoplasm of the muscle cell
 - Glycosomes for glycogen storage
- Contain a lot of glycogen
 - Glucose polymer that can be hydrolyzed to provide glucose for ATP production when sarcoplasmic glucose levels fall during contraction
- Myoglobin
 - Globular protein found only in muscle cells
 - Binds oxygen that diffuses into the muscle cell from the interstitial fluid (fluid directly outside the cell)
 - Similar to hemoglobin of red blood cells
 - Releases oxygen when mitochondria need it to make ATP
 - Function as quick oxygen reserve when sarcoplasmic O₂ levels decline from high contractile rate leading to decrease in blood flow

Muscle Fiber Structure

- Increasing the level of magnification, the myofibrils are seen to be composed of sarcomeres
 - The smallest contractile unit (functional unit) of skeletal muscle fibers
- Align along myofibril like boxcars of a train
- Composed of thick and thin myofilaments made of contractile proteins
- Contains A band with $\frac{1}{2}$ I band at each end
- Z-discs form sarcomere boundary

Thick Filaments

- Composed of protein myosin
- Each composed of 2 heavy and 4 light polypeptide chains
 - Myosin tails contain 2 interwoven, heavy polypeptide chains
 - Myosinheads contain 2 smaller, light polypeptide chains per head that act as cross bridges during contraction
- Binding sites for G-actin of thin filaments
- Binding sites for ATP
- ATPase enzyme activity