

Anatomy and Physiology 121: The Muscular System

Review: three types: skeletal, cardiac, smooth

Muscle cells are called *muscle fibers*

Contraction depends on two kinds of *Myofilaments*

Actin

Myosin

Prefixes to know: **myo**, **mys**, or **sarco** – word relates to muscle

Each muscle is a discrete organ

Muscle Type Overview

Skeletal Muscle tissue

Skeletal

Striated

Voluntary

Cardiac Muscle tissue

Cardiac

Striated

Involuntary

Smooth Muscle tissue

Visceral

Non-striated

Involuntary

Muscle Functions

1. Producing movement
2. Maintaining posture
3. Stabilizing joints
4. Generating heat

Functional Characteristics of Muscles

- Excitability (or Irritability) = ability to receive and respond to stimuli
- Contractility = ability to shorten forcibly
- Extensibility = ability to be stretched or extended beyond resting length
- Elasticity = ability to resume resting length after stretching

Anatomy of a Muscle

Typical ex. is a skeletal muscle

Level of Organization

Muscle (organ)

Fascicle (a portion of the muscle)

Muscle Fiber (a cell)

These levels are supracellular

Connective Tissue Layer

Epimysium

Perimysium

Endomysium

Anatomy of a Muscle

Typical ex. is a skeletal muscle

The following are all subcellular.

- Myofibril = or fibril, complex organelle composed of bundles of myofilaments
- Myofilament = macromolecular structure of contractile proteins
- Sarcomere = the smallest, single contracting unit of a myofibril, a segment

Gross Anatomy

- Deep fascia = binds large groups of muscles into functional groups
- Muscle = hundreds of fascicles bound together by epimysium
- Fascicle = thousands of muscle fibers bound into discrete units by perimysium
- Muscle fiber = single muscle cell surrounded by endomysium
- Generous blood and nerve supply

Microscopic Anatomy of a Muscle Fiber

Muscle Fiber = elongated, cylindrical, multinucleated muscle cell

Sarcolemma = plasma (cell) membrane of a muscle cell

Sarcoplasm = cytoplasm of muscle cell with large amounts of glycogen and myoglobin

Myoglobin = red pigmented oxygen-binding protein

Sarcoplasmic reticulum (SR)

- Modified endoplasmic reticulum
- Run longitudinally and surrounds each myofibril
- *Terminal cisternae*: large cross channels where A and I bands meet
- Stores and releases calcium ions for contractions

Microscopic Anatomy of a Muscle Fiber

T (transverse) - tubules

- Continuations of the sarcolemma invaginating into fiber
- Located at A and I band junction and encircle sarcomere
- Conduct nerve impulses to interior of muscle fiber

Myofibrils

- Contractile elements of muscle cells, thousands per cell
- Striations: series of dark and light bands
 - a) A bands = the dark bands
 - b) I bands = the light bands

Sarcomere

- Smallest contractile unit of a fiber

Structure of a Sarcomere

The region of a myofibril between two successive Z-lines

Chain of sarcomeres aligned end to end form a myofibril

A-bands

- Where thick and thin filaments overlap
- **H-zone**: lighter midsection stripe in A-band
- **M-line**: dark line bisecting the H-zone

I-bands

- **Z-line**: dark, zigzag midline break in I-band

Myofilaments (create banding pattern)

- Thick filaments: run entire length of A-band
- Thin filaments: entire I-band and partway into A-band

Structure of Myofilaments

A. Thick filaments: composed mainly of **myosin**

- Two heads called *cross bridges* (business end) and rod like tail
- Actin binding sites, ATP binding sites, ATPase

B. Thin filaments: composed mainly of **actin**

- Actin subunits and myosin binding sites
- Regulatory proteins: both control myosin-actin interactions
 1. Tropomyosin
 - Two strands spiral around actin, blocks actin's binding sites, stiffens core
 2. Troponin (three unit protein)
 - TnI = actin binding protein
 - TNT = tropomyosin binding protein
 - TnC = calcium binding protein

Generation of an Action Potential

- Resting Membrane Potential and polarization
- Step 1) Depolarization and generation of the action potential
- Step 2) Propagation of the action potential
- Step 3) Repolarization
- Special Terms
- Neuromuscular Junction
- Motor End Plate
- Acetylcholine
- Refractory Period

Excitation-Contraction (E-C) Coupling

- (1) Action potential propagates along sarcolemma and down T-tubule
- (2) Action potential causes release of calcium from terminal cisternae
- (3) Some calcium binds to troponin, changing its shape
- (4) Myosin heads attach and pull thin filaments toward center of the sarcomere
- (5) Calcium reclaimed back into terminal cisternae

- (6) Tropomyosin blockage is reestablished

Muscle Fiber Contraction

- (1) Cross bridge formation
- (2) The working (power) stroke
- (3) Cross bridge detachment
- (4) “Cocking” of the myosin head

Contraction of Skeletal Muscle

- Muscle tension (effort) and load
- The motor unit
- Twitch and tetanus
 - Latent period
 - Period of contraction
 - Period of relaxation
- Graded Responses
 - Wave summation
 - Incomplete tetanus
 - Complete tetanus
- Recruitment
- Muscle tone
- Isotonic contractions
- Isometric contractions

Muscle Metabolism

- Stored ATP
- Anaerobic Glycolysis and Lactic Acid formation
- Aerobic Respiration
- Muscle Fatigue
- Oxygen Debt
- Heat Production During Muscle Activity
- Force of Muscle Contraction
- Velocity and Duration of Contraction
 - Slow Fibers versus fast Fibers

Interactions of Muscles

1. Agonist (or prime mover) = provides major force for producing a specific movement
2. Antagonists = muscles that oppose, or reverse, a particular movement
3. Synergists = aide agonists by:

- a) Promoting the same movement
 - b) Reducing undesirable or unnecessary movements
4. Fixators = synergists that immobilize a bone (ex. Scapula)

Naming Skeletal Muscles

1. Location of the muscle (ex. *Costal*)
2. Shape of the muscle (ex. *Trapezius*)
3. Relative size of the muscle (ex. *Minimus*)
4. Direction of muscle fibers (ex. *Oblique*)
5. Number of origins (ex. *Biceps, Triceps*)
6. Location of the muscle's origins and/or insertions (ex. *Sterno, Brachialis*)
7. Action of the muscle (ex. *Flexor, Adductor*)

Muscle Attachments

- Origin = less or immovable bone
- Insertion = the movable bone
- Direct = origin or insertion: muscle attached directly to bone or cartilage
- Indirect = origin or insertion: muscle fascia extends as tendon or aponeurosis to anchor muscle

Arrangement of Fascicles

- Parallel (biceps brachii)
- Pennate (rectus femoris)
- Convergent (pectoralis major)
- Circular (orbicularis oculi)

Lever Systems: Bone-Muscle Relationships

- Lever Systems
 - Lever, fulcrum, effort and load
- First Class Levers (ex. scissors)
- Second Class Levers (ex. wheel barrow)
- Third Class Levers (ex. tweezers)