Tikrit University
College of Veterinary Medicine

Muscles physiology

Subject name: physiology

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Lecturers link

Muscle Physiology

Muscle Function

- Movement
  - Depends on type of muscle tissue
  - Depends on location of muscle tissue
- Thermogenesis
- Protection
- Posture Maintenance
- Joint Stabilization

Muscle Tissue Characteristics

All muscle tissues share basic characteristics

1. Excitability
2. Contractility
3. Elasticity
4. Extensibility

Muscle Tissue Types

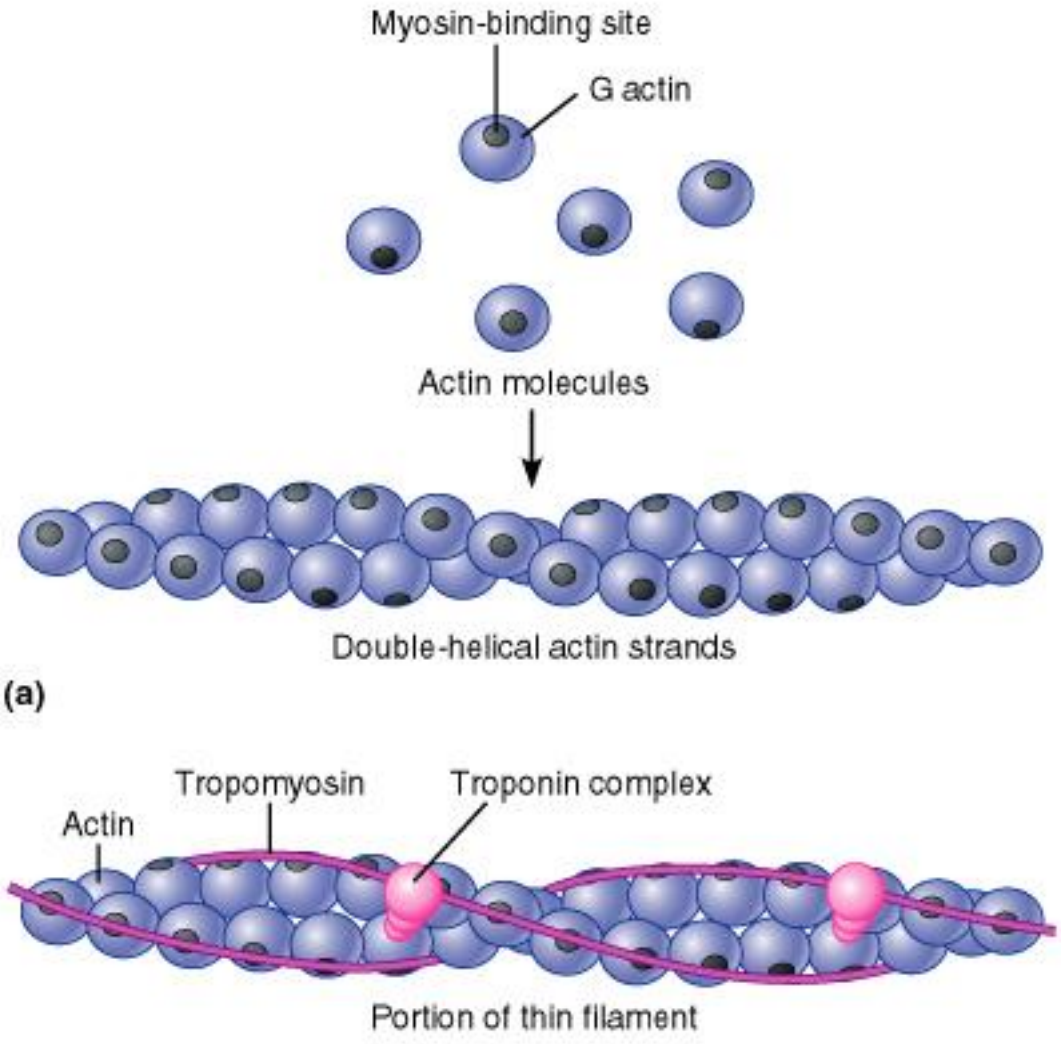
- Skeletal
  - Attached to bones
  - Nuclei multiple and peripherally located
  - Striated, Voluntary and involuntary (reflexes)
- Smooth
  - Walls of hollow organs, blood vessels, eye, glands, skin
  - Single nucleus centrally located
  - Not striated, involuntary, gap junctions in visceral smooth
- Cardiac
  - Heart
  - Single nucleus centrally located
  - Striations, involuntary, intercalated disks

Muscle Comparison Chart

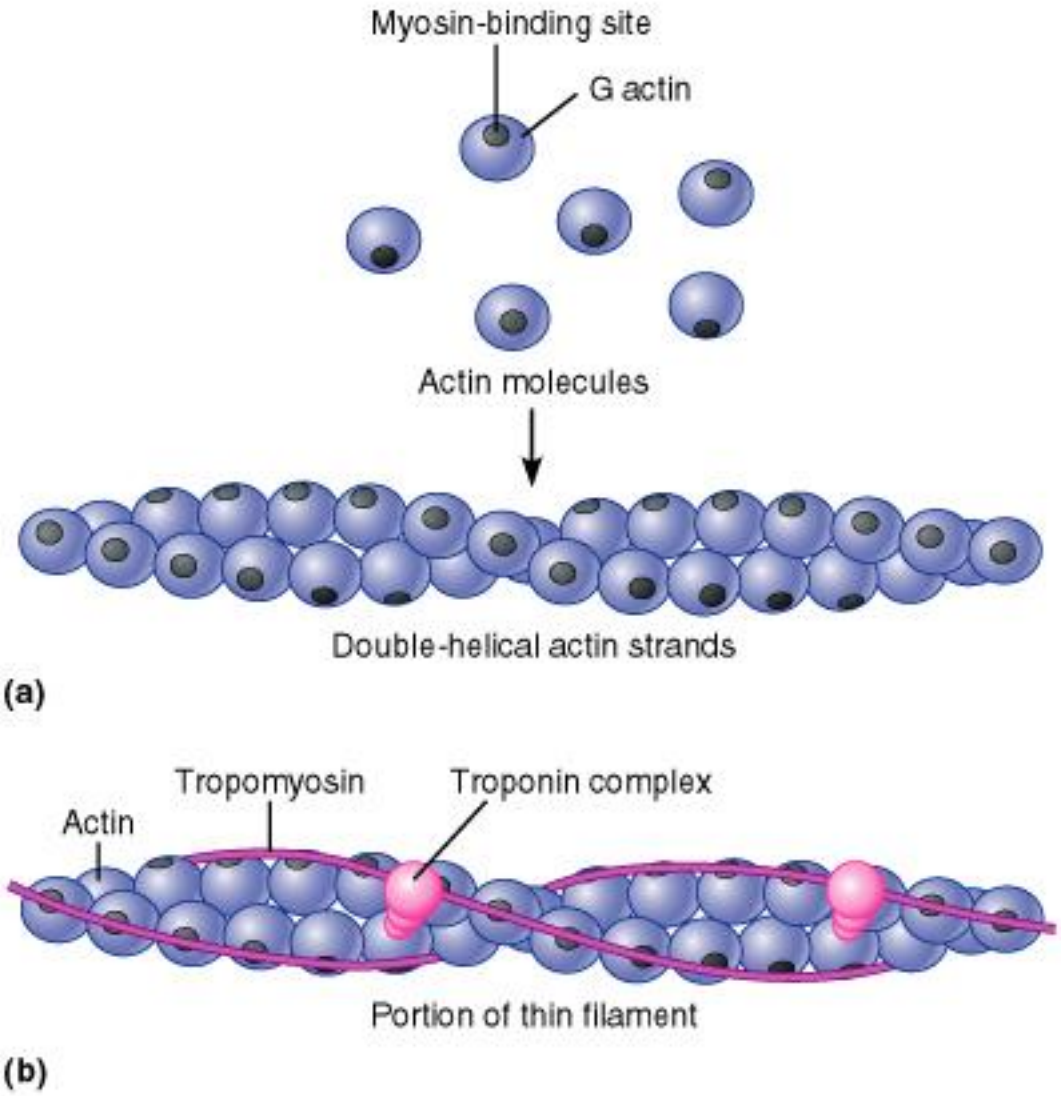
Skeletal Muscle	Smooth Muscle	Cardiac Muscle
Striated	Not striated	Striated
Voluntarily controlled	Involuntarily controlled	Involuntarily controlled
Cells have many nuclei that are peripheral to their fibers	Cells have only one nucleus at the center	Cells have only one nucleus at the center
Attached to bones	Found on hollow internal organs such as stomach and blood vessels	Found on the heart's wall
Responsible for movement of the skeleton and muscles	Responsible for the movement of substances such as food and blood	Responsible for moving blood in the heart

Skeletal Muscle Structure – Molecular Level

- **Actin**
  - ***G-actin*** (globular actin) = the basic component of each actin myofilament
    - Contains myosin binding sites
  - The actin myofilament consists of *two* strands of G-actin molecules
    - The two strands of G-action molecules are twisted together with two regulatory proteins:
      - ***tropomyosin***
      - ***troponin***



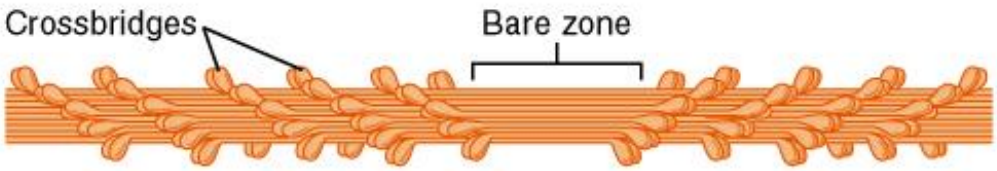
- ***Tropomyosin***
  - Rod-shaped protein that occupies the groove between the twisted strand of actin molecules
  - Blocks the myosin binding sites on the G-actin molecules
- ***Troponin***
  - A complex of three globular proteins.
    - One is attached to the actin molecule
    - One is attached to tropomyosin
    - One contains a binding site for calcium



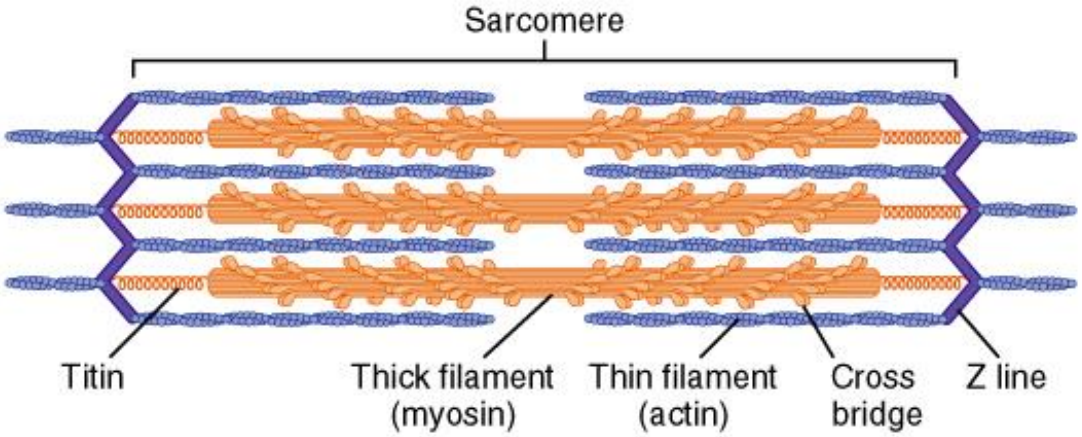
- **Myosin**
  - ***Crossbridges***
    - Composed of a rod-like tail and two globular heads
      - The tails form the central portion of the myosin myofilament
      - The two globular headsface outward and in opposite directions
    - Interact with actin during contraction.
    - Contain binding sites for both actin and ATP
      - The enzyme ***ATP-ase*** is located at the ATP binding site for hydrolysis of ATP

(a) Myosin molecule

(b) Two myosin molecules bound at their tail ends



(c) Portion of thick filament



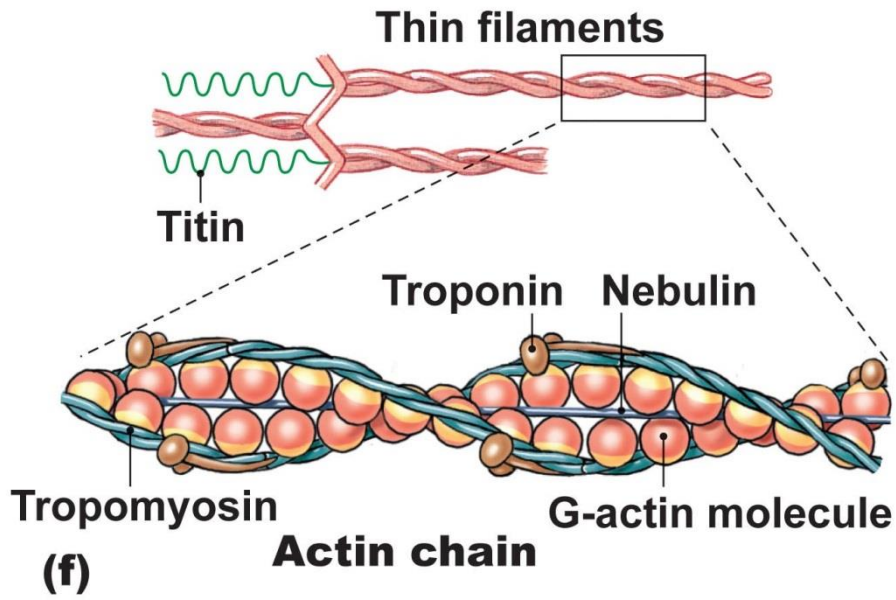
(d) Sarcomere

Titin

- Connects myosin to the Z-lines in the sarcomere
- It is very elastic
- Important molecule because it is responsible for muscle flexibility

Nebulin

- Filament that formsinternal support and attachment for actin



Skeletal Muscle Contraction – Force Generation

- Chemical or heat energy in the body is converted to mechanical work or movement.
- A nerve impulse arrives at the neuromuscular junction (NMJ) and stimulates the beginning of the contraction process
  - NMJ = synapse between a motor neuron and a skeletal muscle cell
- Stimulation of the skeletal muscle cell triggers the release of calcium ions from the terminal cisternae of the sarcoplasmic reticulum
  - Calcium catalyzes the contraction process
- Calcium ions bind to troponin causing a conformational change
  - Troponin then pushes tropomyosin away thus exposing the active site that it is covering on actin
- Myosin crossbridges have a strong affinity for the exposed active site on the actin molecule
  - Myosin binds to the exposed active site
- Myosin crossbridges pull on the actin myofilament pulling it toward the center of the sarcomere
  - This motion physically shortens the sarcomere, the myofibril, and the muscle fiber.
- After the sarcomere is shortened, the calcium ions are pumped back into the sarcoplasmic reticulum

- Calcium ions are stored until another nerve stimulus arrives at the NMJ

- Tropomyosin moves back to its original position of covering the active site
    - This causes the myosin crossbridges to release their hold on the actin myofilament
- The actin myofilaments slide back to their original position

Fatigue

- Decreased capacity to work and reduced efficiency of performance
- **Types:**
    - Psychological
        - Depends on emotional state of individual
    - Muscular
        - Results from ATP depletion
    - Synaptic
        - Occurs in neuromuscular junction due to lack of acetylcholine
    - Differences in smooth muscle include
        - Actin has no troponin, the protein that binds to myosin in skeletal muscle. Rather smooth muscle has a calcium binding protein called ***calmodulin***. This protein activities the actin and myosin crossbridge formation.
        - Most of the calcium required for contraction comes into the cell by diffusion from the extracellular fluid.
        - Smooth muscle is more resistant to fatigue and produces a slower, longer lasting contraction than skeletal muscle.
        - It is more energy efficient than skeletal muscle in that it can maintain a more forceful contraction for a longer period of time with the same amount of ATP.

Questions

Q1 / explain in details mechanism of muscle contraction .

Q2/ put (true) of (false) in front of each item and correct the wrong phrase .

1- ***Nebulin protein Connects myosin to the Z-lines.***
2- ***ATP-ase is located at the ATP binding site on actin protein.***
3- ***binding site for calcium located on Tropomyosin.***
4- ***Calmodulin protein contribute in the contraction of skeletal muscle .***

Q3/ enumerate all proteins that contribute in contraction of skeletal muscle and explain functions of it .