Online Physiology 2130 – Muscles

Introduction

Dear Student,
Thank you for opening this resource for Physiology 2130, and welcome. This resource has been created by the Education Team at WebStraw. The Education Team consists of students that have previously taken and/or students that are currently taking Physiology 2130.

Purpose

This resource focuses on key concepts that are important for students to understand to succeed within this course. This resource was created by students for other students. Our goal is to help students (1) further develop their understanding of course content and (2) achieve greater academic success. (3) Our resource is also open access meaning there are no financial or legal barriers to students who wish to access and use our resource.

Instructions

These study resources consists of several parts. The first part includes a condensed review of the major takeaways from each physiology module. This is followed by a series of questions and fill in the blank worksheets that should be completed after you have gone through the module and course material, in order to verify your understanding.

Disclaimer

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We wish you the best of luck on your exams!
The WebStraw Team

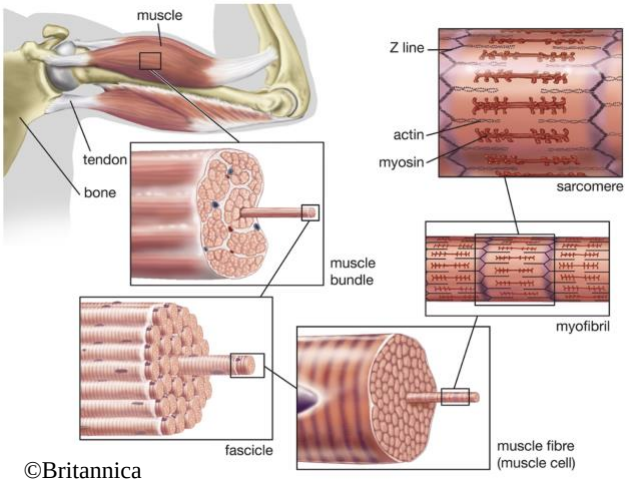
Note to Instructors: If this resource has been created for your course and you would like to collaborate with us, please email us at team@webstraw.ca

Module 5 - Muscles

Structure of a Skeletal Muscle

- **Sarcomeres** slide past each other when a muscle contracts or relaxes
  - Between two Z-lines
- Muscles are composed of groups of **fasciculi**
  - Fasciculi are surrounded by **perimysium** – a white connective tissue
- A **Fascicle** is made up of bundles of **muscle cells/fibers**
  - muscle cells contain MORE THAN ONE nucleus
- **Sarcolemma** is the cell membrane of the muscle cell
  - the action potential is transmitted here
- Within muscle cells are long cylindrical bundles of **myofibrils**
  - Myofibrils are made up of **thick** and **thin myofilaments** – the contractile proteins
  - Myofibrils are surrounded by the **sarcoplasmic reticulum (SR)**, which contains calcium ions
- **Terminal cisternae** is continuous with the SR
  - Close to the T tubule
- **Transverse (T) tubules** extend down into the cell
  - Small tube-like projections

fascicle → muscle cell → myofibril → myofilament



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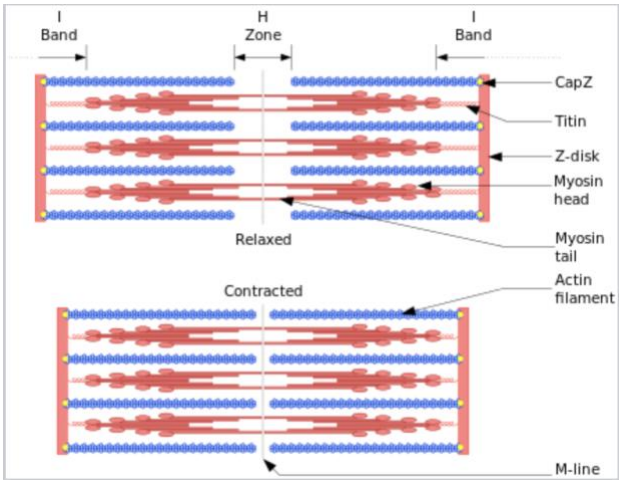
The Sliding Filament Theory

- Interaction between *actin* and *myosin* leads to muscle contractions
- Myosin molecule attaches to binding site on actin → forms crossbridge → myosin changes shape → myosin head swings → **power stroke** → actin slides past myosin



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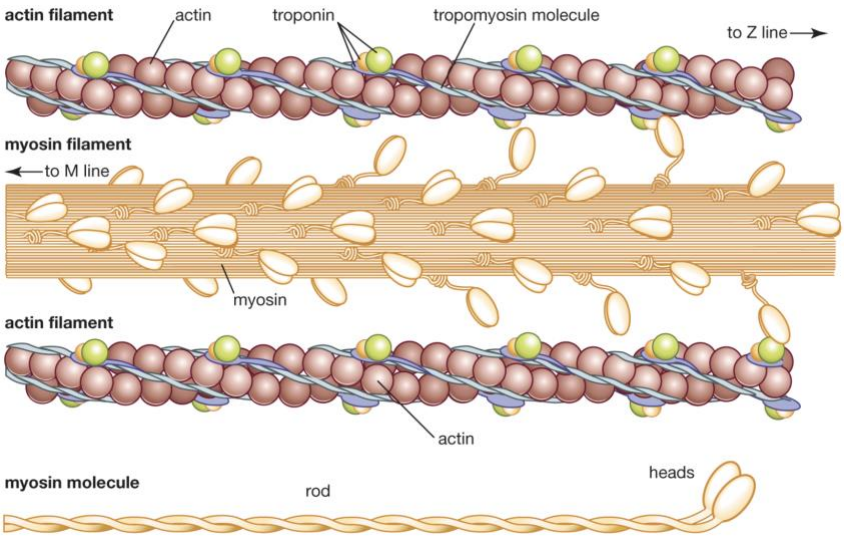
*thin and thick myofilaments **do not** shorten during muscle contractions

Excitation-Contraction Coupling

- Action potential on the sarcolemma excites the muscle cell to produce muscle contractions

Action potentials travel down transverse tubules → Ca^{++} is released → binding of calcium to troponin → shifting of tropomyosin → active sites on actin is exposed



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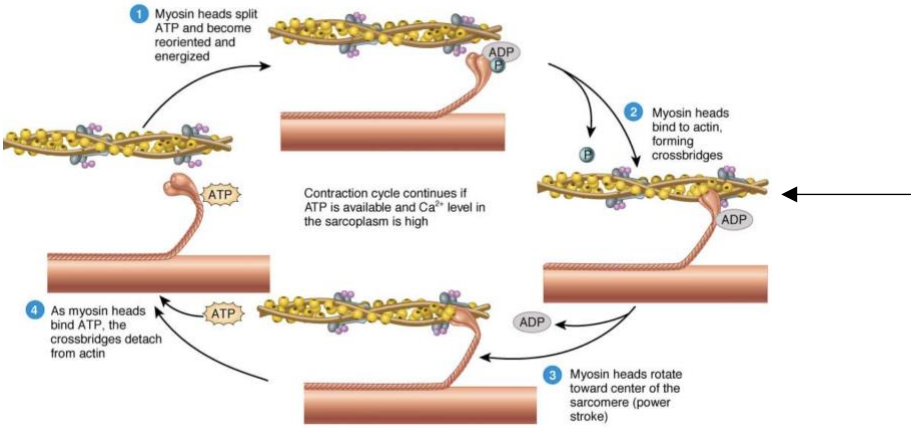
Thin Myofilaments

- Composed of **actin**
  - Actin molecules contains **special binding sites** for myosin
- **Tropomyosin** is a long protein strand found on thin myofilaments
  - Covers the myosin-binding sites to prevent actin from binding to myosin which prevents cross-bridge formation and prevents contraction
- **Troponin** (regulatory protein) is made up of three subunits
  - **Troponin A** (binds to actin)
  - **Troponin T** (binds to tropomyosin)
  - **Troponin C** (binds with Ca^{++})

Thick Myofilaments

- Composed of **myosin**
  - Bendable tail, and two heads that can attach to the myosin binding sites on actin
  - Head can also bind and split ATP – powering muscle contractions



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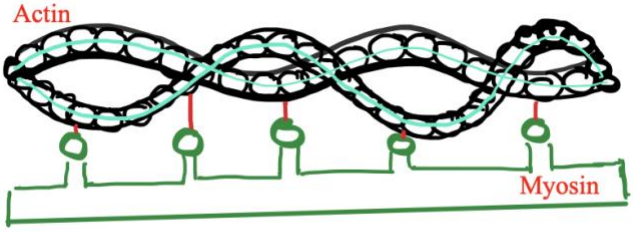
Actin-Myosin and ATP Cycle

1. Splitting of ATP to ADP and Pi releases energy to myosin
2. Formation of actin-myosin crossbridge
3. Power stroke occurs when the myosin head bends/slides thin myofilaments over thick myofilaments
   - ADP and Pi are released from myosin head
4. New molecule of ATP binds to myosin head
   - Breaking of cross-bridge

Rigor Mortis

- Begins 3-4 hours after death
- Muscles become stiff for 12 hours
- Stiffness fades over 24-48 hours

1. Loss of ATP in dead muscle cells
2. Slow degradation of the SR releases Ca++
3. Myosin binds to actin
4. Forms crossbridge between thin and thick myofilaments
5. Muscle rigidity occurs from the **loss** of ATP



- NO ATP
- Myosin heads attached to actin filaments
  - Muscle is locked in contracted position

Summation of Twitch Contraction

- Consecutive stimulation of multiple muscle twitches
- A muscle twitch is a mechanical event that relies on interaction amongst proteins
- Increase number of action potentials per second → increase the force of contraction
  - Increasing number of action potentials is directly proportional to frequency
  - High frequency = maximal tetanic contraction

Force of Muscle Contraction

- Can be altered in two ways:
  1. Recruit motor units
  2. Increase the frequency of action potentials

Review Questions

1. Which of the following terms does not correspond to its function?
   1) Sarcolemma – Muscle cell membrane
   2) Transverse Tubule – Conducts action potential into the cell
   3) Terminal Cisternae – Continuous with the SR
   4) Sarcoplasmic Reticulum – Action potential is transmitted here

   a. 1 & 3 only
   b. 1, 2, & 3 only
   c. 2 & 4 only
   d. 4 only

2. Which element directly triggers contraction in the muscles?
   a. Potassium
   b. Sodium
   c. Calcium
   d. Chloride

3. Which of the follow represents the correct order for the largest to smallest units in muscles?
   a. Fascicle, muscle fiber, myofibril, filament
   b. Fascicle, filament, muscle fiber, myofibril
   c. Muscle fiber, fascicle, filament, myofibril
   d. Myofibril, muscle fiber, filament, fascicle

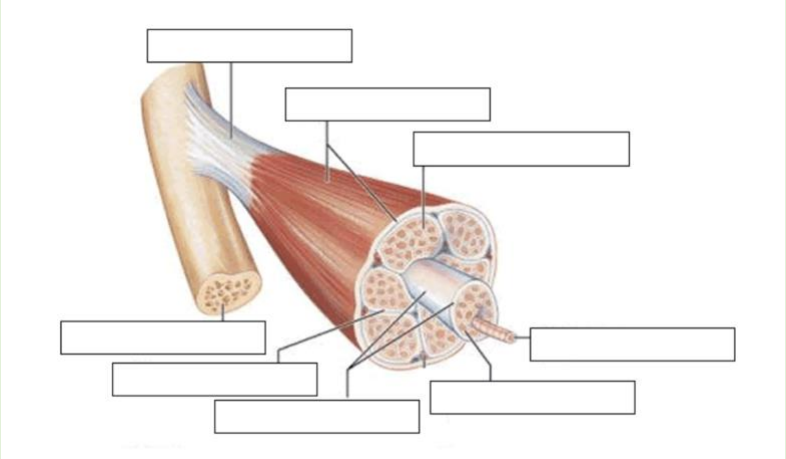
4. The myosin-binding site on actin is blocked by _____, preventing cross-bridge formation.
   a. Titin
   b. Troponin
   c. Tropomyosin
   d. Myosin

5. Binding sites on actin open when _____.
   *HINT: Think about the sliding filament theory.
   a. Calcium rises
   b. ATP rises
   c. Acetylcholine rises
   d. Troponin T rises

6. During muscle contraction, the cross-bridge detaches when _____.
   a. Calcium binds to troponin
   b. Calcium binds to myosin
   c. Myosin head binds to ADP and Pi
   d. Myosin head binds to actin

Structure of a Skeletal Muscle

Label the diagram.



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The Sliding Filament Theory

Fill in the blanks.

- Myosin molecule attaches to binding site on actin → _____ → myosin changes _____ → myosin head swings → _____ → slides actin past _____

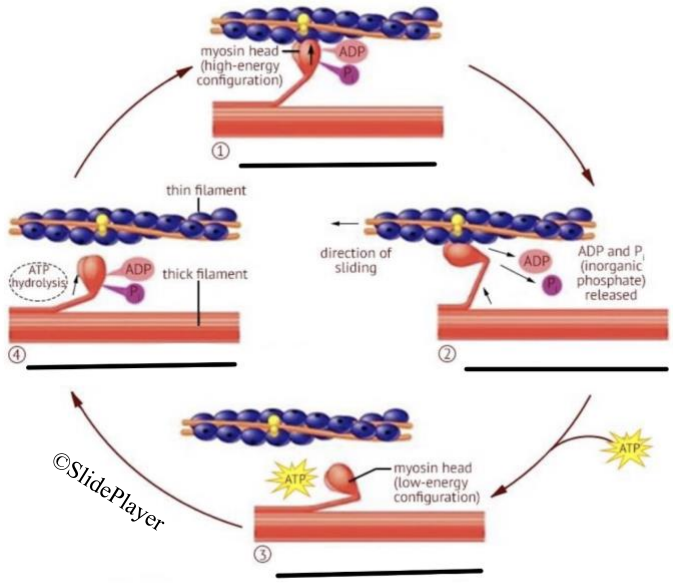
Excitation-Contraction Coupling

Fill in the blanks.

- Action potentials travel _____ → _____ is released → binding of _____ to _____ → shifting of _____ → _____ on actin is exposed

Actin-Myosin and ATP Cycle

Describe what occurs at each stage.



Apply Your Knowledge

7. A patient decides to go to the doctor's office after experiencing muscle pain after starting to work out after 1 year. Along with muscle pain, the patient is also experiencing extreme fatigue. Soon enough, the doctor discovers that the patient has strained their muscle. What is muscle strain often caused by?

a. Excessive contraction of the muscles, causing tetany.
b. Swelling of the muscle fiber, often caused by increase in muscle cells.
c. Actin and myosin filaments have been pulled past their ability.
d. The patient has torn a ligament while exercising.

8. Describe the process of rigor mortis thoroughly.

Answer Key:
1.D 2.C 3.A 4.C 5.A 6.A 7.C