

NAME: Mrs. Davis

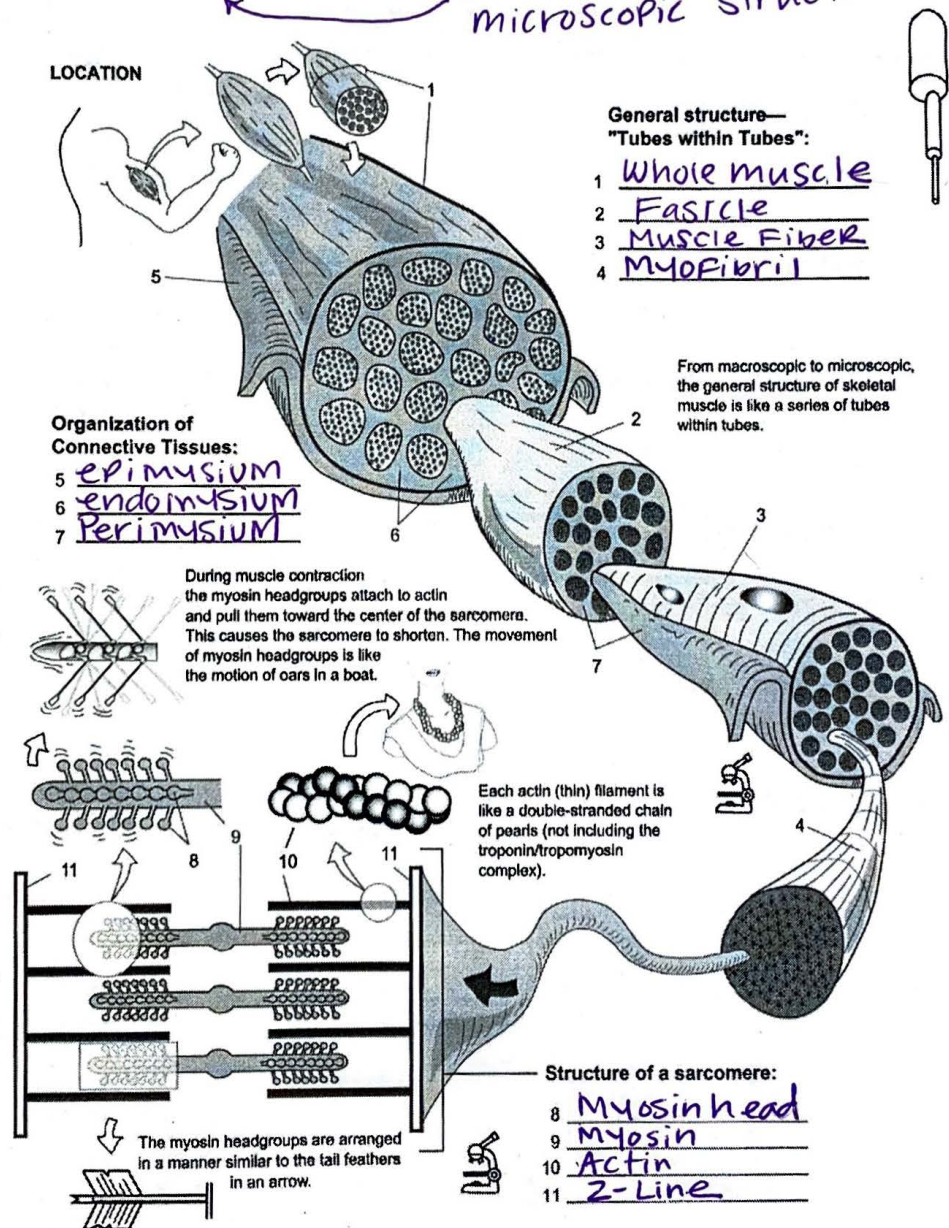
KEY Do not take with you!

The Sliding Filament Theory

"How do muscle cells contract?"

Model 1: Muscle Histology Review

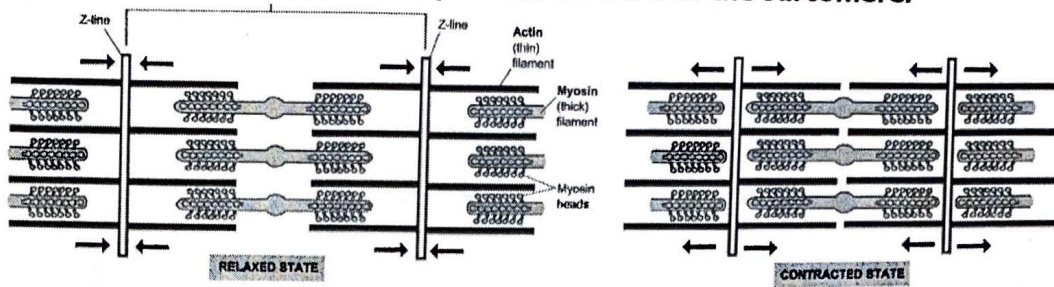
Study of microscopic structure of tissues



Use your knowledge of muscle tissue histology to fill in the blanks numbered 1-11 with the following terms: Fascicle, Myofibril, Perimysium, Myosin heads, Actin (thin) filaments, Whole muscle, Skeletal myocyte, Epimysium, Endomysium, Myosin (thick filaments), Z line.

→ AKA muscle fiber

Model 2: Muscle contraction takes place at the level of the sarcomere.



Critical Thinking Questions

1. What structural component of the sarcomere is associated with arrows in model 2?

Z-line

2. Based on this, which component of the sarcomere is actually being moved when the sarcomere contracts and relaxes?

Actin

3. Which component of the sarcomere is physically attached to the structure that gets moved (i.e. the answer to question 2)?

Actin

4. What component of the sarcomere is NOT directly attached to the Z-line?

Myosin

5. Based on your answer to question 4, what component of the sarcomere is pulling on the thin filaments to bring the Z-lines closer together?

Actin Myosin heads

Application

6. In the space below, write a short description as a group that explains the role of the thin filaments, thick filaments, and Z-line in sarcomere contraction.

Thin filament:

Shorten the sarcomere by cause muscles to contract

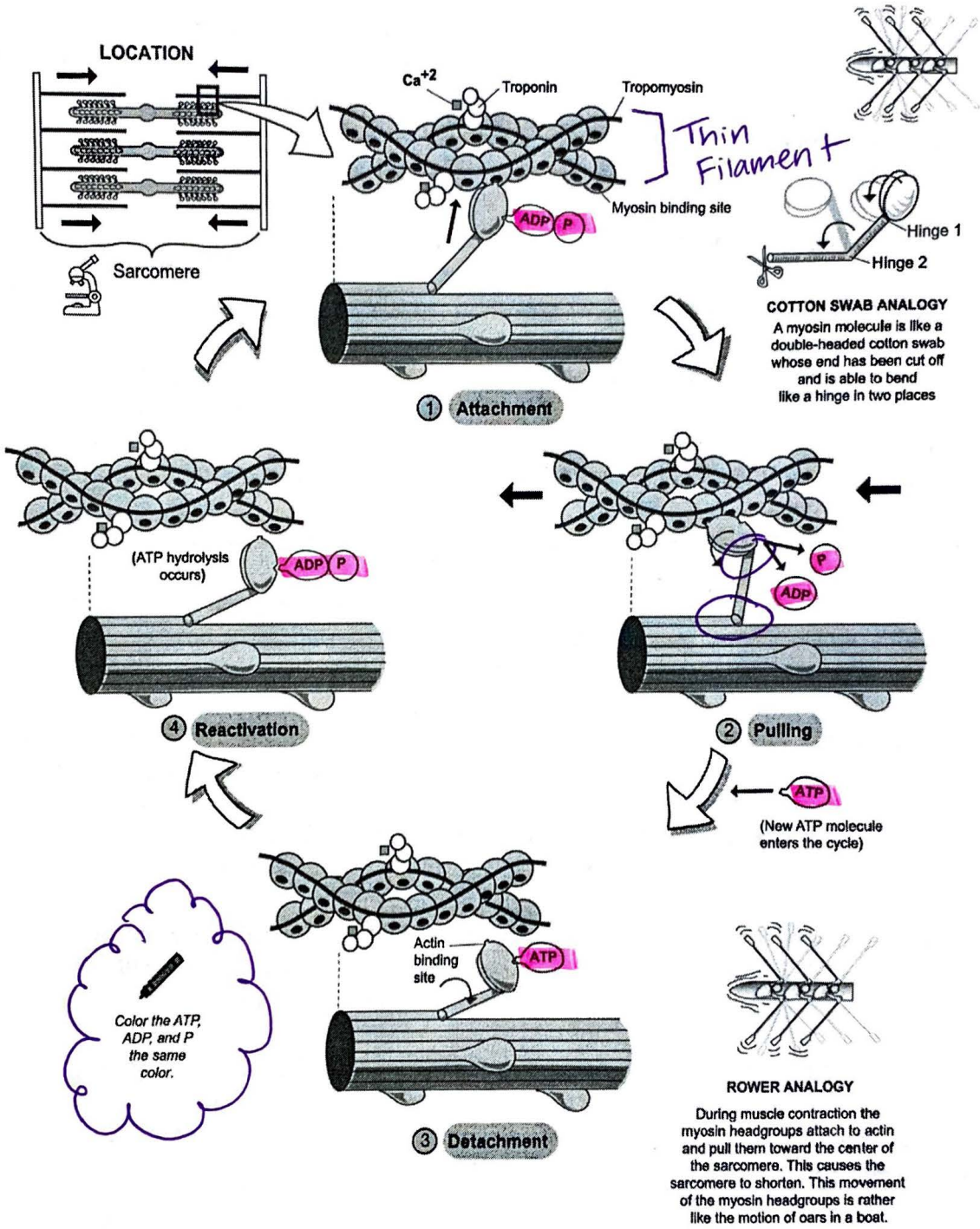
Thick Filament:

Attach to thin filaments by pull them towards the center of the sarcomere

Z-line:

Shortens when muscles contract by lengthen when they relax

Model 3: Molecular events of the contraction cycle



Critical Thinking Questions

7. Find the thin filament in part 1 of model 3 (attachment) and draw a bracket and label it 'thin filament'.

See model 3

8. Which component of the thin filament (which isn't labeled in this model) makes the main 'string-of-pearls' portion of the filament?

Actin Protein

a. in the space below, list the other molecules that are found in/on the thin filament.

troponin + tropomyosin

9. The myosin head is bound to some other molecules, what are they?

ADP + P

a. To which specific region of actin is the myosin head bound?

myosin binding site

10. In your own words, describe the change that occurs in the myosin molecule between stage 1 (attachment) and stage 2 (pulling).

myosin changes shape & bends to pull the actin

a. Circle the two places where the myosin molecule bends in this stage on part 2 of the model.

See model 3

11. The myosin head doesn't release from the actin binding site until a new molecule enters the cycle. According to the model, what molecule allows myosin to release from actin?

ATP

12. In stage 4 of this cycle, the myosin molecule moves back into the **cocked position**.

Where does it get the energy to re-cock itself?

ATP

13. Look at all the myosin binding sites on the actin filament. Does it appear that each site lines up perfectly with a myosin head?

Yes

a. Myosin can only bind to a binding site that is at the tip of a helix in the actin filament (like the one in phase 1 of the model). After the power stroke (pulling phase) and detachment is the myosin head lined up with a binding site at the tip of the filament?

NO



b. Can this particular myosin head bind to the actin filament for the next stroke?

NO

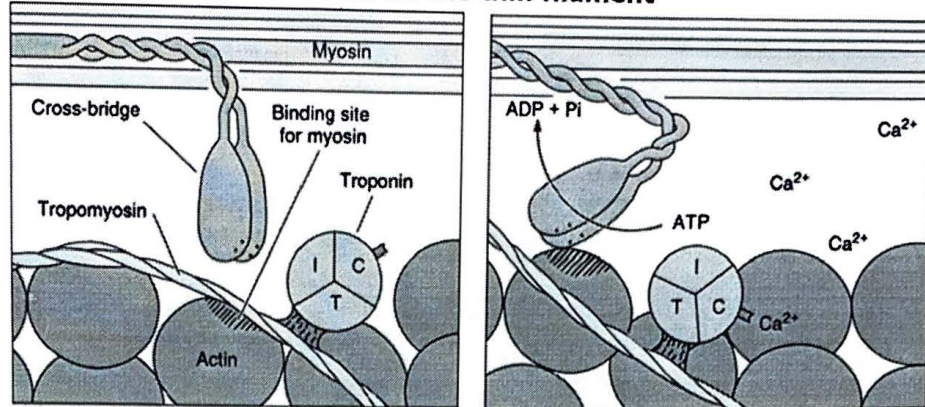
c. Look at the feet of these children. Are they all able to pull at exactly the same time?

Yes

d. As a group, explain how myosin pulling on actin works kind of like kids playing tug-of-war.

you can do this one 😊

Model 4: Effects of calcium on the thin filament



14. Look at the left half of the model. Is calcium present here? **NO**

a. Is the myosin binding site of actin exposed so that myosin can actually bind to it?

NO

b. What is blocking myosin's access to the binding site on actin?

Tropomyosin

15. Now look at the right side of the model. Is calcium present here?

Yes

a. To what molecule did it bind?

Troponin

b. What changed about the troponin molecule after it bound calcium? (hint look at the little orange calcium binding site on troponin)

It rotated down & to the right

c. What effect did this change in troponin have on tropomyosin?

Pushed tropomyosin out of the way

d. Is the myosin binding site of actin exposed when calcium is present?

Yes!

16. In the space below, write a grammatically correct sentence (in English) that explains the role of troponin, tropomyosin, and calcium in muscle cell contraction.

When Ca^{2+} binds to troponin, tropomyosin is move away from the myosin binding site allowing myosin to bond to actin.

myosin + Actin = \heartsuit

Application

17. What would happen to a muscle cell in either of the following situations?

a. The cell runs out of ATP

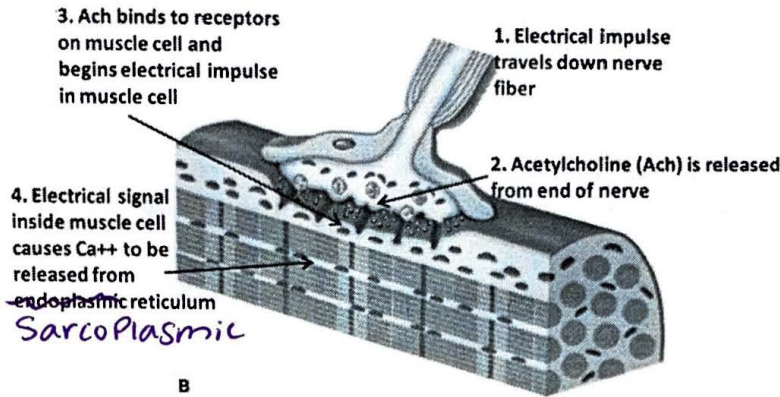
myosin cannot detach from actin

b. There is an excess amount of calcium in the cell.

Muscles contract rapidly & cause muscle spasm.

Ach = acetylcholine

Model 5: Neuromuscular junction



18. Can muscles contract if there isn't any free calcium in the cell?

NO

a. According to model 5, where is calcium stored inside a muscle cell?

Sarcoplasmic reticulum

b. What causes the calcium to be released from where it is stored?

electrical signal inside muscle cell

19. What chemical messenger transmits the electrical impulse between the nerve cell and the muscle cell?

Acetylcholine

Application

AKA cholinesterase

20. Acetylcholine esterase is an enzyme that degrades Ach in the neuromuscular junction. The nerve gas Sarin blocks this enzyme causing Ach to remain available for binding to the muscle cell receptors.

What effect would Sarin gas have on the muscles of your body?

Convulsive muscle spasms → Seizures

As a group, explain why Sarin gas is a deadly poison. [hint: your diaphragm is a muscle]

- Acetylcholine accumulates and nerves keep firing
- Glands & muscles are continually stimulated
- runny nose, rapid breathing, nausea, vomiting, eventually respiratory failure leading to death.

Exercises

1. Use models 5, 4, 3, 2, and 1 to put the following events in order from the signal from the brain reaching a muscle to the contraction of the whole muscle.

- 8 Myosin bends in two places, releasing ADP and pulling on the thin filament
- 2 The nerve impulse reaches the end of the nerve and causes it to release acetylcholine (Ach)
- 1 An electrical impulse travels down a nerve fiber
- 9 The Z-lines are pulled closer together and the A-band shrinks
- 3 Ach binds to receptors on the muscle cell membrane and causes the electrical impulse to be transmitted to the muscle cell
- 5 Calcium ions bind to troponin causing it to rotate
- 10 The myofibril gets shorter (contracts)
- 4 The electrical impulse inside the muscle cell causes the release of calcium ions from the ~~endoplasmic~~ ^{sarco plasmic} reticulum
- 6 Rotation of troponin move tropomyosin off of the myosin binding site on actin
- 7 The myosin head binds the myosin binding domain of actin