PST-musc: Muscle Tissue Poster Kit

Having the entire Muscle Tissue Poster Kit enables broader lessons and discussion about muscle and tissue in general by comparing the different muscle tissue types. This page has the lesson plans that can be done with all of the micrographs. Lessons that are specific to each poster are on the next pages. The final page contains the broader discussion questions related to all of the posters.

Lessons for the Muscle Tissue kit as a whole

1. Have your students identify the type of tissue this is (epithelial, connective, muscle, nervous). Then have them identify the specific type of muscle tissue visible (skeletal, cardiac, smooth). Then ask them to explain where this type of muscle tissue is found.
2. Hand your students a dry erase marker and have them label
   - the outline of any one muscle fiber
   - any muscle fiber/cell nuclei (and identify if only one or more than one per cell)
   - any striations visible and explain why they are not visible in some images
   - any connective tissue (including blood vessels) visible
   - any specializations, such as intercalated disks, spindle-shaped cells, branching cells, or multiple sectional views (cross- and longitudinal- sections).
3. Alternatively, have your students come up with a list of the items they could find in these cells. Then bring out the posters and dry erase markers and have them find everything on their list on the posters.
4. When pairing the use of the poster with microscopy, you can do each of the following:
   - Set up numbered microscopes with pointers on specific muscle tissues and cells and have them match the number to the entire poster or to specific items in the poster. Microscopes could show low power or high power views. Have students put the microscope numbers onto the poster with a dry erase marker, with numbered arrows to specific items in the poster.
   - Use a dry erase marker on the frame to indicate a part of the cell or the field. Have your students, each working on their own microscopes or in pairs, put their pointer on a similar structure in their microscope fields. You can check their choices, or have them check on each other.
5. Have your students describe the features that make each tissue type recognizable. Then have them identify those features on the posters with a dry erase marker.
6. Have your students compare these images to the standardized drawing or model of a typical animal cell. Ask them if they look the same and have them explain why or why not.

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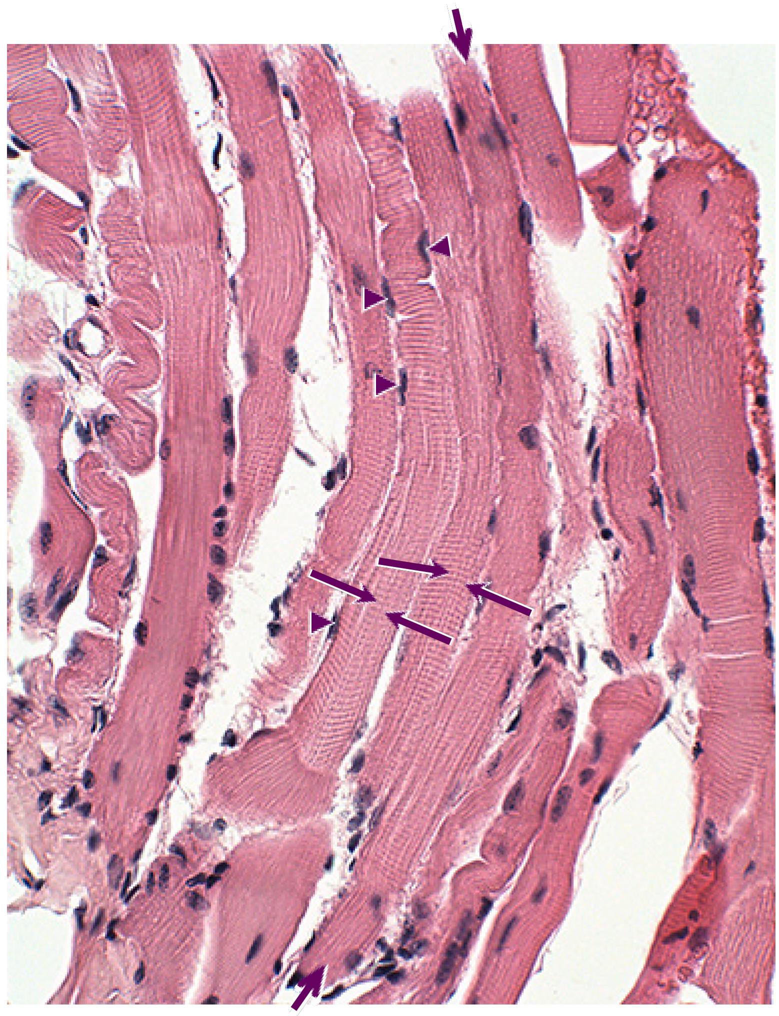
PST-musc-1: Skeletal Muscle Visual Microscopy Kit



This skeletal muscle tissue is a longitudinal section, stained using hematoxylin and eosin. The hematoxylin typically stains nuclei purple because it stains nucleic acids and proteins, while the eosin typically stains cytoplasm pink. Skeletal muscle is characterized by having lengthy cells (that can be measured in centimeters rather than micrometers), multiple nuclei (because embryonic cells fuse to make such large cells), and striations. Because of their large size, skeletal muscle cells are also called muscle fibers.

→ Indicates striations; adjacent striations are indicated in two muscle fibers

▸ Indicates multiple nuclei in one muscle fiber

➔ The exceptionally long length of one muscle fiber in this section is from arrow to arrow.

The striations in skeletal muscle cells are due to organized cytoskeleton within them that has a repeating pattern of actin and myosin filaments. The dark lines, pointed out in the image above, are due to the myosin filaments, while the light lines are due to the actin filaments. The wiggly appearance of some muscle fibers is an artifact from their placement on the slide.

Specific lessons for the Skeletal Muscle poster

1. Ask your students about the size of these muscle fibers, the number of nuclei, and the presence of striations:
   - Are they a similar size to other cells? If they cannot tell (no calibration is on the image), have them evaluate the size of a nucleus relative to the size of one cell.
   - Is each cell uninucleate or multinucleate? They should be able to identify the limits of a cell and count the nuclei. Not all cells show as multinucleate because not all nuclei are in this section of tissue (some are in adjacent sections on other slides).
   - Are these cells striated? How can they tell? How clearly is it striated?
   - Can they tell if this view is a cross- or longitudinal- section? How?

2. Where are the nuclei positioned within the muscle fibers? Centrally? Peripherally? (they are located peripherally just under the sarcolemma)

3. List 3 ways that they can tell that this is skeletal muscle.

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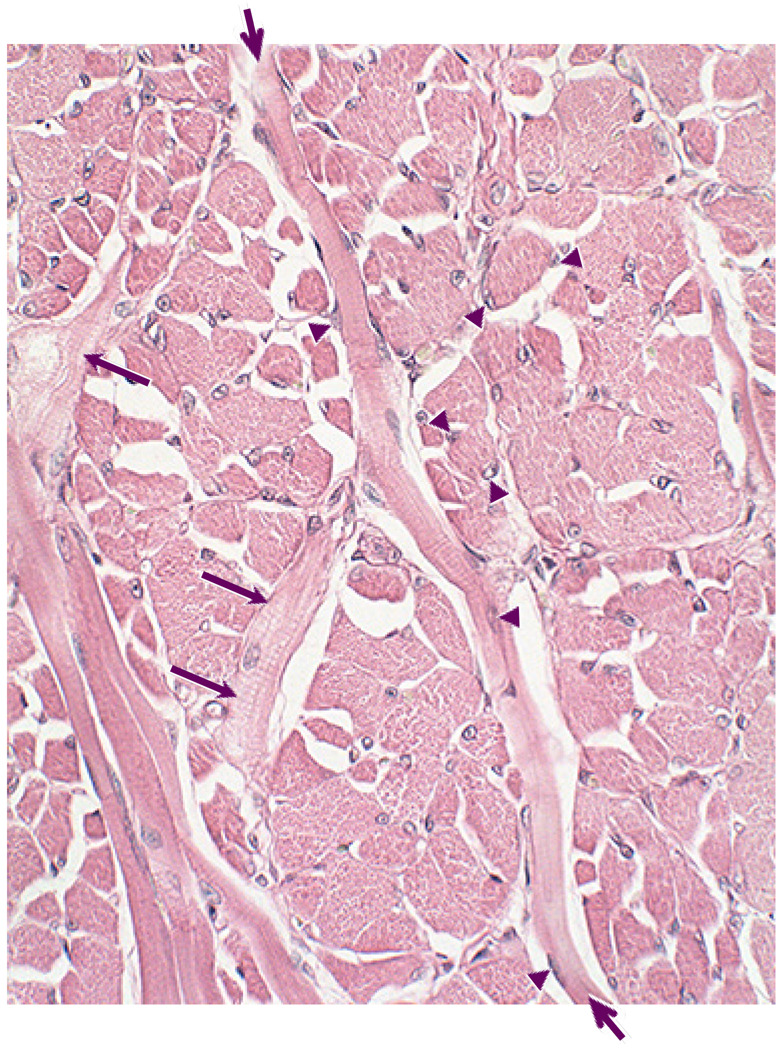
PST-musc-2: Skeletal Muscle from Tongue
Visual Microscopy Kit



The tongue has skeletal muscle fibers which run in multiple directions. Therefore, one can see both longitudinal and cross sections through in this one photomicrograph. The tissue was stained using hematoxylin and eosin; hematoxylin typically stains nuclei purple while the eosin typically stains cytoplasm pink. Skeletal muscle is characterized by having lengthy cells (measured in centimeters rather than micrometers), multiple nuclei (because embryonic cells fuse to make such large cells), and striations that are visible in longitudinal section. Because of their large size, skeletal muscle cells are also called muscle fibers.

⟶ Indicates striations

▸ Indicates multiple nuclei in one muscle fiber

➔ One long muscle fiber runs from arrow to arrow.

The striations in skeletal muscle cells are due to organized cytoskeleton within them that has a repeating pattern of actin and myosin filaments. The dark lines, pointed out in the image above, are due to the myosin filaments, while the light lines are due to the actin filaments. Skeletal muscle has so much cytoskeleton that nuclei are pushed toward cell edges.

Specific lessons for the Skeletal Muscle from tongue poster

1. Ask your students about the size of these muscle fibers, the number of nuclei, and the presence of striations:
    - Are they a similar size to other cells? If they cannot tell (no calibration is on the image), have them evaluate the size of a nucleus relative to the size of one cell.
    - Is each cell uninucleate or multinucleate? They should be able to identify the limits of a cell and count the nuclei. Not all cells show as multinucleate because not all nuclei are in this section of tissue (some are in adjacent sections on other slides).
    - Are these cells striated? Why aren't striations visible in cross sections?

2. Where are the nuclei positioned within the muscle fibers? Centrally? Peripherally? (It is easier to see that they are peripheral in the cross sections.

3. Do these muscle fibers all run in the same direction? Why do the muscle fibers in your biceps brachii run parallel but in the tongue run in different directions? (There are no bones to pull uniformly on when you move your tongue, and the multiple fiber directions let you move your tongue in a variety of ways)

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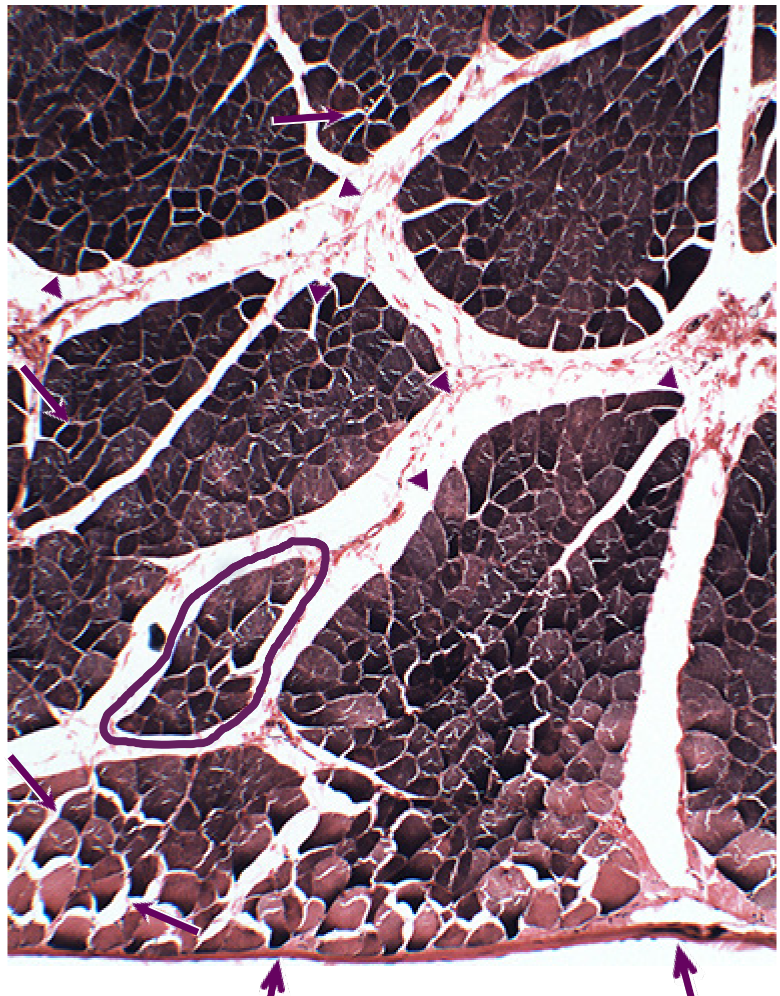
PST-musc-3: Skeletal Muscle and Fascia
Visual Microscopy Kit



This photomicrograph of a skeletal muscle in cross section was taken at 100x to show all three levels of fascia invested in skeletal muscle. The skeletal muscle fibers (or cells) are all reddish black and somewhat circular. The fascia wraps around and through the muscle. The three layers of fascia are:

- Epimysium (dense irregular CT) that wraps around the entire muscle and runs into tendons
- Perimysium (areolar CT) that runs between bundles of muscle fibers (called fascicles), making the fascicles more visible. One fascicle has been outlined.
- Endomysium (areolar CT) that lays upon every muscle fiber, but is difficult to see at this low magnification.

The epimysium encapsulates the entire muscle and blood vessels and nerves travel to the muscle through it. The perimysium provides space and support for blood vessels and nerves to approach every fascicle. The endomysium provides space and support for blood vessels and nerves to reach every muscle fiber (cell).

Specific lessons for the Skeletal Muscle and Fascia poster

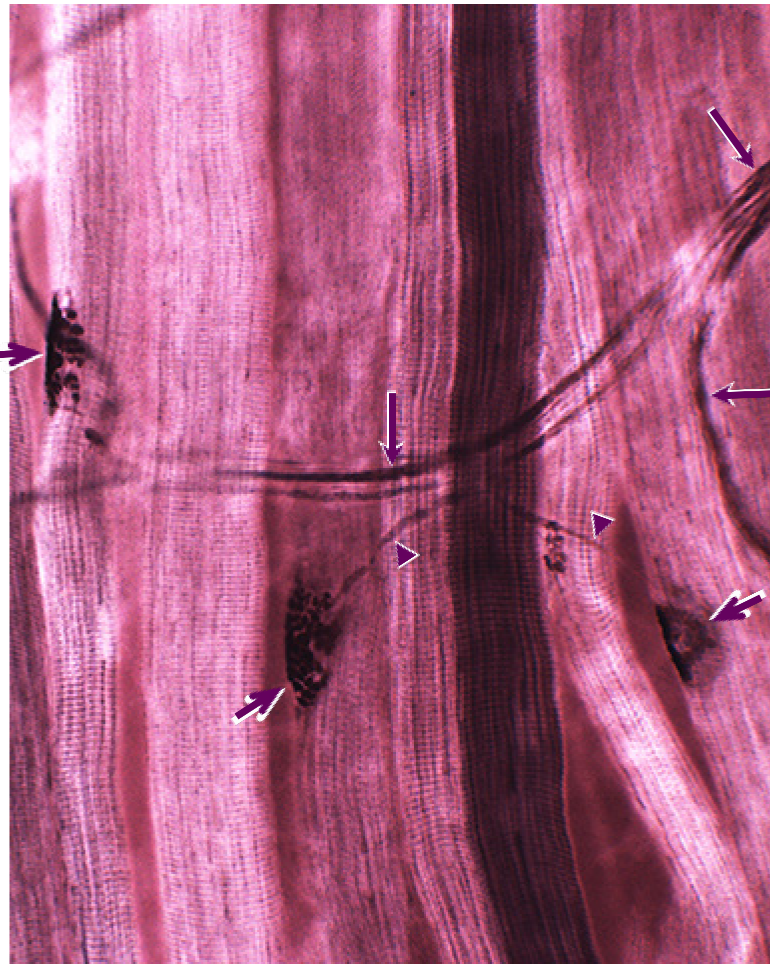
1. Ask your students about the layers of fascia and the organization of skeletal muscle:
   - Which type of fascia is on the outside of the muscle? Which is closest to the sarcolemma of muscle? Which types are composed of areolar connective tissue?
   - What are the skeletal muscle specific terms for a single muscle cell and a bundle of muscle cells?
   - Are these cells striated? Why aren't striations visible in cross sections?

2. Have your students identify each of the following with a dry erase marker on the poster (or have them come up with this list themselves):
   - muscle fiber
   - muscle fascicle
   - endomysium (difficult)
   - perimysium
   - epimysium

3. Why can't they see striations in this image?

4. Although potentially visible in both the cross- and longitudinal- sections, why are these levels easier to see in a cross-section? (because the fascicles are in rounded clusters that are clearer.

PST-musc-4: Skeletal Muscle Endplates
Visual Microscopy Kit



This photomicrograph of skeletal muscle endplates was taken at 400x. The nerves and nerve endings are are stained black, as are striations of the skeletal muscle fibers (or cells) and one muscle fiber. All of the muscle fibers in this photomicrograph are running vertically.

- Endplates of motor neuron axons, where the neuro-muscular junctions occur.
- Individual motor neuron axons running toward end-plates. The axons are stained black, and the pale unstained area around it is likely its myelin sheath.
- Nerves containing multiple axons.

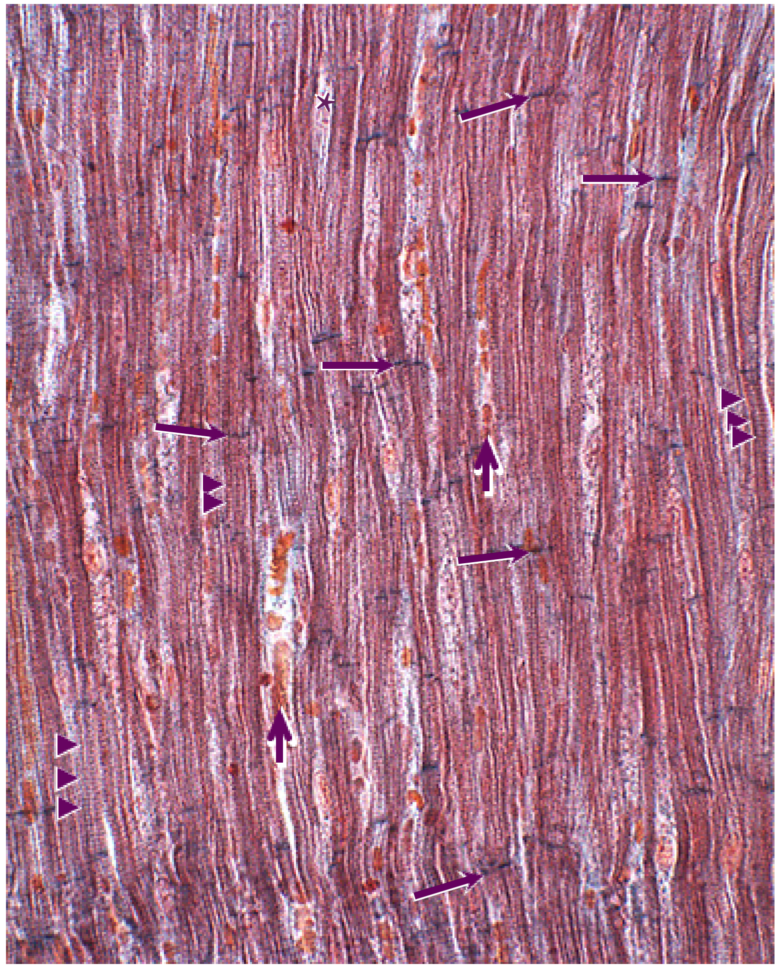
Each endplate appears as a splotchy patch because each motor neuron axon that supplies it branches into many bulbous endings. Note that each muscle fiber only receives one endplate. Nerves are wrapped with fascia, but each motor axon within a nerve is also wrapped by a Schwann cell myelin sheath for improved electrical conduction.

Specific lessons for the Skeletal Muscle Endplates poster

1. What is the purpose of the endplates? (Communication between the nervous system and the muscular system.) What type of communication do they use? (Electrical information comes to them from the nervous system and they relay this information via chemical communication to the muscle. The muscle then responds electrically in order to contract.)

2. Ask your students about the endplates on a skeletal muscle:
   - How many endplates are on each skeletal muscle fiber? Why aren't there multiple endplates on individual fibers?
   - Are motor neuron axons to muscle fibers myelinated? Why?
   - Are the endplates of the axons continuous with the muscle fiber or are they separate? What is the space between the endplates and the sarcolemma called (the synaptic cleft)? How do these cells communicate if they are separate (neurotransmitter)?

PST-musc-5: Cardiac Muscle Longitudinal Section
Visual Microscopy Kit



This is cardiac muscle tissue from the heart, stained using hematoxylin and eosin. The hematoxylin typically stains nuclei purple because it stains nucleic acids and proteins, while the eosin typically stains cytoplasm pink. The cardiac muscle tissue in this image is cut longitudinally enabling visualization of striations. Cardiac muscle is striated, but the striations are not as organized as in skeletal muscle, so not all muscle cells reveal their striations.

- ⟶ Indicates an intercalated disk
- ▶ Indicates striations
- ➔ Indicates a blood vessel
- * Indicates a cellular branch or bifurcation

Cardiac muscle is composed of individual cells connected to one another via intercalated disks; because of the density of proteins for gap junctions and desmosomes, the intercalated disks tend to stain darkly. Cardiac muscle tissue is highly vascularized, so many blood vessels can be seen running through it-- red blood cells are unstained but possess their own coloration due to their hemoglobin content. Some cardiac muscle cells can be seen to branch, giving the tissue an overall messy appearance.

Specific lessons for the Cardiac Muscle Longitudinal Section poster

1. Ask your students to identify the characteristics of cardiac muscle tissue (striated, intercalated disks, well vascularized, branches) and find those features in the image.

2. Have your students evaluate the amount of striation visible in cardiac muscle as compared to other muscle tissues (less than skeletal, more than smooth).

3. Hand your students a dry erase marker and have them label
   - a cell with visible striations
   - an intercalated disk between cells (they may need to first outline a few cells to figure out how to find the cell ends where the intercalated disks are located)
   - a blood vessel or red blood cell
   - any place where a cell may be branching (this is difficult to find)

4. What is the purpose of intercalated disks? (Electrical and physical connections between cardiac muscle cells occur there.) Why do cardiac muscle cells have them but skeletal muscle fibers do not? (Cardiac muscle fibers need them to link up into long chains but skeletal muscle fibers are just really long themselves.) Why do cardiac muscle cells have them but smooth muscle cells do not? (Smooth muscle cells communicate electrically with each other all over their sarcolemma and do not have to endure large forces, while cardiac muscle cells communicate primarily along their chains and have to hold together in the face of significant force.)

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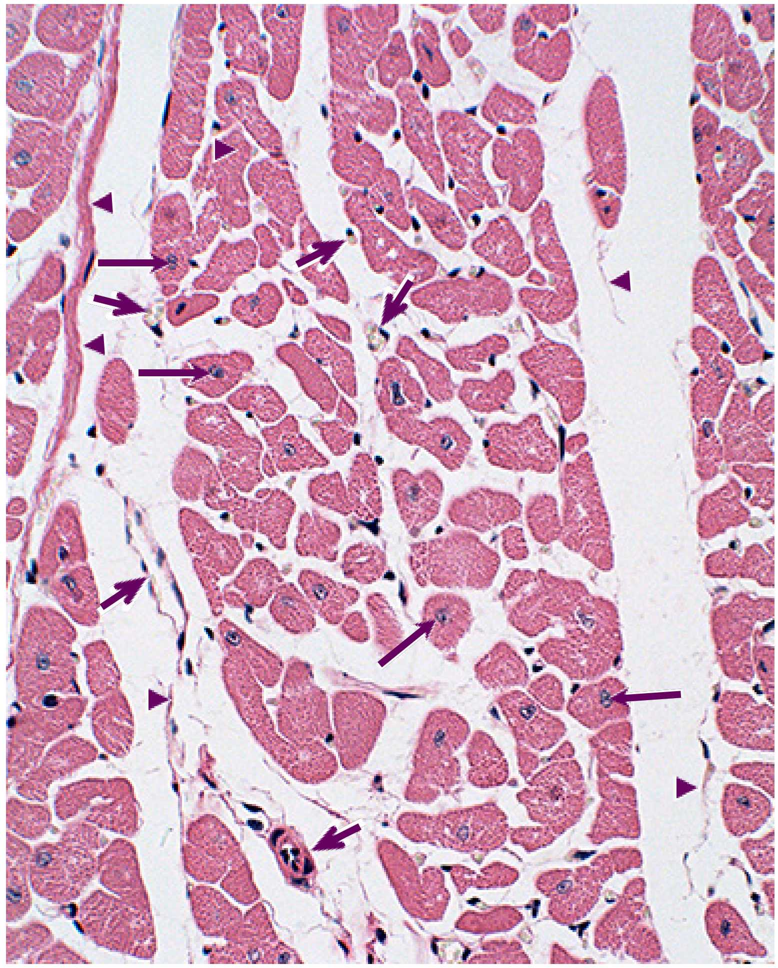
PST-musc-6: Cardiac Muscle Cross-Section
Visual Microscopy Kit



This is cardiac muscle tissue from the heart cut in cross-section, stained using hematoxylin and eosin. The hematoxylin typically stains nuclei purple because it stains nucleic acids and proteins, while the eosin typically stains cytoplasm pink. In cross-section it is possible to see that individual muscle cells and that each has its nucleus centered within it. Since the nucleus is much shorter than the entire cell and the section is only slightly thicker than the size of the nucleus, the nucleus is not in this section for many of the cells.

→ Indicates a myonucleus cut in cross-section

▸ Indicates invested connective tissue

➔ Indicates blood vessels (from arterioles to capillaries to venules)

Cardiac muscle is highly vascularized, and the endothelial cell nuclei are much more compact than cardiac muscle nuclei so they appear blackish. Blood vessels run in connective tissue, and many can be seen invested in this cardiac muscle tissue. Note that this tissue section is looser than most cardiac muscle tissue sections, but it revealed the cells beautifully for understanding cardiac muscle in cross-section.

Specific lessons for the Cardiac Muscle Cross-Section poster

1. Are striations visible in this cross-sectional image of cardiac muscle? (no) Are striations in cardiac muscle? (yes) Why is there a discrepancy between visibility and presence? (because they are not visible in cross-sectional view) Are myofibrils visible? (yes, their cut ends like dots in the cytoplasm)
2. Based on myonuclei position, how can they tell that this is cardiac muscle? (The nuclei are in the center, there is only one nucleus in any cell, and there is a lot of cytoplasm around the nuclei).
3. Can they see intercalated disks in this image? Why not? (only visible in longitudinal section)

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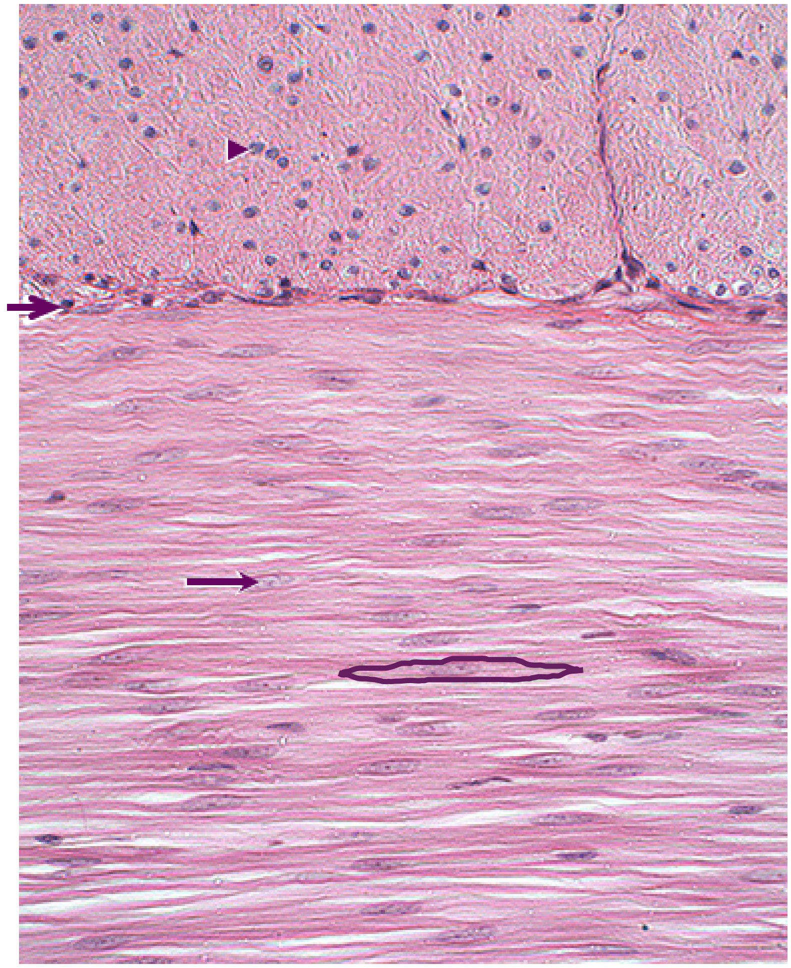
PST-musc-7: Smooth Muscle Visual Microscopy Kit



This is smooth muscle tissue from a cross section of an intestinal wall, stained using hematoxylin and eosin. The hematoxylin typically stains nuclei purple because it stains nucleic acids and proteins, while the eosin typically stains cytoplasm pink. Smooth muscle tissue in the intestinal wall runs in two directions: the outer longitudinal layer and the inner circular layer. The two directions enable the intestine to shorten and widen (outer) as well as lengthen and narrow (inner) in order to propel chyme (digesting food) along through peristalsis.

- ⟶ Indicates a nucleus cut in longitudinal section
- ▸ Indicates a nucleus cut in cross section
- ➔ Indicates the border between the longitudinal (top) and circular (bottom) layers

Smooth muscle cells are described as spindle-shaped, and that is a visible characteristic in the circular layer where the cells were cut in longitudinal section, indicated by the outlined cell. The nuclei are often called corkscrew-shaped because unless the cell is stretched, the nucleus is not taught and may look wiggly like a corkscrew.

Specific lessons for the Smooth Muscle poster

1. Ask your students to explain how it is possible for the top and bottom of this poster image to be the same type of muscle tissue. See if they can explain that the muscle tissue must run in two directions. Then see if they can explain why it has to run in (at least) two directions. (for peristalsis)

2. Hand your students a dry erase marker and have them label
   - each layer of the muscle tissue. Note that it is difficult for a student to label the top half as the longitudinal layer when the cells are clearly cut in cross-section. Therefore, have them label both the name of each layer and the direction of section of each layer.
   - nuclei and make cell outlines in each layer

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For all Cell Zone®, Inc. posters

General Instructions:

- Move from room to room or maintain in one location
- Hang on any permanent or removable hook by the grommet
- Use a dry erase marker on the frame; erase the same day to ensure clarity
- Store multiple posters by stacking so that the grommet cannot scratch the front of a neighboring poster

Advantages with using posters:

- Hanging real cell micrographs makes your classroom or lab space look like a place where real science is done
- The posters can be hung as art or for learning
- The posters can be paired with microscopy or used separately
- You will always have a good example of what you want your students to see

PST-musc: Muscle Tissue Poster Kit

Having the entire Muscle Tissue Poster Kit enables discussion about muscle and tissue types in general by comparison. This page has the broader discussion questions.

Questions for discussion:

1. Which muscle tissue type has cells that should be called fibers?
   Only skeletal muscle is composed of "fibers" to reflect the extreme lengths of these cells. Note that skeletal muscle fibers (cells) are nothing at all like connective tissue fibers (protein complexes). Also, skeletal muscle fibers exist because embryonic cells fuse together to create the extremely long, multinucleate fiber; that doesn't happen in the other muscle tissue types.

2. Describe the number and position of myonuclei within the cells of each type of muscle tissue.
   As noted above, only skeletal muscle has multiple nuclei in each cell (fiber). As for the position of the myonuclei within each cell, students expect nuclei to be centrally located, but that is not the case with skeletal muscle. That is because the main job of skeletal muscle cells is to contract powerfully, and they need to be packed full of contractile machinery to do that; the myofibrils of contractile machinery occupy the majority of the volume of the fiber, pushing the myonuclei to the edges. In cardiac muscle cells, although they have a lot of contractile machinery, it is more disorderly and leaves room for the myonucleus. In smooth muscle cells the contractile machinery is even more disorderly (the myofibrils do not all run parallel to one another) and there aren't as many myofibrils, allowing the myonuclei to occupy the center of the cell.

3. How does the presence or absence of striations relate to muscle strength? Why do striations have anything to do with muscle strength?
   The presence of striations relates to the quantity and organization of myofibrils. When many myofibrils run in parallel (skeletal muscle), striations are clear. When myofibrils are not perfectly parallel (cardiac muscle), striations are visible but not as striking. And when myofibrils are not as numerous and don't all run in parallel (smooth muscle) striations are not visible. The more myofibrils, the more force. And the more the myofibrils all work in unison (by running parallel), the more force.

4. Which muscle tissue type had the least vascularity? Why?
   Smooth muscle, because it has the lowest energy demands.

5. Ask your students how muscle tissue differs from each of the other types of animal tissue (epithelial, connective, and nervous). You could have a group of students working on a single comparison at a time, and then share with each other.