Muscle Tissue

Kristine Krafts, M.D.
Muscle Tissue Lecture Objectives

- Describe the location, type of contraction (e.g., strong vs. weak), and histologic features of the three types of muscle.

- Draw a sarcomere at rest, showing actin and myosin filaments, Z and M lines, and I, A, and H bands. Describe how the sarcomere changes as contraction occurs. Watch youtu.be/U2TSaz8-yNQ if you need a refresher.
Muscle Tissue Lecture Objectives

• Describe the connective tissue sheaths that surround skeletal muscle.
• Explain what an intercalated disc is.
• Explain how smooth muscle is different from skeletal and cardiac muscle.
• Compare the ability of the three types of muscle to regenerate.
Muscle Tissue Lecture Outline

- Introduction
- Skeletal muscle
- Cardiac muscle
- Smooth muscle
Muscle Tissue Lecture Outline

- Introduction
Fun facts about muscle terminology

• “Sarco-” is from the Greek sарx (flesh)
• “Myo-” is from the Greek mys (muscle)
• Muscle cells are longer than they are wide, so they are also called “fibers”
• There are three types of muscle cells: skeletal, cardiac, and smooth. Skeletal and cardiac muscle cells are striated; smooth muscle cells are not.
Don’t make this mistake!

“Striated muscle” and “skeletal muscle” are sometimes used interchangeably.

This is wrong, wrong, wrong!

Skeletal muscle is striated – but so is cardiac muscle.
So if you mean skeletal, say skeletal, not striated.
Muscle types and activity

Skeletal muscle

Cardiac muscle

Smooth muscle

Cross sections

Nuclei

Intercalated disks

Strong, quick discontinuous voluntary contraction

Strong, quick continuous involuntary contraction

Weak, slow involuntary contraction
## Summary that will make sense later

<table>
<thead>
<tr>
<th></th>
<th>Skeletal</th>
<th>Cardiac</th>
<th>Smooth</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
<td>Near bones</td>
<td>Heart wall</td>
<td>Walls of hollow organs and blood vessels</td>
</tr>
<tr>
<td><strong>Cell diameter</strong></td>
<td>Largest</td>
<td>Intermediate</td>
<td>Smallest</td>
</tr>
<tr>
<td><strong>Striations</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td><strong>Sarcoplasmic reticulum</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Not really</td>
</tr>
<tr>
<td><strong>T tubules</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
More summary that will make sense later

<table>
<thead>
<tr>
<th></th>
<th>Skeletal</th>
<th>Cardiac</th>
<th>Smooth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor control</td>
<td>Voluntary</td>
<td>Involuntary</td>
<td>Involuntary</td>
</tr>
<tr>
<td>Contraction</td>
<td>Quick and strong</td>
<td>Quick, strong, rhythmic</td>
<td>Slow, in waves</td>
</tr>
<tr>
<td>Blood supply</td>
<td>Moderate</td>
<td>Extensive</td>
<td>Less abundant</td>
</tr>
<tr>
<td>Other features</td>
<td>Prominent fascicles</td>
<td>Intercalated disks, branching cells</td>
<td>Cells overlap; can synthesize collagen and elastin</td>
</tr>
</tbody>
</table>
Muscle Tissue Lecture Outline

• Introduction

• Skeletal muscle
Skeletal muscle

Transverse section

Longitudinal section

Skeletal muscle
Where do skeletal muscle cells come from?

- Derived from mesenchymal cells, which give rise to myoblasts.
- Myoblasts: spindle-shaped. Fuse to form multinucleated myotubes which elongate.
- Mature skeletal muscle cells (or fibers): long, unbranched tubes with many flattened nuclei.
- Sarcoplasm (cytoplasm) contains a ton of mitochondria, glycogen, and myoglobin.
- Mature skeletal muscle cells can’t divide.
Skeletal muscle

Abundant eosinophilic cytoplasm

Peripheral nuclei

Skeletal muscle
Skeletal muscle

- Cells are long, unbranched tubes
- Peripheral, flattened nuclei
- Can just barely see striations
What’s in an actual skeletal muscle?

A bunch of fascicles.

Each fascicle is composed of a bunch of muscle cells (fibers).

Each muscle cell contains a bunch of myofibrils.
Connective tissue surrounds the cells, fascicles, and entire muscle.

Perimysium
Connective tissue that surrounds each fascicle

Epimysium
Dense layer of connective tissue that surrounds entire muscle

Endomysium
Delicate connective tissue that surrounds each muscle cell (fiber)
So what’s in a myofibril? Myofilaments (actin and myosin).

Thin (actin) filaments

Thick (myosin) filaments
The sarcomere is the basic functional unit of striated muscle. It’s what makes muscles contract.
How do muscles contract?
By shortening their sarcomeres!

Actin filaments get pulled toward the center.
The H band disappears, and the sarcomere shortens.
Striated muscle at high magnification (H&E stain)

- A band
- I band
- Z lines
- Sarcomere
Striated muscle (electron micrograph)
Check out this video to see how the sarcomere shortens!
https://youtu.be/U2TSaz8-yNQ
I bands contain only actin.

A bands contain both actin and myosin.

H bands (zones) contain only myosin.

M lines are where adjacent myosin filaments connect.

Z lines (disks) mark the edges of a sarcomere.
This is a network of tubules that surrounds myofibrils. It stores and releases calcium.

These are deep invaginations of the sarcolemma. They carry impulses from the cell surface to the sarcoplasmic reticulum.
Muscle Tissue Lecture Outline

- Introduction
- Skeletal muscle
- Cardiac muscle
Cardiac muscle
Structure of cardiac muscle cells

- Cardiac muscle cells are branched and striated.
- Intercalated disks glue adjacent cells together.
- Sarcoplasmic reticulum is kind of sparse.
Cardiac Muscle Cells

- Desmosome
- Gap junction
- Intercalated disc
- Openings of transverse tubules
- Sarcolemma
- Nucleus
Fascia adherens

Macula adherens (spot desmosome)

Gap junction

Intercalated Disk
Cardiac muscle with plump nuclei (N), intercalated discs (I), and striations (S)
Muscle Tissue Lecture Outline

- Introduction
- Skeletal muscle
- Cardiac muscle
- Smooth muscle
Smooth muscle

Transverse section

Longitudinal section
Location and function of smooth muscle

- Most smooth muscle is present in walls of hollow organs (such as intestine and uterus).
- Smooth muscle is also present in walls of larger blood vessels and in the eye.
- In addition to their contractile properties, smooth muscle cells produce collagen, elastin and proteoglycans.
Smooth Muscle Morphology

- Smooth muscle cells are spindle-shaped and have a single central nucleus.
- The width of the fiber or cell is only slightly greater than the width of the nucleus.
- They are packed together tightly.
More smooth muscle morphology

- A thin layer of reticular fibers surrounds each cell.
- There’s no real sarcoplasmic reticulum! Just a few little storage areas for calcium right under the sarcolemma.
- Thin (actin) and thick (myosin) filaments are not tightly arranged but just crisscross through cell.
Smooth muscle: thin and thick filaments
Wait, what are dense bodies?

- Anchor sites for actin-myosin filament bundles.
- Comparable to Z-lines of skeletal and cardiac muscle.
- Located along inside of sarcolemma and scattered throughout cytoplasm.
Contraction of smooth muscle

Relaxed smooth muscle cell

Contracted smooth muscle cell
Regeneration of muscle tissue

Cardiac muscle has no regenerative ability. Death of cardiac muscle leads to replacement by dense connective tissue scar.

Skeletal muscle can undergo limited regeneration. Satellite cells are inactive myoblasts. After an injury, they can become activated and make new muscle cells.

Smooth muscle is capable of active regeneration. Muscle fibers undergo mitosis and replace damaged tissue.
Muscle Tissue Lecture Outline

- Introduction
- Skeletal muscle
- Cardiac muscle
- Smooth muscle