Medical School Histology Basics
Muscle

VIBS 289 lab

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MUSCLE Function and Features

Function:
• Generation of contractile force
• Locomotion of multicellular animals, beating of their hearts, and movement of their internal organs depends on muscles of different types.

Distinguishing features:
• High concentration of contractile proteins actin and myosin arranged either diffusely in the cytoplasm (smooth muscle) or in regular repeating units called sarcomeres (striated muscles, e.g., cardiac and skeletal muscles)
• All three muscle types comes from mesoderm
TYPES OF MUSCLE

• SKELETAL MUSCLE
  – VOLUNTARY, LARGE AND MULTINUCLEATED CELLS, STRIATED

• CARDIAC MUSCLE
  – INVOLUNTARY, MONONUCLEATED AND BRANCHED CELLS, STRIATED

• SMOOTH MUSCLE
  – INVOLUNTARY, MONONUCLEATED, NON-STRIATED
Smooth muscle
no striations
Smooth muscle fibers are long, spindle-shaped cells shown here as bundles of cells.
Smooth muscle and psudostratified columnar epithelium in ductus deferens (toluidine blue)
Slide 32409: Rat intestine (toluidine blue)

- Central lacteal
- Gut lumen
- Muscularis externa smooth muscle
- Epithelium
Slide 32409: Rat intestine (toluidine blue)

- Smooth muscle
- Muscularis externa
- Muscularis mucosa
- Auerbach's plexus
- Meissner's plexus
- Vein
- Lacteal
- Epithelium
- Auerbach's plexus
- Smooth muscle, muscularis externa, muscularis mucosa,
Duodenum (Slide 152) Smooth muscle

Longitudinal and transverse profiles of smooth muscle cells

Sarcoplasm in these cells have no regular cross striations

Transverse profiles of smooth muscle cells

Longitudinal profiles
PAS staining of smooth muscle cell basement membrane in the stomach

Smooth muscle cell nuclei
Smooth muscle; EM 9 of smooth muscle cells, note organelles

1. Nucleus of smooth muscle cell
2. Secondary lysosome
3. Mitochondrion
EM 10f: Arteriolar wall; 30,000x

1. Apical caveolae
2. Collagen
3. Dense bodies
4. Elastic fiber
5. Endothelial cell
6. Nuclear pore
7. RER
Smooth muscle; EM 10e of smooth muscle cell. Note nerve attachment

1. Smooth muscle cell
2. Collagen
3. Nerve ending
4. Mitochondrion
Slide 136: Tongue, monkey

- Capillaries
- Nerve
- Connective tissue of the perimysium
- Skeletal muscle cells
- Perimysium
Slide HISTO007: Skeletal muscle – nerve and motor end plates
  Motor end plates in skeletal muscle
  One nerve innervates several muscle cells
Anisotropic to polarized light = “A” band = dark band
Isotropic to polarized light = “I” band = light band
Connective tissue layers of skeletal muscle

- Epimysium - coarse CT
- Perimysium - less coarse CT
- Endomysium - delicate CT

Diagram showing the layers of connective tissue surrounding muscle fibers.
Slide 136: Tongue, monkey

Skeletal muscle nuclei  Fasciculi  Endomysium

Muscle cells
Connective tissue of perimysium

skeletal muscle nuclei,
striations
Slide 136: Tongue, monkey

Capillaries in skeletal muscle endomysium
Skeletal muscle

Striations = A&I bands

skeletal muscle cell nuclei,
Cross striations in skeletal muscle cells (Slide 211-001)

Skeletal muscle cells

- A band
- Z disc
- I band
EM 10; skeletal muscle; 30,000x

1. Mitochondria
2. Sarcoplasmic reticulum
3. Terminal cisternae
Esophagus – skeletal and smooth muscle
Contracted skeletal muscle cells have small I bands

EM 10a: Endothelial cells lining capillary with pericyte in the vessel wall; 20,000x

1. Lumen
2. Endothelial cell
3. Tight junction
Nerve – muscle interface at the motor end plates

Muscle spindles stretch receptors
Muscle fibers inside a connective tissue capsule
Nerve – muscle interface at the motor end plates

Note the motor end plates in several skeletal muscle cells
Muscle spindles

Muscle spindle #19753

19753  Muscle spindles

Intrafusal fibers inside the capsule
136 Tongue  Muscle spindle

Muscle spindles

Intrafusal fibers inside the capsule

capillaries

fibroblasts

nerve
Skeletal muscle cells

Cardiac muscle cells

Intercalated disc = cell attachments
Intercalated disc in cardiac cells of the Heart,

A band
I band
Fig. 5-7 Cardiac Muscle. Stain: hematoxylin-eosin. High magnification.

Fig. 5-8 Cardiac Muscle (longitudinal section). Stain: Masson's trichrome. 130X.
Cardiac muscle cells are striated.

Cardiac cells are separated at the intercalated discs revealing the shape of individual cells, that the cells are branched, and the nuclei are in the center of cells.
Cardiac muscle cells are striated.

Cardiac cells can accumulate a high density of lipofuscin granules resulting from incomplete lysosomal digestion within the cell.
Heart

Internodal connections

Image showing the conduction system of the heart
Cardiac muscle cells

Purkinje fibers
Intercalated discs

EM 10b cardiac muscle cells
CARDIAC MUSCLE – Diad located at Z disc

Skeletal muscle – triad located at A-I junction

Diad = (T tubule + one end of SER)

TRIAD = (T TUBULE + TWO ENDS OF SER)
Skeletal muscle cell triad
Cardiac muscle cell diad
Test Questions on Muscle

Which is (are) true about striated muscle?
   a. The “A” band = dark band = anisotropic to polarized light
   b. The “I” band = light band = isotropic to polarized light
   c. The endomysium is delicate connective tissue around individual myofibrils
   d. a & b
   e. a, b, & c

Which types of muscle have nuclei in the center of its cells and are involuntary:
   a. Smooth muscle
   b. Cardiac muscle
   c. Skeletal muscle
   d. a and b
   e. a, b and c

Which is/are related to stimulation of muscle contraction:
   a. Motor end plate
   b. Gap junctions
   c. Purkinje fibers
   d. a and b
   e. a, b and c
In summary

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- **Distinguishing features:**
- high concentration of contractile proteins actin and myosin arranged either diffusely in the cytoplasm (smooth muscle) or in regular repeating units called **sarcomeres** (striated muscles, e.g., cardiac and skeletal muscles)
Many illustrations in these VIBS Histology YouTube videos were modified from the following books and sources: Many thanks to original sources!

The end of Medical School Histology Basics
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