



# LECTURE 1: INTEGRATED MUSCLE MUSCULOSKELETAL BLOCK



@Histo433

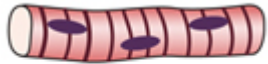
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# MUSCULAR TISSUE

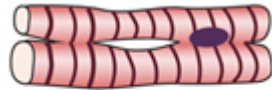
## Objectives:

By the end of this lecture you should be able to:

- Identify and describe the histological structure of the three types of muscle cells and list the differences between them.



**Skeletal Muscle**



**Cardiac Muscle**



**Smooth Muscle**

# MUSCULAR TISSUE

- Made of: **elongated muscle cells (fibers).**

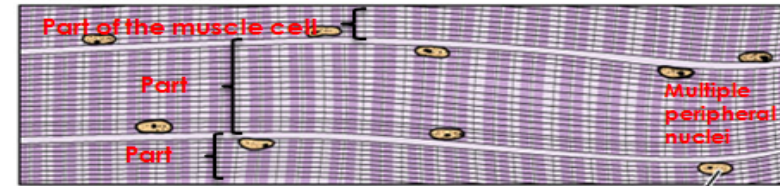
they are not actually fibers but we call them fibers because they are elongated & can be seen by the naked eye.

- 3 types of muscles (muscle fibers):

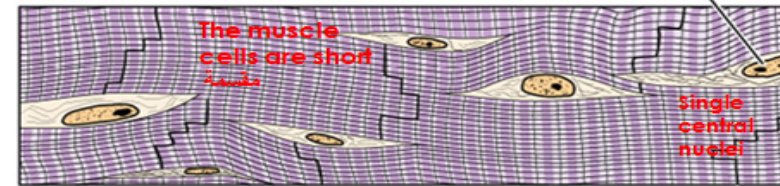
- 1) **Skeletal:** striated, voluntary.
- 2) **Cardiac:** striated, involuntary.
- 3) **Smooth:** non-striated, involuntary

## Muscle types

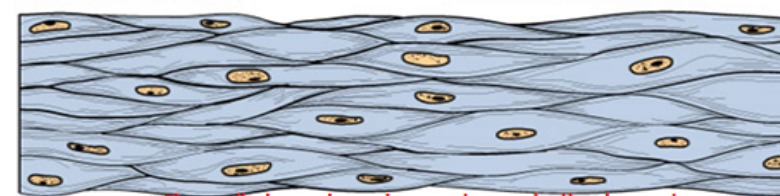
### Skeletal muscle



### Cardiac muscle



### Smooth muscle



# SKELETAL MUSCLE

## Epimysium

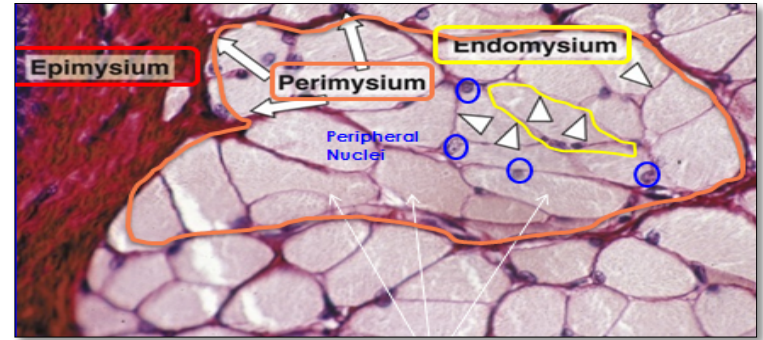
- C.T. that covers the whole muscle.

## Perimysium

- C.T. that separates the parallel bundles of skeletal muscle fibers.

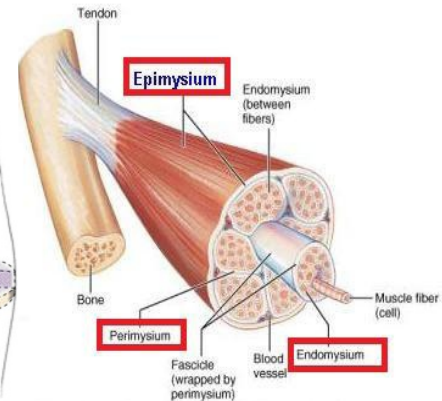
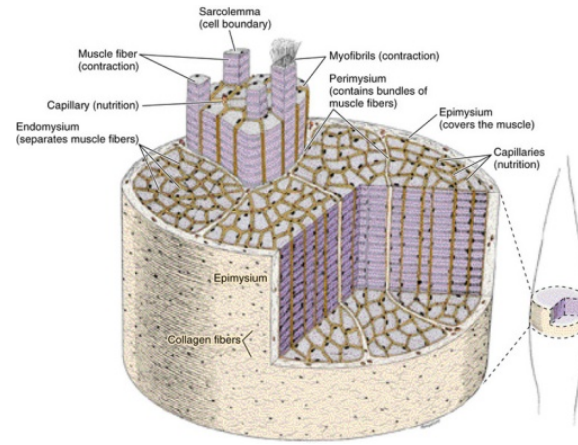
## Endomysium

- C.T. that separates individual muscle fibers.



- Epi = Outer
- Peri = Middle
- Endo = Inner
- Mysium = Muscle

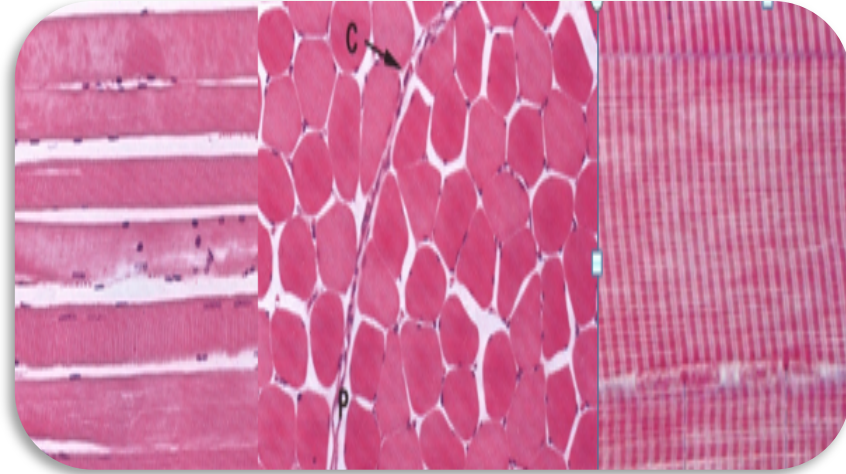
- Epimysium is made of **dense** collagenous C.T.
- Perimysium is made of **less** dense collagenous C.T.
- Endomysium is made up of **loose** collagenous C.T.



# Skeletal Muscle Fibers

## L.M. Picture

- ❑ Shape: **Cylindrical, Non-branched**.
- ❑ Covered by: **sarcolemma** (Clear cell membrane).
- ❑ **Multinucleated** – Nuclei are **multiple** and are **peripherally located** (close to the sarcolemma).
- ❑ Cytoplasm: **sarcoplasm** is **acidophilic** and shows clear transverse **striations**.



- Sarcoplasm = Cytoplasm of muscle cells
- Sarcolemma = Cell membrane of muscle cells.
- ("Sarco" means flesh).

# Skeletal Muscle Fibers

## E.M. Picture

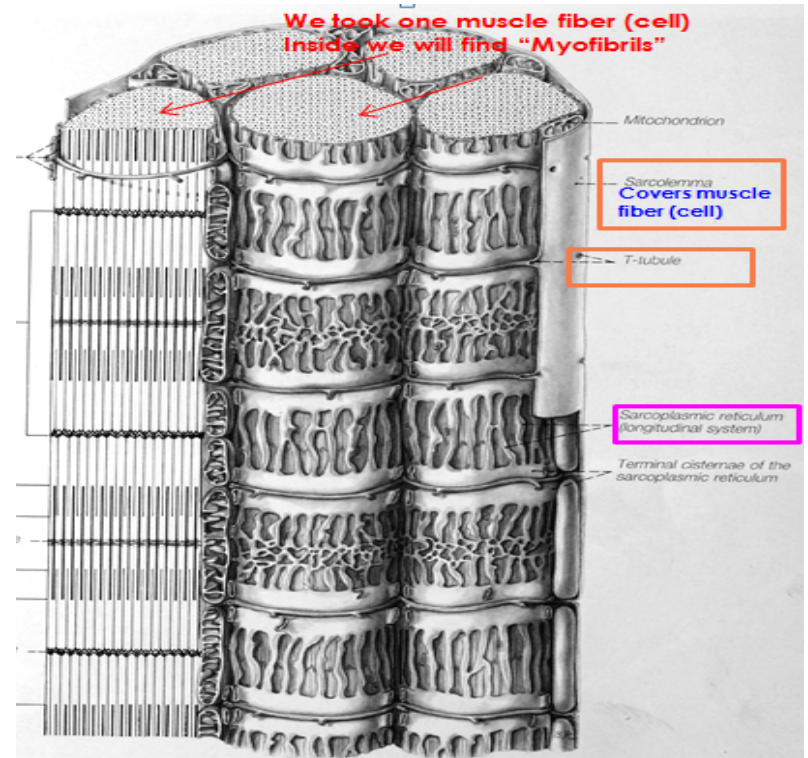
### Sarcoplasm contains:

- Parallel **myofibrils**.
- Numerous **mitochondria** → arranged in rows between the myofibrils.
- Well developed smooth endoplasmic reticulum: **sarcoplasmic reticulum "SR"**.
- **Myoglobin pigment**. [carry & store O<sub>2</sub>]
- **Glycogen**. [store food]

If we open a myofibril, we will find myofilaments [the arrangement of myofilaments give me the striation].

**Muscle fiber > Myofibrils > myofilaments**

Importance of sarcoplasmic reticulum: correlation of calcium + source of glycogen

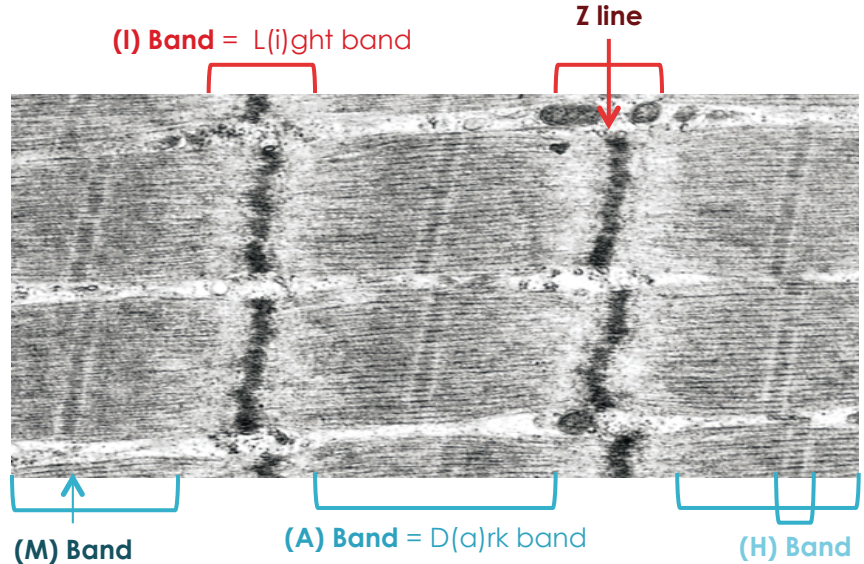




# Skeletal Muscle Fibers

## E.M. Picture of Myofibrils

- Contractile threads (organelles), arranged longitudinally in the sarcoplasm.
- Each myofibril shows alternating **dark bands (A)** and **light bands (I)**
- The A band:** shows a pale area in the middle (**H band**) which is divided by a dark line (**M line**)
- The I band:** shows a dark line in the middle (**Z line**)



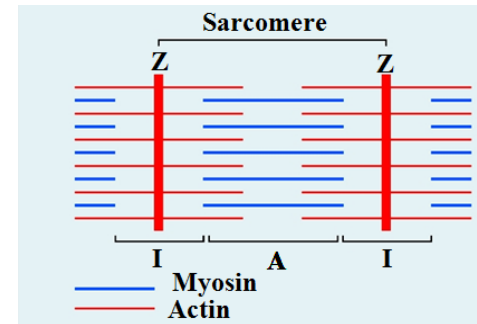
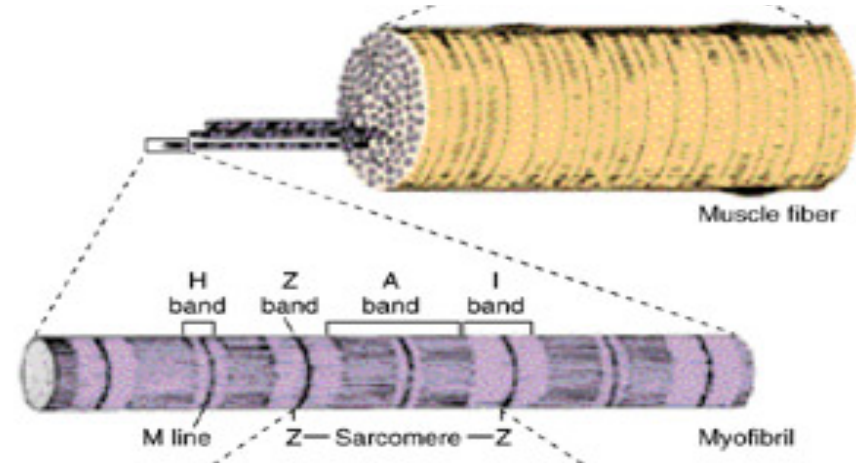
- Actin = Thin      Myosin = Thick
- A= dark (Has 2 types of myofilaments: actin & myosin)
  - I= light (Has only 1 type of myofilament: actin)
  - H= Pale area in A (Has only 1 type of myofilament: myosin)
  - Between every 2 Zs we have the sarcomere. Sarcomere is the functional unit of contraction

# Skeletal Muscle Fibers

- ❑ The **sarcomere** is the distance between 2 successive Z lines.
- ❑ The myofibrils are formed of myofilaments:

(thick = myosin/thin = actin)

- ❑ The **(A) band** is formed of **myosin** myofilaments mainly and the terminal ends of **actin** myofilaments.
- ❑ The **(I) band** is formed of **actin** myofilaments.

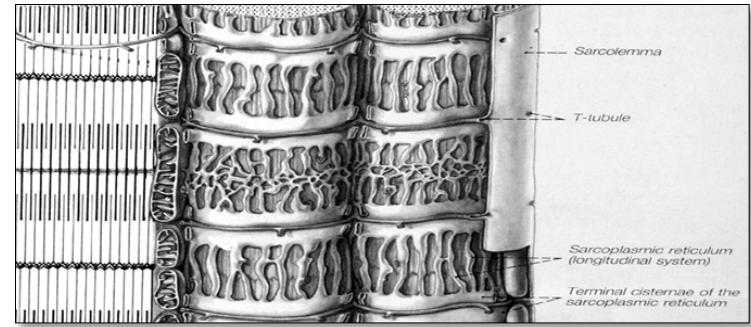




# Skeletal Muscle Fibers

## The **TRIAD** tubular system

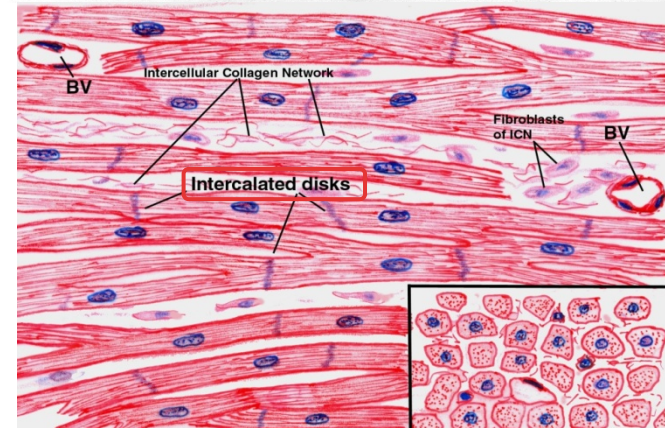
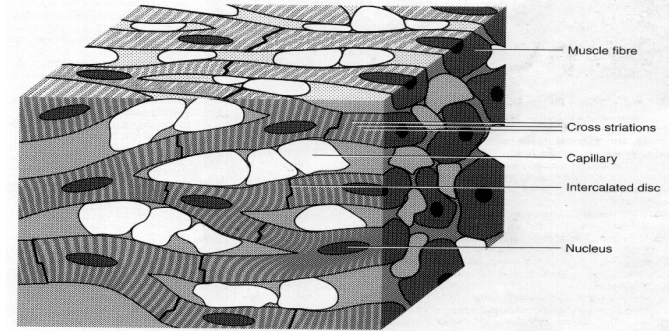
- The **sarcolemma** sends transverse invaginations into the sarcoplasm, **the T-tubules**.
- They form collars around the myofibrils at the level of the A-I junctions.
- The SR forms transverse wider cisternae (**terminal cisternae**) on either side of the T-tubule.
- The **2 terminal cisternae** of the SR and the **T-tubule form the triad tubular system**, which plays an important role during muscle contraction.



- Q. How can the nerve impulse go into the cell and give me the reaction "contraction" from a histological point of view?
- A. By the triad tubular system  
[[in cardiac muscles the T-tubules only come in contact with one cisternae ((2 tubular structures)) → called "Diad" not triad]]
- >> In the sarcolemma you find pits (invaginations)  
.....∇.....∇.....
- We want the nerve impulse to reach the smooth sarcoplasmic reticulum, why? Because the S.R. is important in Ca<sup>++</sup> regulation.
- When does the muscle contract? When the Ca<sup>++</sup> is high.  
→ Stimulation of S.R. to release Ca for muscle contraction
- ((3 Tubular structures))

# CARDIAC MUSCLE

- Location: **myocardium**.
- **Striated** and **involuntary**.
- **L.M. Picture of Cardiac Muscle Fibers:**
  - Cylindrical in shape.
  - Intermediate in diameter between skeletal and smooth muscle fibers.
  - Branch and anastomose.
  - Covered by a thin sarcolemma.
  - Mononucleated. Nuclei are oval and central.
  - Sarcoplasm is acidophilic and shows non-clear striations (fewer myofibrils).
  - Divided into short segments (cells) by the intercalated discs. (suturing between the ends of cells )



# Cardiac Muscle Fibers

## □ E.M. Picture:

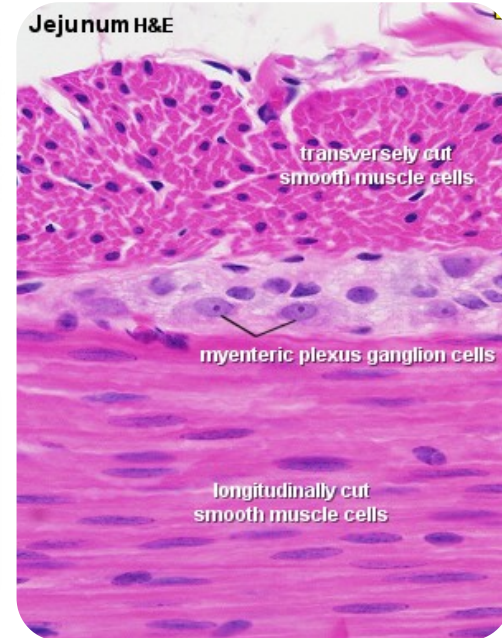
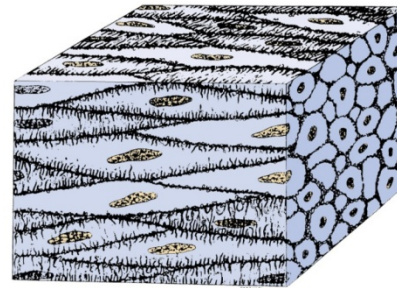
- Few myofibrils.
- Numerous mitochondria.
- Less abundant SR.
- T-tubules come in contact with only one cisterna of SR forming “**Diads**” (not triads).
- Glycogen & myoglobin.
- **Intercalated discs:** are formed of the two cell membranes of 2 successive cardiac muscle cells, connected together by junctional complexes (**desmosomes** and **gap junctions**).



- Gap junctions allow communication and passage of impulses between cardiac muscle cells.
- **Desmosomes junction** (end-to-end): to maintain fixation between cells
- **Gap junction** (Side-to-side): channels allow nerve impulse to pass through easily

# SMOOTH MUSCLE

- Present in **walls of blood vessels** and **viscera** (digestive, urinary, genital .... etc).
- Non-striated and involuntary.
- **L.M. Picture of Smooth Muscle Fibers:**
  - **Fusiform** in shape (spindle-shaped).  
thick in middle , and thin in peripherals.
  - Small diameter.
  - Non-branched.
  - Thin **sarcolemma**.
  - **Mononucleated**. Nuclei are oval & central in position.
  - **Sarcoplasm** is non-striated and acidophilic.



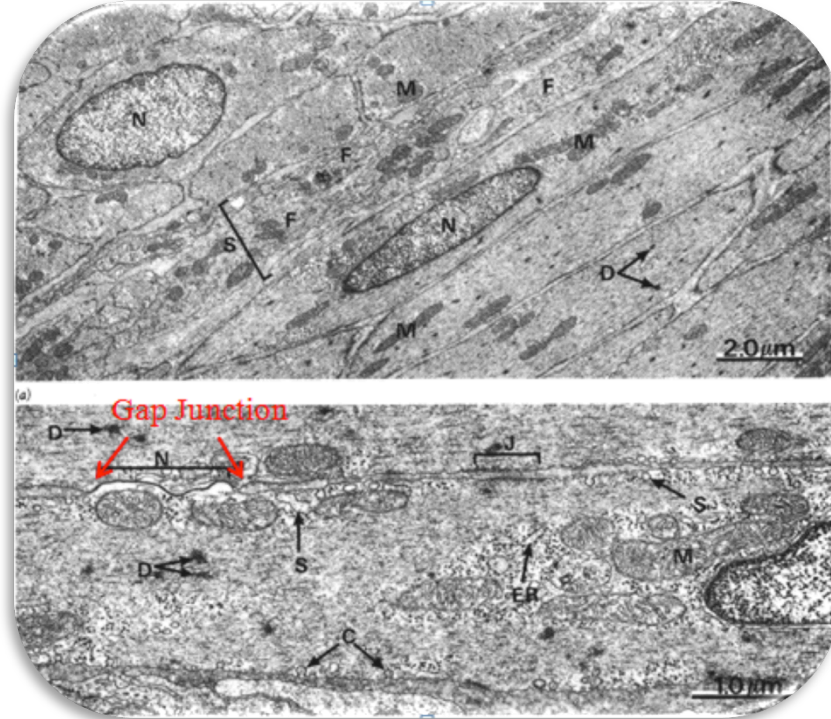
\* all muscle tissue are acidophilic sarcoplasm .



# Smooth Muscle Fibers

## □ E.M. Picture:

- Sarcoplasm contains mitochondria and sarcoplasmic reticulum.
- Myosin & actin filaments are irregularly arranged  
(that's why no striations could be observed).
- Cells are connected together by gap junctions for cell communication.



# REGENERATION OF MUSCLE

## (1) Skeletal muscle cells:

- Can not divide. (but can be hypertrophy)
- Limited regeneration by satellite cells (stem cells on the muscle cell's surface).

## (2) Cardiac muscle cells:

- No regenerative capacity.

## (3) Smooth muscle cells:

- Can divide.
- Regenerate from pericytes → active regenerative response.

Injury in muscle:-

- Skeletal muscle: No mitosis, Regeneration by stem cells "satellite cells" → In car accidents: severe injury it will be deformed because regeneration is limited
- Cardiac muscle: No mitosis, No stem cell = No generation (Replaced by C.T.)
- Smooth muscle: Mitosis + regeneration by stem cells "pericytes" → like in pregnancy:
  1. Increase in size: hypertrophy
  2. Increase in number: Mitosis + stem cells



# Summary

Comparison between different types of muscle fibers:

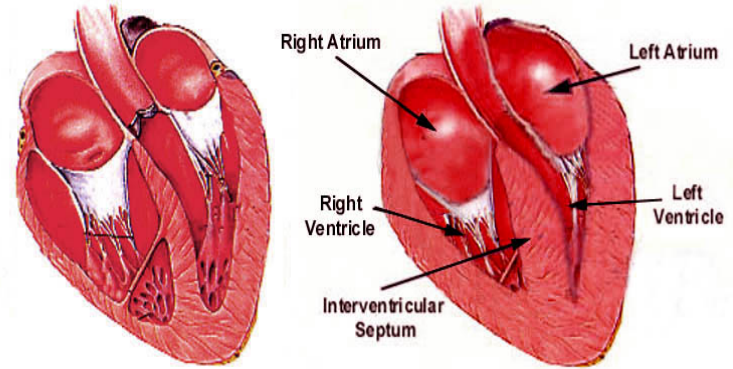
	<u>SKELETAL</u>	<u>CARDIAC</u>	<u>SMOOTH</u>
<u>Site:</u>	<b>Muscle attached to skeleton</b>	<b>Myocardium of the heart</b>	<b>Viscera (e.g. stomach)</b>
<u>Shape:</u>	<b>Cylindrical</b>	<b>Cylindrical</b>	<b>Fusiform</b>
<u>Diameter:</u>	<b>Largest</b>	<b>Medium-sized</b>	<b>Smallest</b>
<u>Branching:</u>	<b>Non-Branched</b>	<b>Branched</b>	<b>Non-Branched</b>
<u>Striations:</u>	<b>Clear</b>	<b>Not clear</b>	<b>Absent</b>
<u>Intercalated Discs:</u>	<b>Absent</b>	<b>Present</b>	<b>Absent</b>
<u>Nuclei:</u>	<b>Numerous &amp; peripheral</b>	<b>One central nucleus</b>	<b>One central nucleus</b>
<u>Action:</u>	<b>Voluntary</b>	<b>Involuntary</b>	<b>Involuntary</b>
<u>Regeneration:</u>	<b>Limited</b>	<b>No</b>	<b>Yes</b>

# Clinical Application

## Cardiac hypertrophy:

- During cardiac hypertrophy the number of cardiac muscle cells is **not** increased; instead, they become **longer and larger** in diameter.

Hypertrophic Cardiomyopathy



Normal Heart

Hypertrophied Heart

\* Cardiac hypertrophy happens to people with **hypertension**

# MCQs

1) Which is not a feature of skeletal muscles?

- a) Cylindrical b) involuntary c) Non-branched d) Attached to skeleton

2) which of the following muscles has no regenerative capacity?

- a) Skeletal muscle b) Cardiac muscle c) Smooth muscle

3) The sarcomere is the distance between:

- a) 2 successive H lines b) 2 successive M lines c) 1 M line and 1 Z line d) 2 successive Z lines

4) the epimysium is found in the:

- a) Skeletal muscle b) Cardiac muscle c) Smooth muscle

5) The cytoplasm ( sarcoplasm) of skeletal muscle fibers is:

- a) Acidophilic b) Basophilic

# MCQs

6) Skeletal muscle cells cannot divide at ALL?

a)True b)False

7) Which of the following C.T separates the individual fibers?

a)Sarcolemma b)Perimysium c)Endomysium d)Epimysium

8) Smooth muscle fibers contain myosin & actin?

a)True b)False

9) The cardiac muscle divided into short segmented by ?

a)Gap junction b)Intercalated disc c)Sarcoplasm

10) What happens in cardiac hypertrophy?

a)Increase in number of cells b)decrease in number of cells c)decrease in size of cells  
d)Increase in size of cells

Answers: 6) b 7) c 8) a 9) b 10) d

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