The objectives

1-To understand the different type of muscles in human body

2- Learn the different function, shape and structures

3- Give an example for each type of muscle tissue

3- Muscle Tissue

Muscle tissue, the third basic tissue type with epithelia, connective tissues, and nervous tissue, is composed of cells that optimize the universal cell property of contractility. As in all cells, actinmicrofilaments and associated proteins generate the forces necessary for the muscle contraction. Essentially all muscle cells are of mesodermal origin and differentiate by a gradual process of cell lengthening with abundant synthesis of the myofibrillar proteins actin and myosin. Three types of muscle tissue can be distinguished on the basis of morphologic and functional characteristics:

■ Skeletal muscle contains bundles of very long, multinucleated cells with cross-striations. Their contraction is quick, forceful, and usually under voluntary control.

■ Cardiac muscle also has cross-striations and is composed of elongated, often branched cells bound to one another at structures called intercalated discs that are unique to cardiac muscle. Contraction is involuntary, vigorous, and rhythmic.

■ Smooth muscle consists of collections of fusiform cells that lack striations and have slow, involuntary contractions.

There are basic similarities among the three muscle types:

1. **All are mesodermally derived and are elongated parallel to their axis of contraction.**
2. **All possess numerous mitochondria to accommodate their high energy requirements.**
3. **All contain contractile elements known as myofilaments, in the form of actin and myosin, as well as additional contractile-associated proteins.**

1- Skeletal Muscle: (or striated) muscle consists of muscle fibers, which are long, cylindrical multinucleated cells with diameters of 10 to 100 µm. Elongated nuclei are found peripherally just under the sarcolemma, a characteristic nuclear location unique to skeletal muscle fibers/cells. Longitudinally sectioned skeletal muscle fibers show cross striations of alternating light and dark bands. The dark bands are called A bands and the light bands are called I band. In the TEM, each I band is seen to be bisected by a dark transverse line, the Z disc. The repetitive functional subunit of the contractile apparatus, the sarcomere, extends from Z disc to Z disc and is about 2.5 µm long in resting muscle.

There are three types of skeletal muscle fibers: red, white, and intermediate depending on their contraction velocities, mitochondrial content, and types of enzymes the cell contains.

Types of Skeletal Muscle Fibers:

Red Fibers

- Contraction Velocity: Slow
- Mitochondrial Content: High
- Metabolism: Primarily aerobic (oxidative)
- Enzymes: High oxidative enzyme content
- Fatigue Resistance: High
- Color: Red due to high myoglobin content

White Fibers

- Contraction Velocity: Fast
- Mitochondrial Content: Low
- Metabolism: Primarily anaerobic (glycolytic)
- Enzymes: High glycolytic enzyme content
- Fatigue Resistance: Low
- Color: Pale due to low myoglobin

Intermediate Fibers

- Contraction Velocity: Fast
- Mitochondrial Content: Moderate to high
- Metabolism: Both aerobic and anaerobic
- Enzymes: Mixed oxidative and glycolytic enzyme content

- Fatigue Resistance: Moderate
- Color: Pink or red

Muscle Type	Myoglobin Content	Mitochondrial Population	Enzyme Content	ATP Generation	Contraction Characteristics
Red (slow)	High	Abundant	High in oxidative enzymes, low ATPase	Oxidative phosphorylation	Slow and repetitive; not easily fatigued
Intermediate	Intermediate	Intermediate	Intermediate-oxidative enzymes and ATPase	Oxidative phosphorylation and anaerobic glycolysis	Fast but not easily fatigued
White (fast)	Low	Sparse	Low oxidative enzymes; high ATPase and phosphorylases	Anaerobic glycolysis	Fast and easily fatigued

2- Smooth Muscle: Smooth muscle is specialized for slow, steady contraction and is controlled by a variety of involuntary mechanisms. Fibers of smooth muscle (also called visceral muscle) are elongated, tapering, and nonstriated cells, each of which is enclosed by a thin basal lamina and a fine network of reticular fibers, the **endomysium**. Smooth muscle cells may range in length from 20 µm in small blood vessels to 500 µm in the pregnant uterus. Each cell has a single long nucleus located in the center of the cell's central, broadest part.

3- Cardiac Muscle:.

Cardiac muscle cells have central nuclei and myofibrils that are less dense and less well-organized than those of skeletal muscle. Also, the cells are often branched. Mature cardiac muscle cells are approximately 15 µm in diameter and from 85 to 100 µm in length. They exhibit a cross-striated banding pattern comparable to that of skeletal muscle. Unlike multinucleated skeletal muscle, however, each cardiac muscle cell possesses only one (or two) centrally located, pale-staining nuclei.

Surrounding the muscle cells is a delicate sheath of endomysium with a rich capillary network. A unique and distinguishing characteristic of cardiac muscle is the presence of dark-staining transverse lines (Intercalated disk) that cross the chains of cardiac cells at irregular intervals where the cells join. These intercalated discs represent the interface between adjacent muscle cells and contain many junctional complexes.

Characteristics	Skeletal Muscle	Smooth Muscle	Cardiac Muscle
Location	Generally attached to skeleton	Generally in hollow viscera, iris, blood vessels	Myocardium, major blood vessels as they enter or leave the heart.
Shape	Long, cylindrical parallel fibers	Short, spindle-shaped	Branched and blunt ended
Striations	Yes	No	Yes
Number and location of nucleus	Numerous, peripherally	Single, central	One or two, central
T tubules	Present at A-I junctions	No—but caveolae	Present at Z discs
Sarcoplasmic reticulum (SR)	Complex surrounds myofilaments forming meshwork. Forms triads with T tubules	Some smooth SR but poorly developed	Less developed than in skeletal muscle; forms diads with T tubules
Gap junctions	No	Yes	Yes—within intercalated discs
Control of contraction	Voluntary	Involuntary	Involuntary
Sarcomere	Yes	No	Yes
Regeneration	Restrictive	Extensive	Perhaps some limited
Histological distinction	Multiple striations and numerous peripherally located nuclei	No striations, central nucleus	Intercalated discs

MEDICAL APPLICATION

1- Muscular Dystrophies (MD) -------Cause : genetic mutations.

2- Inflammatory Myopathies---------- Cause: Autoimmune conditions

3- Metabolic Muscle Diseases-----Cause: Enzyme deficiencies that affect muscle metabolism.

4- Neuromuscular Junction Disorders----------Cause: Impaired signal transmission between nerves and muscles.

5- Toxic or Drug-Induced Myopathies-----Cause: Medications (e.g., statins), alcohol, or toxins.