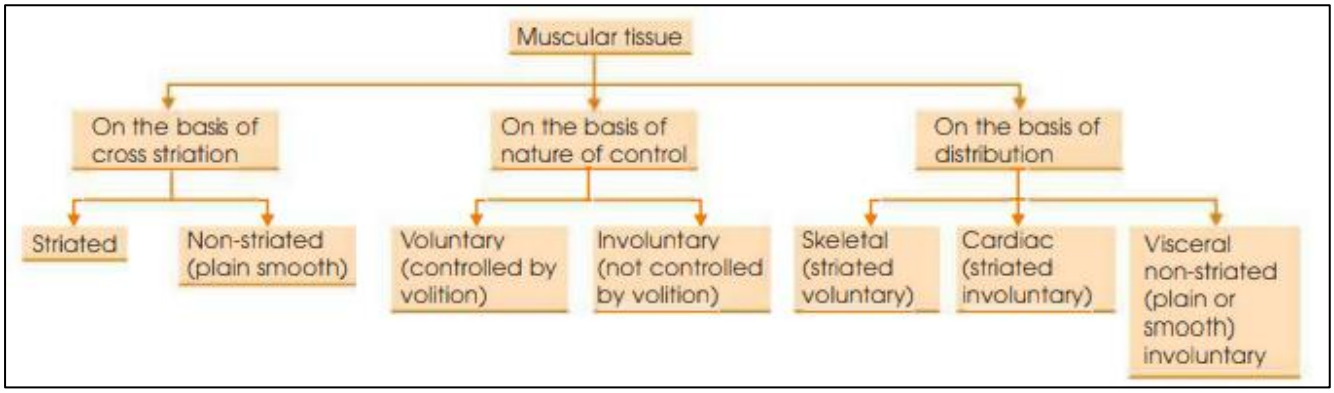
MUSCULAR SYSTEM

Functional Characteristics of the Muscular Tissue:

1. Ability to contract when excited.
2. Conductivity though not to the degree as that of nervous tissue.

Muscle Classification: Muscles are classified into three types (Q/ Discuss the classification of muscle)

1. Morphological basis: As striated and non-striated (plain smooth)
2. Functional basis: Basis of their control: Voluntary and involuntary.
3. Basis of distribution: Skeletal (striated voluntary), cardiac (striated involuntary) and visceral (plain or smooth and non-voluntary).



Skeletal Muscles

Functions of Skeletal Muscles:

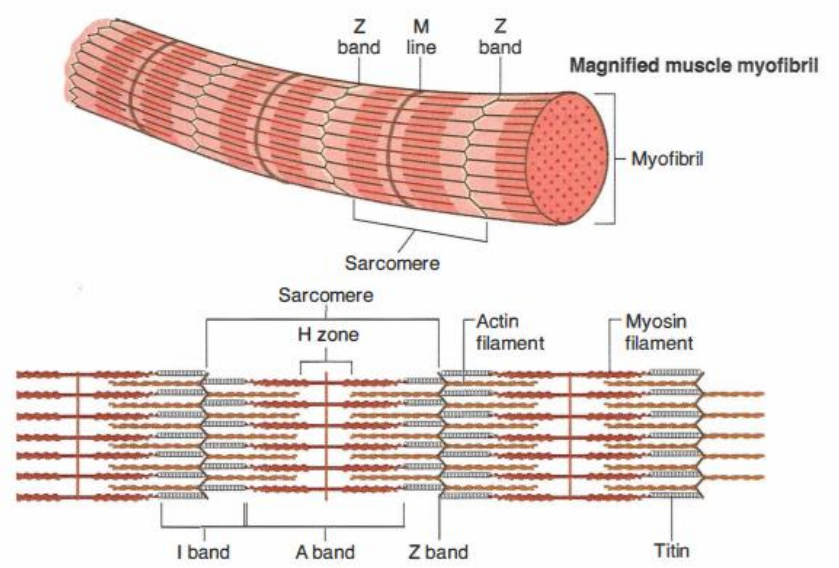
1. Muscles of the skeleton are responsible for large and forceful movements of the body, such as those involved in walking, running, and lifting heavy objects.
2. Large skeletal muscle groups, such as those in the lower back, buttocks, and thigh, are also responsible for stabilizing the body's position against gravity. This function allows us to sit and stand upright without teetering.
3. This muscle type is also used for the fi ne, delicate movements of the hands, such as those used in writing, playing the violin, and manipulating tiny objects.
4. A secondary function of skeletal muscle is the production of heat. Heat given off in shivering or during general exercise is an important source of heat generation in the body.

Structure of the Skeletal Muscle:

A muscle fiber is equivalent to a cell.

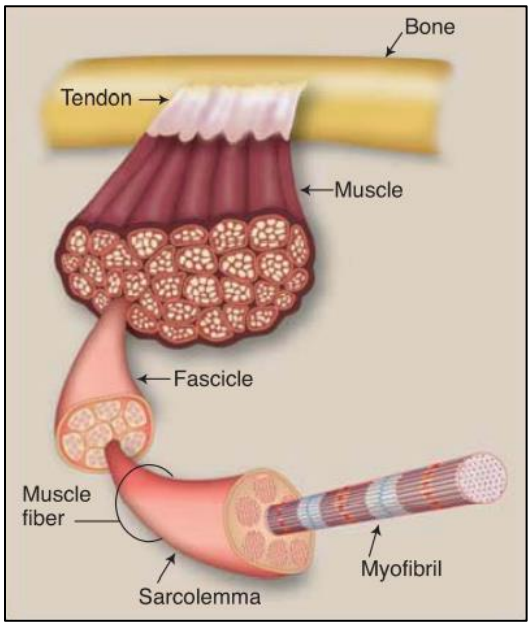
A muscle fiber, or cell, is elongated and densely packed with contractile proteins.

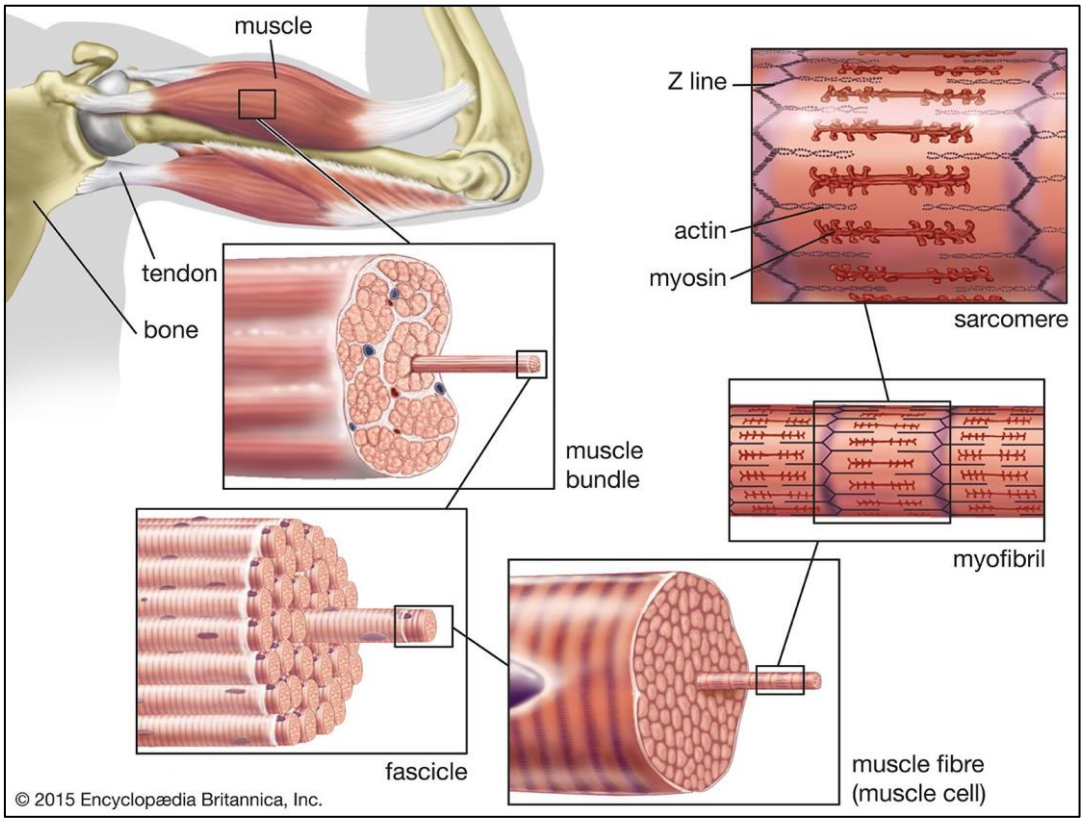
The contractile proteins; myosin and actin are arranged in such a way as to give it a striped or striated appearance.
The cell membrane around a muscle cell is called sarcolemma.
Its cytoplasm is called sarcoplasm.
A muscle cell is multinucleated, the nuclei being pushed by contractile elements to be just beneath the sarcolemma.



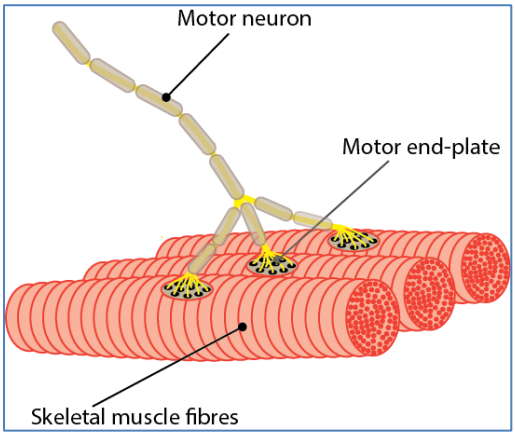
- The line called the Z-line extends through the middle of the light band.
- The part of the muscle fiber that extends between two consecutive Z-lines is called a sarcomere, which is the contractile unit of muscle (the functional unit of contraction).
- During muscle contraction, the Z-lines come closer together, and the sarcomeres shorten.
- Immediately adjacent to the Z line is the I band.
- The central portion of the sarcomere is occupied by the A band.
- In the middle of the A band is the H band.
- At the center of the H band is the M line.
- The A band is made up primarily of myosin filaments.
- The I band is made up primarily of actin fi laments.
- Actin filaments extend partly into the A band.
- H band represents the region where there is no overlap between actin and myosin filaments.
- In light microscopy, A band is darkly stained and I band is lightly stained, giving a striped appearance.
- All the myofibrils in a muscle fiber are arranged in a ‘perfect’ manner so that the A and I bands of all myofibrils are at the same level. This gives a striped appearance to the whole muscle fiber. That is why skeletal muscle is also known as striped or striated.
- When a muscle contracts, the length of the A band does not change but the I band shortens and H band shortens. This has been explained by proposing that actin filaments slide between myosin filaments towards the center of the sarcomere during contraction.
- The structure of the sarcomere is replicated many times down the length of a muscle to build up a myofibril.

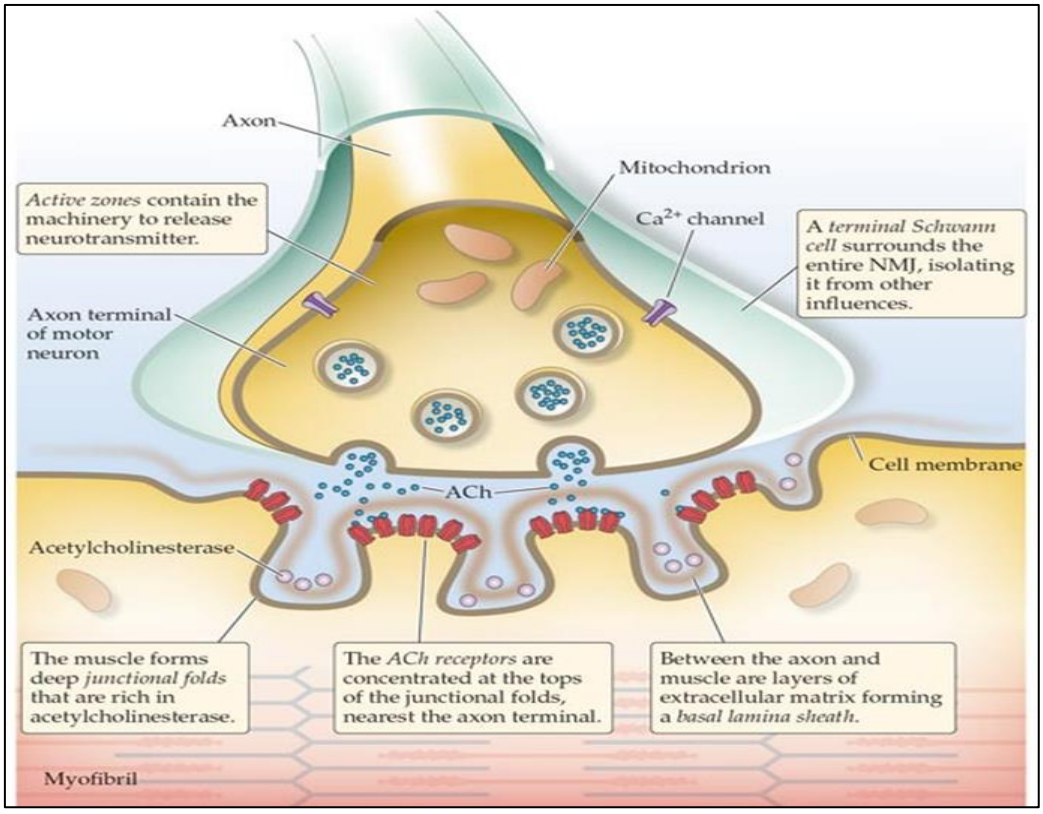
- Many hundreds or even thousands of myofibrils are then bundled and wrapped in a sarcolemma sheath, which comprises plasma membrane. The result is a muscle fiber.
- Multiple muscle fibers are bundled and wrapped in connective tissue to form a fascicle.
- Fascicles, in turn, are bundled to form a muscle.
- A tendon fiber is fused to the ends of individual muscle fibers to provide a mechanical link between muscle and bone. Tendon fibers are made of collagen. The two ends of a muscle are referred to anatomically as its insertion and origin. The insertion attaches to the bone that moves when the muscle contracts and is usually more distal than its stationary origin.





- Skeletal muscles are innervated by motor nerves.
- As the axon innervating a skeletal muscle fiber approaches its termination, it loses its myelin sheath. The axis cylinder then branches into several bulb-shaped endings called terminal buttons, each of which innervates a muscle fiber. The terminal buttons contain many small synaptic vesicles that contain acetylcholine, which is the neurotransmitter at neuromuscular junctions.
- The terminal buttons come in close proximity with a thickened trough on the muscle membrane called the motor end plate that bears receptors for acetylcholine (ACh).
- Each branch of the motor nerve fiber innervates one muscle fiber. But the number of muscle fiber innervated by a motor nerve fiber varies from less than ten to several hundred. A motor neuron together with all the muscle fibers it innervates is called a motor unit.





- Note: Skeletal muscle is innervated by motor neurons, while smooth muscle is innervated by the autonomic nervous system.
- When the action potential reaches the axon of the motor neuron, voltage-gated calcium ion channels on the axon are activated and calcium enters in. The calcium causes acetylcholine vesicles in the axon to fuse with the membrane, and releases acetylcholine into the cleft between the axon and the motor end plate of the muscle fiber. The acetylcholine then diffuses across the cleft and binds to nicotinic receptors on the motor end plate, in the membrane and sodium enters in, and potassium rushes out. However, because sodium is more permeable, the muscle fiber membrane becomes more positively charged, and triggers an action potential.
  the depolarization causes the release of calcium from the sarcoplasmic reticulum which in tum activates the myosin ATPase. This activated ATPase breaks the ATP to ADP and the ADP to AMP with the release of certain amount of energy which is required for the process of contraction. The released calcium causes subsequent molecular changes in actin and myosin filaments resulting in the sliding of these filaments over each other shortening the length of the sarcomere and causing muscle contraction.

MYASTHENIA GRAVIS:

- It is an autoimmune disease characterized by profound muscular weakness.
- The patients carry antibodies to ACh receptors in the circulation so the body tends to destroy or neutralize its own ACh receptors.
- The patient is usually at his best in the morning and worsens as the day progresses. The reason is that ACh synthesized throughout the night can be utilized in the morning. Excess of ACh can overcome the block produced by the antibodies. But that degree of excess of ACh cannot be maintained throughout the day, and hence the patient gets weaker.
- Weakness of levator palpebrae superioris muscle (muscle of the upper eyelid) leads to drooping eyelids, which is an early and prominent sign.
- The disease responds dramatically to AchE inhibitors such as neostigmine. AChE inhibitors allow ACh to accumulate at neuromuscular junctions. High concentrations of ACh are able to displace antibodies from the ACh receptor-antibody complex and thereby overcome the neuromuscular block.
- The situation in myasthenia gravis bears a striking resemblance to that after administration of curare. In both cases there is a competitive blockade at the ACh receptor level which can be overcome by AChE inhibitors.