Muscular tissue

Muscle tissue is composed of differentiated cells containing **contractile proteins**, that have the special ability to shorten or contract in order to produce movement of the body parts. Muscle tissues are derived from the mesodermal layer of embryonic germ cells.

Muscle cells contain protein filaments of **actin** and **myosin** that slide past one another, producing a contraction that changes both the length and the shape of the cells. Muscles functions to produce force and motion. They are primarily responsible for maintaining of posture, locomotion, as well as movement of internal organ, such as the contraction of the heart and the movement of food through the digestive system, circulation of blood, and heat generation.

Characteristics of all muscle tissues

1. Specialized cells: elongated, high density of myofilaments or cytoplasmic filaments of actin and myosin.

2. Excitability/irritability: ability to respond to stimuli.

3. Contractility: ability to contract.

4. Extensibility: ability of a muscle to be stretched.

5. Elasticity: ability to recoil and return to its normal shape after stretch**.**

Types and functions of muscle

There are three types of muscle tissues can be distinguished on the basis of morphologic and functional characteristics. These are include: skeletal or striated, cardiac and smooth muscles (Figure 1).

a- Skeletal muscles

These are **voluntary, striated muscle**. It is composed of bundles of very long, cylindrical, multinucleated cells, striated, and under voluntary control. Attached to bones producing locomotion, general support and posture and producing heat.

c- Smooth muscles

These are **involuntary, nonstriated muscle**. Consist of collection of fusiform cells, lack striations and involuntary control. It is found in the lining of blood vessels, urinary bladder, kidneys, esophagus and small intestine.

b- Cardiac muscles

These are **involuntary, striated muscle**. It is composed of elongated, branched individual cells that lie parallel to each other. At sites of end to end contact are the intercalated disks. Contraction of cardiac muscle is involuntary. Found only in the heart and responsible for contraction of cardiac tissue and distribution of blood.

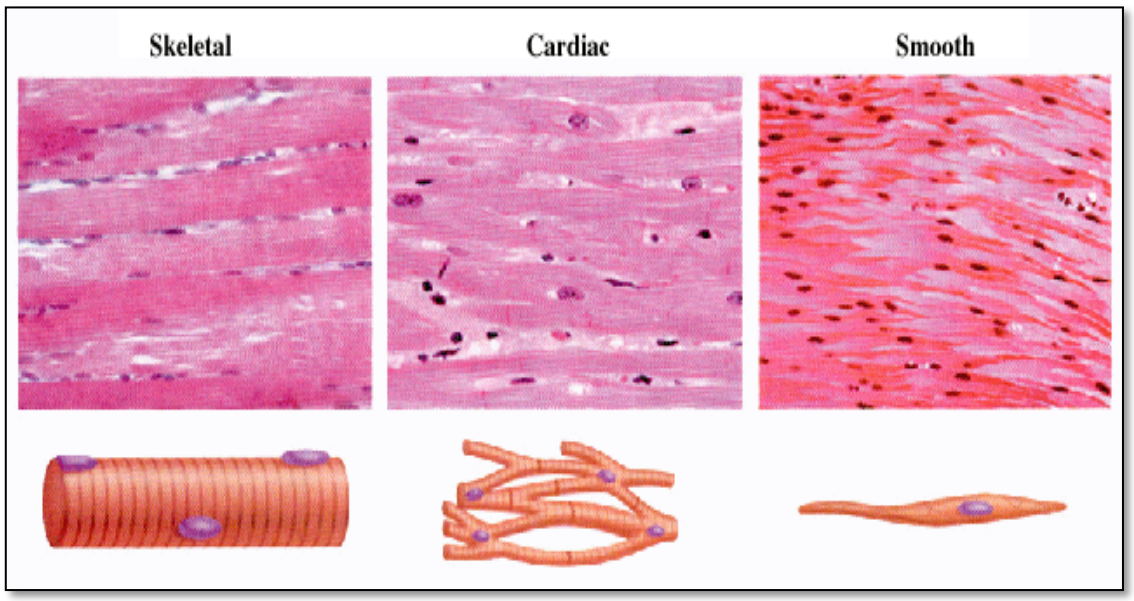


Figure (1): The types of muscular tissues.

The Skeletal Muscle

It consists of muscle fibers which are long cylindrical multinucleated cell with a diameter of (10-100) µm. The long oval nuclei are usually found at the periphery of the cell under the cell membrane. Skeletal muscle is organized into bundles of muscle cells or fibers that are held together by a sheath of connective tissue. It is voluntary muscle that anchored by tendons to bone and is used to effect skeletal movement such as locomotion and in maintaining posture.

Organization of skeletal muscle

The skeletal muscle fibers arranged in regular bundles surrounded by epimysium , an external sheath of dense connective tissue surrounding the entire muscle. From the **epimysium**, thin septa of connective tissue extend inward, surrounding the bundles of fibers within a muscle (fascicles). The connective tissue around each bundle of fibers within a muscle fibers (fascicle) is called the **perimysium**. Each muscle fiber is itself surrounded by a delicate layer of connective tissue called the **endomycium,** composed of basal lamina and reticular fibers (Figure 2). Within each fiber the nuclei are displaced peripherally against the sarcolemma. The important role of connective tissue is to transmit the mechanical forces generated by contracting muscle cells. Blood vessels and lymphatic vessels penetrate the muscles within the connective tissue septa and form a rich capillary network that runs between and parallel to the muscle fibers.

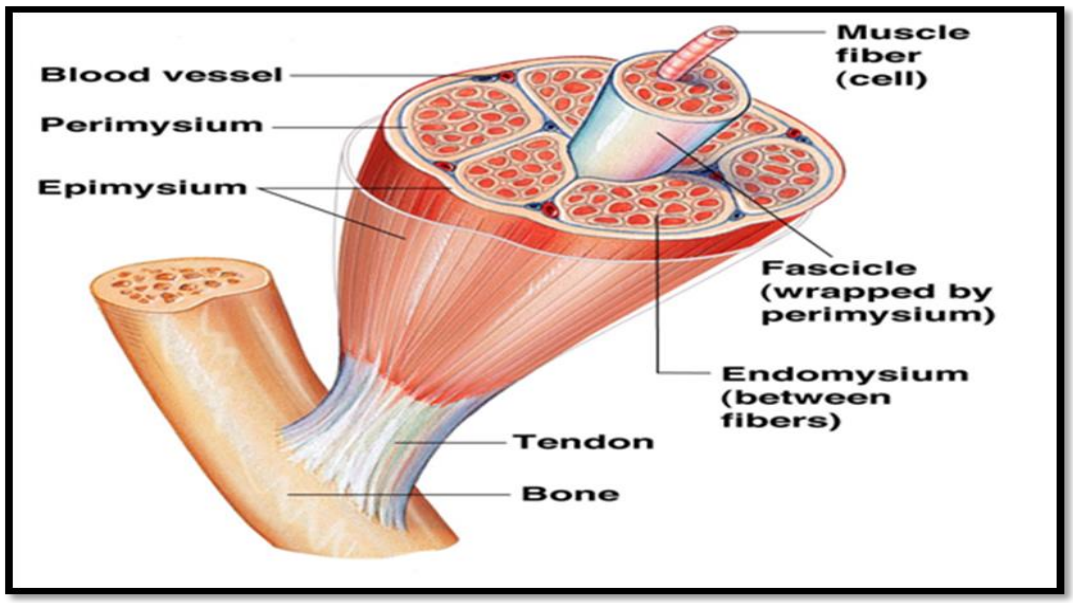


Figure (2): The distribution of connective tissue within muscle fiber.

Organization of skeletal muscle fibers

A typical fiber is multinucleated, striated and surrounded by cell membrane called **sarcolemma** and cytoplasm called **sarcoplasm**. A network of membranous channels (**sarcoplasmic reticulum**) are dispersed throughout the sarcoplasm (Figure 3). The sarcoplasm of muscle fiber is filled with long cylindrical filamentous bundles called **myofibrils**. Within each muscle fiber are long cylindrical filamentous bundles structures called myofibrils that lie parallel to the long axis of the muscle fiber (Figure 4). Hundreds to thousands can be found inside one muscle fiber. The functional unit of a muscle tissue consist of protein filaments called **myofilament** which consists of thin filaments (**actin**) and thick filaments (**myosin**). The characteristic light and dark bands on a muscle are due to the arrangement of these myofilaments (Figure 5). They attach to the sarcolemma at their ends, so that as myofibrils shorten, the entire muscle cell contracts.

The muscle cell or fiber show cross striations of alternating light and dark bands. The dark bands are called **A-bands** and the light bands are called **I- bands**. Each I-band is bisected by a dark transverse line called **Z disc**.

A band shows the presence of lighter zone in its center called **H zone**. The A-band and I-band overlap in arrangement. The repetitive functional subunits of the contractile apparatus, the **sarcomere**, extends from **Z disc** to **Z disc** (Figure 6).

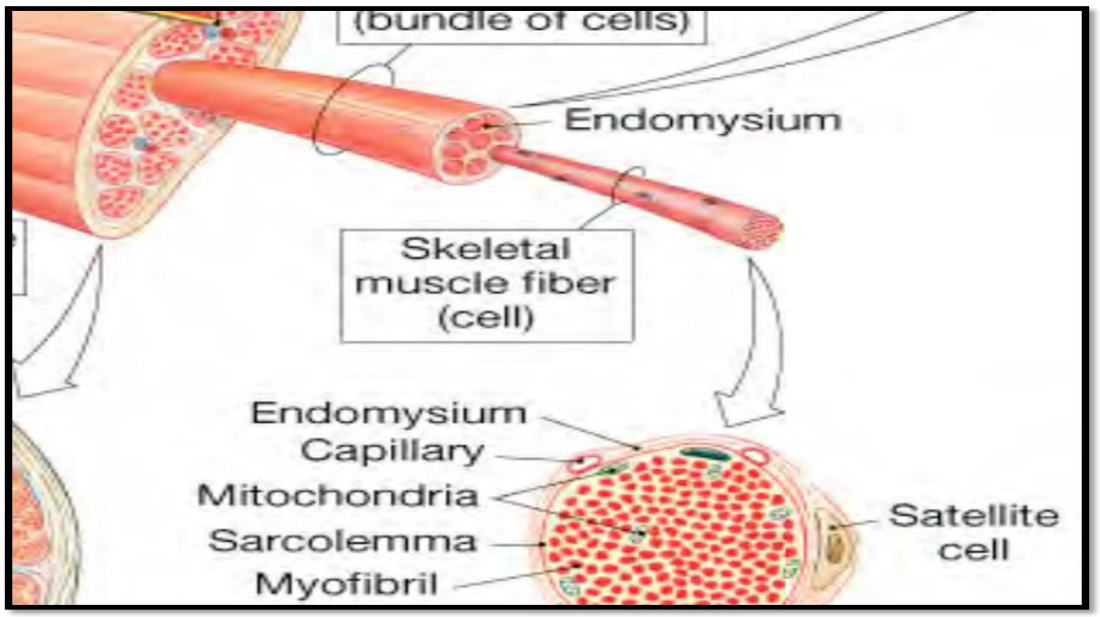


Figure (3): The structure of muscle fiber

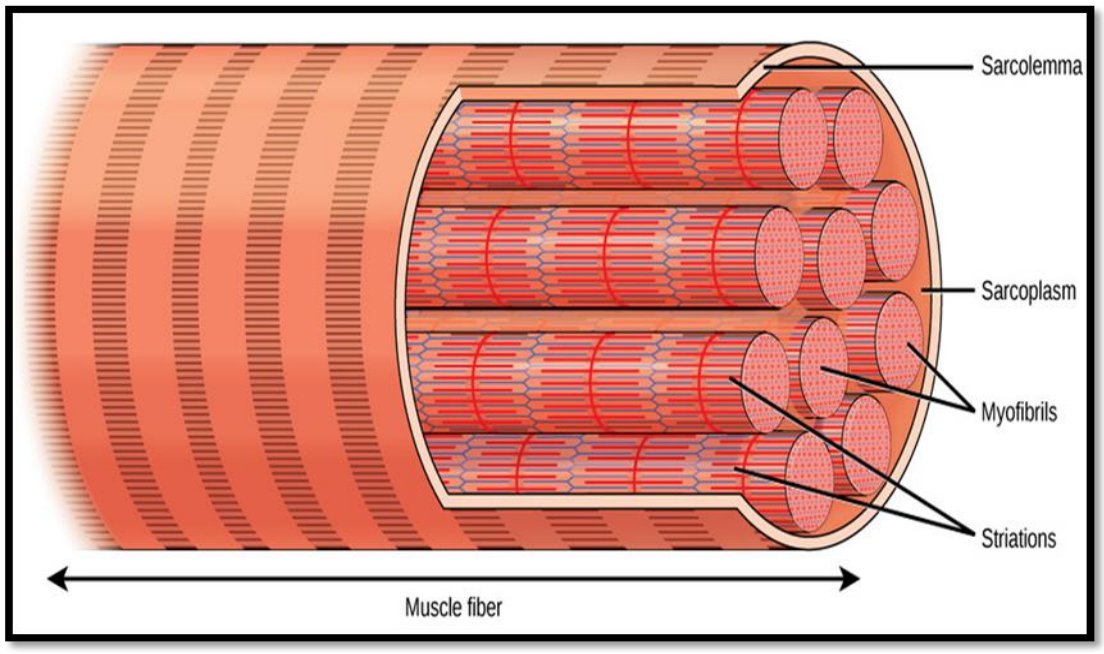
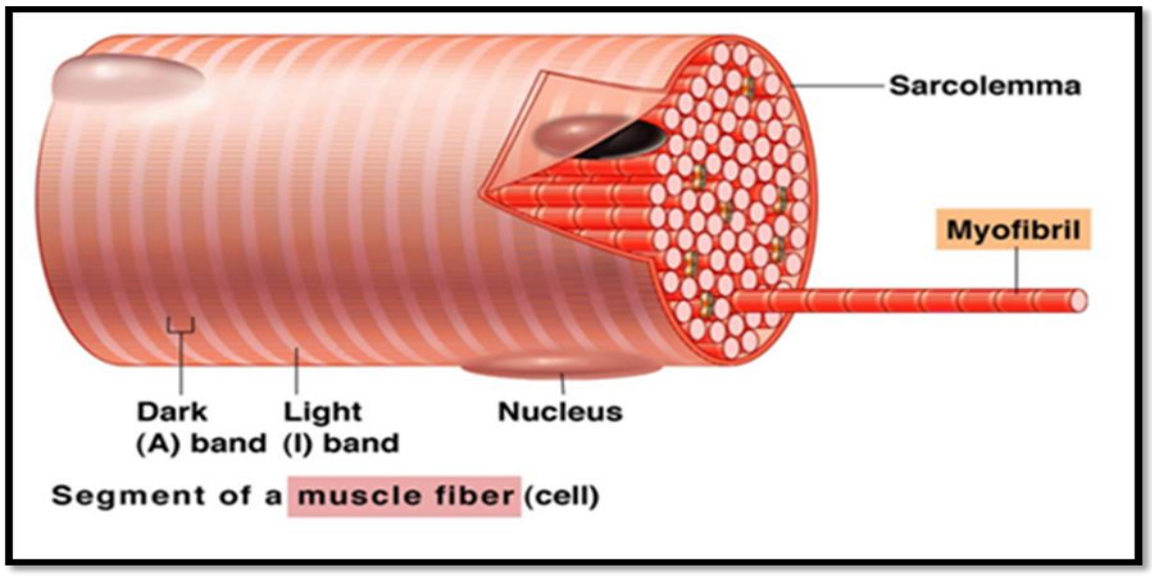


Figure (4): The structural unit of muscle fiber.



(Figure 5): The dark and light band of muscle fiber.

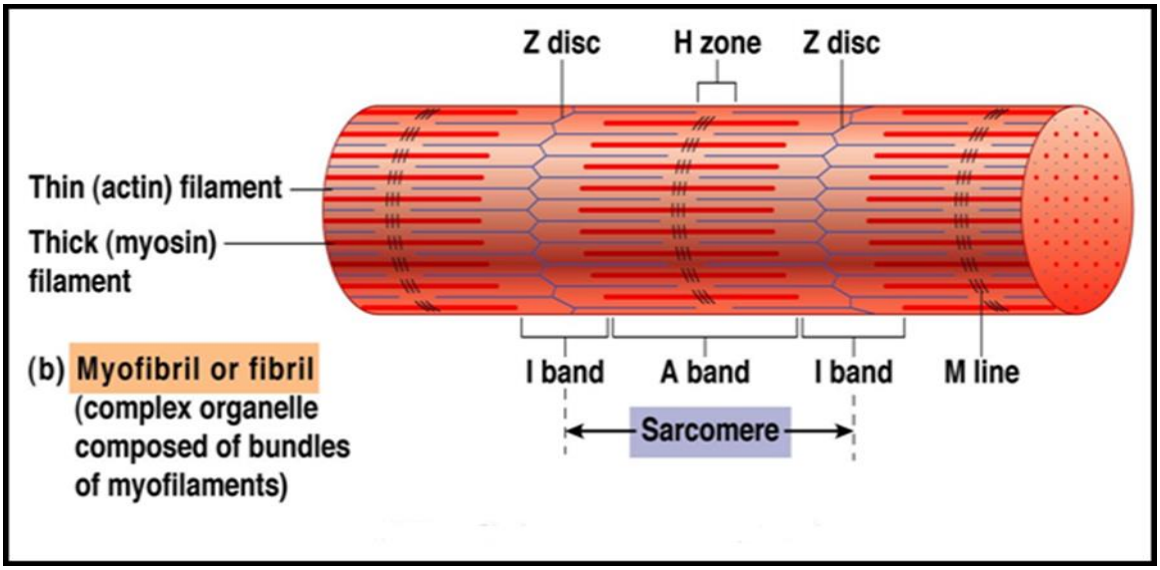


Figure (6): The striation of muscle fibril.

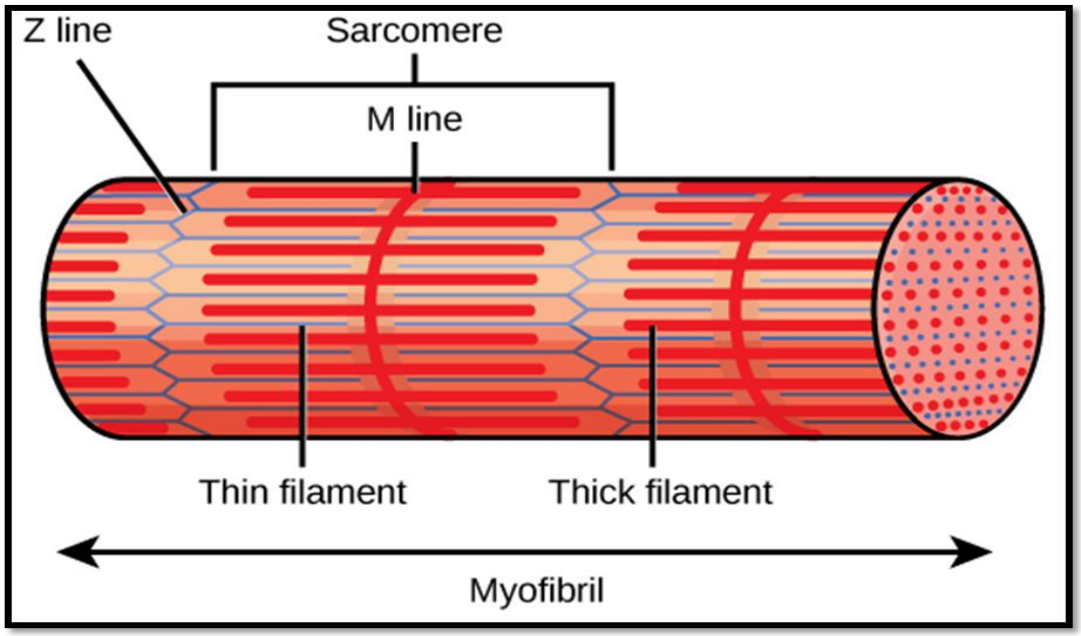
Sarcomere

Myofibrils are composed of long proteins such as actin and myosin that are organized into thin filaments and thick filaments, which repeat along the length of the myofibril in sections called **sarcomeres** (Figure 7). Muscles contract by sliding the thin (actin) and thick (myosin) filaments along each other.

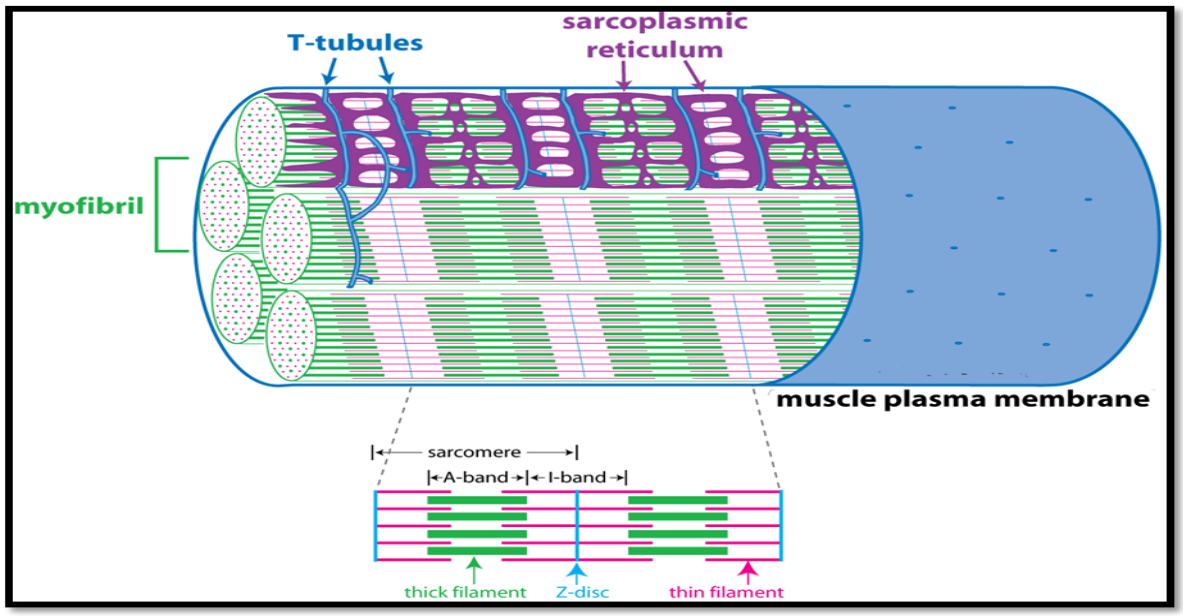
The Z discs mark the border of sarcomeres units, which are the functional units of skeletal muscle. The repetitive functional units of the contractile apparatus of muscle, the sarcomere, extends from Z disc to Z disc.

One sarcomere, the space between two consecutive Z discs, contains one entire A band and two halves of an I band, one on either side of the A band (Figure 8).

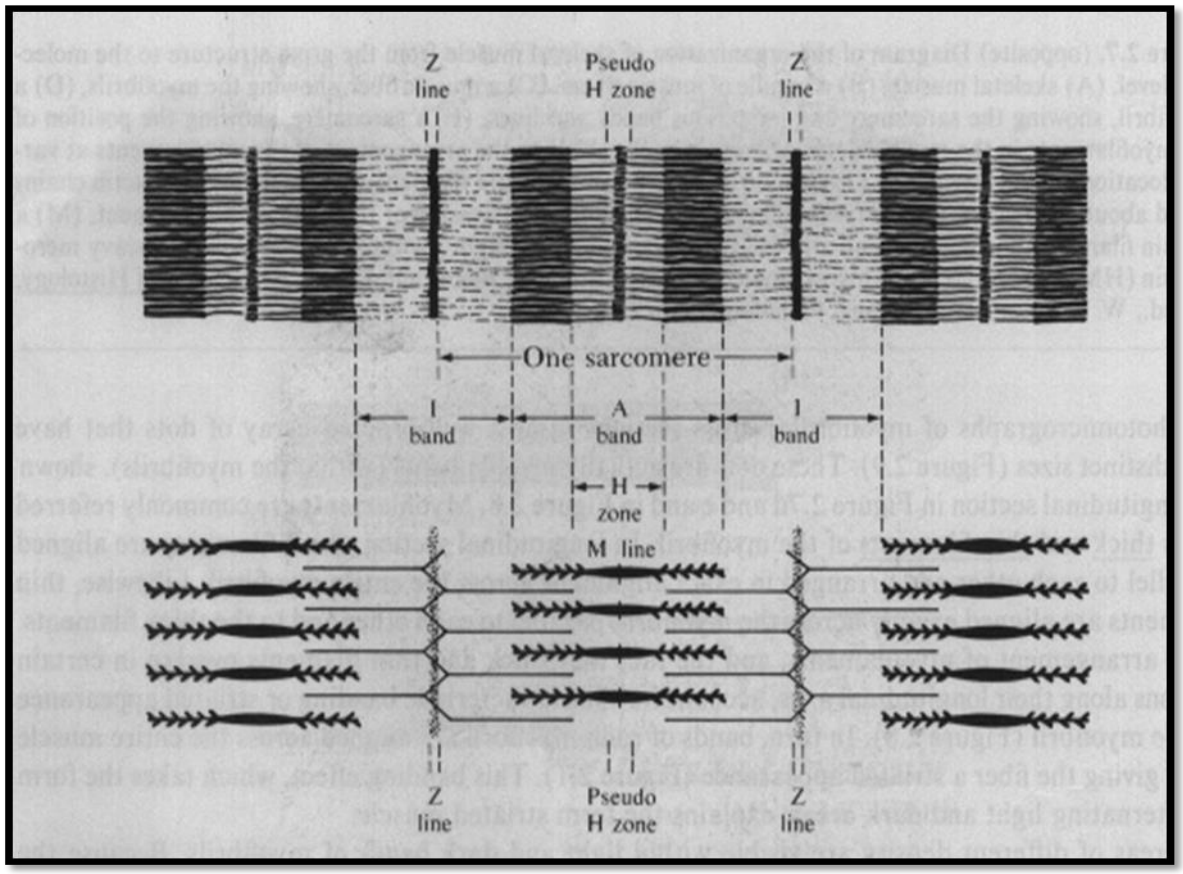
The thin filaments run between and parallel to the thick filaments and have one end attached to the Z line. As a result of this arrangement, the I band consist of the portions of the thin filaments that do not overlap the thick filaments. A band shows the presence of lighter zone in its center called H zone that consisting only of myosin molecules with no thin filaments present (Figure 9). Myofibril is composed of many sarcomeres running along its length. As the sarcomeres individually contract, the myofibrils and muscle cells shorten.



(Figure 7): The structural unit of sarcomere



(Figure 8): The arrangement of filaments within sarcomere.



(Figure 9): The integrated of bands within sarcomere.

Innervation

Skeletal muscle contract or relax when they receive signals from the nervous system. The nerves that are responsible for innervating muscle fibers are called motor neurons. At the site of junction (innervation) with a muscle fiber, the axon branches into several short ending (axon terminals), each occupying a shallow depression on the muscle cell surface. This structure is called the motor end plate, or the neuromuscular junction (Figure 8, 9). The Contraction of muscle is induced by **neuromuscular junction**, where it is the site of signal exchange between skeletal muscle and motor axon of nerve (Figure 7).

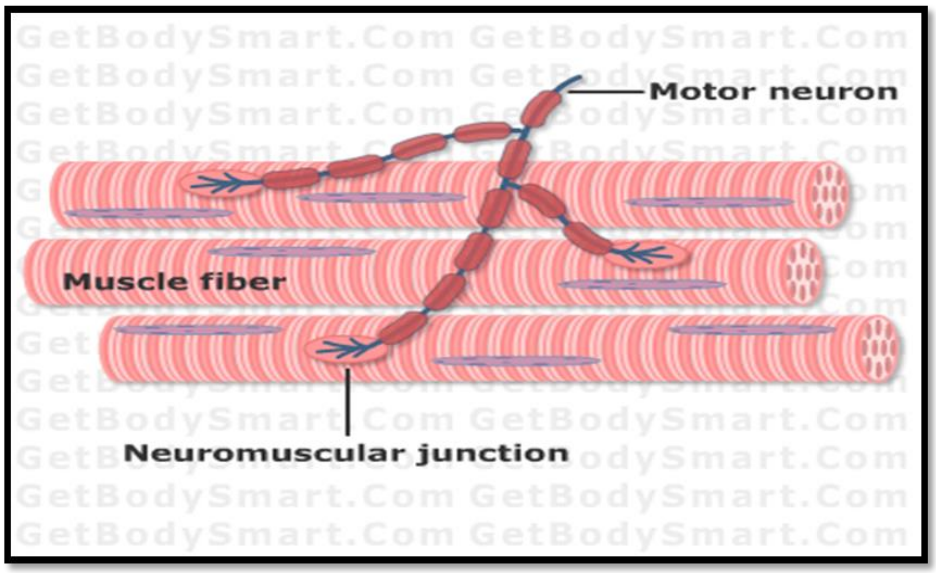


Figure (7): The connection of synaptic bulb and muscle fiber.

At this site, within the terminal axon are numerous mitochondria and synaptic vesicles that containing the **neurotransmitter acetylcholine**. That discharge these content during transmission of nerve impulse into narrow space (**synaptic cleft**) between the terminal axon and the sarcolemma of the muscle fiber.

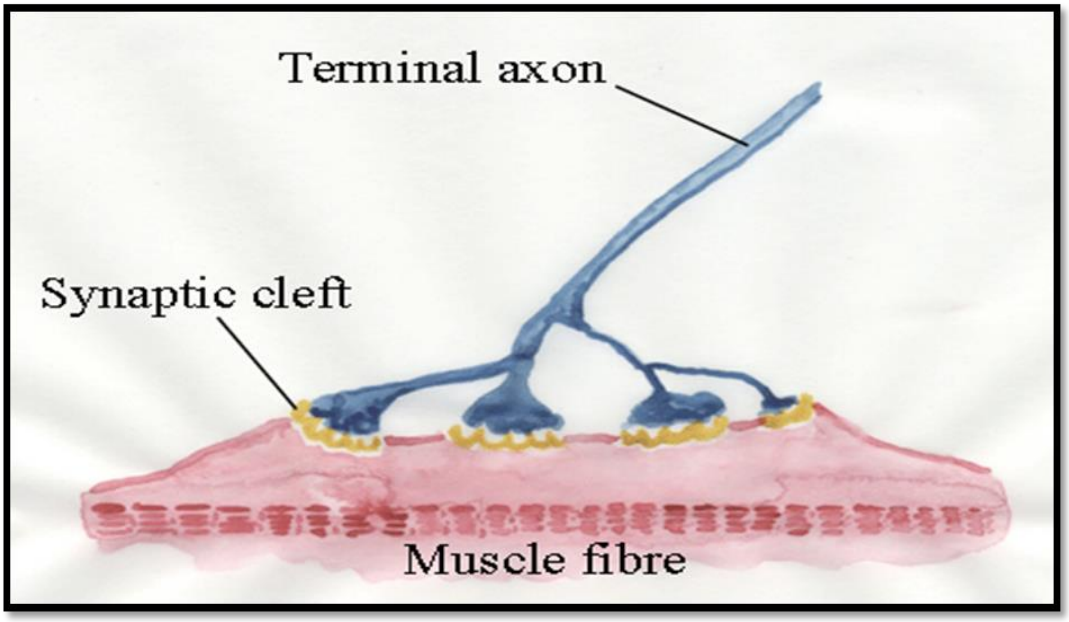


Figure (8): The neuromuscular junction.

Figure (9): Motor end plate on skeletal muscle.