Programme/Class: Certificate	Year: First	Semester: Second
Subject: Biochemistry		
Course Code: B110201 T	Course Title:Human Physiology and Clinical Biochemistry	

Course outcomes-

After the successful course completion, learners will develop following attributes

- Develop an understanding of the inter relationships within and between anatomical and physiological systems of the humanbody.
- Develop the understanding of basic concepts of clinicalbiochemistry.
- To understand disorder related with bio molecules metabolism.
- Anticoagulant preservatives for blood and urine.
- Metabolism of bilirubin, jaundice - types, differential diagnosis and Liver function.

Credits: 4	Core Compulsory
Max. Marks: 25+75	Min. Passing Marks:

Total No. of Lectures (in hours per week):

III	**Nervous System and Muscular System** • Structure of neuron, and physiology of nerve impulse transmission • Histology of different types of muscle, Ultra structure of skeletal muscle • Molecular and chemical basis of muscle contraction • Control of muscle contraction by nerve impulses	8

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REFERENCE: OPEN ACCESS

REFERENCE: Human Physiology: Guyton
Open access

STRUCTURE OF MUSCLE

Muscle is the major component of meat. A variable quantity of other tissues like connective, nervous and epithelial tissues also present in meat. There are three distinct types of muscle i.e., skeletal, cardiac and smooth muscle and out of these three, slteletal muscle is the principal source of muscle tissue in meat. However, a small amount of smooth muscle is also present in meat as a component of blood vessel while cardiac muscle is confined to heart only. The proportion of muscle varies from 25 per cent (lamb) to 50 per cent (turkey) of the live weight. Skeletal and cardiac muscle are referred to as striated muscle because of the transverse banding pattern. Skeletal muscle is also referred to as voluntary muscle while smooth and cardiac muscles are called as involuntary muscles.

Skeletal Muscle Skeletal muscle constitutes about 35-65% of the carcass weight of meat animals. Most skeletal muscles are attached directly to bone but some of them are attached indirectly to bones through ligaments, fascia, cartilage and skin. In the animal body there are more than 600 muscles and they vary widely in shape, size and activity. A thin connective tissue sheath covers each muscle; nerve fibers and blood vessels enter and exit the muscles with the connective tissue networks.

(i) **Skeletal Muscle Fiber**: Muscle fiber is a highly specialised cell and is the structural unit of skeletal muscle tissue. Muscle fibers constitute 75 to 92 per cent of the total muscle volume. Mammalian and avian skeletal muscles are composed of a large number of long, cylindrical (thread like), unbranched multi nucleatedcells called muscle fiber which taper slightly at both ends and are arranged parallel to each other. Muscle fibers vary in length and diameter. The fibers measure betwee 0.01 to 0.10 mm (10 to 100 p m) in diameter and are several centimeters long. The diameter varies within the same species and even within the same muscle.

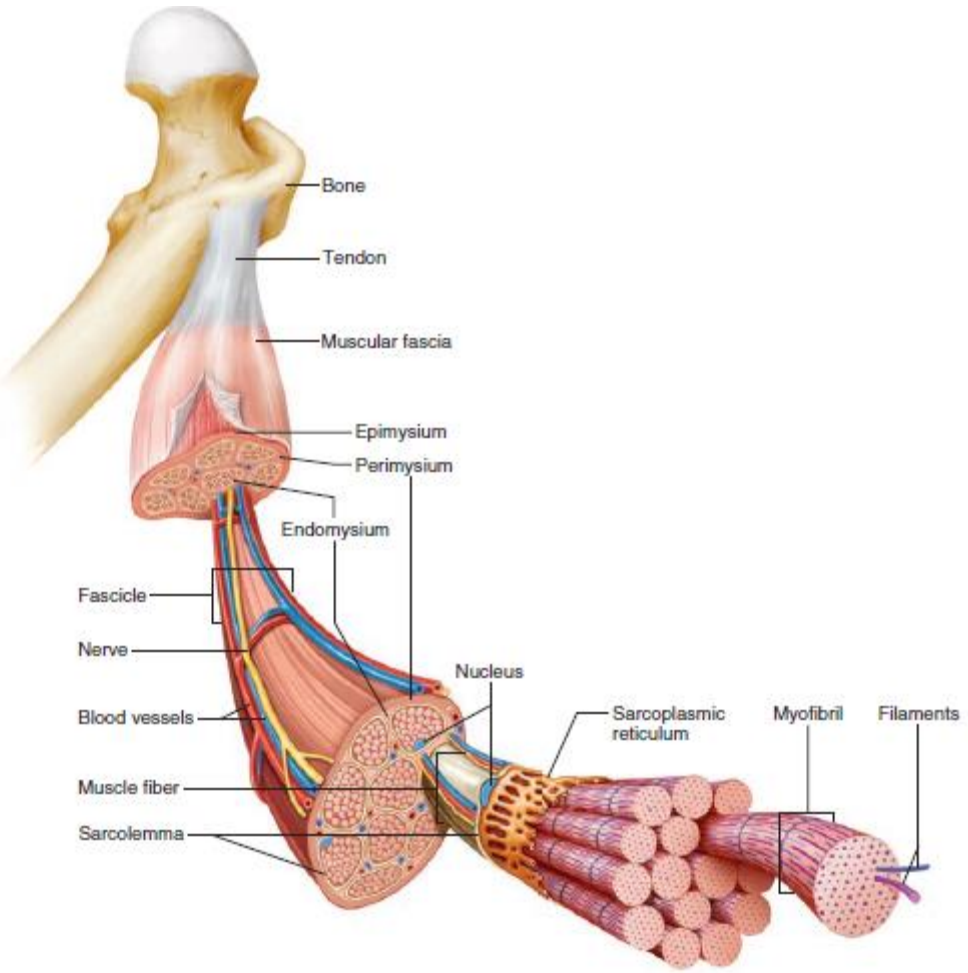
(ii) **Sarcolemma:** Each muscle fiber is completely surrounded by a plasma membrane which is called the sarcolemma. It is composed of protein and lipid material. It is relatively elastic to sustain contraction, relaxation and stretching. Sarcolemmacomprises of plasmalemma, basal lamina and a thin layer of collagenous fibrils. It folds in to give a system of tubules that form a network through the fiber and this is called T-tubules or transverse tubules. The T-tubules and sarcoplasmic reticulum form a functionally continuous system. Motor nerve fibers are implanted in small invaginations of the sarcolemma i.e., myoneural junction.

(iii) **Sarcoplasm:** The cytoplasm of muscle fiber is called sarcoplasm. It is the intracellular colloidal substance in which all the organelles like nuclei, mitocliondria and sarcoplasmic reticulum are suspended. The sarcoplasm contains water (75%- go%), lipid droplets, variable quantities of glycogen granules, ribosomes, numerous proteins, nonprotein nitrogenous compounds and a number of inorganic constituents.

(iv**) Nuclei:** Skeletal muscle fibers are multinucleated. The nuclei lie just below the sarcolemma and at the periphery of the fiber. They are ellipsoidal in shape with their longest axis oriented parallel to the long axis of the fiber. The number of nuclei per fiber is not constant but it increases in the vicinity of the myoneural junction.

(v) **Myofibrils:** Myofibrils are long, thin, cylindrical rods, usually 1 to 2 pm in diameter. They constitute 75-85% of the fiber volume. They lie in parallel to form a cell and their long axis is parallel to the long axis of the fiber. The myofibrils are bathed by the sarcoplasm and extend the entire length of the muscle fiber. A muscle fiber from meat animals with a di~rneter of 50 pm will have at least 1000 myofibrils.

REFERENCE: Human Physiology: Guyton; Open access



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There are two types of filaments within the myofibrils- thick and thin filaments. Structure of Muscle and Cross-sections of myofibrils show a well-ordered array of dots and these dots are Associated Tissues actually the myofilaments.

The myofilaments are commonly known as the thick and thin filaments. These thick and thin filaments are aligned parallel to each other and they also ovel-lap in certain regions along with their longitudinal axes.

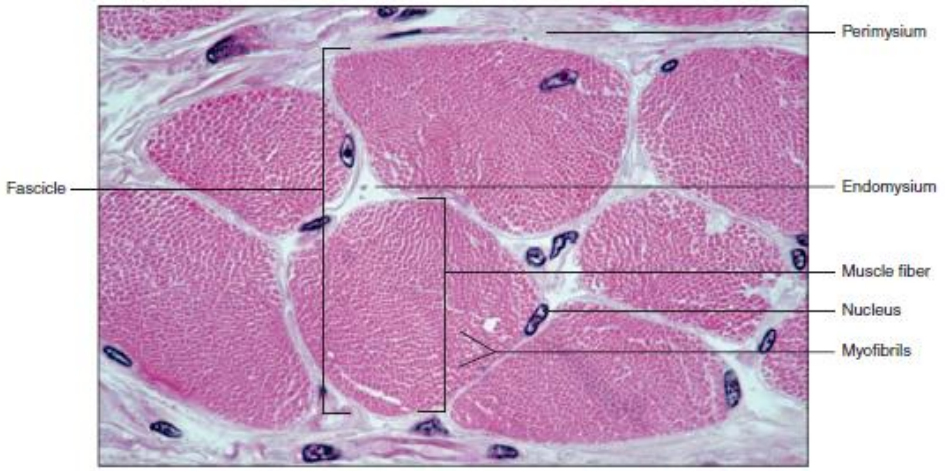
This arrangement of myofilaments gives a characteristic banding or a striated appearance to the myofibril and that's'why the skeletal inuscle is **called as striated muscle**. This banding effect takes the fonn of alternating light and dark areas. They are respectively also known as I band (isotropic zone) and A band (anisotropic zone). I band is bisected by a dark thin band called the Z line. The distance between two adjacent Z-lines is known as sarcomere which is thestn~ctural and functional unit of myofibril. Sarcomere is the basic unit of the muscle's contraction- relaxation cycle. The sarcomere includes both an A band and the two half of I bands located on either side of the A band. Sarcomese length is not constant. At rest, the sarcomere length is nearly 2.5 µm (micrometer) in mamalian muscle.

In the central region of the A band, there is a slightly less dense area which is called as H zone. Additionally, a narrow dense band, bisects the centre of the A band and this zone is known as M line. On either side of* the M line, there is a narrow and relatively less dense area which is known as pseudo H Zone.

(vi) Myofilaments: The thick filaments of vertebrate muscles are approximately Composition of Meat 1 4 to 16 nm (nanometers) in diameter and 1.5 pm long. The main component of thick filament is **'myosin'** and these filaments are therefore, referred to as

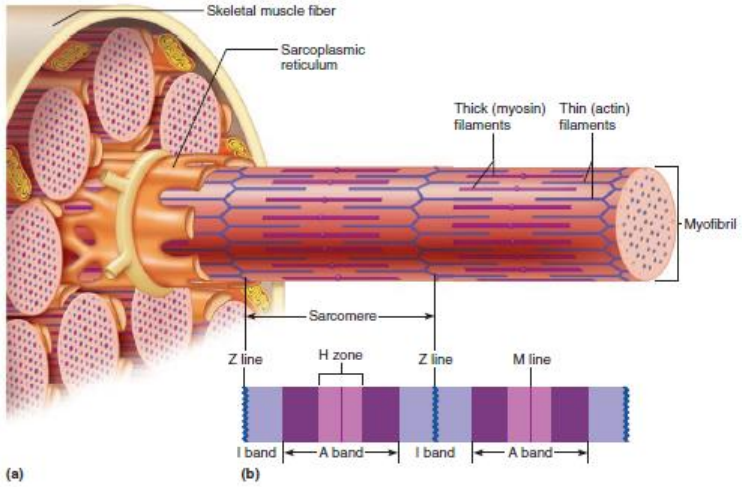
Myosin constitutes about 50-55 per cent of the myofibrillar protein. The isoelectric pH of myosin is 5.4. Each myosin filament contains about 200-300 myosin molecule which are again divided into two heavy chains and four light chains. Myosin - molecule is an elongated rod shaped with a thickened portion at one end. This thickened portion is called as head region and the long r&d-like portion is called as tail region.

The head portion is double headed and project laterally from the long axis of the myosin filament. The region in between head and tail is called as neck. The enzyme trypsin can spilt the myosin molecule at neck region and results in two fraction-light meromyosin and heavy meromyosin

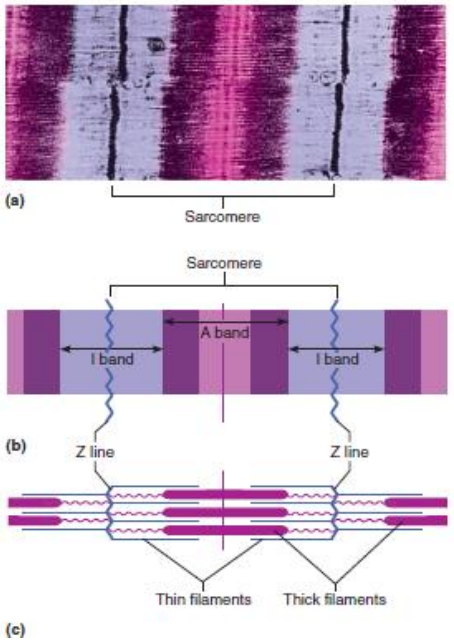


The thin filaments are about 6 to 8 nm in diameter and they extend approximately 1.0 vm on either side of the Z line. They consist primarily of the protein 'actin' and are referred to as the actin filaments. 20-25% of the myofibrillarprotein is actin which is rich in proline (amino acid). The amino acids form the globular molecule i.e., (3-actin (globular actin) which again polymerizes to form F-actin (fibrous actin). G-actin is the monomeric form and F-actin is the polymeric form. Two strands of F-actin form a super-helix which is the characteristic form of actin filament. The isoelectric pH of actin is4.7.

The proteins actin and myosin constitute approximately 75 to 80 per cent of the myofibrillar protein and the remaining fraction consists of the 'regulatory proteins' such as tropomyosin, troponin, M protein, a-actin, C protein and p- actin. Tropomyosin, troponin and actinin m associated with the actin filament. Tropornyosin helps in attachment of actin filament to Z-line and it extends along the helical groove in the actin filament. Troponin is of three types-C, I and T. Troponin C has calcium binding site, troponin I inhibits actomyosin ATPase and troponin T binds to troponin C and tropomyosin. a-actinin is a component of the 2-line and it promotes the lateral association of F-actin. p-actinin is located at the endof the actin filaments and inhibits polymerization of G-actin. M proteins compose the M-line. C protein is found in the myosin filament and binds the myosin molecules together into the bundle that forms myosin filament.

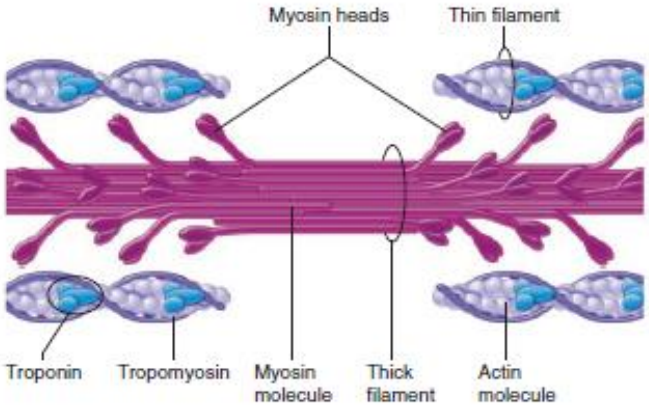


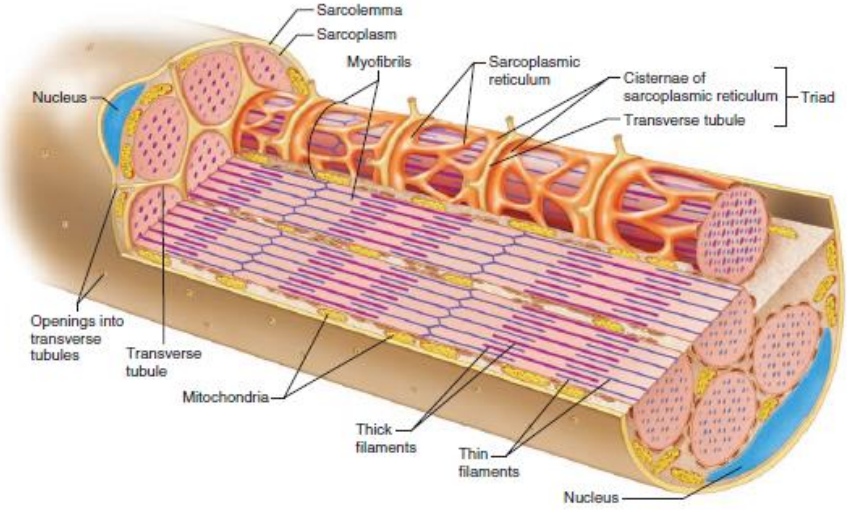
skeletal muscle fiber. (*a*) a skeletal muscle fi ber contains numerous myofi brils, each consisting of (*b*) repeating units called sarcomeres. the characteristic striations of a sarcomere refl ect the organization of actin and myosin fi laments



sarcomere. micrograph (16,000×).

(vii) Sarcoplasmic reticulum and T tubules: The sarcoplasmic reticulum is a ~nembranousystem of tubules and cisternae (flattened reservoirs for Ca2+) that forms a network around each myofibril. It is the storage site of calcium ion. The T (Transverse) tubules are associated with the sarcolemma. Relatively thin h~bules, oriented in the direction of the myofibrillar axis, constitute the L (Longitudinal) tubules of the reticulum.





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The longitudinal tubules form a perforated sheet that is called a 'fenestrated (window Composition of Meat like opening) collar' (in the H zone region of the sarcomere). The longitudinal tubules join with a pair of larger, transversely oriented, tubular elements called 'terminal cisternae' (at the junction of A and I bands) and form a structure called as triad. (viii) Mitochondria: Mitochondria are located in the sarcoplasm and are referred to as the 'power-house' of the cell. They contain the enzymes of oxidative metabolism. The number and size of mitochondria vary in muscle fibers. Mitochondria are relatively abundant at the periphery of the fiber near the poles of the nuclei and are especially abundant at the myoneural junctions. (ix) Lysosomes: Lysosomes are located in the sarcoplasm and contain a number of enzymes. Lysosomal enzymes are a group of proteolytic enzymes which have effects on some of the muscle proteins that might contribute to meat tenderization during postmortem ageing. (x) Golgi complex: Golgi complex are located in the sarcoplasm near the iv-lei. They consist of flattened vesicles which apparently function as the 'concentrating and packaging' apparatus for the metabolic products. The muscle fiber has numerous golgi complexes.

Smooth Muscle The wal Is of arteries, lymph vessels, gastro intestinal tract and reproductive tracts are composed of smooth muscles. Smooth muscle fibers vary in size and shape depending upon their location. They vary from extremely flattened ellipsoids to triangular and polyhedral shapes. The smooth muscle fiber has a single centrally located nucleus. The sarcoplasmic reticulum is less developed than that in skeletal muscle. The myofilaments of smooth muscle are arranged in pairs that run parallel to thelongitudinal axis of the fiber. Actin and myosin are present in the smooth muscles in the same proportion as in skeletal muscle but there are no striation. These are involuntary in nature. These fibers are long, unevenly thickened in the centre and tapering on both the sides. There is no M or Z-lines. Smooth muscle fibers occur either singly or in bundles. Each fiber is surrounded by a delicate network of reticular fibers that support and bind them in place. Smooth muscle, compared to skeletal muscle, is poorly supplied with blood.

Cardiac Muscle Cardiac muscles are found in the heart and involuntary in nature. Cardiac rnuncle has properties that resemble characteristic properties of both skeletal and smooth muscle. It has a single centrally placed nucleus, generally. The fibers of cardiac muscle are branched and shorter than the fibers of skeletal muscle. The sarcoplasm of cardiac musclecontains numerous glycogen granules. The mitochondriaofcardiac muscle are especially large and numerous. Thick and thin filaments are aligned to give a striated appearance identical to that of skeletal muscle. The intercalated discs are present in the position of Z-lines. The myocardium is the contractile layer of the heart and contains the bulk of the cardiac muscle. Blood and lymph vessels and nerve fibers enter and exit the myocardium via the connective tissue between muscle bundles.

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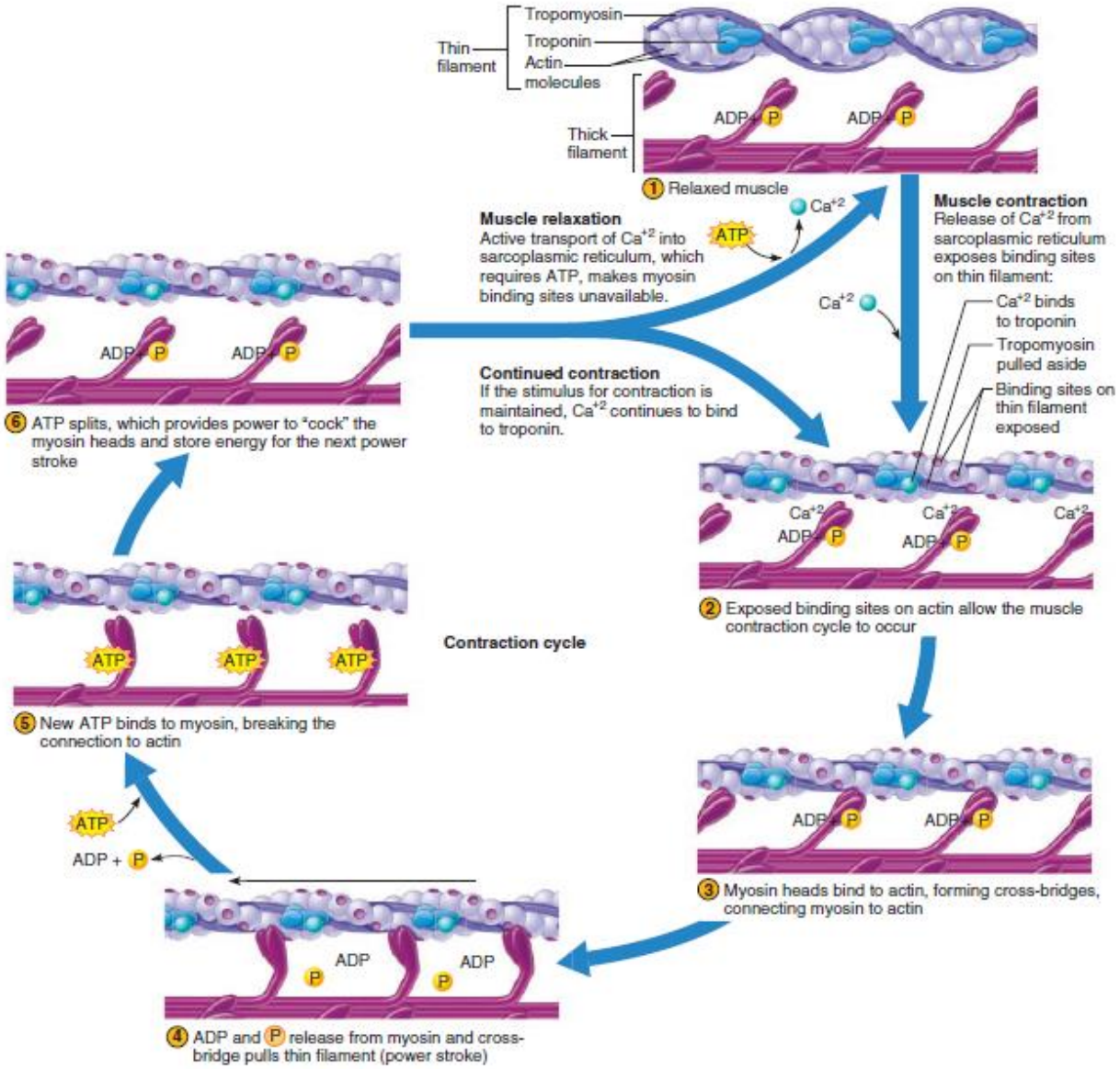

The sliding fi lament model. *(1)* relaxed muscle. *(2)* and *(3)* When calcium ion concentration rises, binding sites on actin fi laments open and myosin heads bind to the actin, forming cross-bridges. *(4)* upon binding to actin, myosin heads spring from the cocked position and pull on actin fi laments. *(5)* atp binds (but is not yet broken down), causing the myosin heads to release from the actin fi lament. *(6)* atp breakdown provides energy to "cock" the unattached myosin heads. as long as atp and calcium ions are present, the cycle continues. When the calcium ion concentration in the cytosol is low, the muscle is relaxed.

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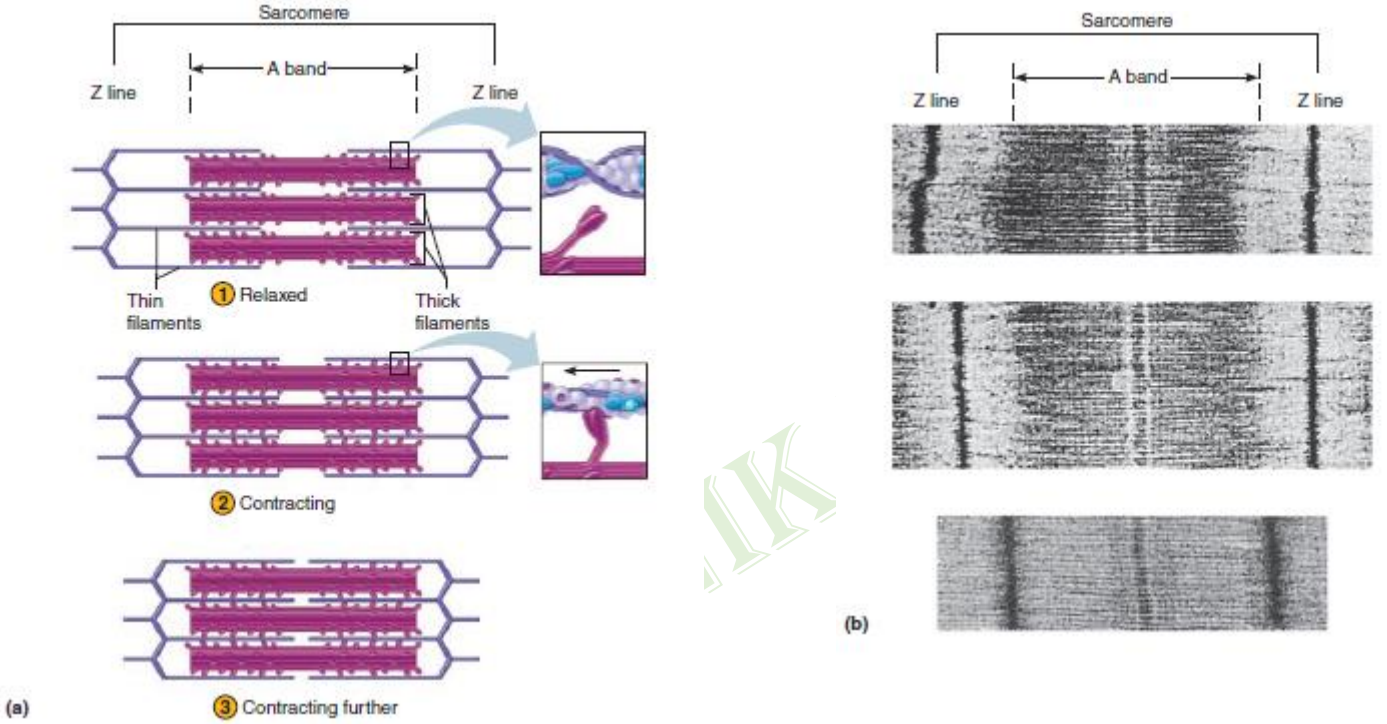

When a skeletal muscle contracts (*a*), individual sarcomeres shorten as thick and thin fi laments slide past one another.
(*b*) transmission electron micrograph showing a sarcomere shortening during muscle contraction (23,000×).

REFERENCE: OPEN ACCESS

1. What do you mean by sarcomere?
2. What are the different forms of actin?
3. How do you differentiate between skeletal muscle and smooth muscle?
4. Short notes on (a)Transverse tubules (b) Skeletal, smooth, cardiac muscle (c) Actin, myosin or thin, thick (d) Myofibril (e) Myosin, actin (t) Tropomyosin, troponin, actinin, M-protein, C protein