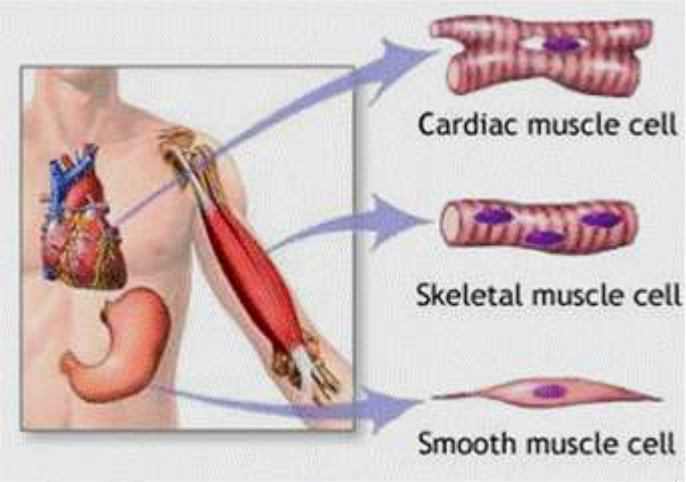
B. A program in Physical Education (Semester 2)
College: Raniganj Girls College (K.N.U)
Department: Physical Education

Muscular System

Introduction: -

Muscular system is the system of Human Body that provides motor power for all movements of body parts. Muscular system is composed of special tissue called muscular tissue. Muscles have the ability to contract actively to provide the force for movements of body parts. Muscular system is an important system of human body because without it, life will completely stop. Muscles produce not only those movements that are under the control of our will and that we can see and feel, but also those movements that are responsible for activities like breathing, digestion of food, pumping of blood etc.

The muscular system consists of all the muscles of the body. The largest percentage of muscles in the muscular system consists of skeletal muscles, which are attached to bones and enable voluntary body movements. There are almost 650 skeletal muscles in the human body, many of them shown in Figure. Besides skeletal muscles, the muscular system also includes cardiac muscle — which makes up the walls of the heart — and smooth muscles, which control movement in other internal organs and structures.



Muscular System

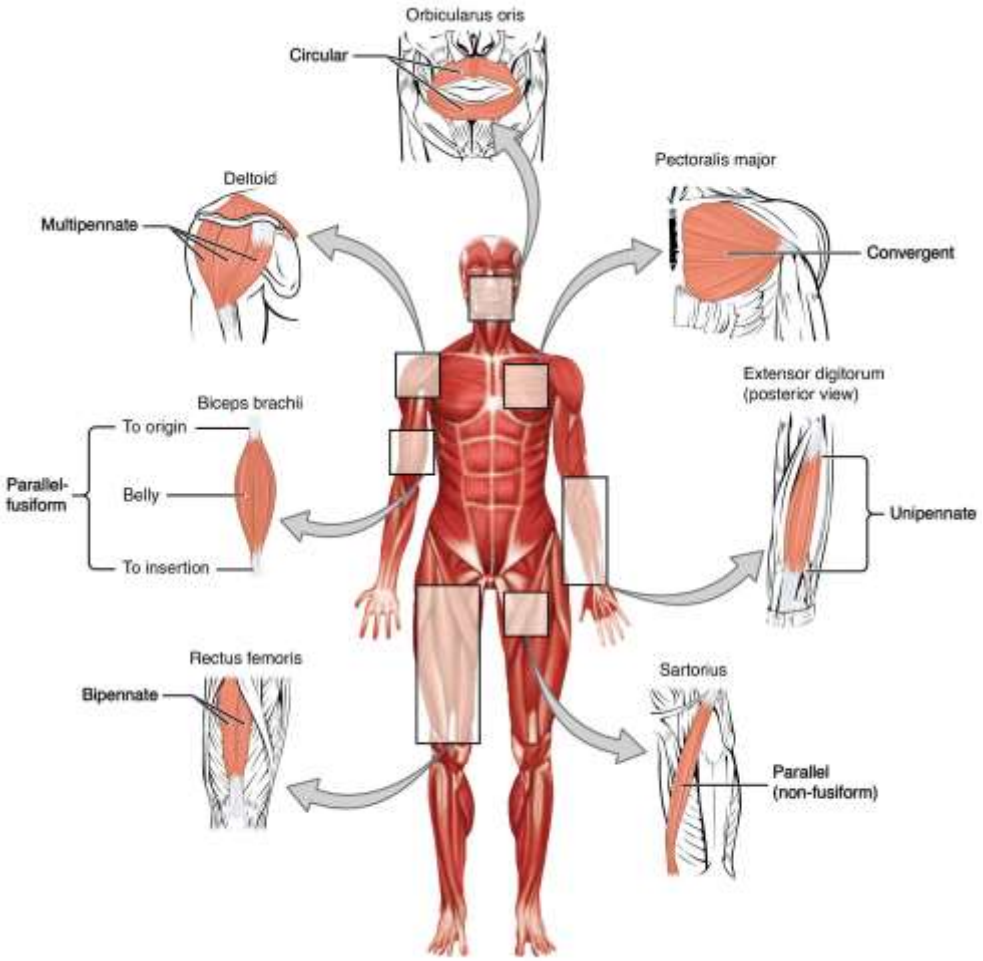
Muscular System Outline:

Components	**Muscles:** Muscles are special type of tissues of human body that posess the ability of contraction and relaxation. They can contract actively thus producing force for different body movements.	
Types of Muscle	**Skeletal Muscle**	Striated, under voluntary control, found attached to skeleton, produce major movements of body parts
	Smooth Muscle	Non striated, not under voluntary control, found in soft organs of body, responsible for processes like digestion of food etc.
	Cardiac Muscle	Striated, involuntary, present exclusively in heart, responsible for pumping activit of heart, very strong and tough
Functions	Movements of body parts, Stability and Posture, Heat production, Circulation, Help in Digestion	

Functions of the Muscular System

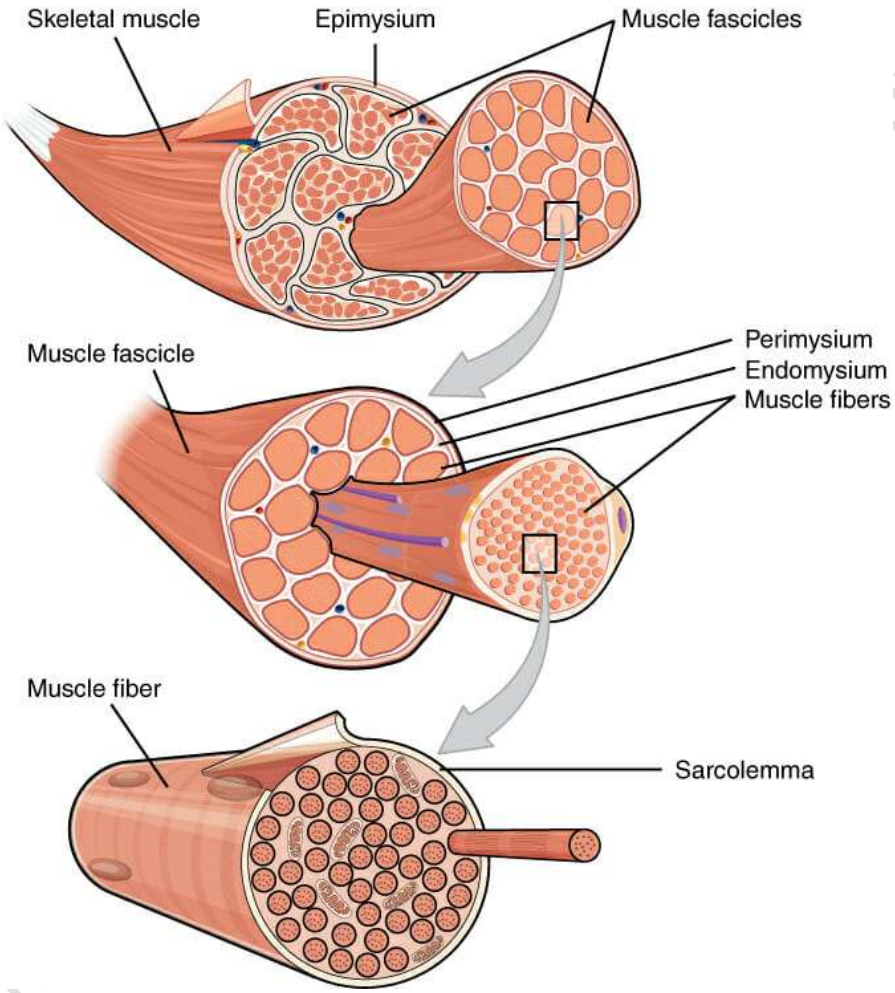
Producing movement is a common function of all muscle types, but skeletal muscle plays three other important roles in the body as well.

- **Producing movement.** Mobility of the body as a whole reflects the activity of the skeletal muscles, which are responsible for all locomotion; they enable us to respond quickly to changes in the external environment.
- **Maintaining posture.** We are rarely aware of the skeletal muscles that maintain body posture, yet they function almost continuously, making one tiny adjustment after another so that we can maintain an erect or seated posture despite the never-ending downward pull of gravity.
- **Stabilizing joints.** As the skeletal muscles pull on bones to cause movements, they also stabilize the joints of the skeleton; muscle tendons are extremely important in reinforcing and stabilizing joints that have poorly fitting articulating surfaces.
- **Generating heat.** The fourth function of muscle, generation of body heat, is a by-product of muscle activity; as ATP is used to power muscle contraction, nearly three-quarters of its energy escape as heat and this heat is vital in maintaining normal body temperature.



Structure of Muscle

A muscle consists of many muscle tissues bundled together and surrounded by epimysium, a tough connective tissue similar to cartilage. The epimysium surrounds bundles of nerve cells that run in long fibers, called fascicles. These fascicles are surrounded by their own protective layer, the perimysium. This layer allows nerves and blood to flow to the individual fibers. Each fiber is then wrapped in an endomysium, another protective layer. As seen in the image below, a muscle is arranged in a basic pattern of bundled fibers separated by protective layers.

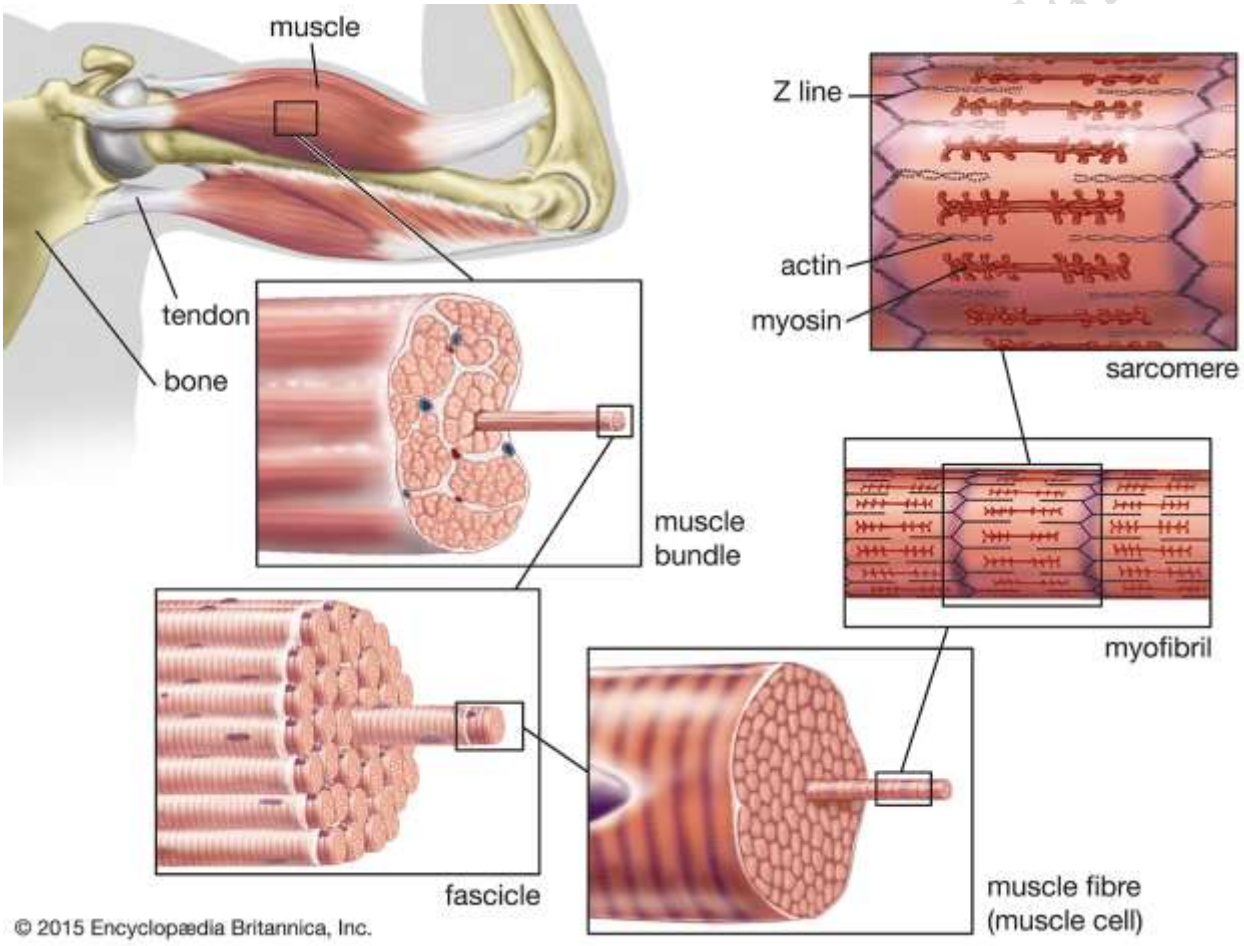


These layers and bundles allow different parts of a muscle to contract differently. The protective layer surrounding each bundle allows the different bundles to slide past one another as they contract. The epimysium connects to tendons, which attach to the periosteum connective tissue that surrounds bones. Being anchored to two bones allows movement of the skeleton when the muscle contracts. A different type of muscle surrounds many organs, and the epimysium connects to other connective tissues to produces forces on the organs, controlling everything from circulation to food processing.

Types of Muscle

Skeletal Muscle

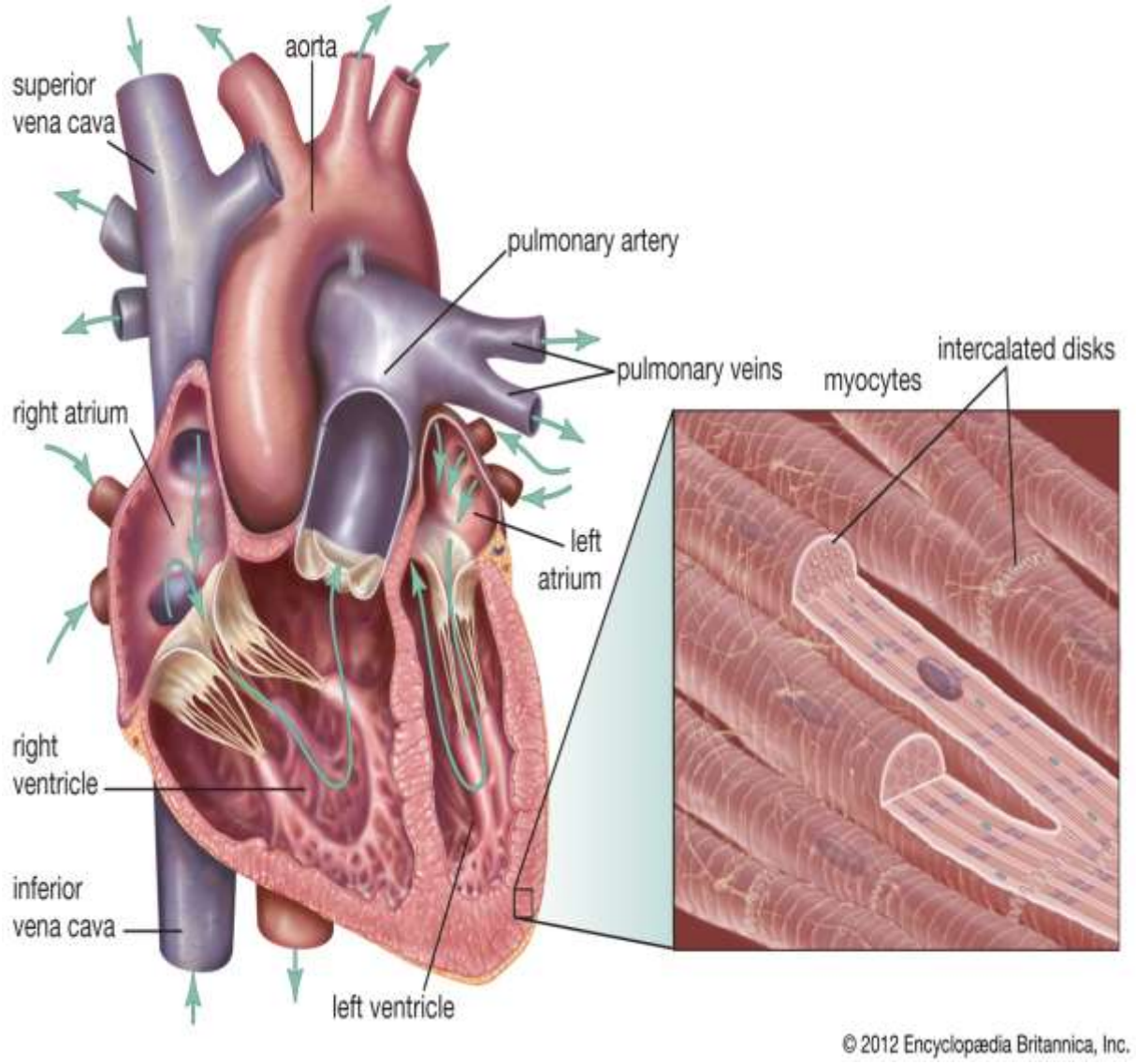
When you think of a muscle, most people generally think of a skeletal muscle. The biceps, triceps, and quadriceps are all common names for muscles that body builders tend to focus on. In fact, these general muscles are often composed of many small muscles that attach to different places to give a joint its full range of motion. Skeletal muscle is a **striated muscle.** This means that each muscle fiber has striations, or linear marks, which can be seen when this muscle is put under a microscope. The striations correspond to the sarcomeres present in striated muscles, which are highly organized bundles of muscle cells which can contract quickly in concert.



Skeletal muscle is controlled via the **somatic nervous system**, also known as the voluntary nervous system. Point your finger to the ceiling. This is your somatic nervous system in action, controlling your skeletal muscles.

Cardiac Muscle

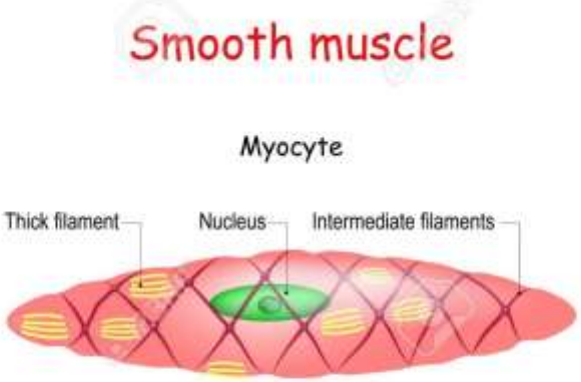
Cardiac muscle, while similar to skeletal muscle in some ways, is connected to the autonomous nervous system. This system controls vital organs such as the heart and lungs and allows us to not have to focus on pumping our heart each time it needs to beat. While there is a certain amount of conscience control we have over the autonomous nervous system, it will always kick in when we are unconscious. For instance, you can hold your breath if you like but you do not have to remember to breathe all the time. Cardiac muscle surrounds the chambers of the heart and is used to pump blood through the body.

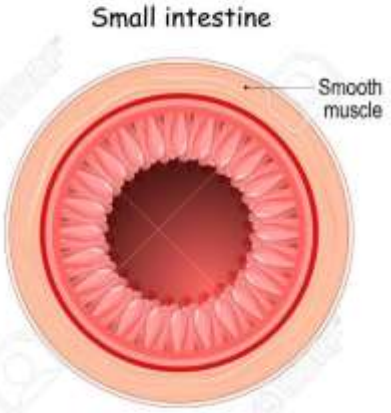


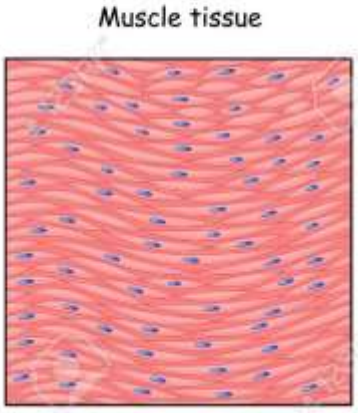
Cardiac muscle is similar to skeletal muscle in that it is striated. Unlike skeletal muscle, cardiac muscle fibers are arranged in a branching pattern instead of a linear pattern. Both skeletal muscle and cardiac muscle need to contract quickly and often, which is why the striations can be seen.

Smooth Muscle

Unlike skeletal and cardiac muscle, smooth muscle is not striated. This is because the individual muscle cells are not perfectly aligned into sarcomeres. Instead, they are displaced throughout the fibers. This gives smooth muscle the ability to contract for longer, although the contraction happens more slowly. Consider the muscle that contracts the sphincter on your bladder. This muscle may need to stay clamped shut for hours at a time and only gets a minute of relief when you go to the bathroom. Many other smooth muscles operate in the same manner.



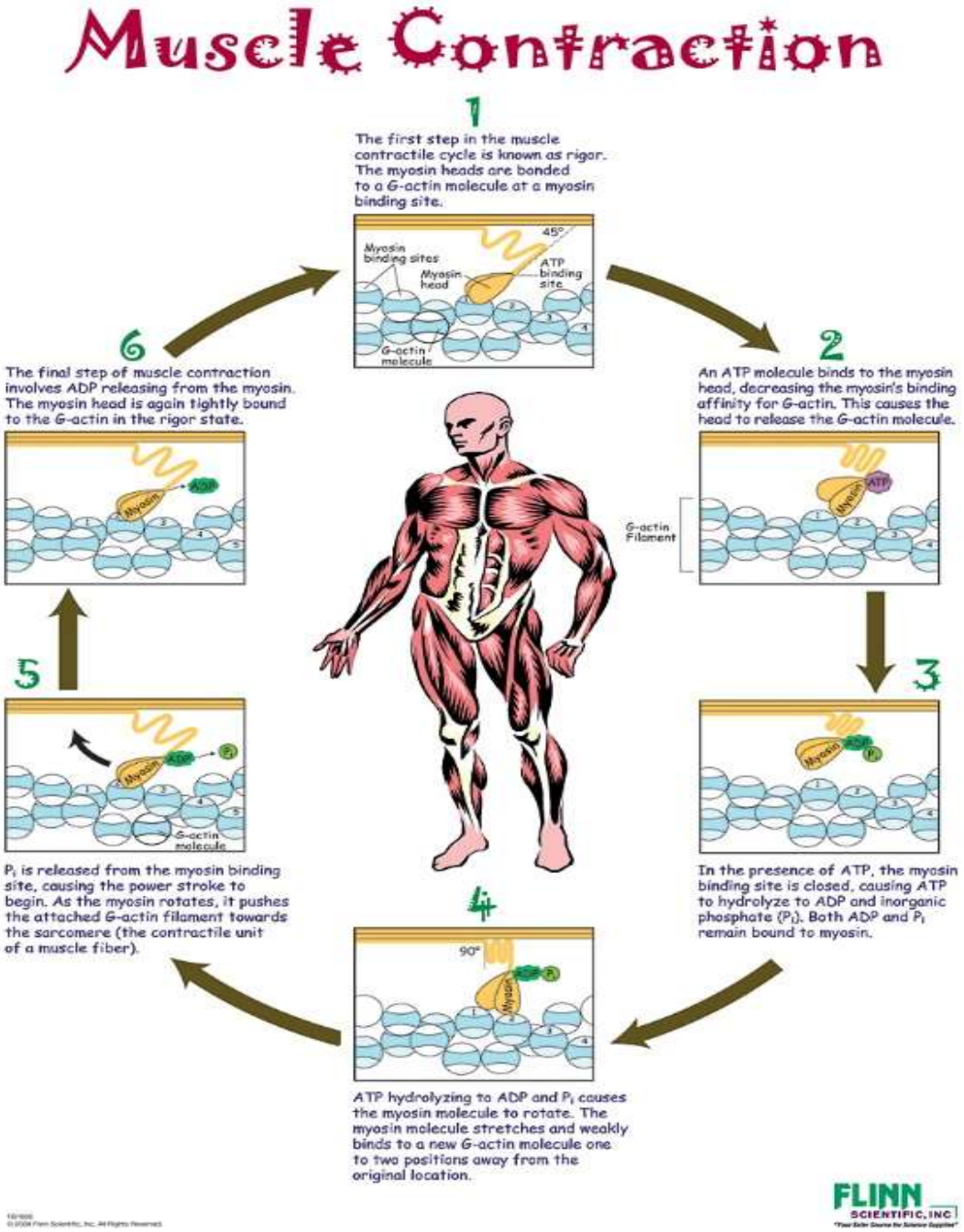




Like cardiac muscle, smooth muscle is mostly controlled by the autonomous nervous system. The many muscles that line your digestive tract work together to move food through the digestive system. Muscles attach to your hair follicles that all your hairs to stand up when it's cold. Smooth muscle is almost everywhere in your body and aids in everything from circulation to digestion.

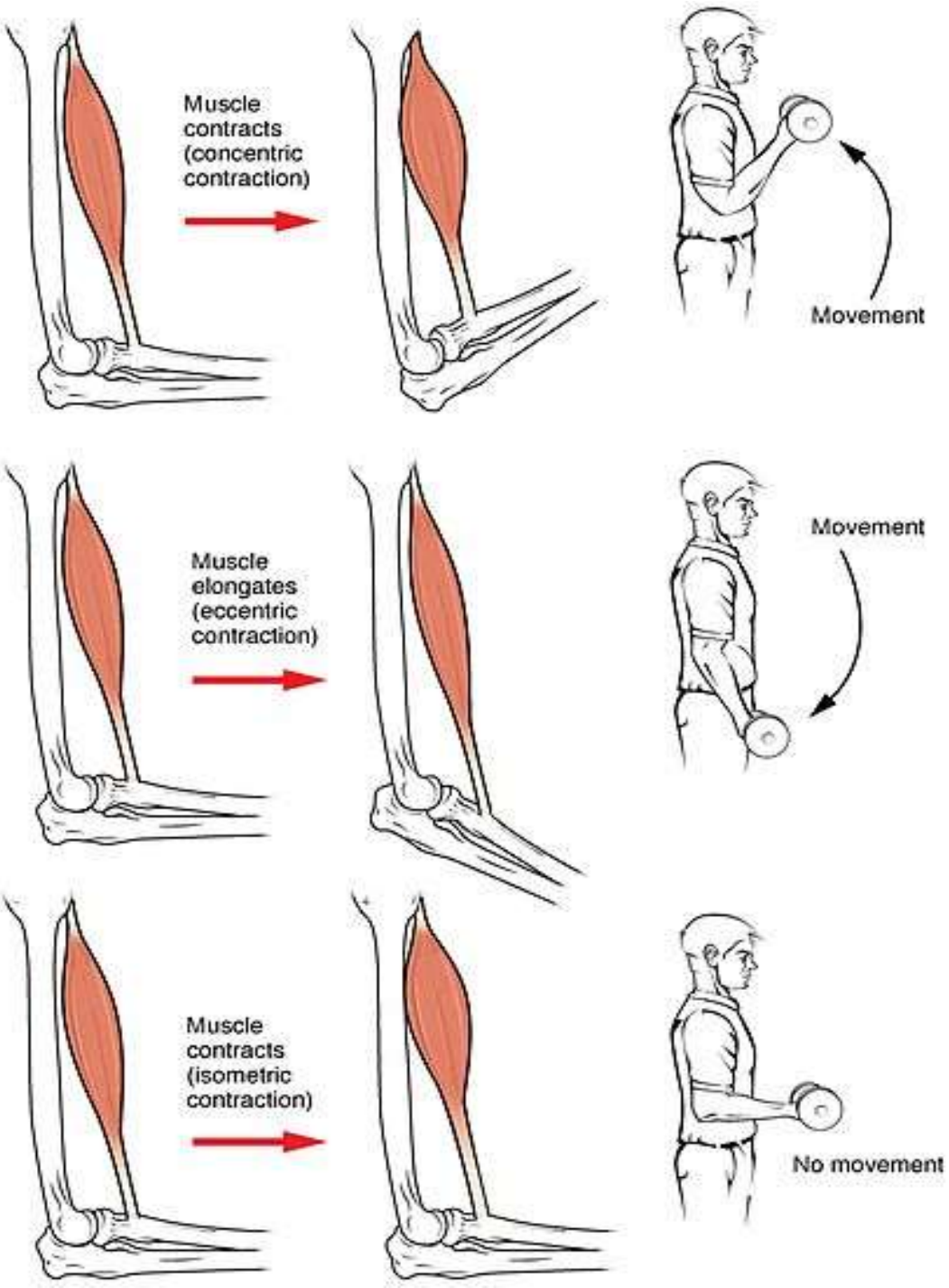
Muscular contraction

Muscle contraction is the activation of tension-generating sites within muscle fibers. In physiology, muscle contraction does not necessarily mean muscle shortening because muscle tension can be produced without changes in muscle length, such as when holding a heavy book or a dumbbell at the same position. The termination of muscle contraction is followed by muscle relaxation, which is a return of the muscle fibers to their low tension-generating state.



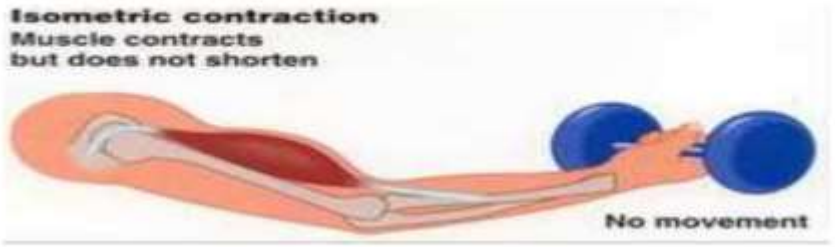
Types of muscular contractions

Muscle contractions can be described based on two variables: force and length. Force itself can be differentiated as either tension or load. Muscle tension is the force exerted by the muscle on an object whereas a load is the force exerted by an object on the muscle.



Isometric contraction/ Exercise

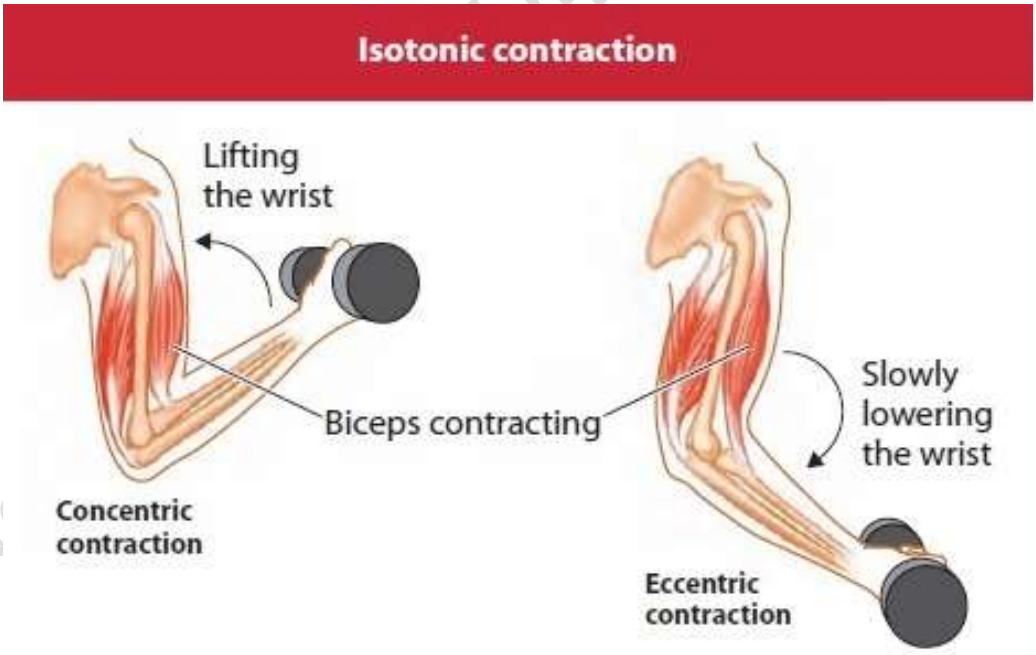
An isometric contraction of a muscle generates tension without changing length.



An example can be found when the muscles of the hand and forearm grip an object; the joints of the hand do not move, but muscles generate sufficient force to prevent the object from being dropped.

Isotonic Contractions/Exercise

Isotonic contractions maintain constant tension in the muscle as the muscle changes length. This can occur only when a muscle's maximal force of contraction exceeds the total load on the muscle. Isotonic muscle contractions can be either concentric (muscle shortens) or eccentric (muscle lengthens).



Concentric Contractions

A concentric contraction is a type of muscle contraction in which the muscles shorten while generating force. This is typical of muscles that contract due to the sliding filament mechanism, and it occurs throughout the muscle. Such contractions also alter the angle of the joints to which the muscles are attached, as they are stimulated to contract according to the sliding filament mechanism.

Eccentric Contractions

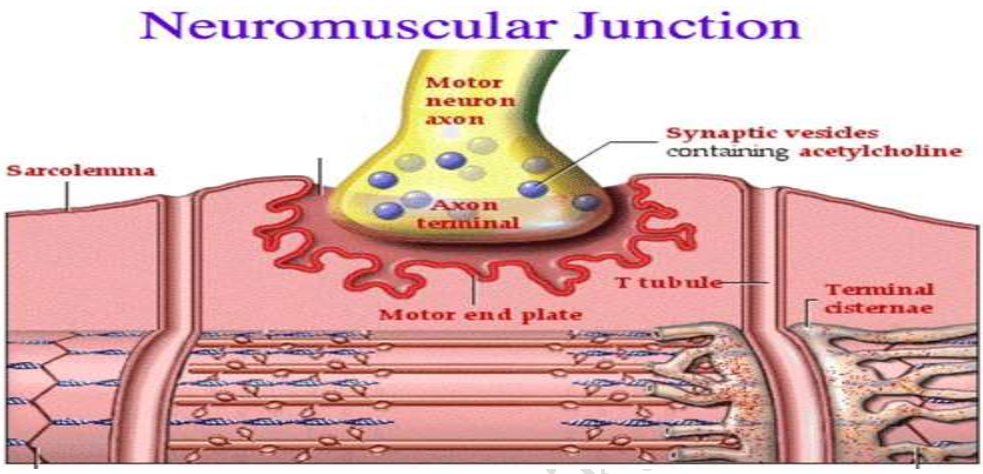
An eccentric contraction results in the elongation of a muscle. Such contractions decelerate the muscle joints (acting as "brakes" to concentric contractions) and can alter the position of the load force. These contractions can be both voluntary and involuntary. During an eccentric contraction, the muscle elongates while under tension due to an opposing force which is greater than the force generated by the muscle. Rather than working to pull a joint in the direction of the muscle contraction, the muscle acts to decelerate the joint at the end of a movement or otherwise control the repositioning of a load.

Isokinetic contractions/Exercise

Isokinetic contractions are similar to Isotonic in that the muscle changes length during the contraction, where they differ is that Isokinetic contractions produce movements of a constant speed. To measure this a special piece of equipment known as an Isokinetic dynamometer is required. Examples of using Isokinetic contractions in the day-to-day and sporting activities are rare. The best is breaststroke in swimming, where the water provides a constant, even resistance to the movement of adduction.

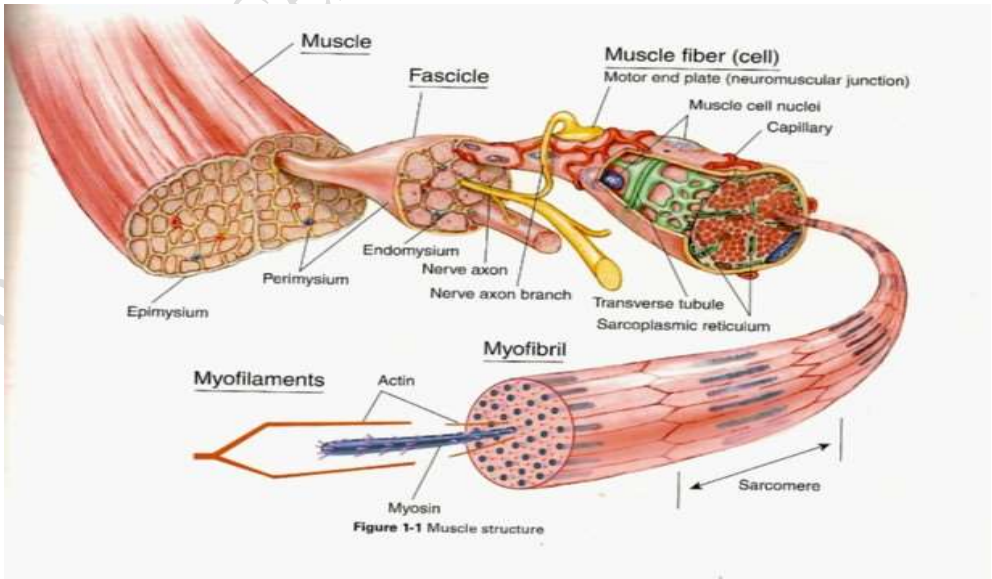
Neuromuscular junction

Where the synaptic knobs of the neuron meet the muscle fibres is known as the neuromuscular junction. When an impulse reaches the neuromuscular junction, a neurotransmitter called Acetylcholine is released which filters across the synaptic cleft (microscopic space between the synaptic knob and motor endplate). This causes depolarization of the motor endplate and puts the sliding filament theory of muscular contraction into practice.



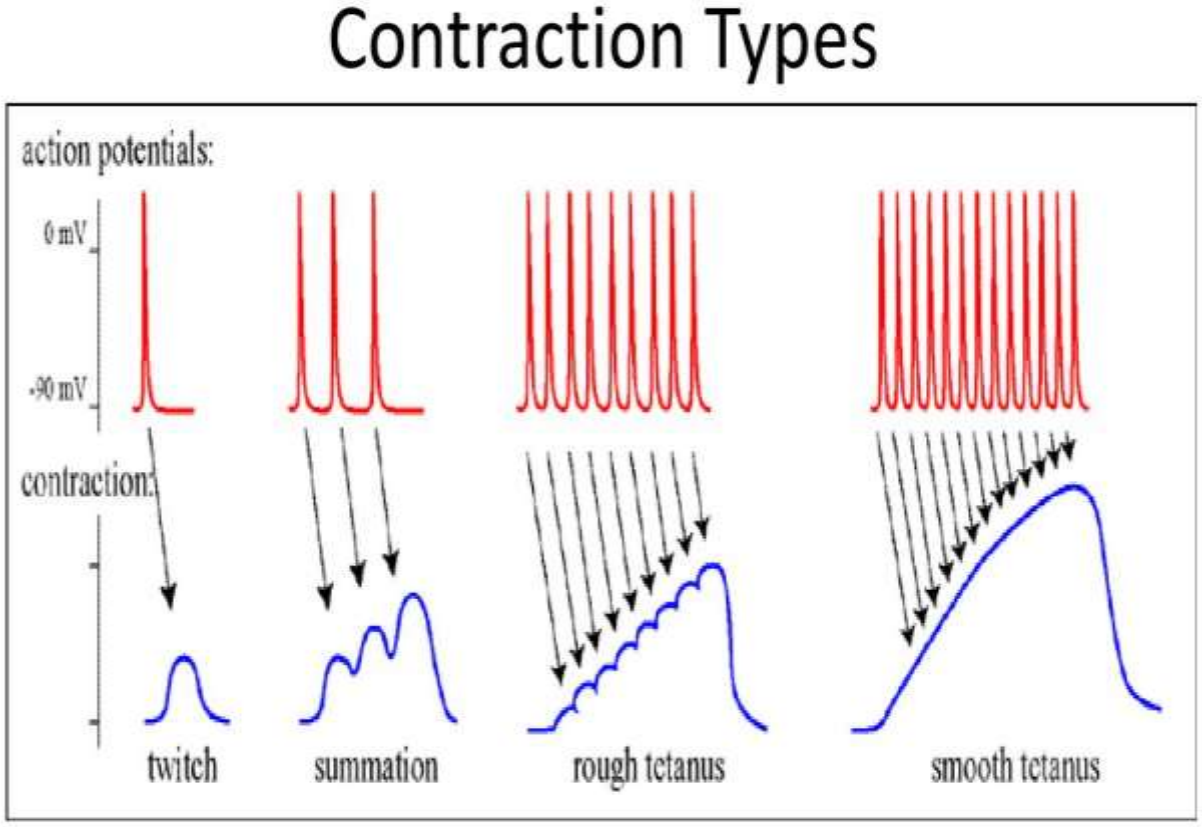
Motor Units

A motor unit is described as a single motor neuron and all of the muscle fibres it innervates. A motor unit can contain anywhere between 10 and thousands of muscle fibres. Muscles that produce large powerful movements contain motor units with large numbers of fibres, and those for small intricate movements contain only a few fibres per motor unit.



All or none law

The 'all or none' law as mentioned above also applies to the contraction of fibres within a motor unit. When a motor unit activates, all of the fibres within the unit contract and at full force, there is no strong or weak contraction. The strength of the resultant whole muscular contraction depends upon the number of motor units recruited.



All or None Law – A muscle fiber will fully contract if it reaches threshold.

TONIC CONTRACTION – Keeps your tone. Right now you are recruiting enough fibers to maintain your posture over gravity.

Effect of Exercise on Muscles

Exercise involves a series of sustained muscle contractions, of either long or short duration, depending on the nature of the physical activity. Effects of exercise on muscles can be considered short-term or immediate, both during and shortly after exercise; as well as long-term, lasting effects.

Immediate, Short-Term Effects

- The effects of exercise on muscles varies with the type and duration of the activity. Aerobic exercise is typical of activities requiring endurance and sustained muscle contractions. Such activities rely mainly on Type I (slow-twitch muscles) which sustain maximal contraction for extensive periods of time. This use of slow-twitch muscles, and the availability of oxygen, prevents the buildup of lactic acid, and typically does not result in substantial muscle fatigue in the short-term. Sustained aerobic respiration tends to shift the metabolic pathways of muscle to favor the use of fat as the primary source of ATP, and glycogen is generally avoided.

- Anaerobic respiration, typical of sprinting and weight lifting, prioritizes the use of Type II (fast-twitch) muscles fibers for short, high-intensity contractions. Muscles prioritize the use of readily-available ATP, glucose and glycogen for these contractions, which results in a build-up of lactic acid. Though traditionally viewed as the cause of muscle fatigue, recent research indicates ion shortages, particularly of calcium, during an aerobic exercise, causes such muscle fatigue. However, lactic acid inhibits further ATP production, indirectly causing fatigue.

- Muscle soreness, once thought to be due to lactic acid accumulation, has more recently been attributed to small tearing of the muscles fibers caused by eccentric contraction.

Long-Term Effects

- Muscle hypertrophy, or the increase in muscle mass due to exercise, particularly weight training, is a noticeable long-term effect of exercise. Exercise of specific muscles can often result in hypertrophy in the opposite muscles as well, a phenomenon known as cross education.

- Experts and professionals differ widely on the best approaches to specifically achieve muscle growth, as opposed to focusing on gaining strength, power, or endurance. It was generally considered that consistent anaerobic strength training will produce hypertrophy over the long term, in addition to its effects on muscular strength and endurance.

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