

Lec.3

Muscular System

Main Topic

- What is muscular system and Its Function
- How is muscular system work
- Type of muscle and Its characteristic

The **muscular system** is an organ system consisting of **skeletal**, **smooth** and **cardiac** muscles. It permits movement of the body, maintains posture, and circulates blood throughout the body. The muscular system is controlled through the nervous system.

There are approximately 650 skeletal muscles in the human body, but an exact number is difficult to define.

The muscular system is one component of the musculoskeletal system, which includes not only the muscles but also the bones, joints, tendons, and other structures that permit movement.

▪ Muscular System Working With Other Body Systems

1. Homeostasis
2. Protection
3. Calcium Metabolism
4. Maintaining Body Temperature

Muscle

Muscle is a soft tissue found in most animals . 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 cell. Muscles function to produce force and motion.

Muscles are predominantly powered by the oxidation of fats and carbohydrates, but anaerobic chemical reactions are also used, particularly by fast twitch fibers. These chemical reactions produce adenosine triphosphate (ATP) molecules that are used to power the movement of the myosin heads.

■ Characteristics of muscle

- excitability - responds to stimuli (e.g., nervous impulses)
- contractility - able to shorten in length
- extensibility - stretches when pulled
- elasticity - tends to return to original shape & length after contraction or extension

■ Functions of muscle

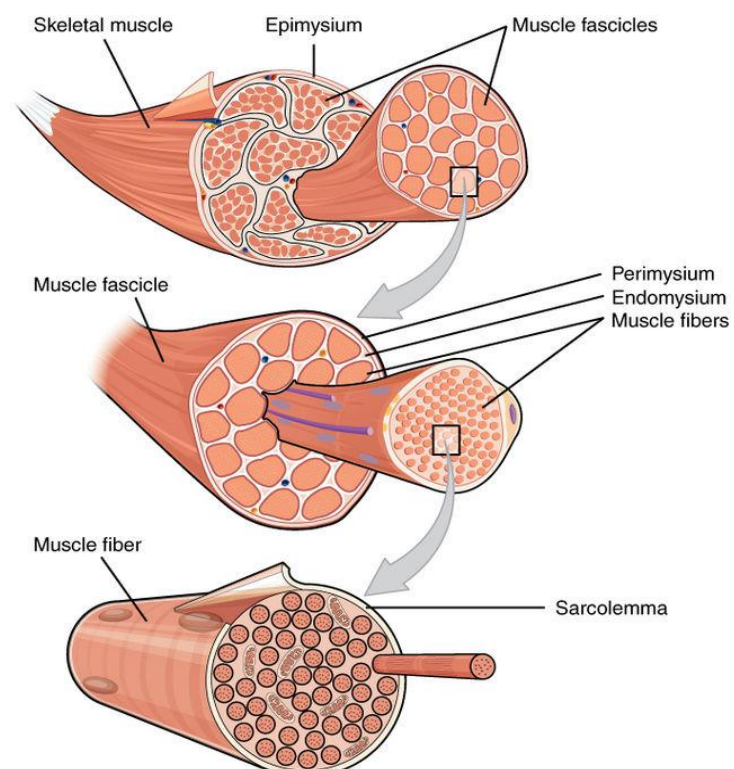
1-motion. 2-maintenance of posture. 3-heat production 4-Balance

○ Sarcomere

A **sarcomere** is the basic unit of a muscle. Muscles are composed of tubular muscle cells (myocytes or myofibers), which are formed in a process known as myogenesis. Muscle cells are composed of tubular myofibrils. Myofibrils are composed of repeating sections of sarcomeres, which appear under the microscope as dark and light bands.

Sarcomeres are composed of long, fibrous proteins that slide past each other when the muscles contract and relax.

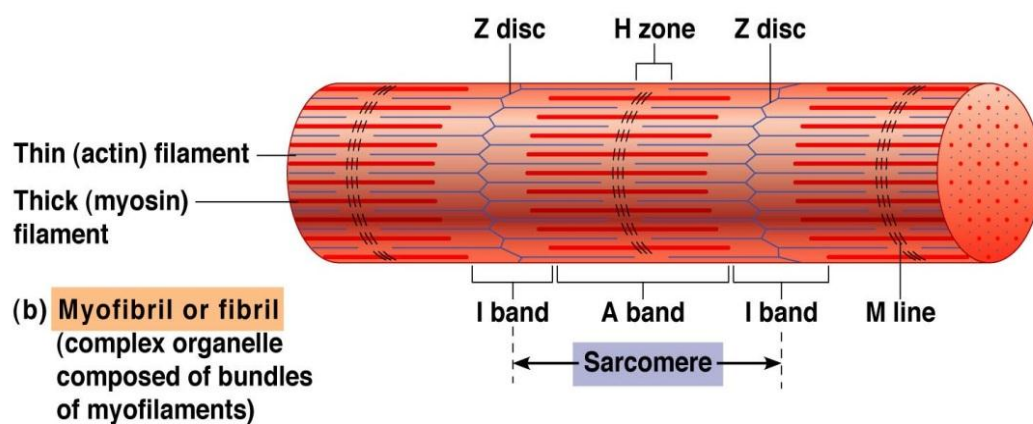
Sarcomeres are the areas within the skeletal muscle cell where the thick and thin filaments overlap and allow for interaction



Sarcomere Structure

Sarcomeres are made of two types of protein fibers: thick filaments and thin filaments.

Thick filaments. Thick filaments are made of many bonded units of the protein myosin. Myosin is the protein that causes muscles to contract. The myosin head also binds to ATP, which is the source of energy for muscle movement. Myosin can only bind to actin when the binding sites on actin are exposed by calcium ions.

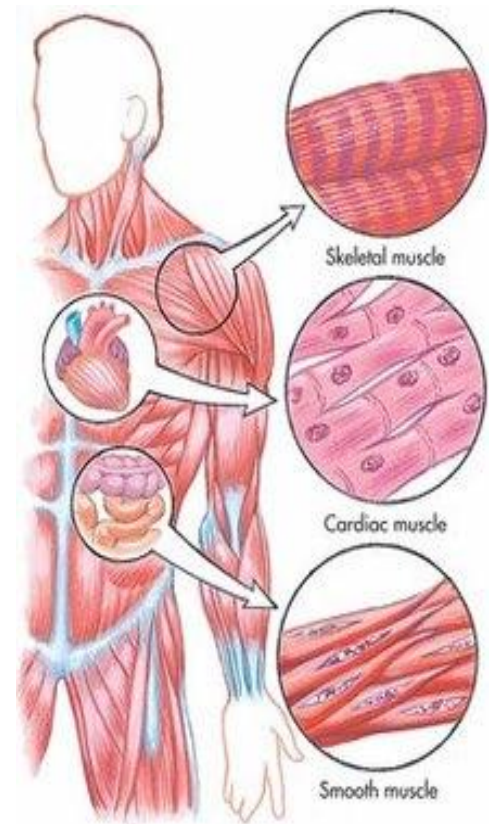


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- **Thin filaments.** Thin filaments are made of three proteins:
 1. **Actin.** Actin forms a helical structure that makes up the bulk of the thin filament mass. Actin contains myosin-binding sites that allow myosin to connect to and move actin during muscle contraction.
 2. **Tropomyosin.** Tropomyosin is a long protein fiber that wraps around actin and covers the myosin binding sites on actin.
 3. **Troponin.** Bound very tightly to tropomyosin, troponin moves tropomyosin away from myosin binding sites during muscle contraction.

▪ **There are three types of muscle**

- **Smooth muscle** or "involuntary muscle" consists of spindle shaped muscle cells found within the walls of organs and structures such as the esophagus, stomach, intestines, bronchi, uterus, ureters, bladder, and blood vessels. Smooth muscle cells contain only one nucleus and no striations.
- **Cardiac muscle** is also an "involuntary muscle" but it is striated in structure and appearance. Like smooth muscle, cardiac muscle cells contain only one nucleus. Cardiac muscle is found only within the heart.
- **Skeletal muscle** or "voluntary muscle" is anchored by tendons to the bone and is used to effect skeletal movement such as locomotion. Skeletal muscle cells are multinucleated with the nuclei peripherally located. Skeletal muscle is called 'striated' because of the longitudinally striped appearance under light microscopy.






Functions of the skeletal muscle include:

- Support of the body
- Aids in bone movement
- Helps maintain a constant temperature throughout the body
- Assists with the movement of cardiovascular and lymphatic vessels through contractions
- Protection of internal organs and contributing to joint stability

Cardiac and skeletal muscle are striated in that they contain sarcomere and are packed into highly-regular arrangements of bundles; smooth muscle has neither. Striated muscle is often used in short, intense bursts, whereas smooth muscle sustains longer or even near-permanent contractions.

Different between these muscles

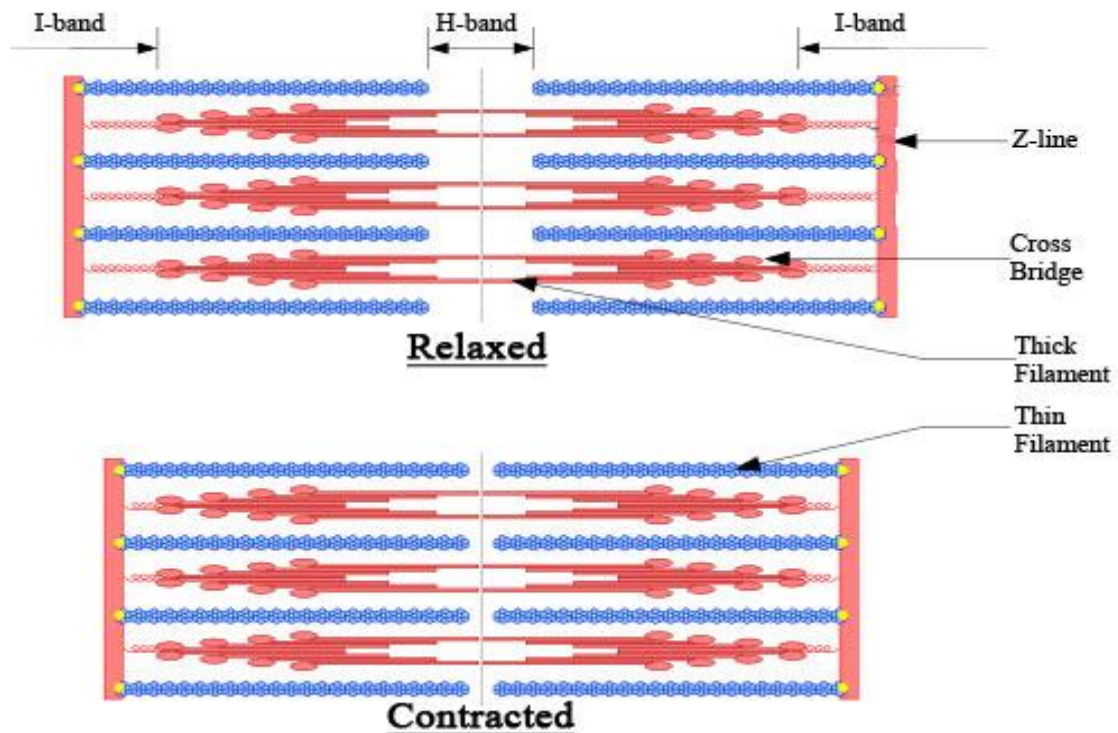
	Location	Function	Appearance	Control
Skeletal 	skeleton	movement, heat, posture	striated , multi-nucleated (eccentric), fibers parallel	voluntary
Cardiac 	heart	pump blood continuously	striated , one central nucleus	involuntary
Visceral (smooth muscle) 	G.I. tract, uterus, eye, blood vessels	Peristalsis, blood pressure, pupil size, erects hairs	no striations , one central nucleus	involuntary

○ How the Muscular System Works

Motion is a result of muscle fibers contracting and relaxing. The actions of your muscular system are controlled by your nervous system, which sends a never-ending stream of messages along your nerves. When a skeletal muscle fiber receives a signal, it will either relax or contract. If told to contract, the resulting motion will pull on a bone and create body movement.

▪ Physiology

Skeletal muscle contraction occurs by way of a "sliding filament" mechanism. In this mechanism, neither the thick nor the thin filament shortens. Instead, the two filaments slide over one another and pull the Z-lines closer. This action causes the length of the sarcomere to decrease by reducing the open spaces found at the H-band and the I-band ,



At the molecular level, myosin cross bridges from the thick filament bind to actin on the thin filaments at specific binding sites. Once bound, the cross bridges pull the thin filament inward causing the Z-line to move toward the H-band. This process of cross bridge pulling requires energy in the form of ATP .

The usage of ATP by skeletal muscle, and the contraction that follows, is regulated by free calcium ions (Ca^{2+}). Tropomyosin and troponin found on the thin filament control the availability of the actin-cross bridge binding site.

When Ca^{2+} is absent, the tropomyosin-troponin complex exists in a state that blocks the actin-cross bridge binding site and contraction cannot occur.

When Ca^{2+} is present, the ion binds to troponin and alters the tropomyosin-troponin complex to a state that makes it possible for myosin cross bridges to bind to the thin filament. Contraction occurs until the free Ca^{2+} concentration drops and the tropomyosin-troponin complex reverts to blocking the cross bridge binding site .

- How to Keep a Healthy Muscular System

Muscles need action to maintain their strength, so exercise is very important. Cardio exercises that cause you to sweat and breathe heavily are important for working out the muscles of your heart and blood vessels. Strength training or resistance training can enlarge or firm your muscles to give your body a more defined shape. Massage and stretching, like yoga, may help loosen your muscles and prevent painful muscular tightness.

After exercise, you need to get plenty of rest so that the little tears that may occur in your muscles can heal. If you have not worked out for a while, these little tears can create soreness in your muscles.

It is also important to have a balanced diet with plenty of calcium and potassium, which are key players in muscle contraction. Having strong, well-exercised muscles increases your metabolism and helps you to stay energized for longer periods of time.