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B.Sc. III/ Sem V/ Unit II
(Muscle Physiology)

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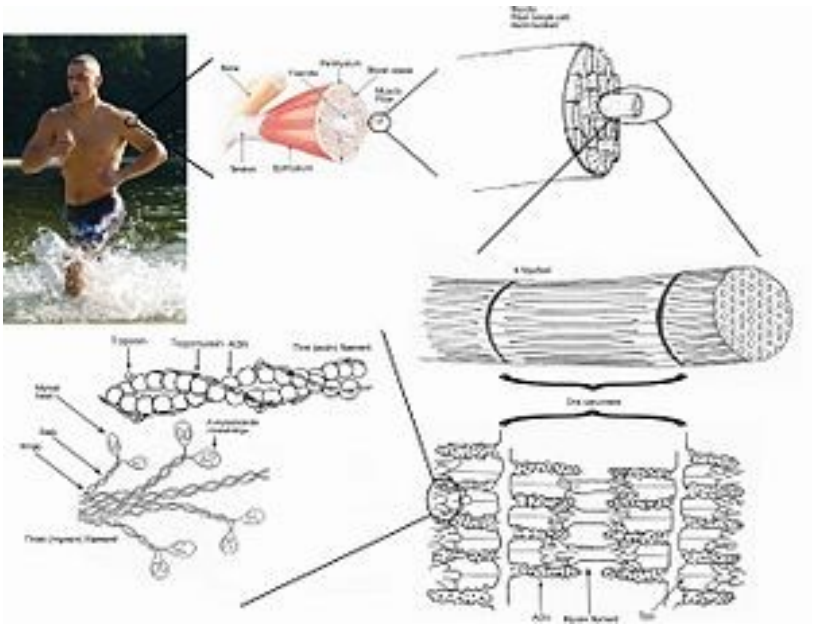
Muscles and its Types

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. They are primarily responsible for maintaining and changing posture, locomotion, as well as movement of internal organs, such as the contraction of the heart and the movement of food through the digestive system via peristalsis.

Muscle tissues are derived from the mesodermal layer of embryonic germ cells in a process known as myogenesis. There are three types of muscle, skeletal or striated, cardiac, and smooth. Muscle action can be classified as being either voluntary or involuntary. Cardiac and smooth muscles contract without conscious thought and are termed involuntary, whereas the skeletal muscles contract upon command. Skeletal muscles in turn can be divided into fast and slow twitch fibers.

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.

The term muscle is derived from the Latin ***musculus*** meaning "little mouse" perhaps because of the shape of certain muscles or because contracting muscles look like mice moving under the skin.

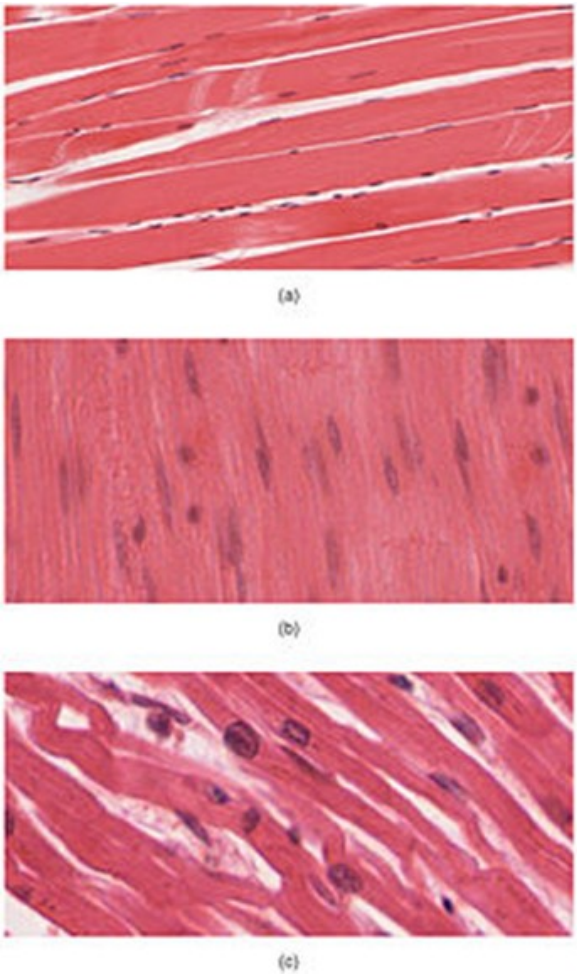


Structure

The anatomy of muscles includes gross anatomy, which comprises all the muscles of an organism, and microanatomy, which comprises the structures of a single muscle.

Types: *Muscle tissue*

The body contains three types of muscle tissue: (a) skeletal muscle, (b) smooth muscle, and (c) cardiac muscle. (Same magnification)



Muscle tissue is a soft tissue, and is one of the four fundamental types of tissue present in animals. There are three types of muscle tissue recognized in vertebrates:

- Skeletal muscle or "voluntary muscle" is anchored by tendons (or by aponeuroses at a few places) to bone and is used to effect skeletal movement such as locomotion and in maintaining posture. Though this postural control is generally maintained as an unconscious reflex, the muscles responsible react to conscious control like non-postural muscles. An average adult male is made up of 42% of skeletal muscle and an average adult female is made up of 36% (as a percentage of body mass).
- Smooth muscle or "involuntary muscle" is found within the walls of organs and structures such as the esophagus, stomach, intestines, bronchi, uterus, urethra, bladder, blood vessels, and the arrector pili in the skin (in which it controls erection of body hair). Unlike skeletal muscle, smooth muscle is not under conscious control.
- Cardiac muscle (myocardium), is also an "involuntary muscle" but is more akin in structure to skeletal muscle, and is found only in the heart.

Cardiac and skeletal muscles are "striated" in that they contain sarcomeres that are packed into highly regular arrangements of bundles; the myofibrils of smooth muscle cells are not arranged in sarcomeres and so are not striated. While the sarcomeres in skeletal muscles are arranged in regular, parallel bundles, cardiac muscle sarcomeres connect at branching, irregular angles (called intercalated discs). Striated

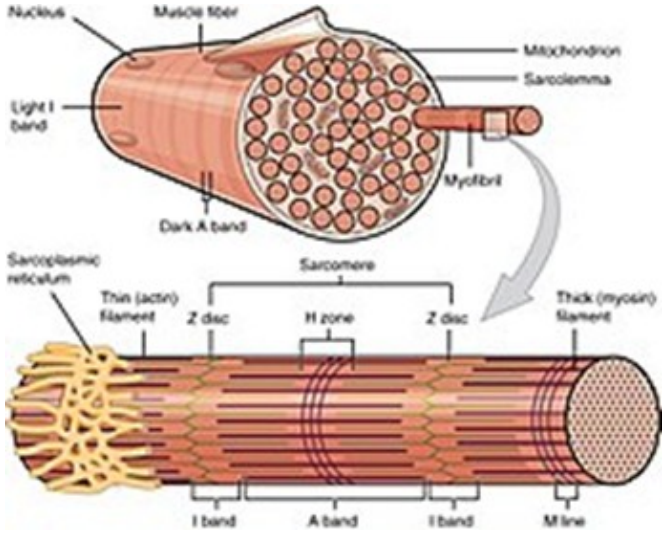
muscle contracts and relaxes in short, intense bursts, whereas smooth muscle sustains longer or even near-permanent contractions.

Skeletal Muscle Fiber Types

The muscle fibers embedded in skeletal muscle are relatively classified into a spectrum of types given their morphological and physiological properties. Given a certain assortment of these properties, muscle fibers are categorized as slow-twitch (low force, slowly fatiguing fibers), fast twitch (high force, rapidly fatiguing fibers), or somewhere in between those two types (i.e. intermediate fibers). Some of the defining morphological and physiological properties used for the categorization of muscle fibers include: the number of mitochondria contained in the fiber, the amount of glycolytic, lipolytic, and other cellular respiration enzymes, M and Z band characteristics, energy source (i.e. glycogen or fat), histology color, and contraction speed and duration. Note that there is no standard procedure for classifying muscle fiber types. The properties chosen for classification depends on the particular muscle. For example, the properties used for distinguishing fast, intermediate, and slow muscle fibers can be different for invertebrate flight and jump muscle. To further complicate this classification scheme, the mitochondria content and other morphological properties within a muscle fiber can change with exercise and age.

Microanatomy

Main articles: Myocyte and Sarcomere



A skeletal muscle fiber is surrounded by a plasma membrane called the sarcolemma, which contains sarcoplasm, the cytoplasm of muscle cells. A muscle fiber is composed of many fibrils, which give the cell its striated appearance.

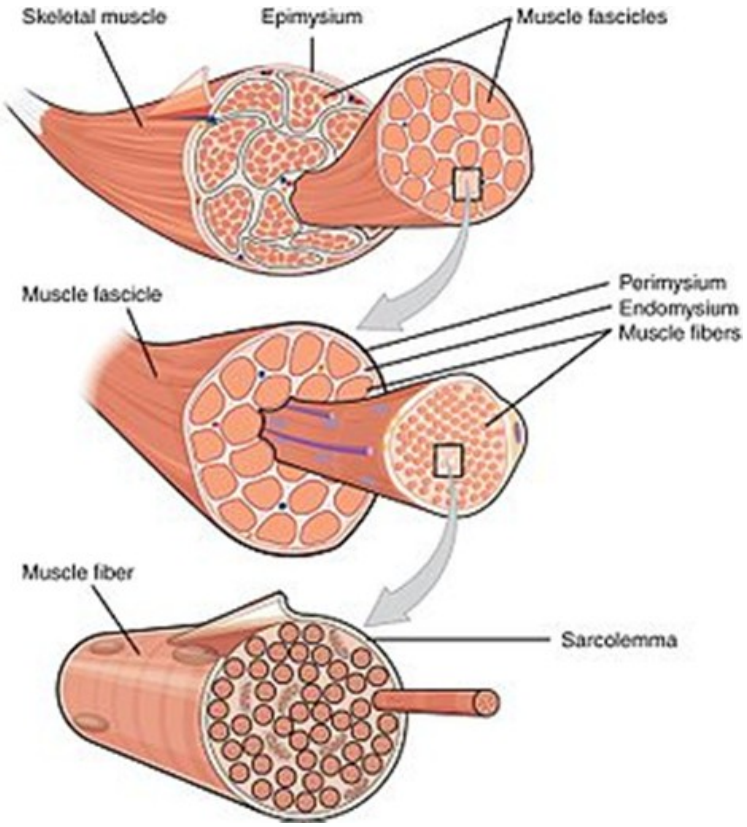
Skeletal muscles are sheathed by a tough layer of connective tissue called the epimysium. The epimysium anchors muscle tissue to tendons at each end, where the epimysium becomes thicker and collagenous. It also protects muscles from friction against other muscles and bones. Within the epimysium are multiple bundles called fascicles, each of which contains 10 to 100 or more muscle fibers collectively sheathed by a perimysium. Besides surrounding each fascicle, the perimysium is a pathway for nerves and the flow of blood within the muscle. The threadlike muscle fibers are the individual muscle cells (myocytes), and each cell is encased within its own endomysium of collagen fibers. Thus, the overall muscle consists of fibers (cells) that are bundled into fascicles, which are themselves grouped together to form muscles. At each level of bundling, a collagenous membrane surrounds the bundle, and these membranes support muscle

function both by resisting passive stretching of the tissue and by distributing forces applied to the muscle. [12] Scattered throughout the muscles are muscle spindles that provide sensory feedback information to the central nervous system. (This grouping structure is analogous to the organization of nerves which uses epineurium, perineurium, and endoneurium).

This same bundles-within-bundles structure is replicated within the muscle cells. Within the cells of the muscle are myofibrils, which themselves are bundles of protein filaments. The term "myofibril" should not be confused with "myofiber", which is a simply another name for a muscle cell. Myofibrils are complex strands of several kinds of protein filaments organized together into repeating units called sarcomeres. The striated appearance of both skeletal and cardiac muscle results from the regular pattern of sarcomeres within their cells. Although both of these types of muscle contain sarcomeres, the fibers in cardiac muscle are typically branched to form a network. Cardiac muscle fibers are interconnected by intercalated discs, [13] giving that tissue the appearance of a syncytium.

The filaments in a sarcomere are composed of actin and myosin.

Gross anatomy



Bundles of muscle fibers, called fascicles, are covered by the perimysium. Muscle fibers are covered by the endomysium.

The gross anatomy of a muscle is the most important indicator of its role in the body. There is an important distinction seen between pennate muscles and other muscles. In most muscles, all the fibers are oriented in the same direction, running in a line from the origin to the insertion. However, In pennate muscles, the individual fibers are oriented at an angle relative to the line of action, attaching to the origin and insertion tendons at each end. Because the contracting fibers are pulling at an angle to the overall action of the muscle, the change in length is smaller, but this same orientation allows for more fibers (thus more force)

in a muscle of a given size. Pennate muscles are usually found where their length change is less important than maximum force, such as the rectus femoris.

Skeletal muscle is arranged in discrete muscles, an example of which is the *biceps brachii* (biceps). The tough, fibrous epimysium of skeletal muscle is both connected to and continuous with the tendons. In turn, the tendons connect to the periosteum layer surrounding the bones, permitting the transfer of force from the muscles to the skeleton. Together, these fibrous layers, along with tendons and ligaments, constitute the deep fascia of the body.