Histology of muscle.

Muscle function:

1. contraction for locomotion and skeletal movement.
2. contraction for propulsion.
3. contraction for pressure regulation.

Muscle classification: muscle tissue may be classified according to a morphological classification or a functional classification.

Morphological classification (based on structure)

There are two types of muscle based on the morphological classification system.

1. Striated.
2. Non striated or smooth.

Functional classification.

There are two types of muscle based on a functional classification system.

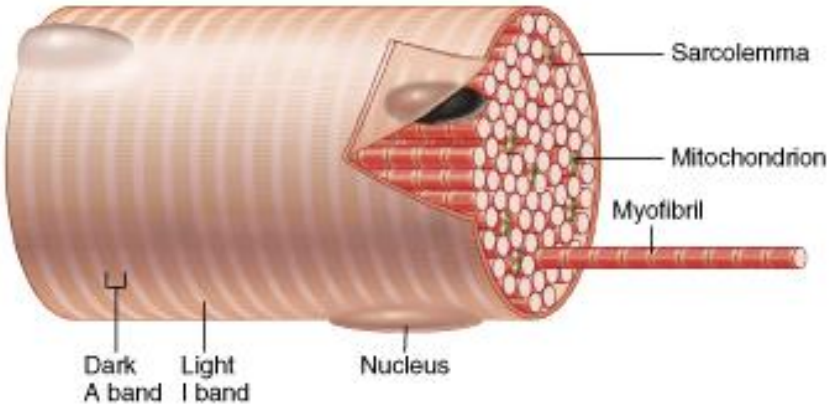
1. Voluntary.
2. Involuntary.

Types of muscle: there are generally considered to be three types of muscle in the human body.

Skeletal muscle: which is striated and voluntary.
Cardiac muscle: which is striated and involuntary.
Smooth muscle: which is non striated and involuntary.

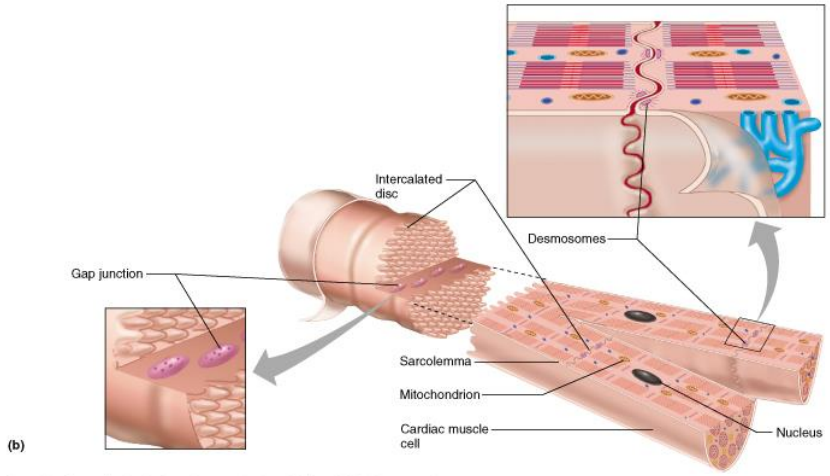
Characteristics of skeletal muscle.

Skeletal muscle cells are elongated or tubular. They have multiple nuclei and these nuclei are located on the periphery of the cell. Skeletal muscle is striated. That is, it has an alternating pattern of light and darks bands that will be described later.



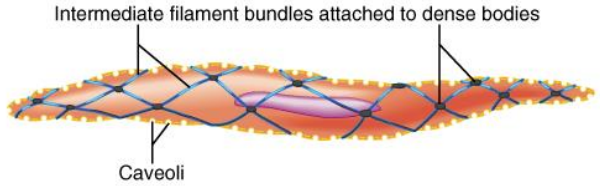
Characteristics of Cardiac muscle.

Cardiac muscle cells are not as long as skeletal muscles cells and often are branched cells. Cardiac muscle cells may be mononucleated or binucleated. In either case the nuclei are located centrally in the cell. Cardiac muscle is also striated. In addition cardiac muscle contains intercalated discs.

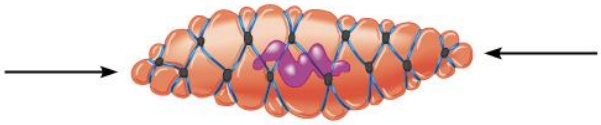


Characteristics of Smooth muscle.

Smooth muscle cell are described as spindle shaped. That is they are wide in the middle and narrow to almost a point at both ends. Smooth muscle cells have a single centrally located nucleus. Smooth muscle cells do not have visible striations although they do contain the same contractile proteins as skeletal and cardiac muscle, these proteins are just laid out in a different pattern.



(a) Relaxed smooth muscle cell



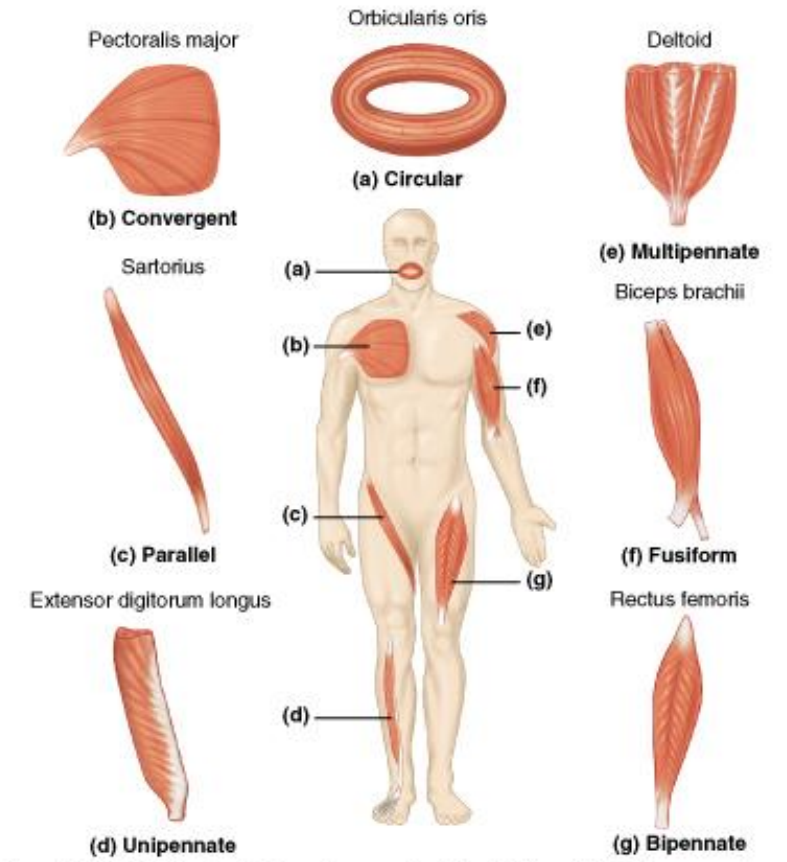
(b) Contracted smooth muscle cell

For the purposes of this class we will focus mainly on skeletal muscle.

Shapes of skeletal muscles:

1. Parallel or fusiform: as their name implies their fibers run parallel to each other. These muscles contract over a great distance and usually have good endurance but are not very strong. Examples: Sartorius muscle and rectus abdominus muscle.

2. Convergent: the muscle fibers converge on the insertion to maximize the force of muscle contraction. Examples: Deltoideus muscle and Pectoralis Major muscle.



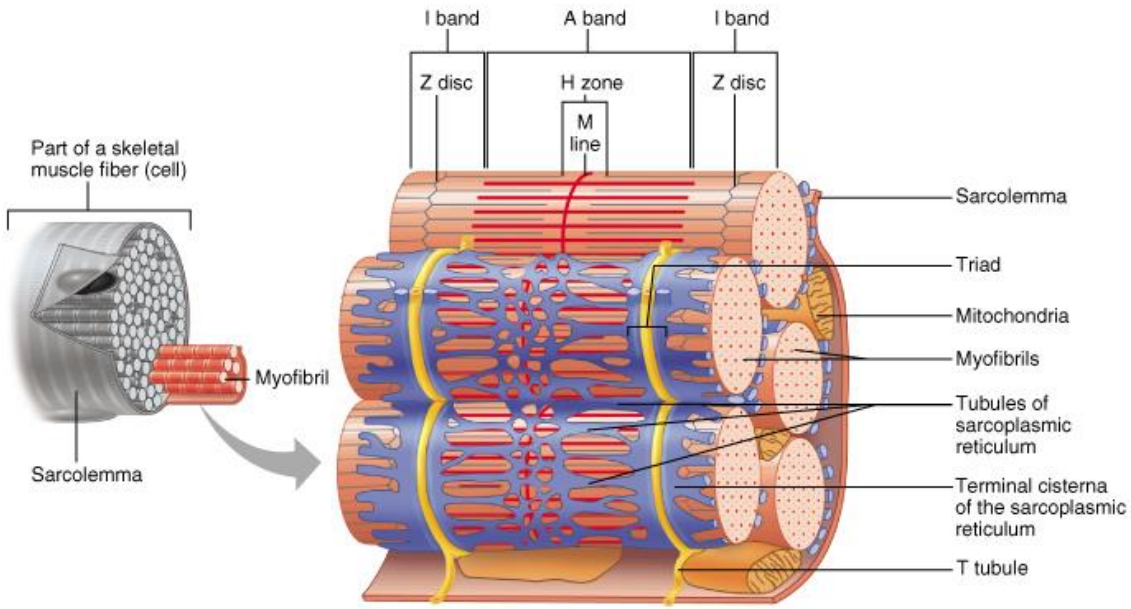
3. pennate: have many fibers per unit area. These types of muscles are strong but they tire quickly. There are three types of pennate muscle.
   Unipennate.
   Bipennate.
   Multipennate.

4. Circular: the muscle fibers surround an opening to act as a sphincter. Examples: Orbicularis oris and Orbicularis oculi muscles.

5. fusiform: some texts classify parallel muscles that are slightly wider in their middle (spindle shaped) as fusiform. This term will not be used in this course.

Muscle terminology

myofiber or myocyte: a muscle cell.
sarcolemma: the plasma membrane of a muscle cell.
sarcoplasm: the cytoplasm of the muscle cell.
sarcoplasmic reticulum: the endoplasmic reticulum of a muscle cell.
sarcosome: the mitochondria of a muscle cell.
sarcomere: the contractile or functional unit of muscle.



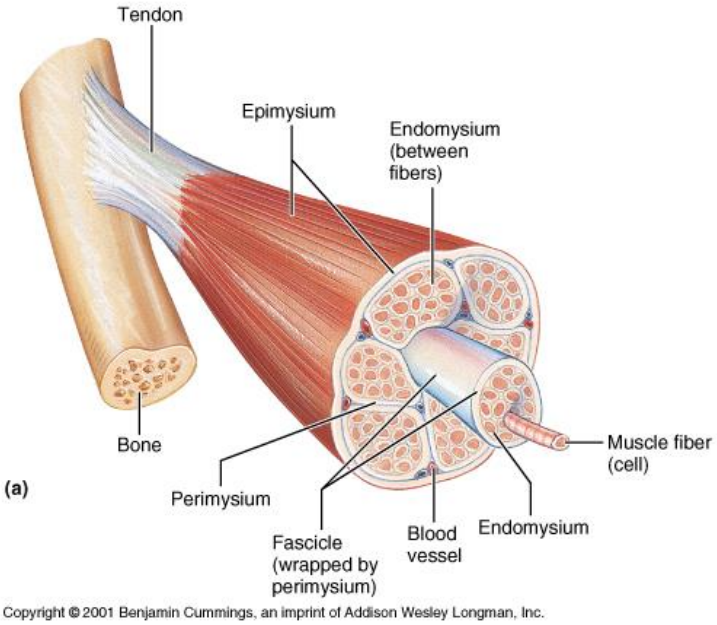
For the purposes of this class we will focus mainly on skeletal muscle.

Muscles have three major areas:

1. a belly or Gaster.
2. an origin: a tendinous connection of the muscle to a bone, usually the bone that is stabilized.
3. an insertion: a tendinous connection of the muscle to a bone, usually the bone to be moved.

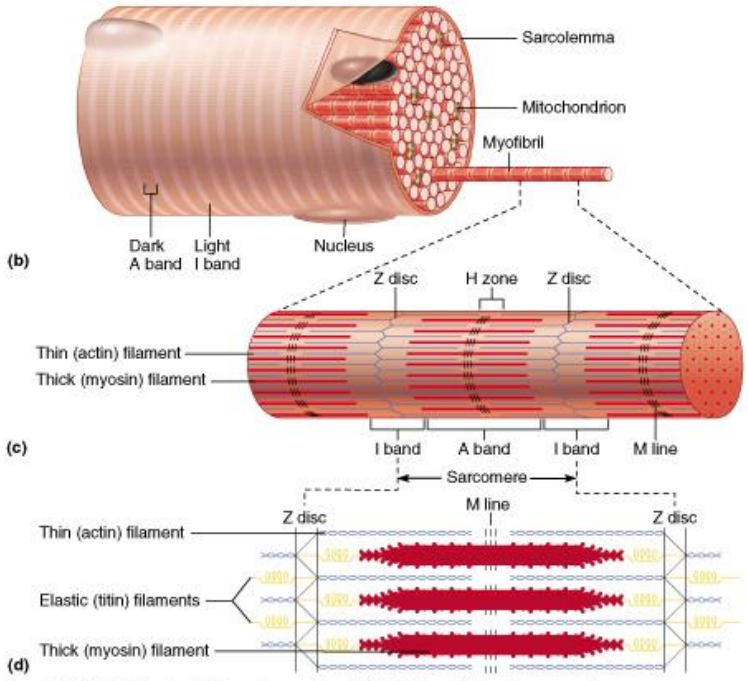
Skeletal muscle is designed as a bundle within a bundle arrangement. We will start with a whole muscle and then work our way down to the microscopic level of the muscle.

The entire muscle is surrounded by a connective tissue called the epimysium.



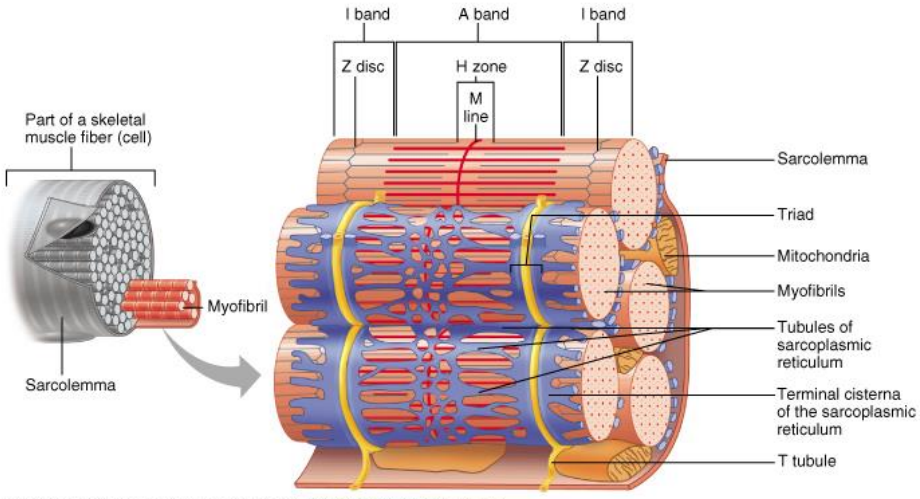
The muscle is made up of smaller bundles known as fascicles. Fascicles are actually bundles of individual muscle cells (myofibers or myocytes). These bundles are surrounded by a connective tissue sheath called the perimysium.

Each fascicle is made up of several muscle cells known as myocytes. They may also be called myofibers or muscle fibers. Each muscle cell is surrounded by a connective tissue sheath known as the endomysium. This sheath is very important in the physiology of muscle contraction because it electrically insulates the individual muscle cells from each other.



At the ends of the muscle all of the connective tissue sheaths (epimysium, perimysium, and endomysium) converge to form a tendon which will connect the muscle to its attachment site.

Each muscle fiber (muscle cell) contains all of the organelles that we find in other cell types.
Although these organelles are the same as in other cells they are given special names. Note that the prefixes sarco and myo both refer to muscle. Therefore if you see a word with either of these prefixes you should immediately think MUSCLE.



The nucleus contains the genetic material of the muscle cell.

The sarcolemma is the name given to the plasma membrane of the muscle cell. There are specialized invaginations of the sarcolemma that run transversely across the cell. These invaginations are known as T tubules (short for transverse tubules). The T tubules are essential for carrying the depolarization brought to the cell by a motor nerve impulse, down into the muscle cell where it can have an affect on the terminal cisternae. We will cover more about this in the unit on the physiology of muscle contraction.

The cytosol is the cytoplasm of the muscle cell.

The sarcoplasmic reticulum is the endoplasmic reticulum of the muscle cell. There are sac-like regions of the sarcoplasmic reticulum, known as terminal cisternae. The terminal cisternae act as calcium storage sites. The calcium ions stored in the terminal cisternae are essential in muscle contraction. We will cover more about this in the unit on the physiology of muscle contraction. NOTE: this is not calcium storage for use in general body physiology as we would see with bone tissue, but rather is calcium storage for muscle contraction.

In skeletal muscle two terminal cisternae are associated with a T tubule to form a structure known as a triad. This differs from cardiac muscle where one terminal cisternae associates with one T tubule, to form a diad.

Mitochondria are sites of energy production (ATP synthesis) in the muscle cell as in all other cells of the body, except for mature red blood cells.

A myofibril is a cylindrical bundle of contractile proteins found within the muscle cell. Note that there are several myofibrils within each muscle cell. It is the arrangement of the contractile proteins within the myofibril that cause the striated appearance of skeletal and cardiac muscle.

Myofibrils are composed of individual contractile proteins called myofillaments. These myofilaments are generally divided into thick and thin myofilaments.

The thin myofilaments are composed mainly of a protein known as actin. Actin filaments are anchored into the z-line of a sarcomere.

The thick myofilaments are composed mainly of the protein myosin.

It is the orderly overlapping of the actin and myosin filaments that give cardiac and skeletal muscle their striated appearance (light and dark bands).

The A band is the dark band and corresponds to the length of a bundle of myosin filaments. Because muscle contraction is a sliding of the myofilaments past each other we do not see any of the myofilaments actually shorten. However the width of the banding patterns change as the degree of overlap changes. Because the A band corresponds to the length of the myosin filaments, and these filaments do not shorten, the width of the A band also does not shorten.

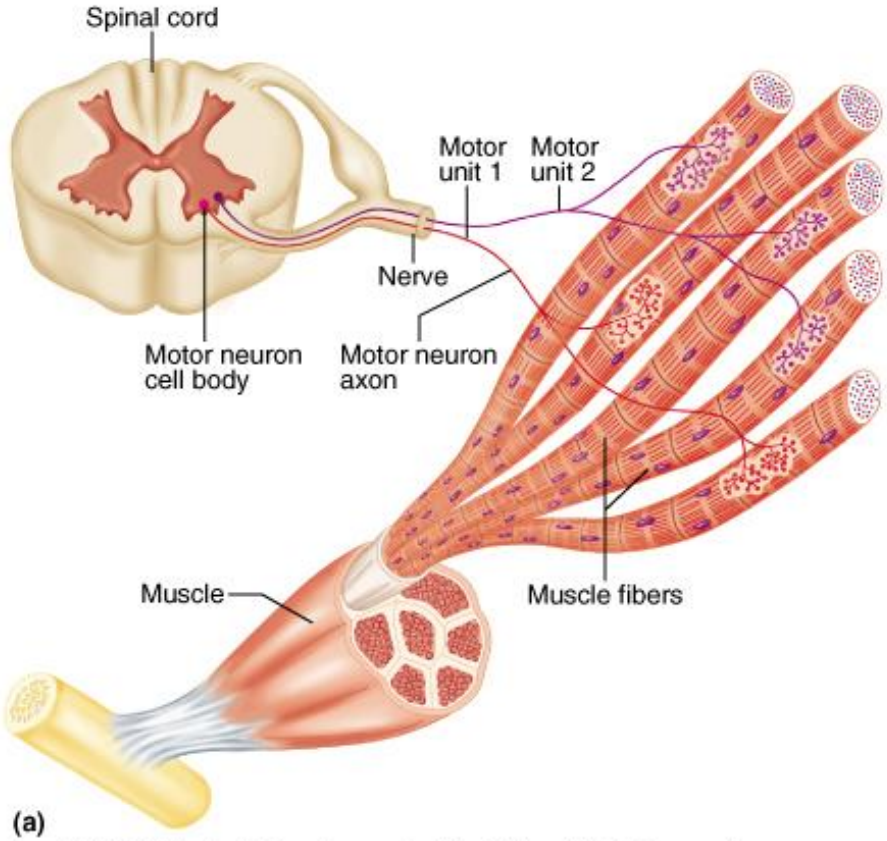
The light bands are known as I bands. The I bands are composed mainly of actin filaments. Each I band is bisected by a protein disc known as the Z-line. Actin filaments are anchored into the Z-line. During muscle contraction the actin filaments slide over the myosin filaments which results in a shortening of the I band.

In the middle of the A band is a somewhat lighter area known as the H zone. This zone corresponds to the area where we have myosin not overlapped by actin (the area between the thin filaments). During muscle contraction the actin sliding over the myosin encroaches into this area so that the H zone shortens. In the middle of the H zone we see a dark band known as the M line. The M line is comprised of protein fibers that function to anchor the myosin filaments.

The area between two Z lines is known as a sarcomere. The sarcomere is the contractile unit of muscle.

To recap, a whole muscle if made up of many smaller bundles known as fascicles. Each fascicle is made up of many muscle cells (myofibers). Myofibers contain cylindrical bundles of myofibrils which in turn contain many smaller bundles of myofilaments.

Muscles contract when they receive a motor impulse from a motor nerve. These nerve impulses serve only a limited number of muscle fibers. The muscle fibers served by a single motor neuron make up a structure known as a motor unit. Motor units allow for selective contraction of muscle fibers so that we may control the strength and extent of muscle contraction. Without motor units a nerve impulse to the muscle would result in the entire muscle contracting to its full extent. That would make every motion that we make an, "all or none" motion. This type of movement would make life nearly impossible.



Note that this diagram shows a neuromuscular junction of one motor neuron with one muscle fiber. In a motor unit the motor neuron branches to form neuromuscular junctions with several muscle fibers. To repeat, a motor neuron and all of the muscle fibers it supplies is called a MOTOR UNIT.