Skeletal Muscle

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Lec.5

- Muscle cells, like neurons, can be excited chemically, electrically, and mechanically to produce an action potential that is transmitted along their cell membranes.
- Unlike neurons, they respond to stimuli by activating a contractile mechanism.
- Muscle is generally divided into three types: skeletal, cardiac, and smooth

* Skeletal muscle makes up the great mass of the somatic musculature. It has well-developed cross-striations, does not normally contract in the absence of nervous stimulation.
* It lacks anatomic and functional connections between individual muscle fibers, and is generally under voluntary control.
* About 40% of our body is skeletal muscle and 10% is smooth muscle.

*Skeletal Muscle Morphology

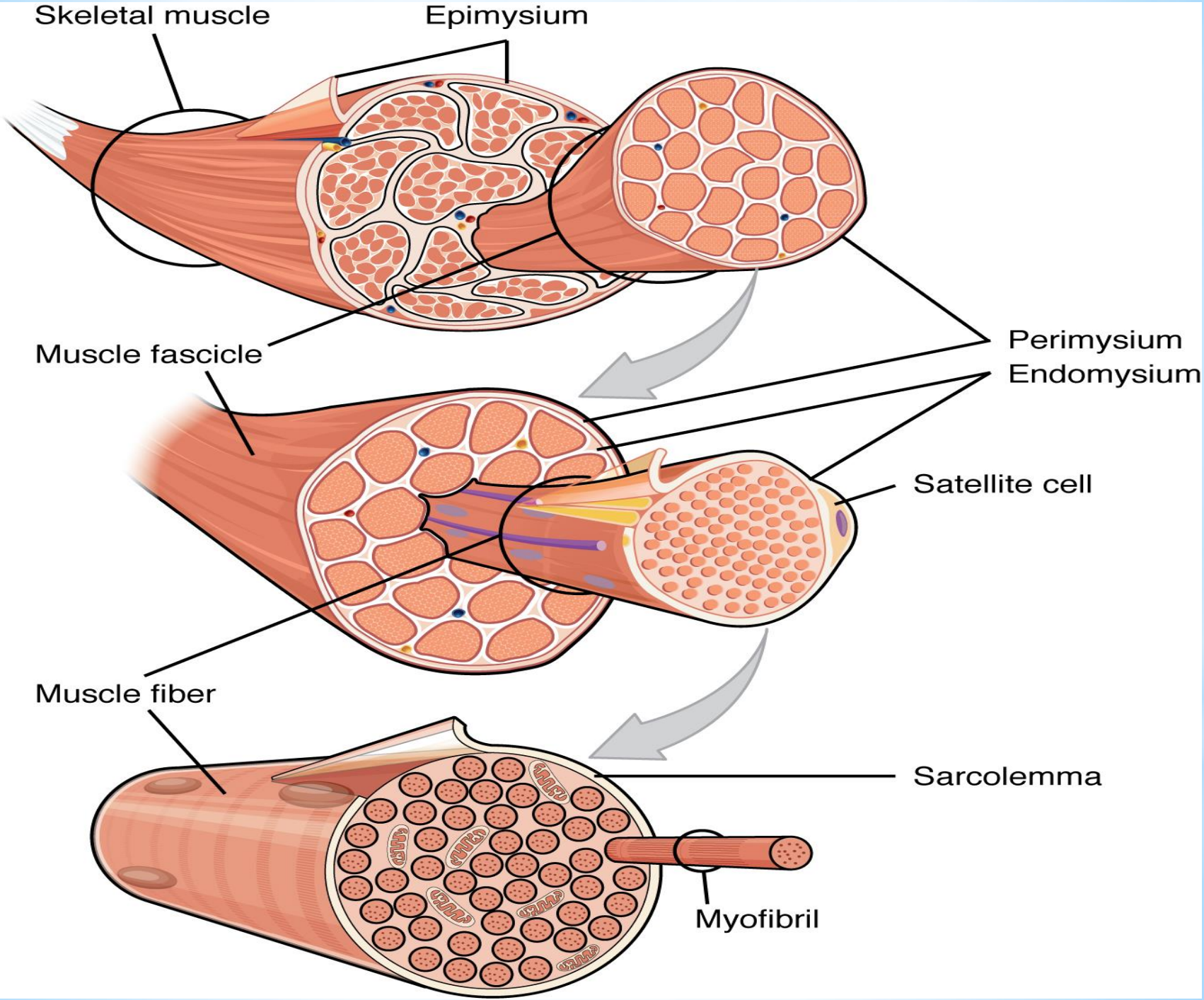
*Skeletal muscle is made up of individual **muscle fibers** that are the "building blocks" of the muscular system. Most skeletal muscles begin and end in tendons, and the muscle fibers are arranged in parallel between the tendinous ends, so that the force of contraction of the units is additive.

*The muscle surrounded by a layer of connective tissue continuous with that surrounds the tendon, called the **epimysium**.

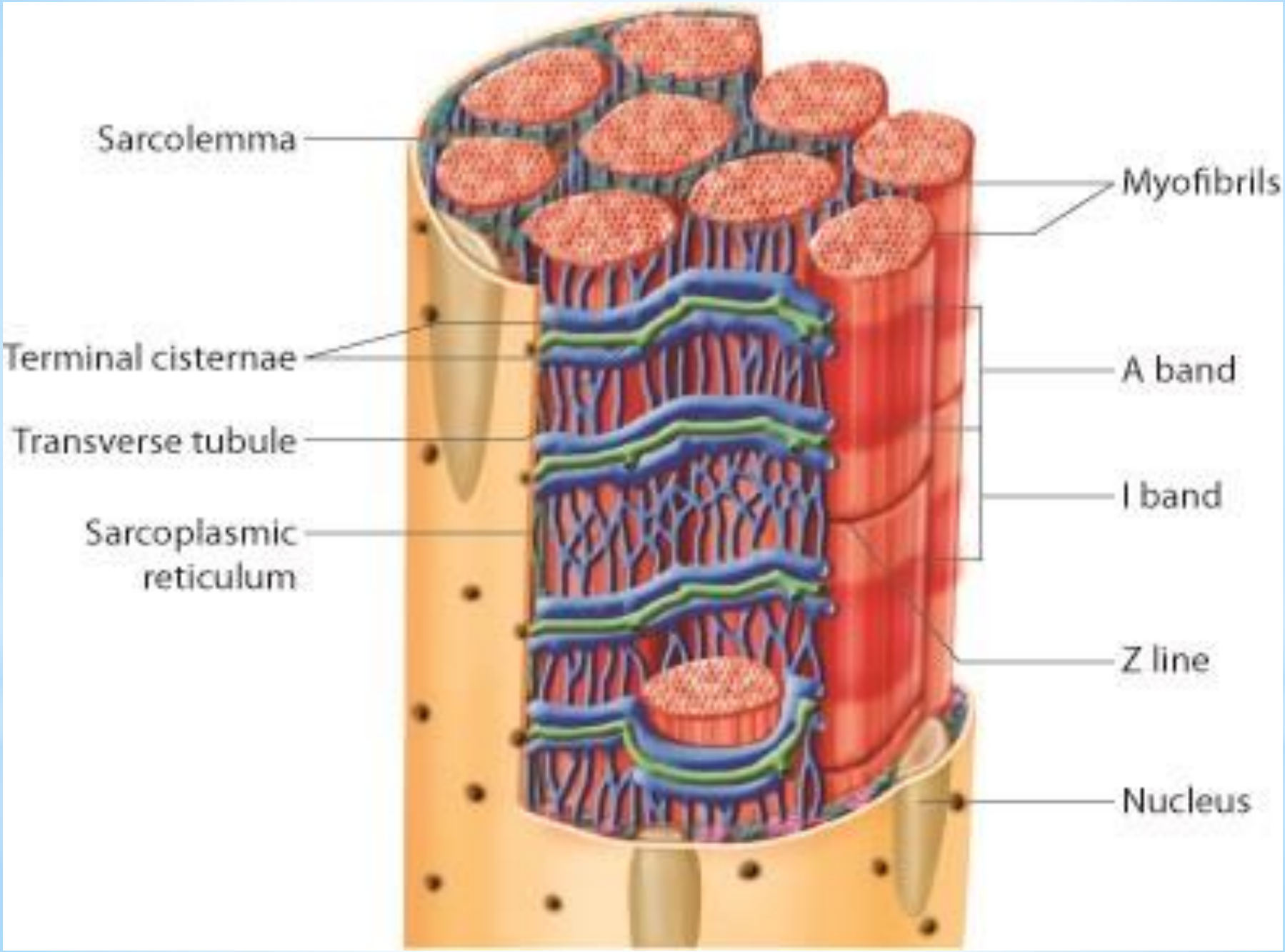
* Each muscle fiber runs the full length of the muscle and is encased in a thin sheath of connective tissue, called **endomysium**.

* Bundles of muscle fibers form fascicles, that surrounded by connective tissue called **perimysium** and bundles of fascicles form muscle tissue.

* Unlike most cells, which have a single nucleus, muscle fibers have many because each muscle fiber is formed during embryonic life from the fusion of several cells.


Skeletal muscle
Epimysium
Muscle fascicle
Perimysium
Endomysium
Satellite cell
Muscle fiber
Sarcolemma
Myofibril

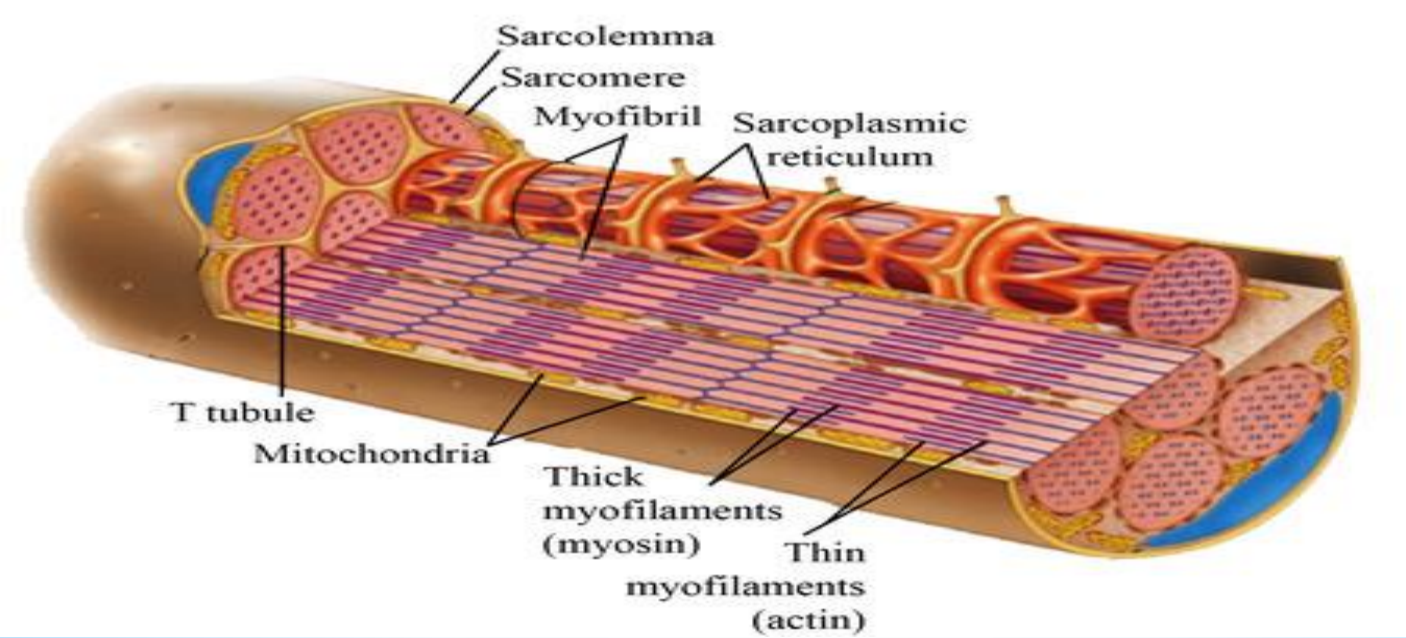
* These nuclei lie immediately below the muscle fiber's plasma membrane, which is called the sarcolemma.
* A muscle fiber's semifluid cytoplasm, called **sarcoplasm**, is packed with mitochondria and hundreds of banded, rod-like elements called myofibrils, which are divisible into individual filaments called myofilaments, which are responsible for the fiber's contractile machinery.
* Each **myofibril** contains contractile proteins, described as thick and thin filaments, which are arranged longitudinally into units called **sarcomeres**.


Sarcolemma
Terminal cisternae
Transverse tubule
Sarcoplasmic reticulum
Myofibrils
A band
I band
Z line
Nucleus

* A saclike membranous network called the sarcoplasmic reticulum surrounds each of the myofibrils and is closely associated with other structures called **transverse tubules (T tubules**), which are continuous with the sarcolemma and penetrate into the cell's interior.

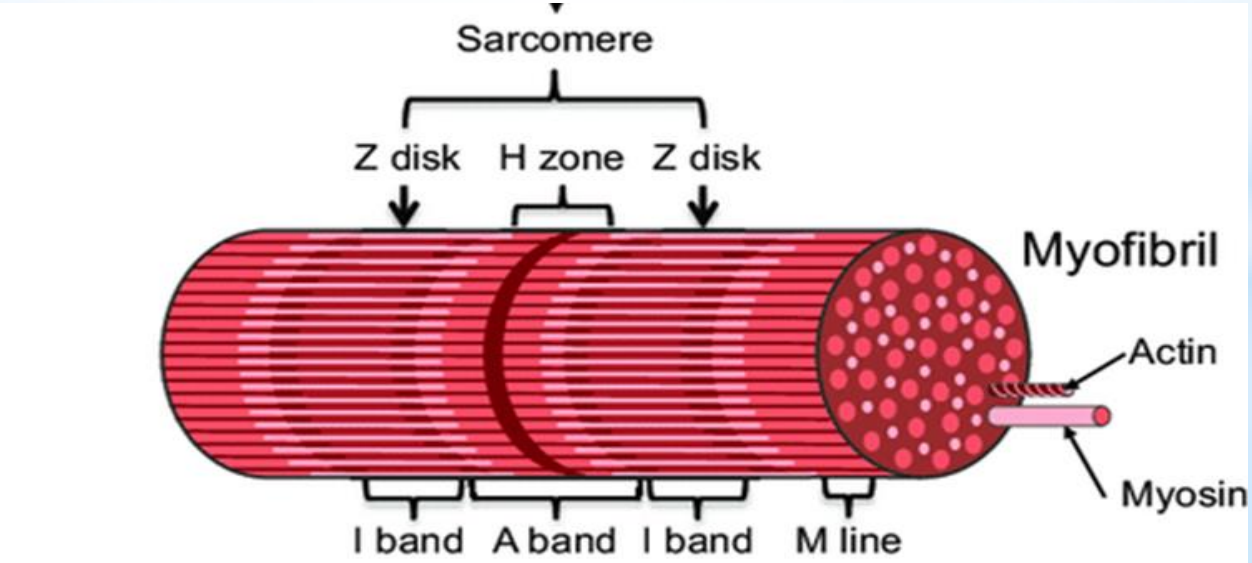
* Near the T tubule, the sarcoplasmic reticulum has enlargements called lateral sacs or terminal cisternae, which store calcium. The function of the sarcoplasmic reticulum is to store calcium ions (Ca).

* Each T tubule is associated with two lateral sacs, forming a triad.
* The sarcoplasmic reticulum and T tubules play important roles in the activation of muscle contractions: T-tubules help transmit signals from the sarcolemma to the myofibrils, enabling a muscle cell to respond to neural input.



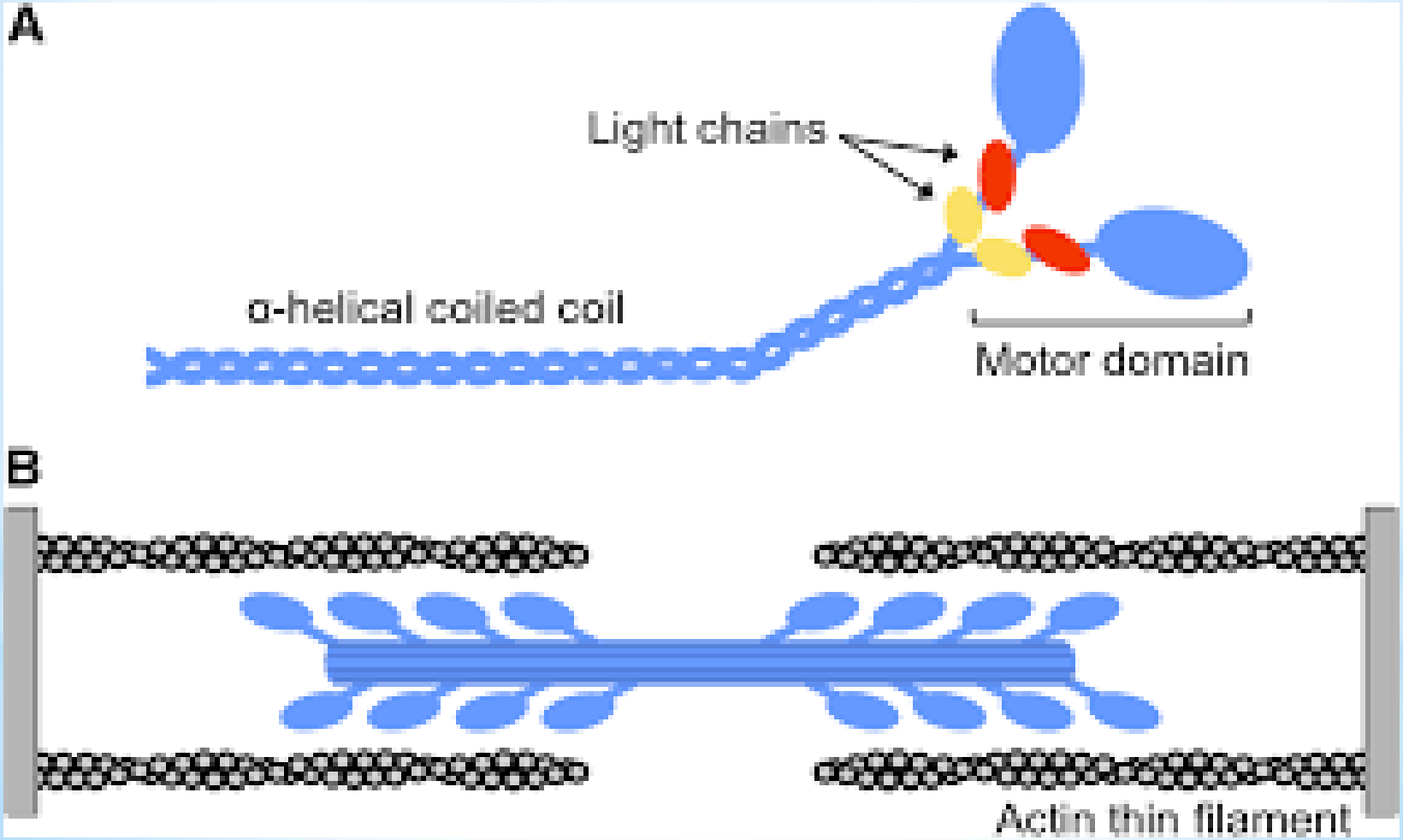
*Structure at the Molecular Level

- When viewed under a microscope, skeletal muscle cells have a striped appearance; for this reason, such muscle (and also cardiac muscle) is referred to as striated muscle.
- A close-up view shows that these striations are created by the orderly arrangement of protein fibers in the myofibrils called thick filaments and thin filaments, which run parallel to the muscle cell's long axis.



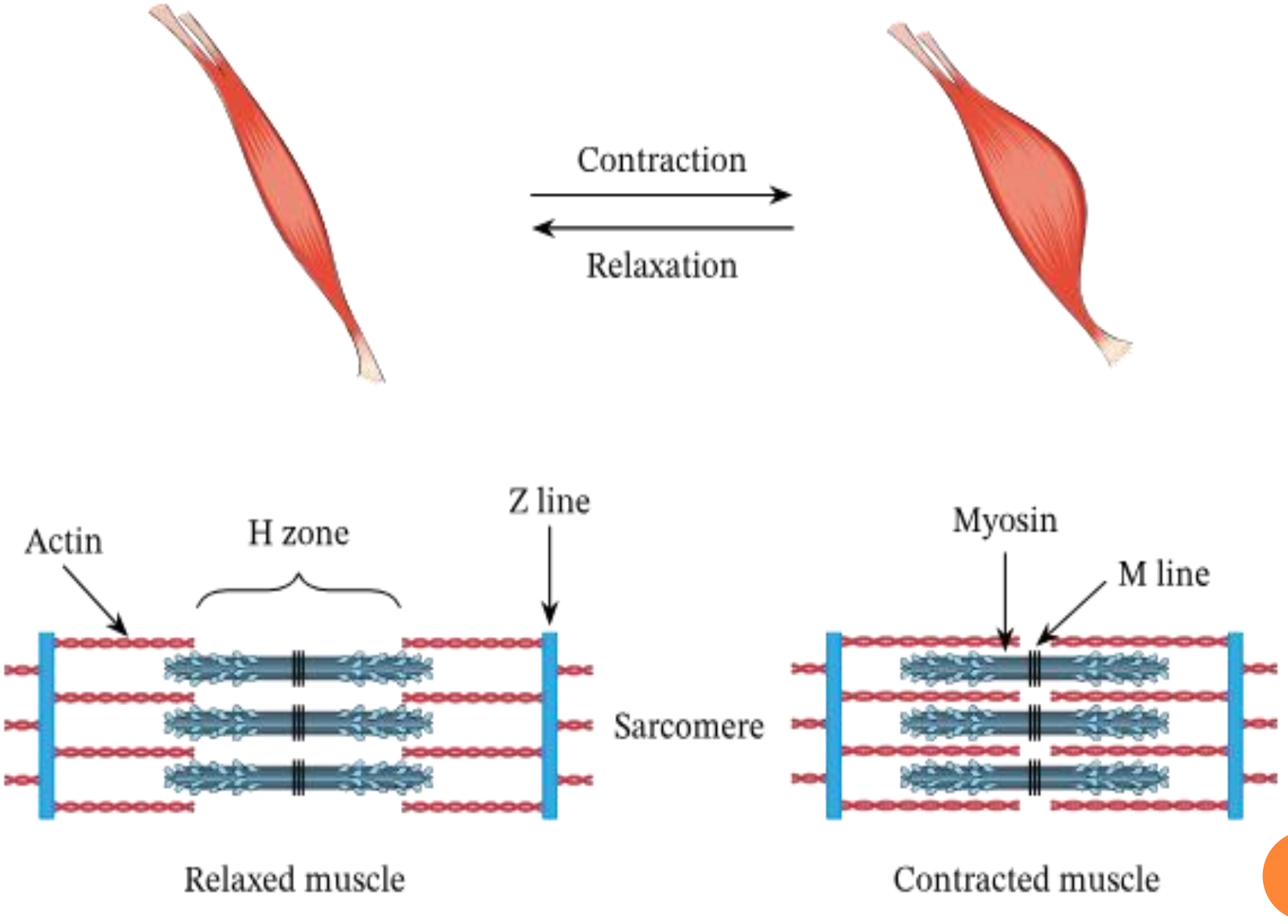
* The thin and thick filaments are made up of two proteins called **actin** and **myosin**, respectively, which are referred to as contractile proteins because they constitute the machinery that generates contractile force.
* The ends of actin filaments are attached to Z discs and from this disc actin extend in both directions to interdigitate with myosin. The area of muscle between two Z discs are called **sarcomere** which constitute contractile unit of the muscle.
* Each thick (myosin) filament is made of 200 of myosin molecules, each of which looks a bit like two golf clubs wrapped around each other.
* Each myosin molecule is a dimer consisting of two intertwined subunits, each having a long tail and a fat, protruding head.

- Also myosin head functions as adenosin triphosphate enzyme (ATPase) that cleaves the ATP molecule and provide energy necessary for muscle contraction.



The Mechanism of Force Generation in Muscle
The Sliding-Filament Model

- Previously, it was thought that muscle contraction is brought by shortening of the contractile proteins themselves (thick and thin filaments), but now it is well known that muscles contract because the thin filaments of the myofibrils slide past the thick filament bringing either end of a sarcomere move closer together, thereby shortening the sarcomere.
- As sarcomeres shorten, myofibrils also shorten, as do muscle fibers and ultimately whole muscles.
- Appropriately, this is called the **sliding-filament model of muscle contraction.**


Contraction
Relaxation
Actin
H zone
Z line
Sarcomere
Myosin
M line
Relaxed muscle
Contracted muscle