Biology Lecture 5 and 6 (part 2)

Muscle tissues:

Muscle cells are motors of the animal body. There are three type of muscles, two of them can contract without ordered by the nervous system (without conscious control) while other contracts only if specially commanded by the nervous system. The three types of tissues are smooth muscles, cardiac muscles, and skeletal muscles.

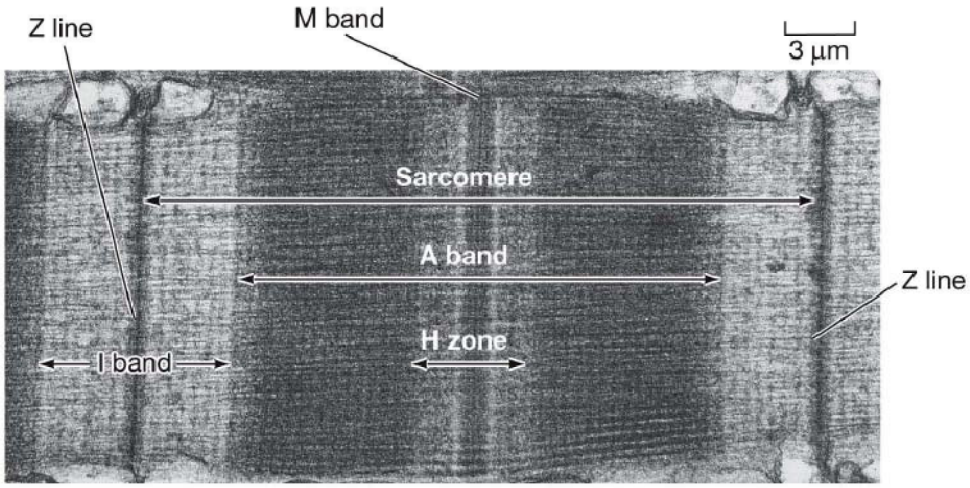
Smooth muscles line the internal organs and blood vessels.

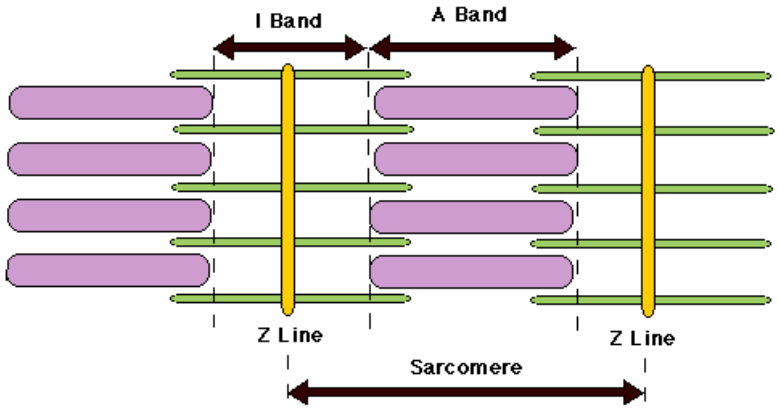
Cardiac muscles exist in the heart. A special cardiac muscle cell called the pacemaker can generate action potentials that cause the nearby cardiac muscle tissues to contract. This contraction is generated entirely by the heart muscle itself and requires no input from the nervous system.

Skeletal muscles are made up of cells called **muscle fibers**. These muscle fibers only contract if they are stimulated by the a nerve fiber. If more muscle fibers are stimulated, a stronger contraction results. Inside muscle fibers are substructures called myofibrils. These myofibrils contains highly ordered arrays of actin and myosin filaments (proteins).

Sliding muscle contraction:

Myofibrils are divided into regions by the **Z line.** A Z line is a vertical line of proteins that anchors the actin filaments. Two Z lines form a repeating structure called **sarcomere.** Sarcomere is the smallest subunit of muscle contraction. Proceeding inwards from the Z lines we have the light I bands where only actin or thin filaments exist. More inwards, we have the dark A bands where both actin and myosin filaments exist and overlap with each other. A band is the length of the myosin filament. Even more inwards, at the center of the sarcomere, we have the H zone where only myosin or thick filaments exist. M band exists in the middle of H zone. It is a vertical line of proteins that help to hold the myosin filaments together.





When the muscle contracts, the actin and myosin filaments slide towards each other. The overlap between myosin and actin filaments increases. This means that the length of the H band and I band shortens. (More overlap of myosin and actin results in smaller areas where myosin and actin filaments remain alone). The distance between two Z lines shortens. (This also means that the sarcomere shortens) The length of myosin and actin filaments stay the same during contractions, they only slide relative to each other. The length of the A band also stays the same since A band is defined as the length of myosin filaments.

Myosin filaments and Actin filaments:

Each myosin filament has a filamentous body and a large globular head at its end.

The actin filaments are composed of three types of molecules. There are the **actin monomers, tropomyosin** and **troponin.**

Actin filaments are helical arrangement of two chains of actin monomers twisted together like strands of pearl. Tropomyosin, a filamentous substance twists around the actin monomers and cover the binding sites on the actin monomers. Troponin are attached to the tropomyosin at regular intervals. They can make three attachments. One to the actin monomers, another to the tropomyosin and the last to calcium ions. Troponin can twist the tropomyosin to release the binding sites on the actin.

The heads of myosin filaments can bind to ATP and hydrolyze them to ADP. This process generates energy, which is used by the myosin filament to "cock" its head. This allows the myosin filament's head to attach to the actin monomers if the binding sites are not covered by the tropomyosin. Once the myosin head attaches to the actin monomer, it undergoes a shape change and this pulls the actin towards the center of the sacromere. This is the muscular contraction, or the "power stroke".

Once this power stroke is over, the myosin head binds to ATP and this releases the actin filament. Thus, ATP is required to break the actin-myosin bonds but do not form them. Muscles need ATP to stop contracting. This is the reason why muscles stiffens when animals die. Dead animals do not produce ATP and therefore the muscle cannot relax.

Control of Muscle contraction:

When muscles are relaxed, the myosin heads are “cocked” and ready but unable to bind to actins. This is due to the fact that the attachment sites on the actin are physically blocked by tropomyosin. Therefore, for contractions to occur, the tropomyosin must be physically moved away by troponin. To see how this works, it is necessary to trace the event all the way back to the arrival of the action potential. Action potentials are initiated first in the motor neurons. Depolarization passes to the plasma membrane of the muscle fibers and to the **T-tubules.** T-tubules are transverse tubules that descends into and branch throughout the muscle fibers.

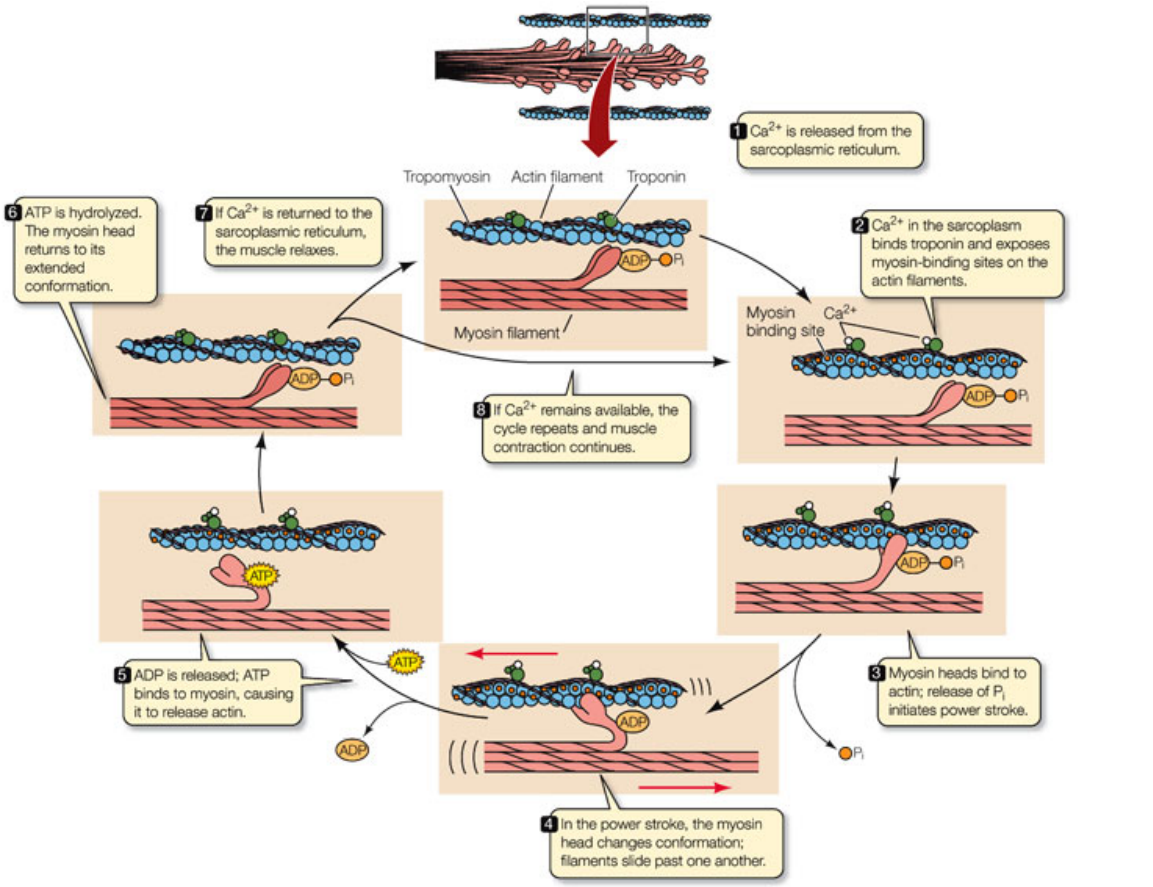
The T tubules also come close to a network of intracellular membranes called the **sarcoplasmic reticulum.** These membranes surrounds every microfibril.

At rest, calcium pumps on the sarcoplasmic reticulum take up calcium ions from the sacroplasm, the cytoplasm of the muscle fibers. Thus, there is a higher concentration of calcium ions in the sarcoplasmic reticulum compared to the outside. There are also calcium gated channels on the sarcoplasmic reticulum. These channels are voltage gated and when AP arrive from the T tubules, they open up and this cause the calcium ions inside the reticulum to diffuse out into the sarcoplasm.

Tropoin can bind to the calcium ions. When it binds to the calcium ions, it changes its shape and this twist the tropomyosin away to uncover the binding sites on the actin monomers. This allows the myosin filaments to attach to the actin filaments and causing muscle contractions.

When the T tubules repolarize, the calcium pumps on the reticulum remove calcium ions from the sarcoplasm and this cause the tropomyosin to return to its original position, closing off the binding sites.

Muscles can keep contracting as long calcium ions still remain in the sarcoplasm to keep the binding sites open.



***LIFE 8e*, Figure 47.6**

Skeletal Systems:

Muscles can only contract and relax. They need something to pull on to create significant movement.

There are three types of skeletal systems:

1) **Hydrostatic**, where liquid are enclosed by a body cavity. This body cavity is in turn surrounded by muscle that contact to force the liquid inside to bulge out. This enables locomotion. This system is employed by cnidarians, annelids, and cephalopods.
2) **Exoskeleton,** a hardened outer surface to which muscles can be attached. Contractions of the muscle cause jointed segments to move against each other. There are two types of exoskeletons, shells employed by mollusks and cuticles employed by arthropods. The shells used in mollusks do not molt and grow with the animal. Arthropods' cuticle does not grow with the animal and have to be molt regularly so that the animal can increase its size.
3) **Endoskeletons** are employed by vertebrates and echinoderms. Muscles are attached to it and pull the skeletons to enable movement. It is also able to grow with the animal.

Flexor muscles bend or flexes the joint. **Extensor muscles** straightens or extends the joint. These two muscle systems work antagonistically to move the joints since muscles can only pull, but not push.