Lecture 13 – Types of muscle tissues and muscle contraction

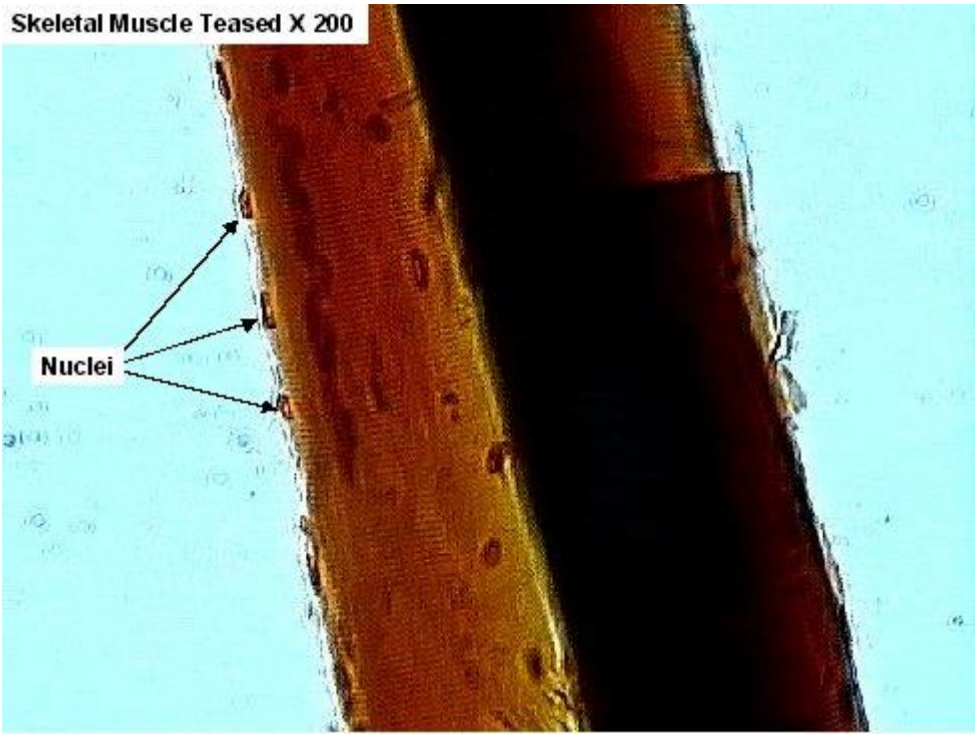
Types of Muscle

Skeletal Muscle

Skeletal muscle is voluntary.

The cells are long (up to 30 cm, [12 in.]), striated, and multinucleate.

Groups of cells are surrounded by connective tissues to form bundles.

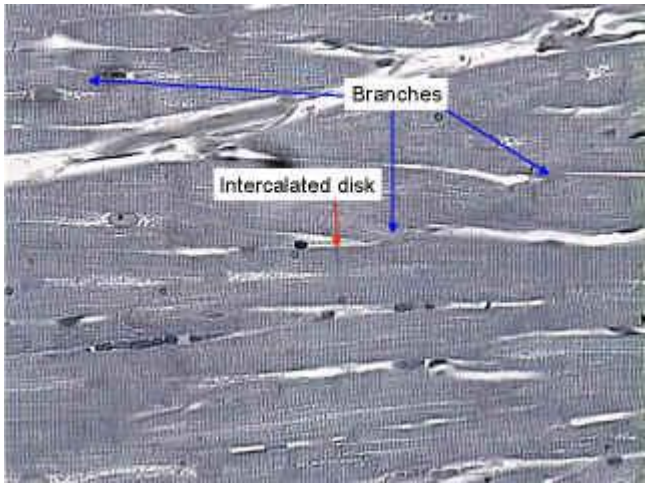


Cardiac Muscle

Cardiac muscle is found in the heart.

The cells are short, branched, and striated. The blue arrows in the photograph below point to branches.

Intercalated disks are regions where cells join together (see below).

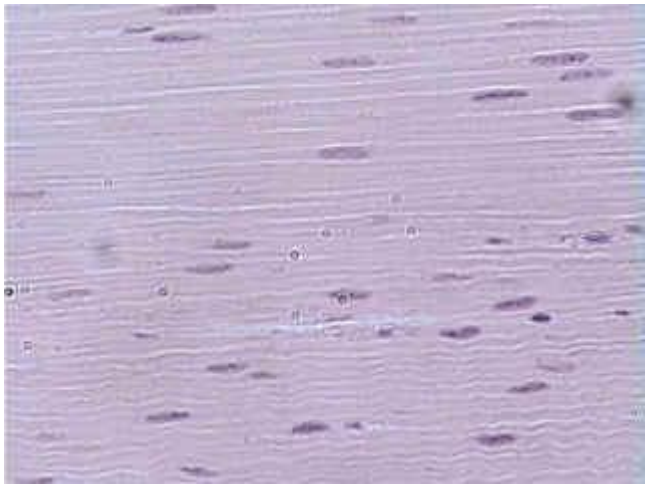


Smooth Muscle

Smooth muscle is involuntary.

It lines the gut, blood vessels, and reproductive tract.

The cells are tapered on the ends.



Structure of Skeletal Muscle

Skeletal muscles are composed of many cells. Muscle cells are also called ***muscle fibers***.

Myofibrils are strands found within muscle cells that are composed of the proteins ***actin*** and ***myosin***. They extend from one end of the cell to the other and are capable of contraction, causing the cell to shorten.

Membrane system

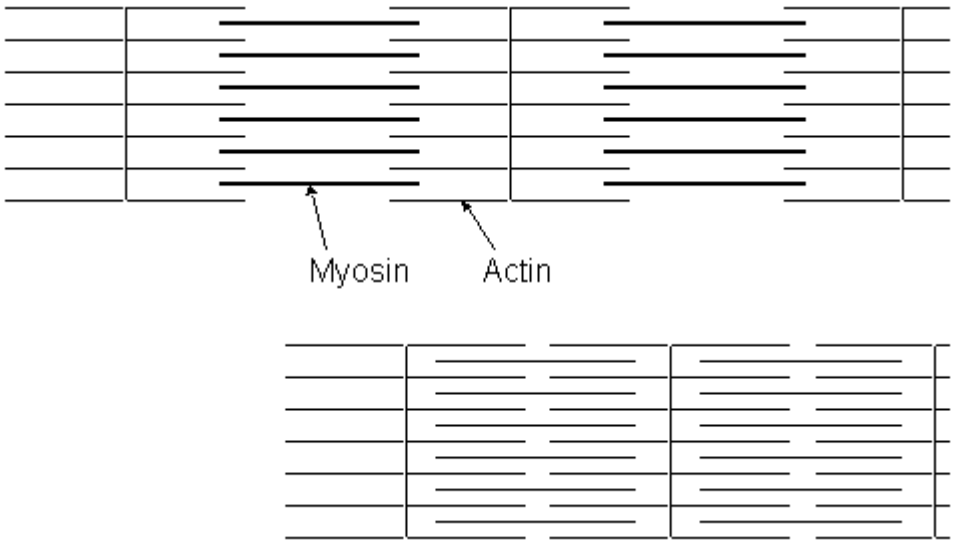
The plasma membrane is referred to as the ***sarcolemma.***

Extensions of the endoplasmic reticulum form a network of canals that surround the myofibrils and function to store Ca^{++}. It is called the ***sarcoplasmic reticulum***.

T-tubules (transverse tubules) are membranous tubules formed from the sarcolemma (plasma membrane) that extend throughout the cell. They are next to but not fused with the sarcoplasmic reticulum. T-tubules spread action potentials throughout the cell.

Muscle Contraction

During muscle contraction, actin and myosin filaments slide over each other as diagrammed below.



Cross-bridges (not shown) form between the heads of myosin molecules and binding sites on the actin filaments.

After attachment, the myosin heads bend, causing the two filaments to move with respect to each other.

The energy is derived from ATP. ATP binds the heads and causes them to detach and become primed (straightened) for a new cycle as the ATP is broken down to ADP + P_i, releasing it's energy.

At death, there is no ATP to cause the heads to detach, and the body enters rigor mortis (it becomes stiff) because the myosin heads remain attached to the actin filaments.

Control of Muscle Contraction

An action potential depolarizes the sarcolemma (the plasma membrane of the muscle cell). T-tubules spread the action potential throughout the cell. When the depolarization reaches the sarcoplasmic reticulum (calcium storage sacs), they release Ca^{++}.

Calcium triggers the contraction.

Pumps in the sarcoplasmic reticulum return the Ca^{++} to the sarcoplasmic reticulum for storage causing the muscle to relax.

Function of Ca^{++}

The actin filaments are composed of two rows of actin subunits that are wound around with ***tropomyosin*** threads.

In a relaxed muscle, contraction does not occur because the myosin binding sites on the actin filament are covered by the tropomyosin threads.

Troponin occurs at intervals along the threads. When Ca^{++} combines with troponin, the tropomyosin threads shift, exposing the myosin binding sites.

When the binding sites are exposed, the myosin heads attach and the filament contracts as previously described.

Neuromuscular Junction

Each motor axon branches to several muscle fibers and each branch has several terminal knobs. A single action potential can therefore stimulate several muscle fibers (cells).

Collectively, a motor neuron and all of the muscle fibers that it controls are called a ***motor unit***.

The neurotransmitter is acetylcholine (Ach).

The region where a motor neuron forms a synapse with a muscle cell is called a ***neuromuscular junction***.

Summary of muscle contraction

An action potential reaches the terminal end of a motor neuron where it arrives at several muscle fibers (cells).

Acetylcholine is released into the synaptic cleft of the neuromuscular junction.

The muscle fiber depolarizes, and the action potential is spread to the interior of the cell by the T-tubules.

When the action potential reaches the sarcoplasmic reticulum, calcium is released into the cell.

Calcium binds with troponin, causing tropomyosin to uncover the myosin binding sites on the actin filaments.

The myosin cross bridges bind with the actin.

When ADP + P_i drop off of the myosin, the myosin cross-bridges bend, moving the two filaments.

The myosin cross bridges release the actin filaments.

ATP binds to the cross bridges, bending the bridges and forming ADP + P_i.