

Structures and mechanisms of muscle contractions

By

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Outline

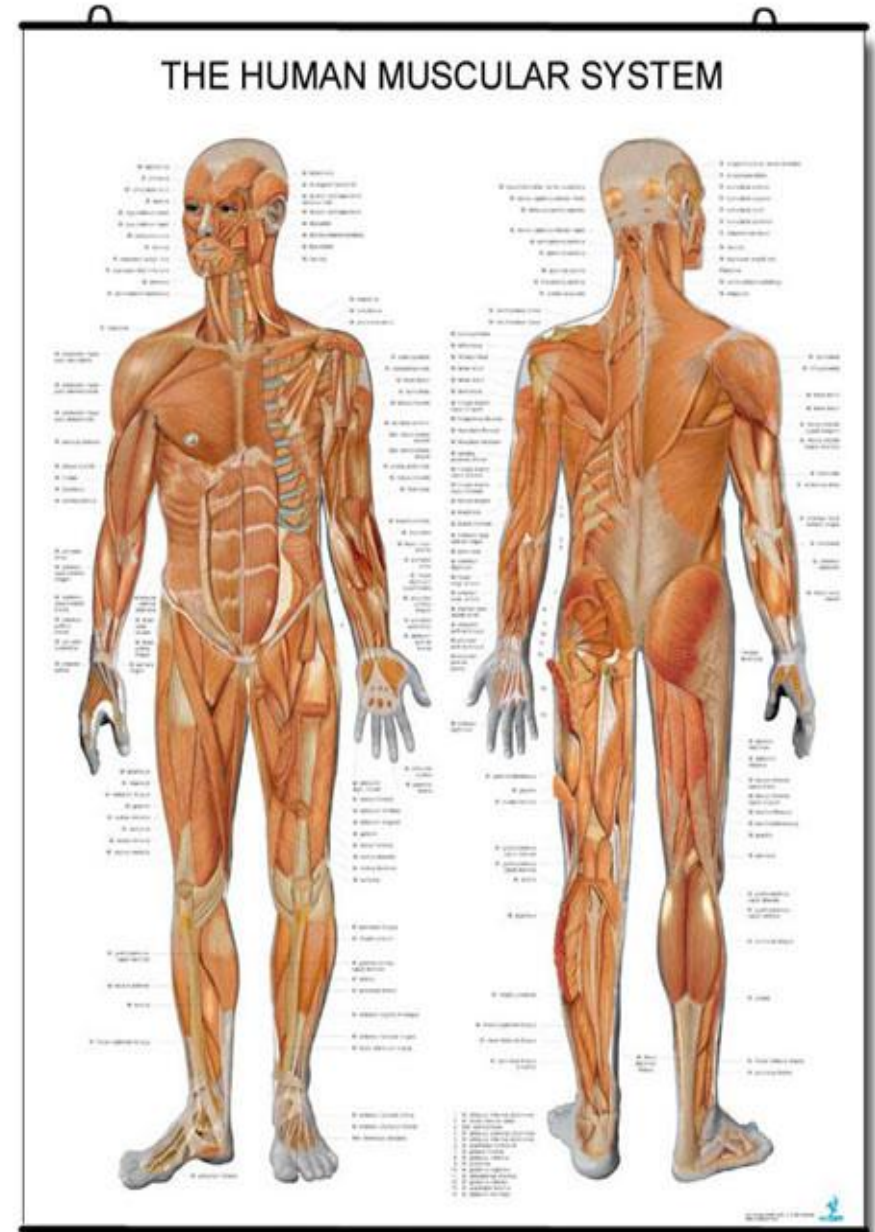
- ✓ Skeletal muscle structure and contraction
- ✓ Cardiac muscle structure and contraction
- ✓ Smooth muscle structure and contraction

Introduction

- ✓ All activities that involve movement depend on muscles
- ✓ Muscles are used for various purposes:
 - Locomotion
 - Upright posture
 - Balancing on two legs
 - Support of internal organs
 - Controlling valves and body openings
 - Production of heat
 - Movement of materials along internal tubes
- ✓ Three types of muscles in the human body
 - Skeletal
 - Cardiac
 - Smooth

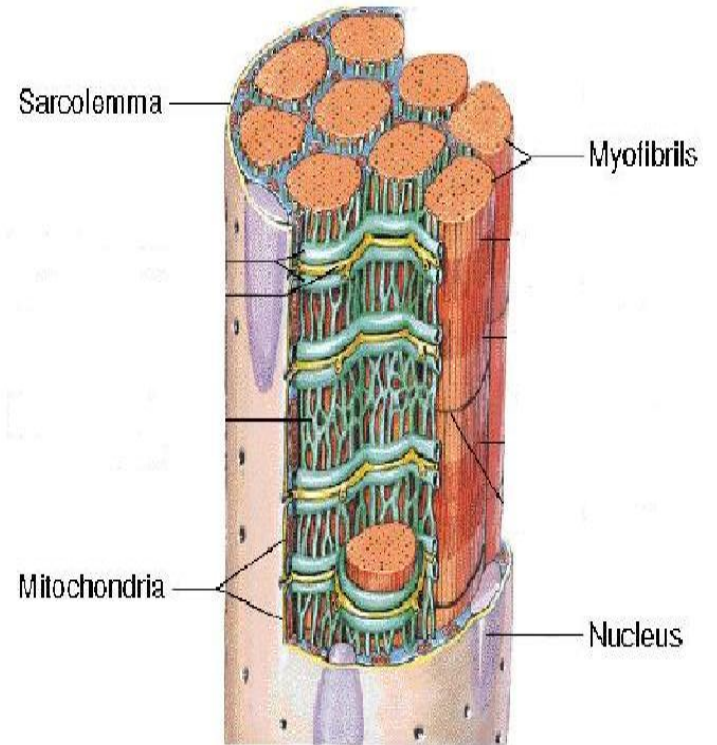
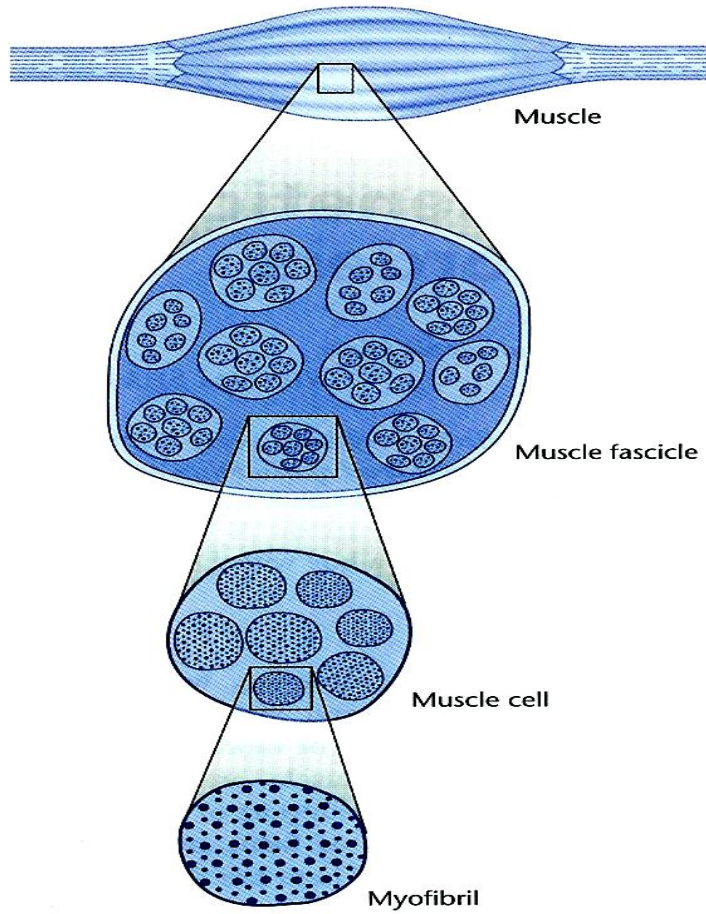
Skeletal muscle

- ✓ Skeletal muscles are muscles which are attached to the skeleton
- ✓ 40% of human body mass
- ✓ Skeletal muscles are mainly responsible for locomotion, and *voluntary* contraction and relaxation



Structure of skeletal muscle

- ✓ Skeletal muscles are composed of clusters of muscle cells (Muscle fibers).
- ✓ A muscle consists of packages of muscle cells called **fascicles**
- ✓ **A muscle cell is long and spindle shaped**



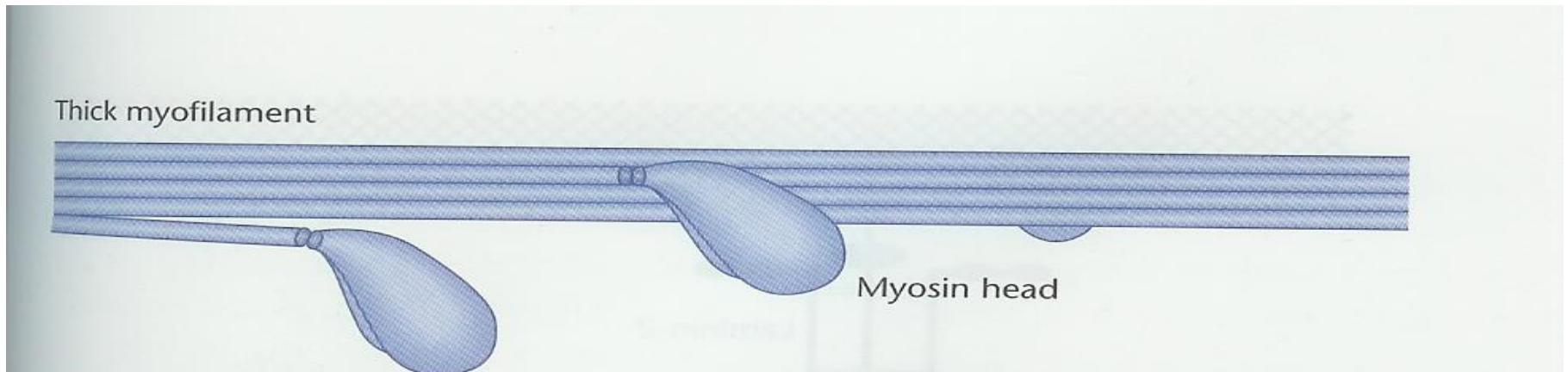
Structure of skeletal muscles

✓ Cell structure

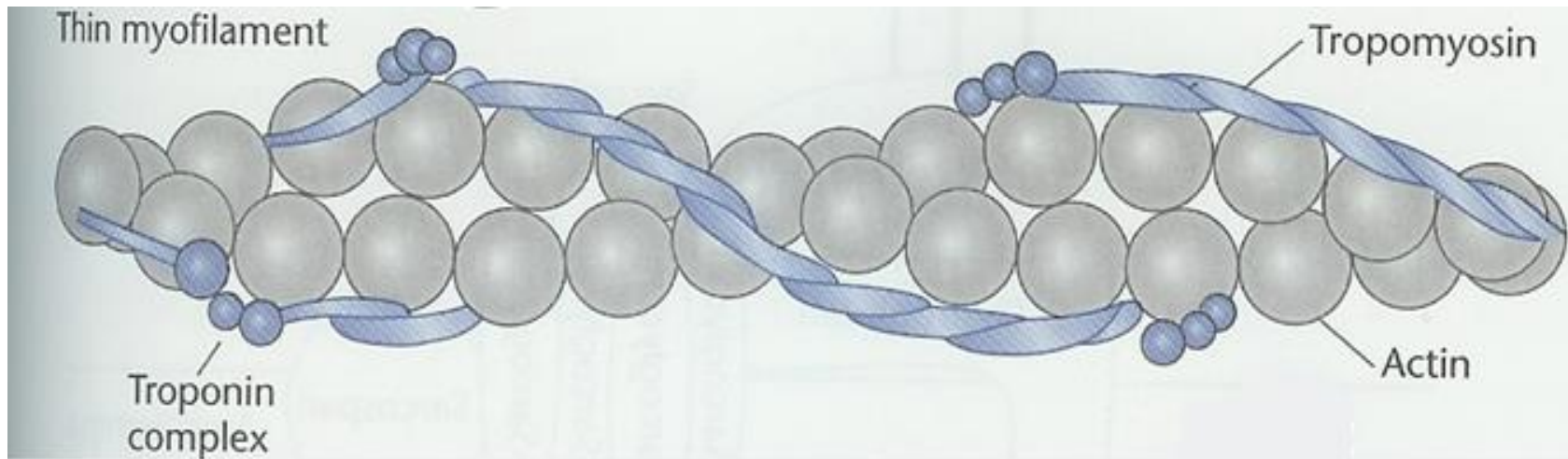
- Muscles cells contain many nuclei
- The plasma membrane → *sarcolemma*
- The cytoplasm → *sarcoplasm*
- Length
 - ranges from 0.1cm to more the 30cm in length
- Diameter
 - ranges from 0.001cm to 0.01cm in diameter
- Myofibrils →
 - elongated protein molecules
 - aligned in parallel arrangements
 - extend the full length of the cell.

Myofibril

- ✓ The myofibril consists of protein chains called **myofilaments**
 - Myofilaments have a symmetrical, alternating pattern of thick and thin elements.
- Thick myofilament consists of a large number of bundled **myosin molecules** aligned in overlapping arrays. Hexameric proteins with two identical heavy chains and two pairs of different light chains.

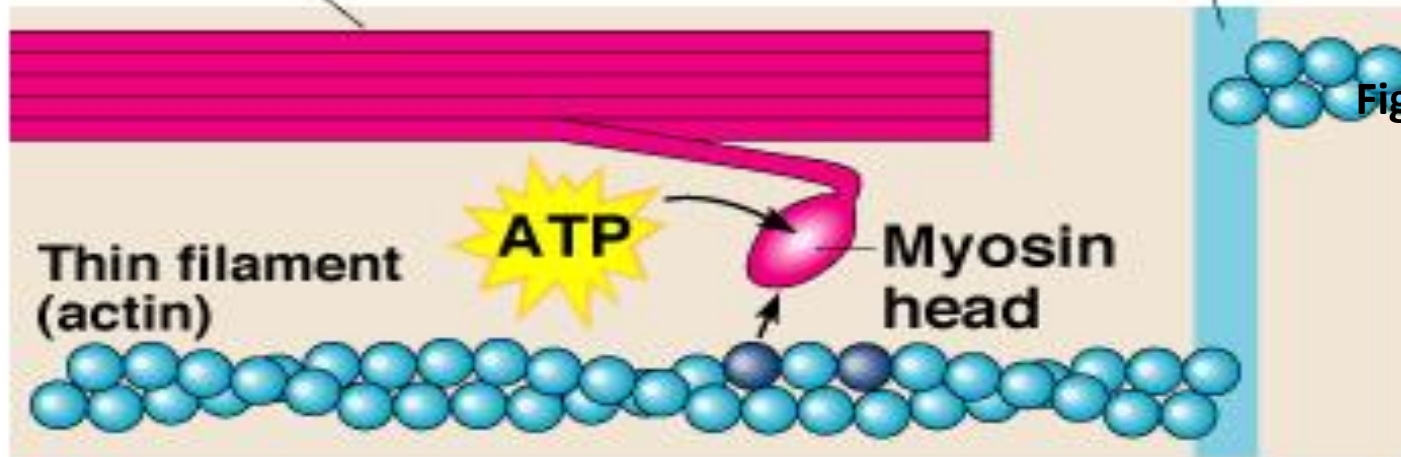


- ✓ The thin myofilament (F-actin, filamentous actin) made up of two helically intertwined chains of G-actin (globular actin) units.
- ✓ Other proteins that bind to the actin molecules:
 - ❖ Tropomyosin
 - ❖ The Troponin complex → made up of three members

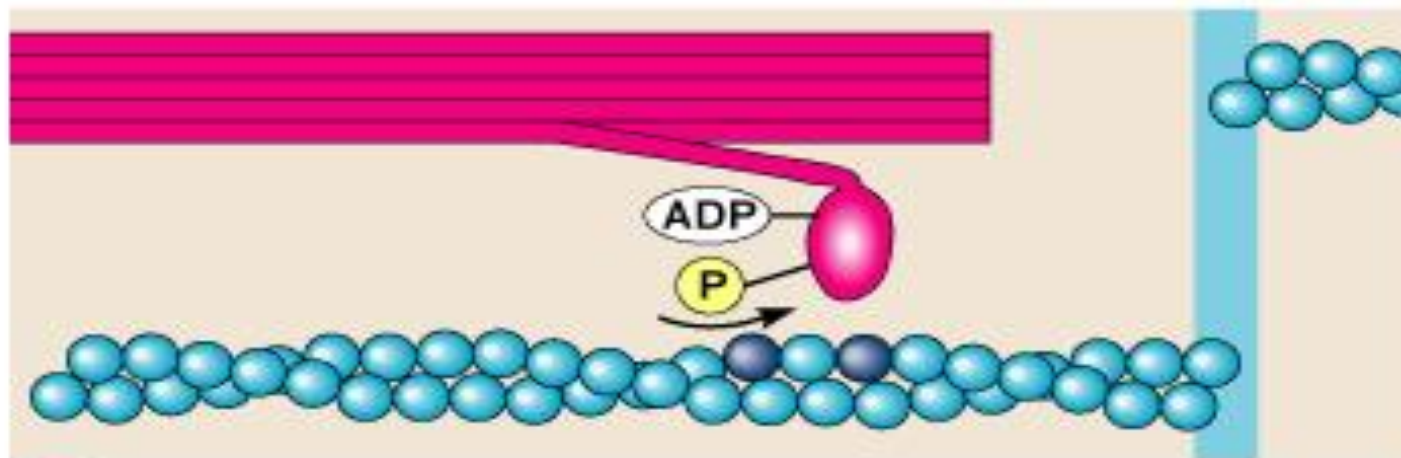


Thick filament (myosin)

Z line



- 1 ATP binds to a myosin head, which is released from an actin filament.



- 2 Hydrolysis of ATP cocks the myosin head.

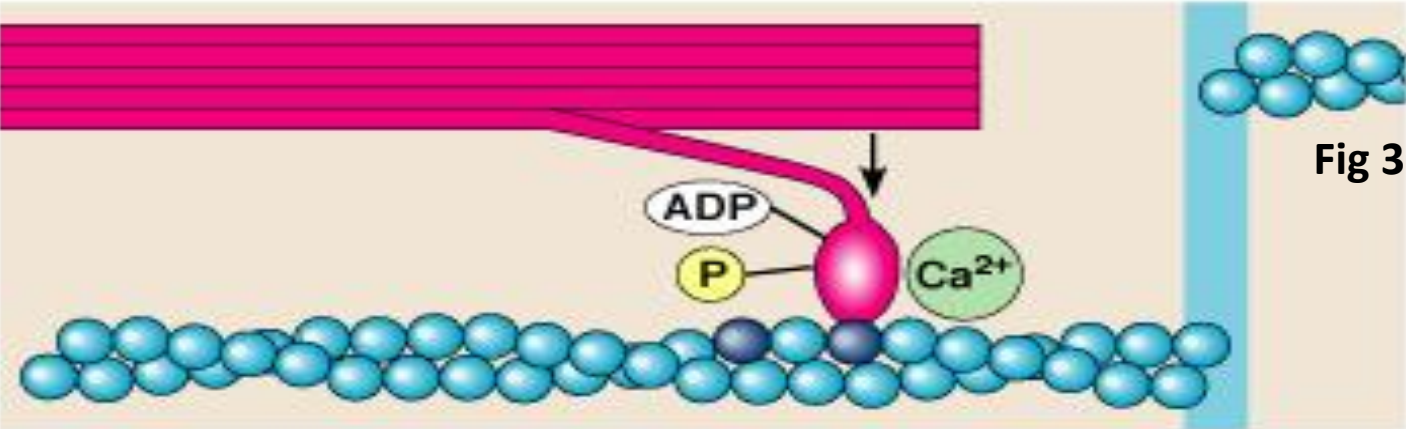
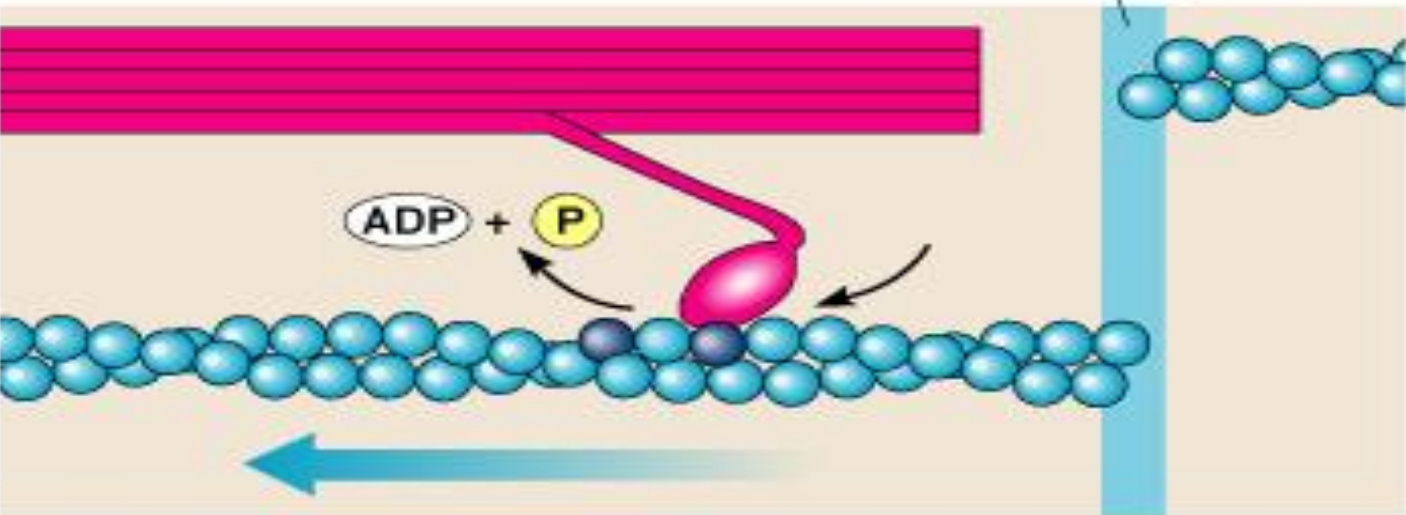
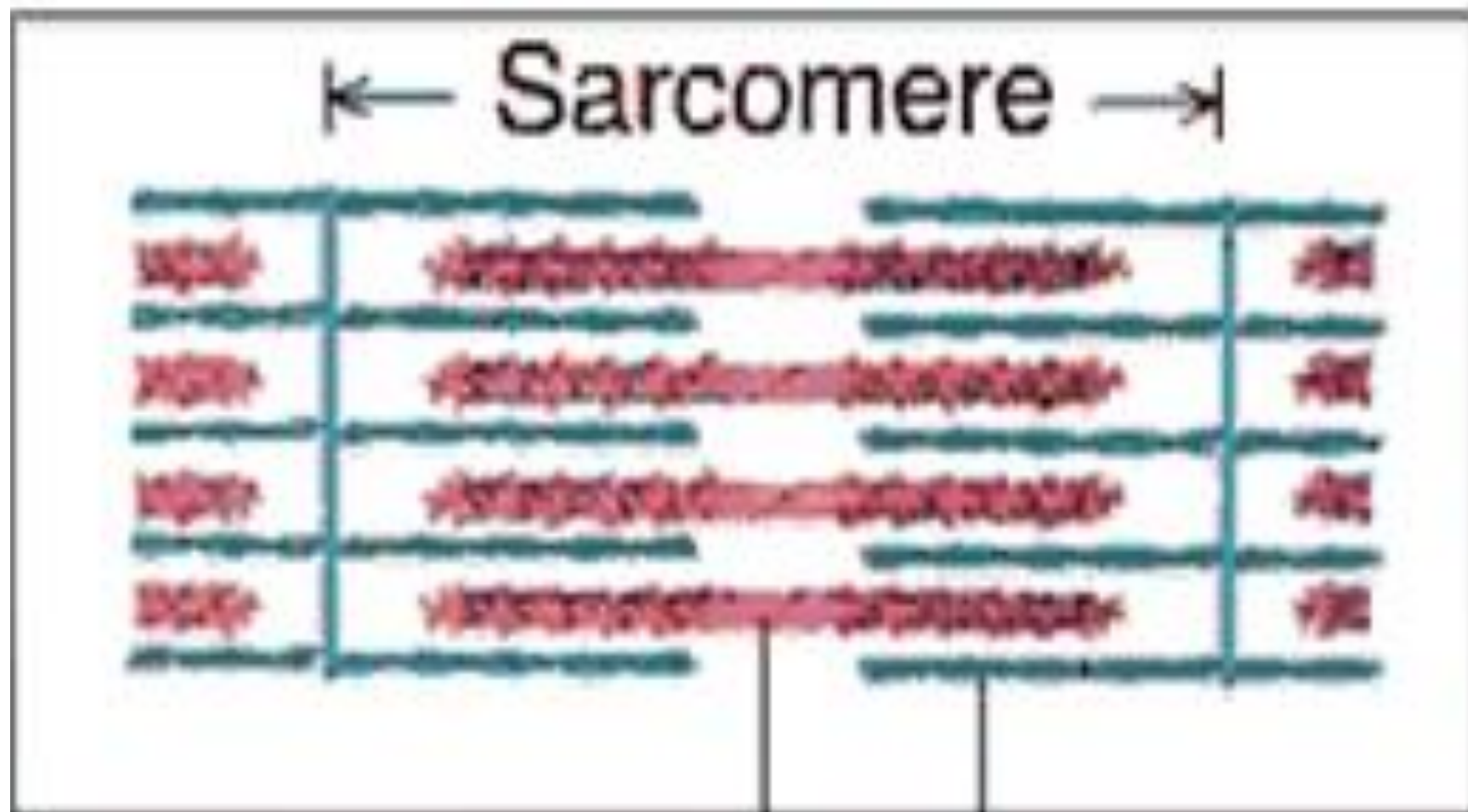


Fig 30.9B

3 The myosin head attaches to an actin binding site, with the help of calcium. **New position of Z line**



4 The power stroke slides the actin (thin) filament.



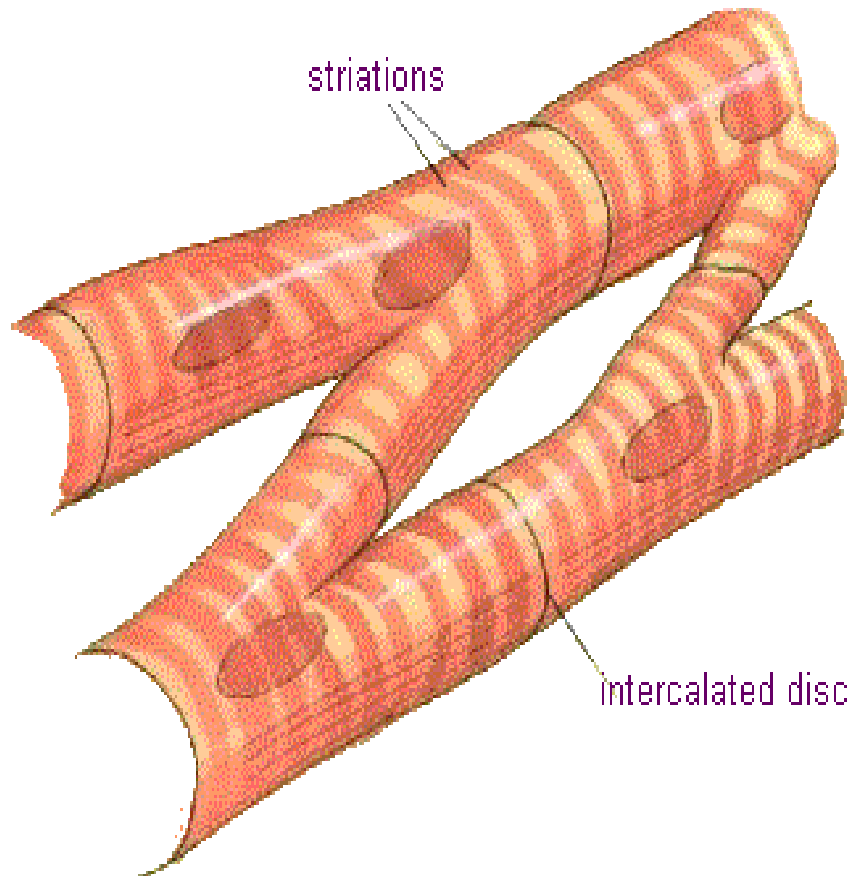
Thick filaments

Relaxation of skeletal muscle

- ✓ Calcium ions are carried away from the myofilaments
- ✓ Myosin- actin linkages loosen
- ✓ The troponin complex and tropomyosin bind to the myosin binding sites on the F-actin subunits.
- ✓ Myosin and F- actin myofilaments return to their original positions

Cardiac & Smooth Muscle

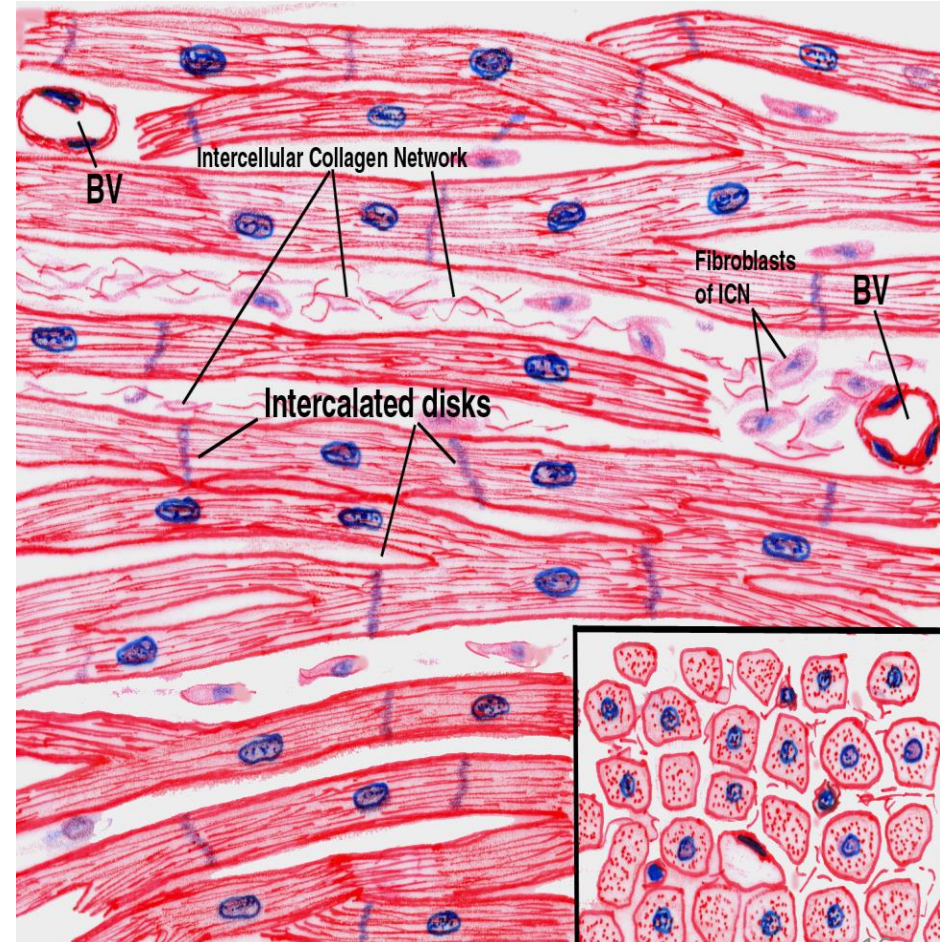
Cardiac muscle cell



- Involuntary and striated muscle
- Cardiocyte = Muscle Cell of the Heart
- Short, thick, branched cells
- Each cell has only 1 nucleus

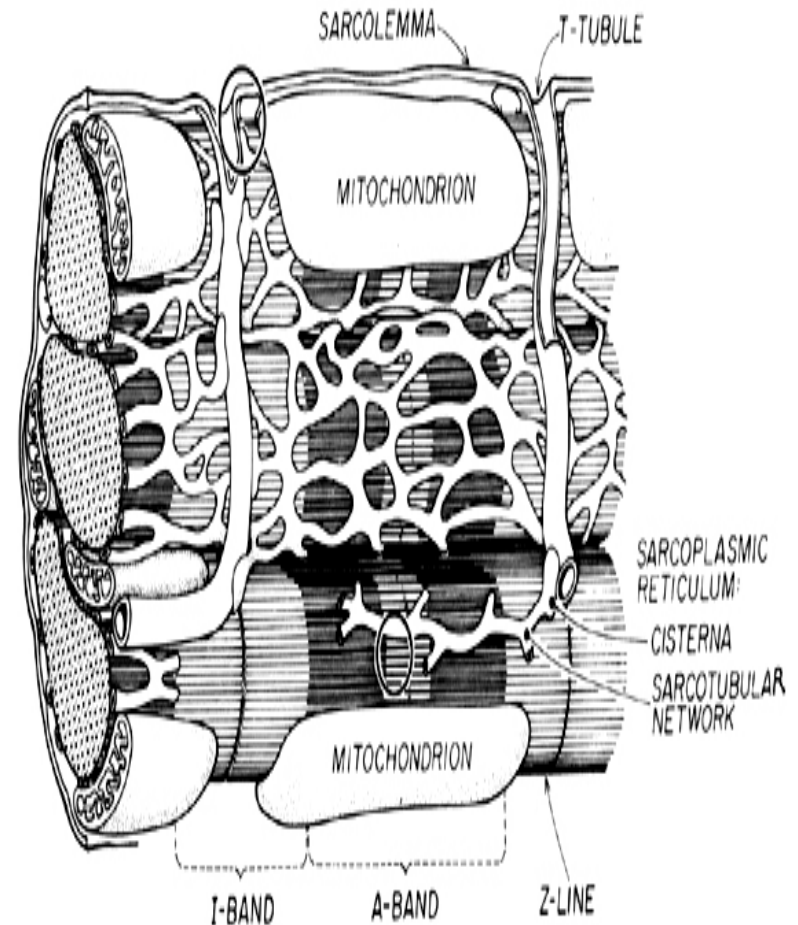
Cardiac muscle

- ~10-20 μm in diameter
- ~50-100 μm in length
- Each cell joined by Intercalated Disks.
- No Neuromuscular Junctions

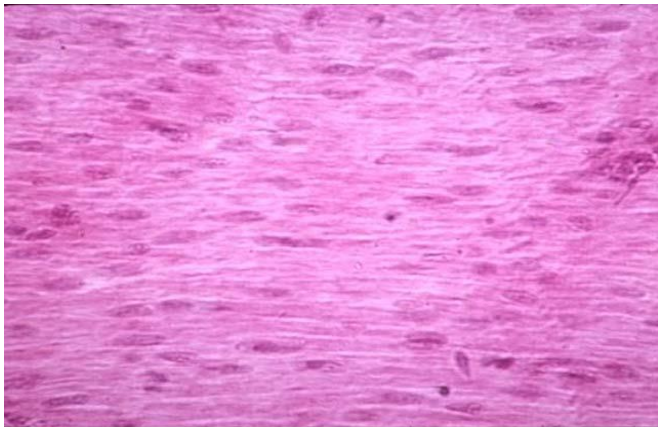
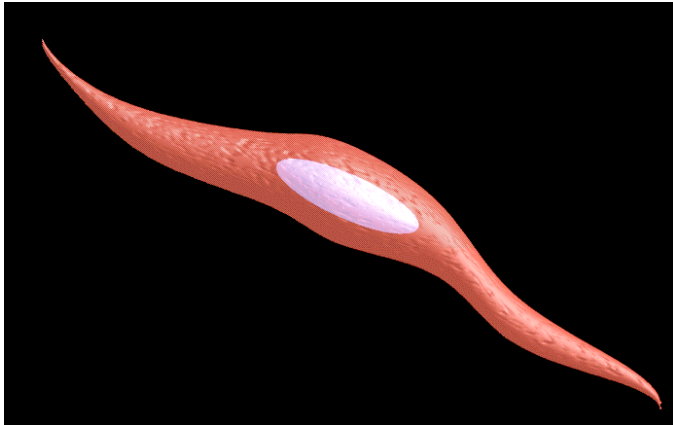


Cardiac muscle

- Contain Large Mitochondria
- Proteins of Cardiac Muscle are similar to Skeletal Muscle
- Mechanism of Contraction similar to Skeletal Muscle
- Fatigue Resistant



Smooth muscle

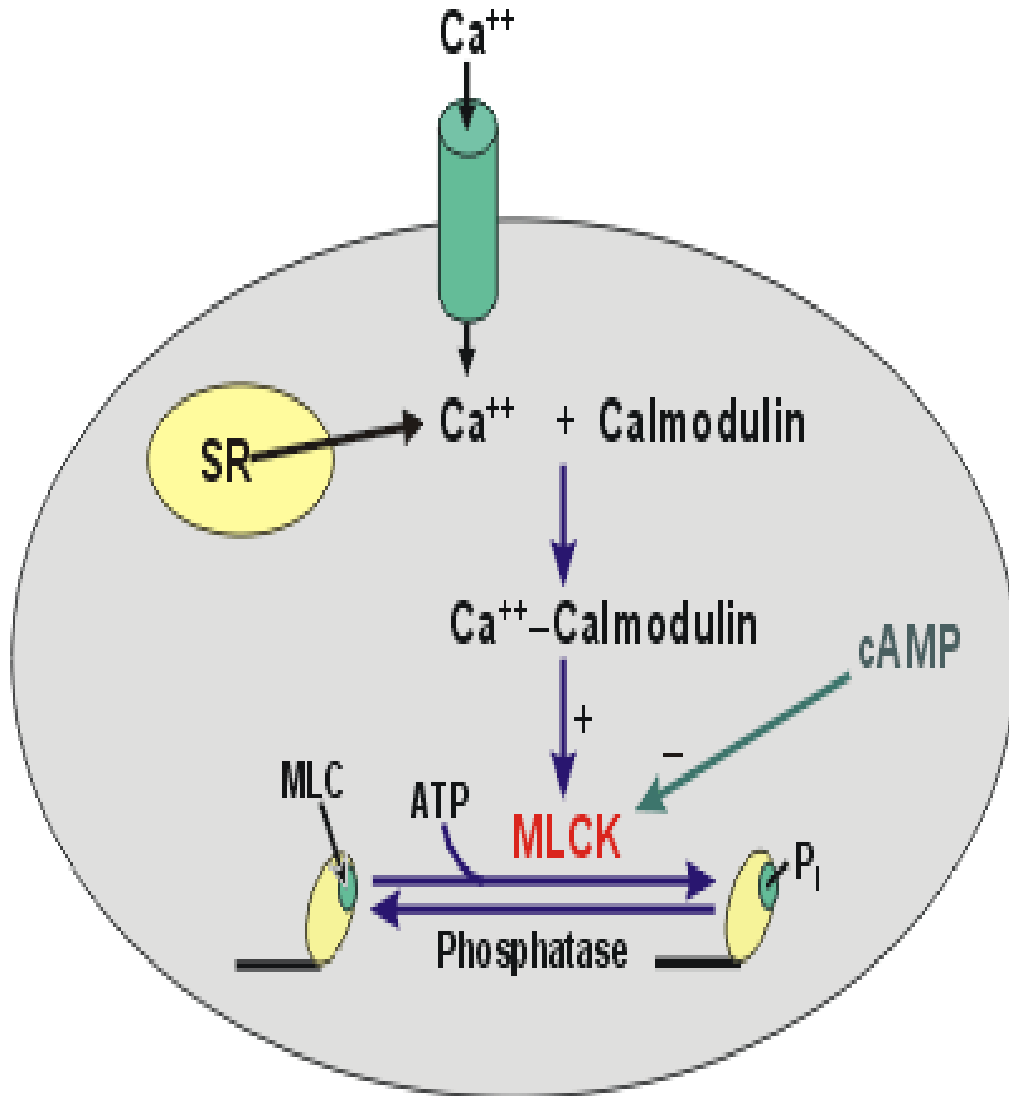


- Long, spindle-shaped cells
- No Striations or Sarcomeres
- Single centrally located nucleus
- Sarcolemma possess invagination called caveolae
- Dense bodies and intermediate filaments
- Actin and Myosin filaments not in sarcomeres
- Found in hollow organs e.g esophagus, stomach, small and large intestine, urinary bladder, blood vessels, bronchioles, arrector pili muscles
- Autonomic nervous system

Types of smooth muscle

1. **Single-unit:** one neuron extensively connect to many cells. These cells are connected by gap junction, gross control of movements. Found in stomach, intestines, bladder , blood vessels,
2. **Multi-unit :** Each cell is supplied by at least one or more neurons. Cells can contract independently of its neighboring cells. Found in arrector pilli muscle, muscles of the iris.

Smooth muscle



- Increase intracellular calcium ions
- Calcium-Calmodulin Complex.
- MLCK Phosphorylation
- Contraction
- Dephosphorylation by Myosin Phosphatase
- Interaction of Myosin with Actin same as in Skeletal and Cardiac Muscle.

Thank you