



Faculty of Veterinary
and Agricultural
Sciences

Contraction of Cardiac and Smooth Muscle

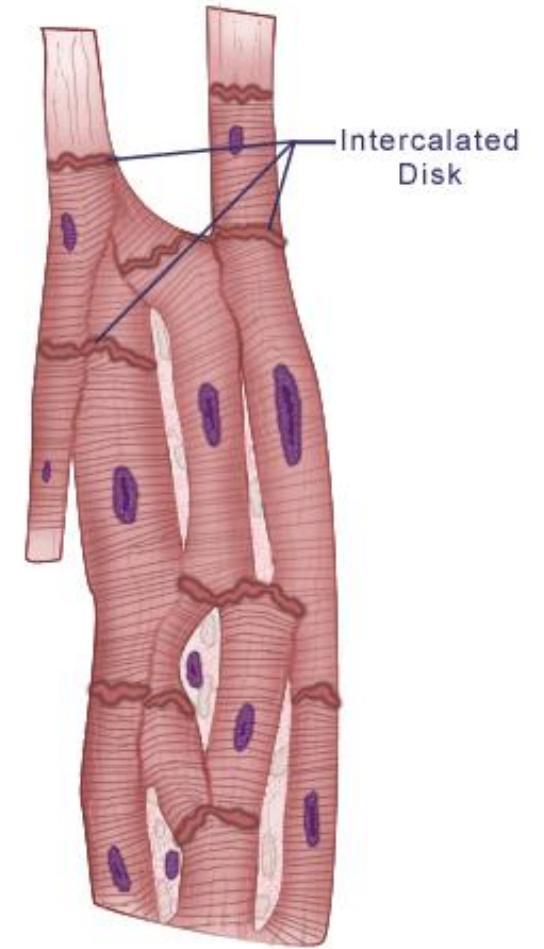
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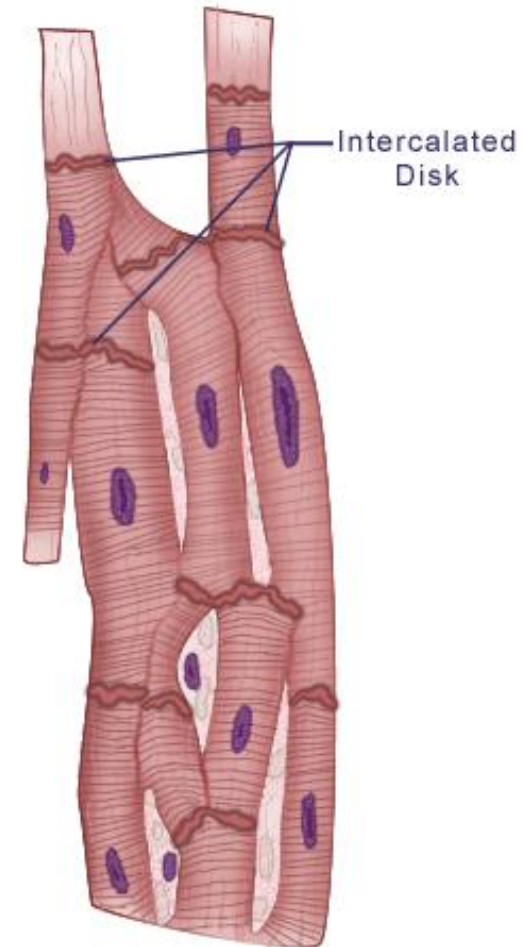
Cardiac muscle contraction

- **Similar to skeletal muscle**
 - Contractile force generated by sarcomere
 - Role of calcium
- **Differences**
 - Not initiated by neuronal input
 - All cells are electrically coupled
 - Long action potential



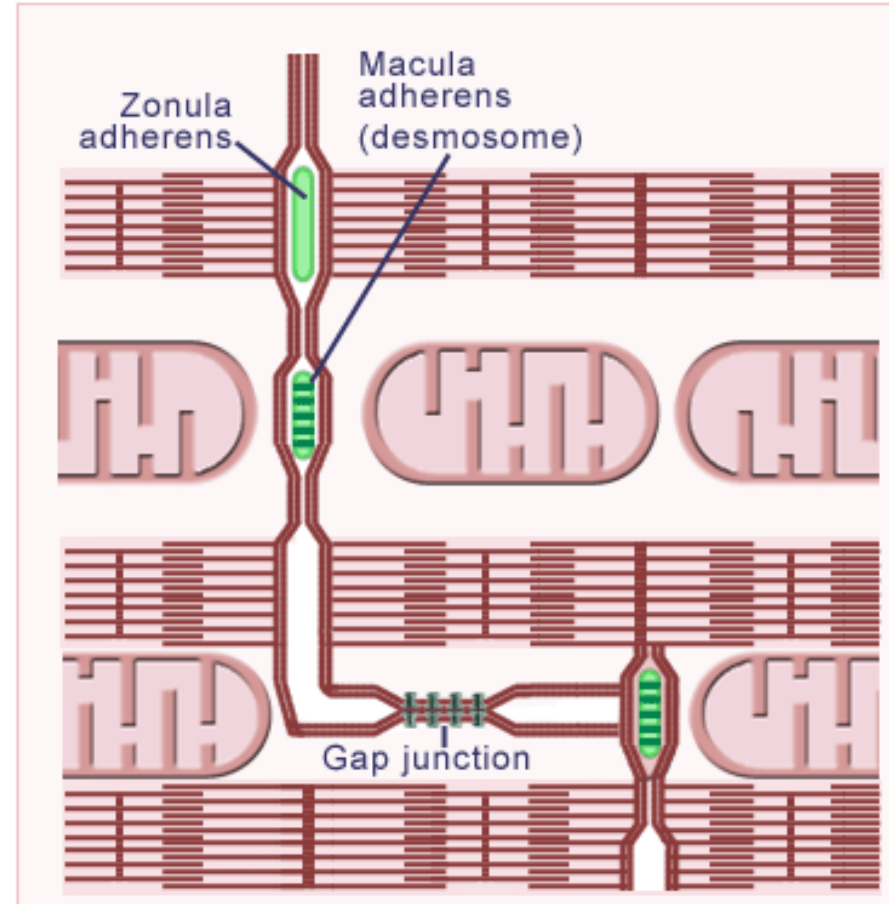
Structure of cardiac muscle

- Mononucleate muscle cells
- Relatively short fibres
- Branching and interdigitate
- Arranged in series and parallel
- Z lines, M lines, A bands, I bands are present



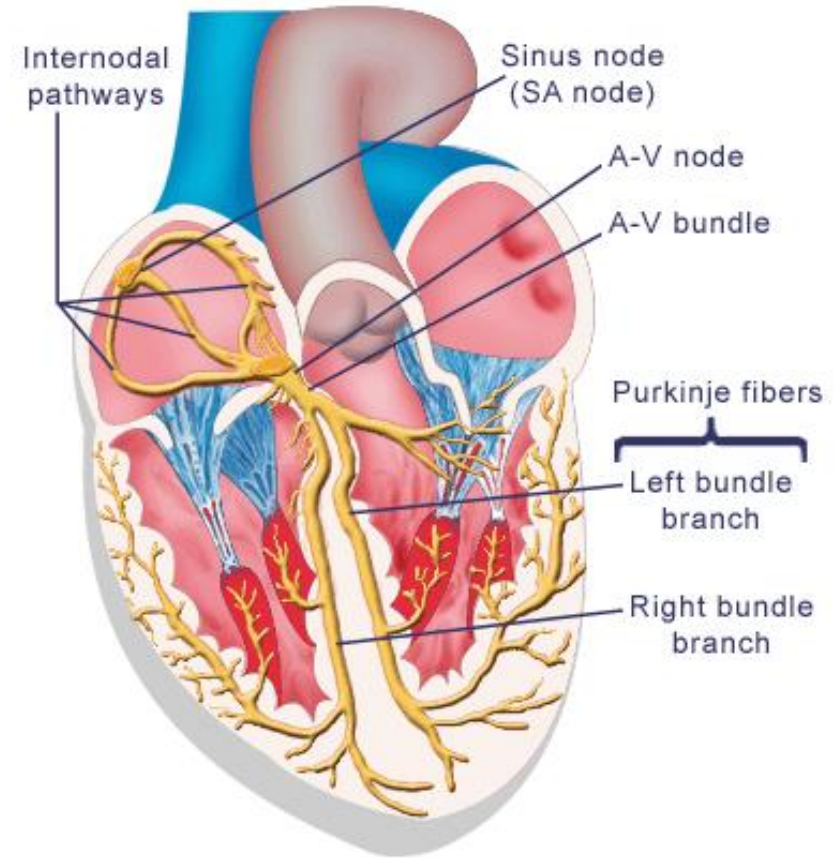
Intercalated Disk

- Two regions
 - Transverse portion, aligned with Z line, desmosomes, mechanical cohesion
 - Lateral portion, parallel to myofilaments, rich in gap junctions, low resistance pathways



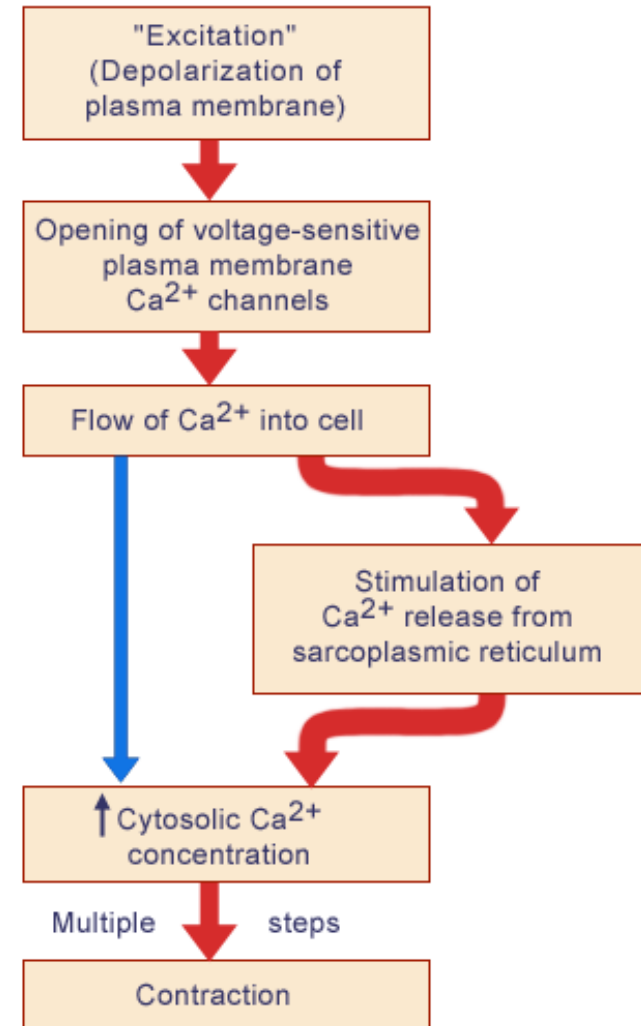
Three (3) types of heart muscle cells

1. Cells of myocardium
2. Rhythmically active self excitatory “pacemaker” cells
3. Purkinje fibres, specialised conducting pathways which enhance spread of localised excitation



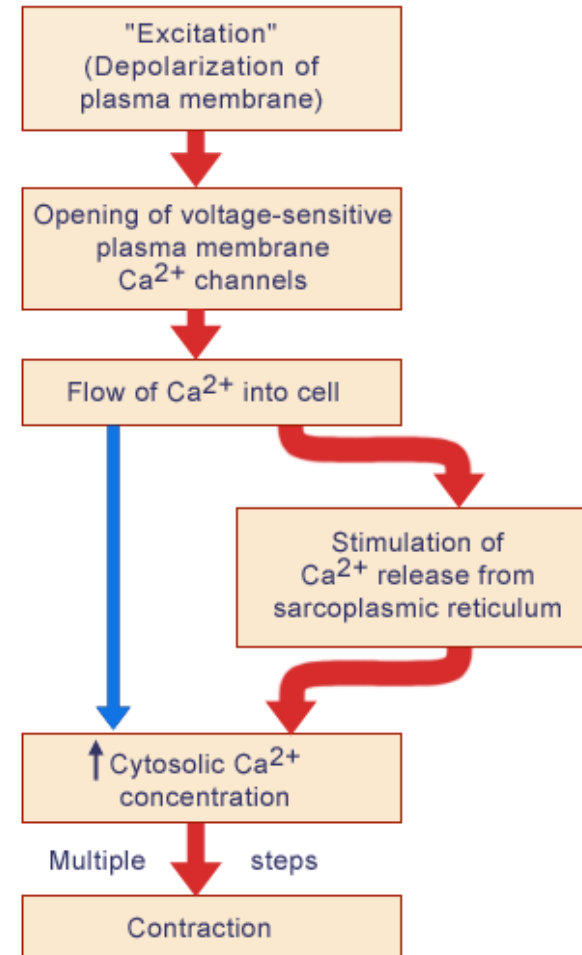
Excitation contraction coupling

- AP spreads along plasma membrane and invades T tubules
- This opens voltage sensitive Ca^{++} channels in T-tubule membrane
- Diffusion of extra-cellular calcium



Excitation contraction coupling

- Extracellular Ca^{++} stimulates release of Ca^{++} from SR
- Results in contraction (systole)
- Strength of contraction dependent on presence and concentration of extracellular Ca^{++}



Cardiac muscle force - Contractility

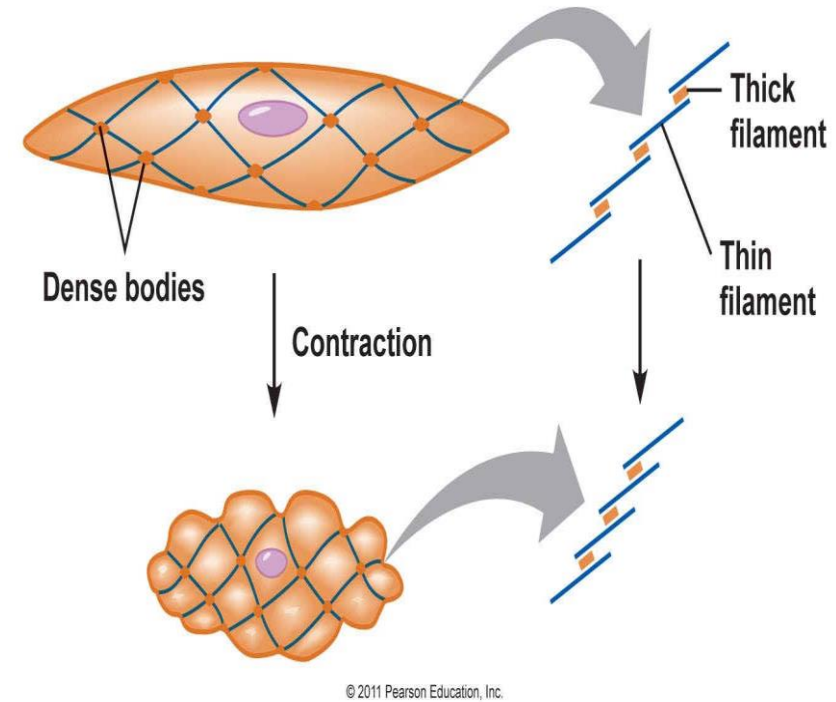
- Influenced by
 - Ca^{++} levels
 - Hormones (epinephrine)
 - Nervous (autonomic)
 - Extent of stretch
 - Cardiac muscle operates in a range of lengths shorter than optimal

Smooth Muscle Contraction

- Contraction is mediated by actin and myosin cross-bridge cycling
- Undefined sarcomere structure
- Cells bound together by basement membrane and transmits force
- Lack T-tubules
 - Small membrane invaginations called caveoli
 - SR if rudimentary

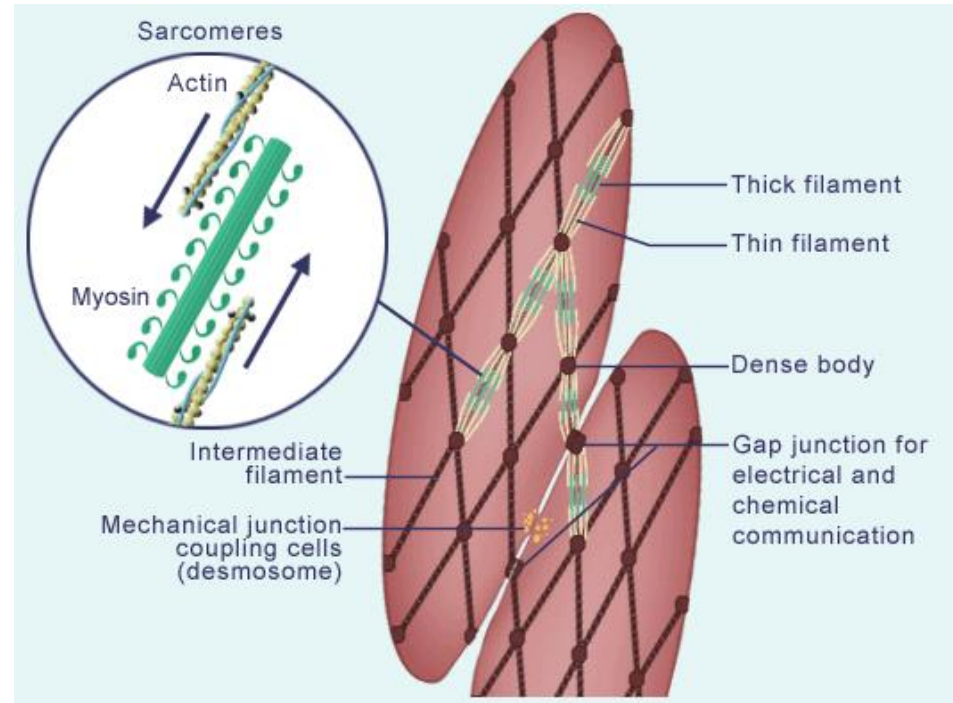
Dense bodies

- Actin filaments attached to dense bodies
- Dense bodies are attached to membrane
- Linked by diagonal network of intermediate filaments (desmin)



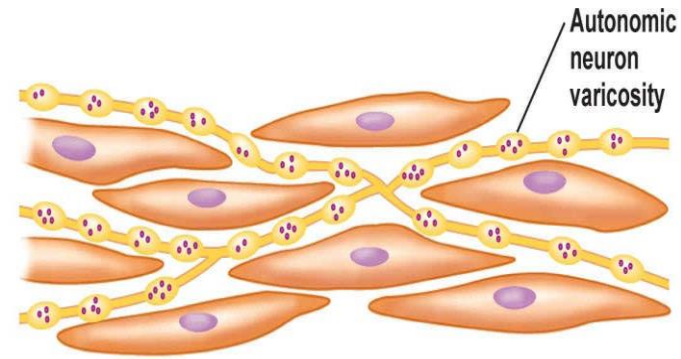
Smooth Muscle

- Thick filaments
 - Myosin
- Thin filaments
 - Actin, tropomyosin and calmodulin
 - **NO Troponin**
- Myosin heads along entire length

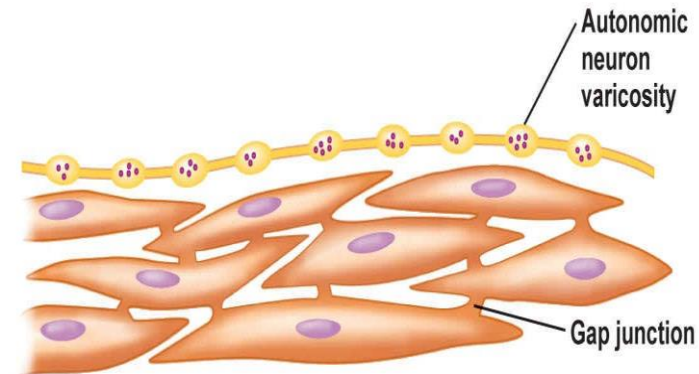


Multi-unit Smooth Muscle

- Individual cells
- Discrete innervation
 - Individual activity
- Few gap junctions
- Poor response to stretch
- Minimal response to hormones
- Ciliary muscle of eye, large airways of lung



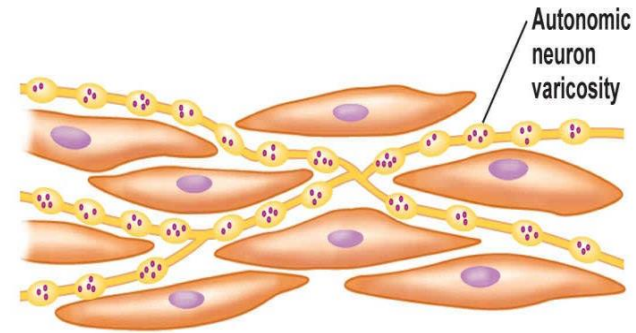
(a) Multi-unit smooth muscle



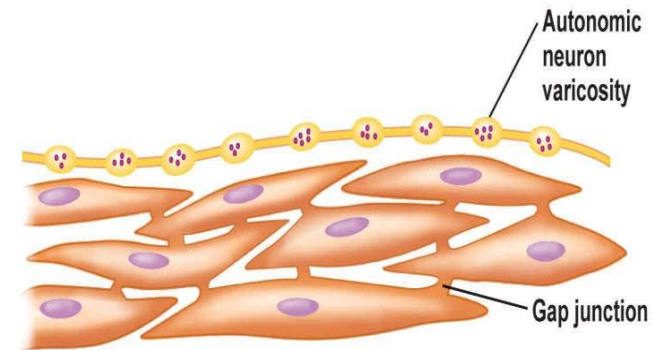
(b) Single-unit smooth muscle

Single-Unit Smooth Muscle

- Visceral (function not anatomy)
- Network of closely apposed cells acting as a single unit
- Direct stimulation of only a few
- Multiple adherence points (desmosomes)
- Linked electrically by gap junctions



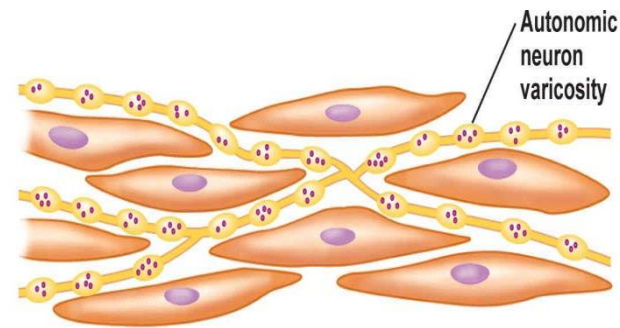
(a) Multi-unit smooth muscle



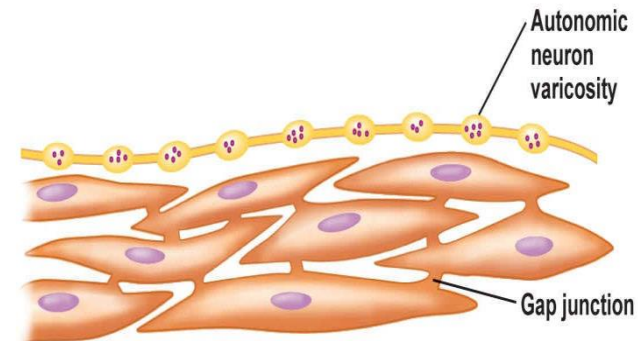
(b) Single-unit smooth muscle

Single-Unit Smooth Muscle

- Respond to
 - Neural signals
 - Hormones
 - Mechanical stretch
 - Local “pacemaker” potentials
- Muscles of uterus, intestinal tract, bile duct, small blood vessels



(a) Multi-unit smooth muscle



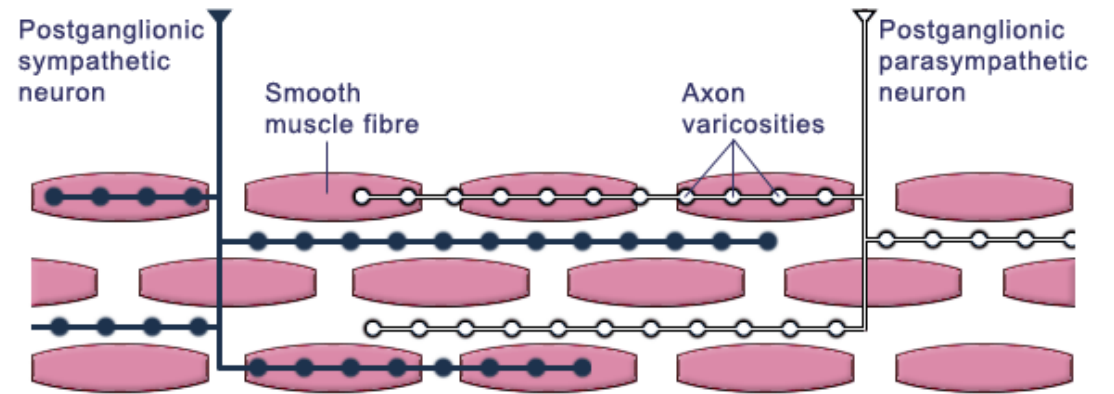
(b) Single-unit smooth muscle

Innervation

- Three types
 - Extrinsic: both sympathetic and parasympathetic
 - Intrinsic: short neurons forming plexuses (networks) with tissue
 - Afferent sensory: autonomic reflexes

Innervation

- No neuromuscular junction
- Branching of fibres with “varicosities” that contains vesicles with neurotransmitter (both acetylcholine and nor-epinephrine)
- Neurotransmitter is released into interstitial fluid and then diffuses
- Potential for both sympathetic and parasympathetic input
- Modulatory rather than inducing



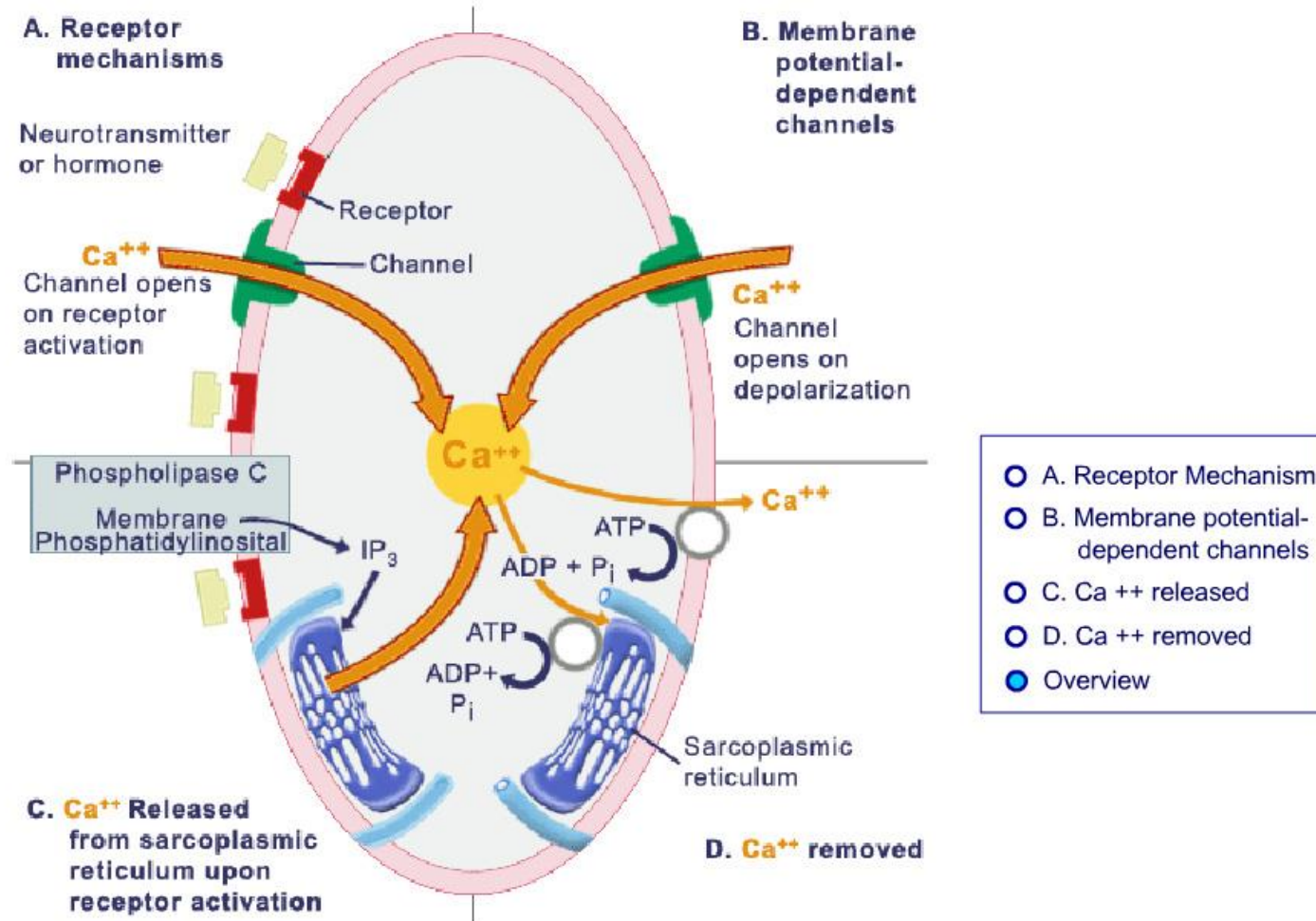
Non-neural activation

- Hormones can open and/or close ion channels changing membrane potential
- Chemical stimuli can cause release of Ca^{++} from SR without a change in membrane potential
- Other influences
 - Decreased oxygen, pH, body temperature

Ca⁺⁺ regulation of smooth muscle contraction

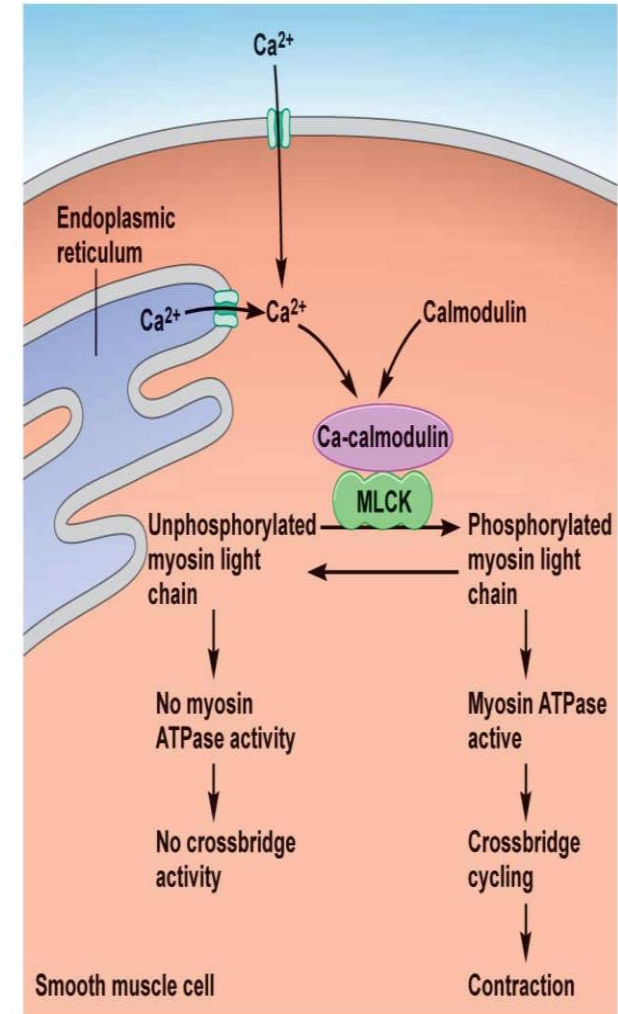
- Ca⁺⁺ regulates cross bridge formation and thus cycling
- BUT different from skeletal muscle
 - Control of Ca⁺⁺ levels
 - Influence on cross bridge formation (myosin)

Control of cytosolic Ca^{++}

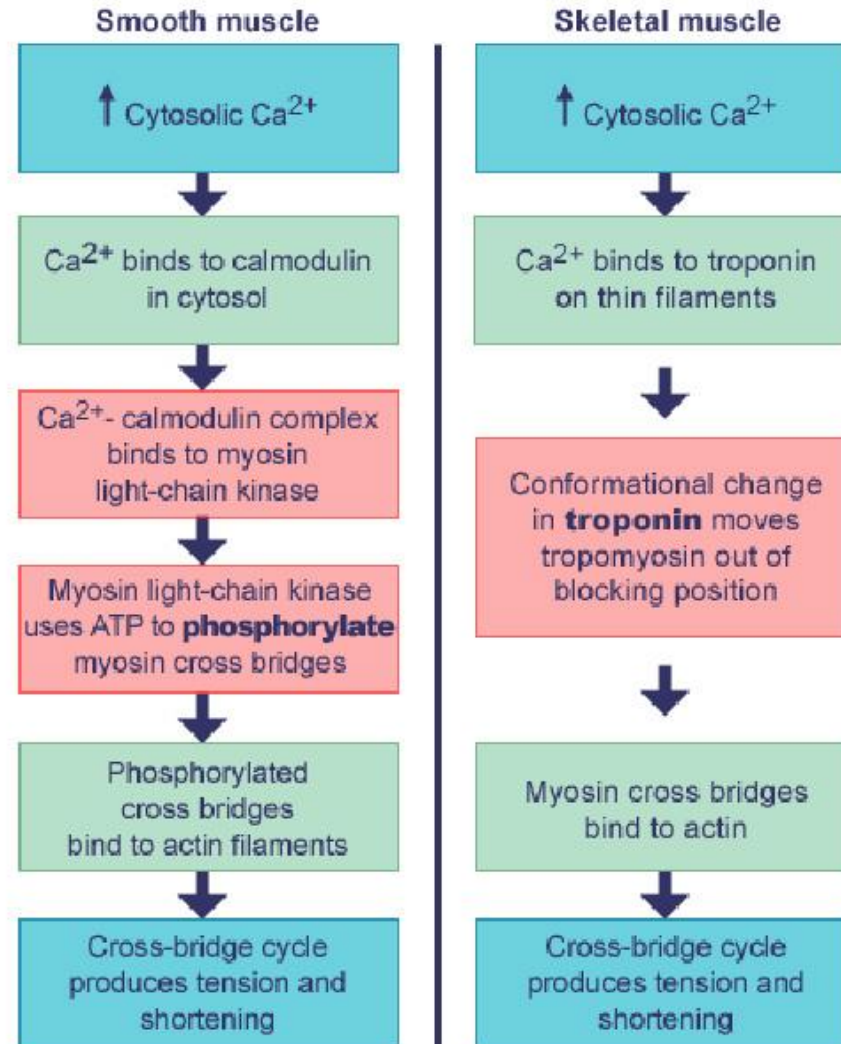


Ca^{++} and the cross bridge

- Smooth muscle lacks troponin
- Cross bridge binding modulated by Ca^{++} dependent phosphorylation of myosin



Ca⁺⁺ and the cross bridge





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