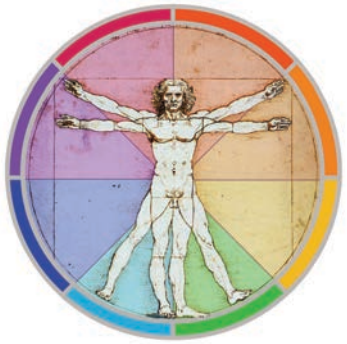
HUBS191 Lecture Material

This pre-lecture material is to help you prepare for the lecture and to assist your note-taking within the lecture,

it is NOT a substitute for the lecture !



Please note that although every effort is made to ensure this pre-lecture material corresponds to the live-lecture there may be differences / additions.

HUBS191

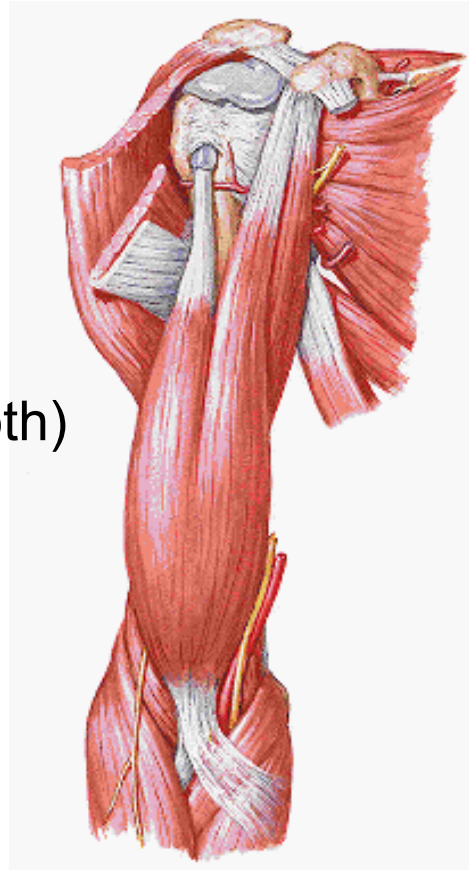
Physiological
Principles of Human Movement and Sensation

Dr Regis Lamberts

Lecture 25 – Skeletal Muscle: Structure and function

Topics of Today's Lecture

1. Why do we need muscle? (skeletal, cardiac, smooth)
2. The Structure of Skeletal Muscle
3. The Motor Unit
4. Mechanism of Contraction of Skeletal Muscle

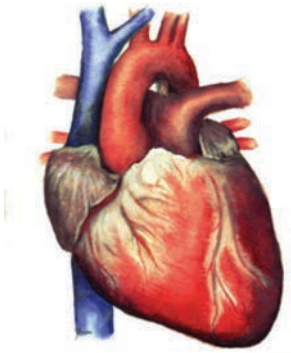


Anatomy Resource Collection, University of Otago, 2011

1. Why do we need muscle ?

Cardiac Muscle

Pumping of blood



Smooth Muscle

To control the movement of fluids
(blood, urine, digestion, …)

1. Why do we need muscle ?

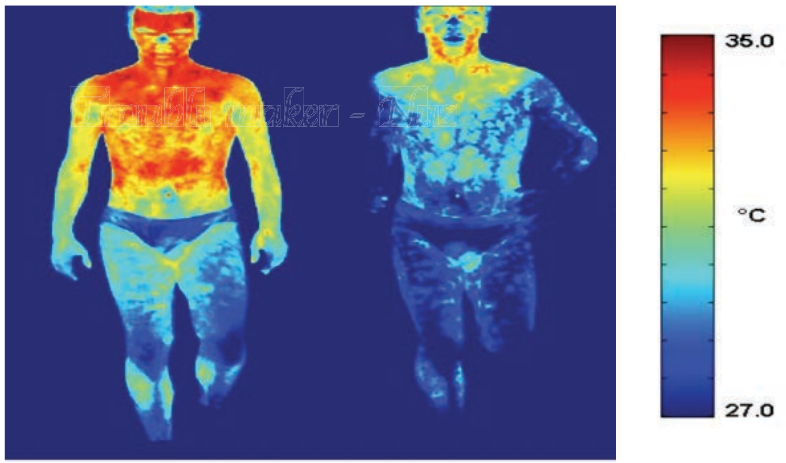
Skeletal Muscle

To move

To maintain posture

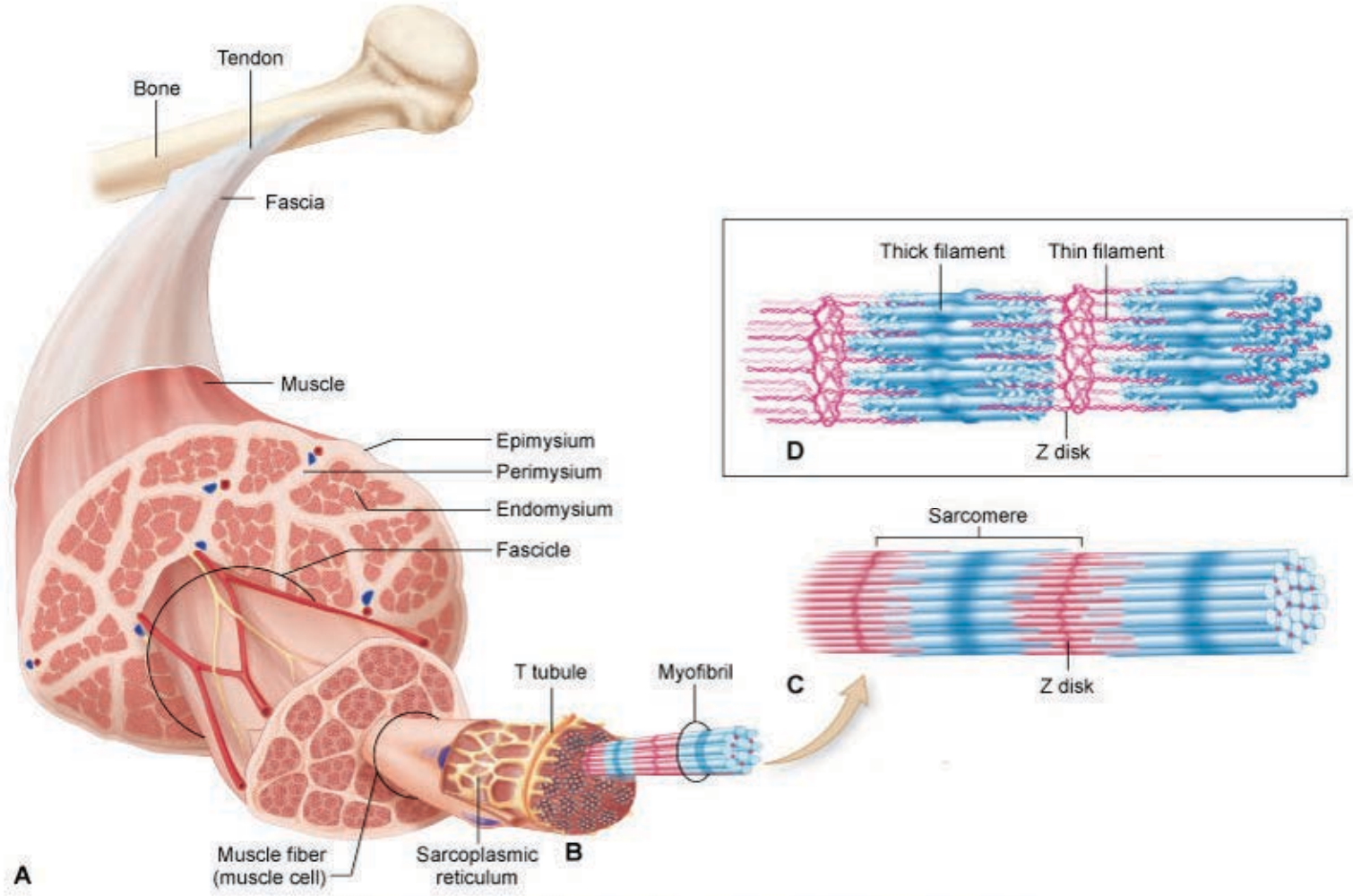
To generate heat

(numerous, highly active)



Active Inactive

2. Structure of Skeletal Muscle



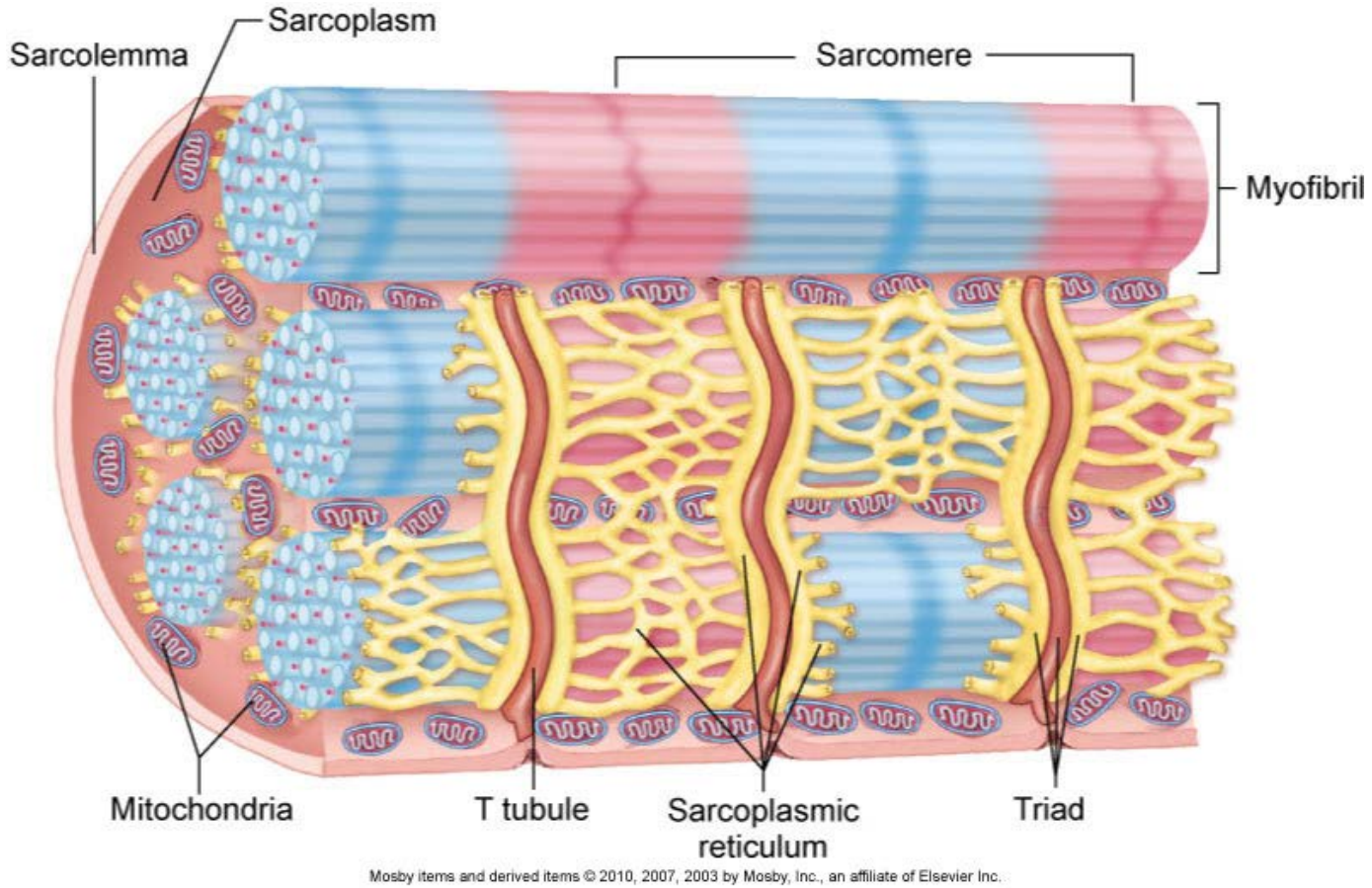
Muscle – muscle bundle – muscle cell – myofibril – sarcomere – myofilaments

myocyte

muscle fibre

Fig 12-1, p. 349 Thibodeau & Patton 8th edition

2. Skeletal Muscle: Muscle Cell



Sarcolemma = Plasma membrane of the muscle cell
Sarcoplasm = Cytoplasm of the muscle cell

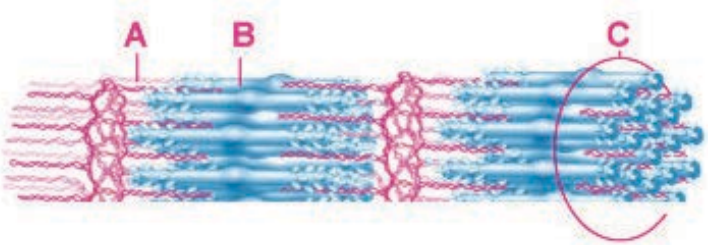
Sarcoplasmic Reticulum = SR, internal calcium store
T-tubule = transverse tubule, invaginated sarcolemma
Triad = T-tubule sandwiched between two SR

Muscle cell = contains >1000 myofibrils
Myofibril = contains 15,000 sarcomeres
Sarcomere = myofilament between two Z-disks = basal contractile unit

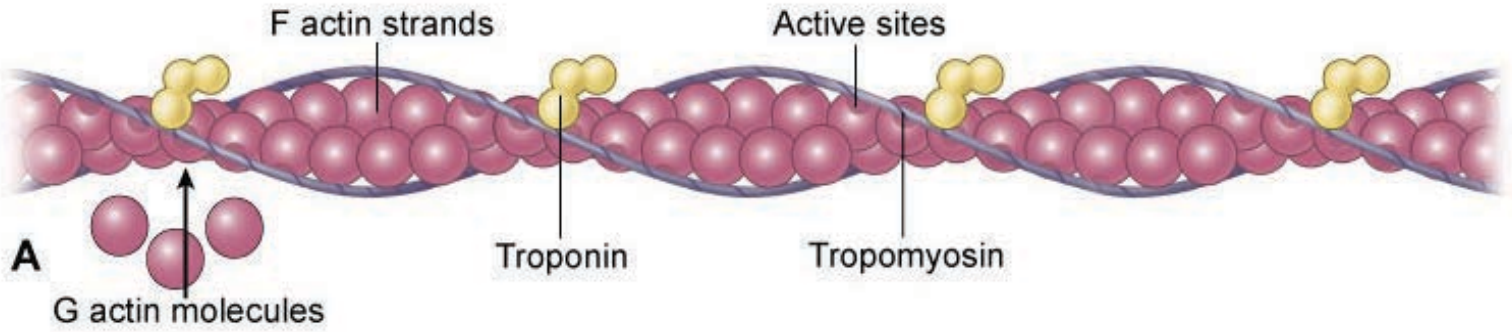
Mitochondria = energy production

Fig 12-2, p. 349 Thibodeau & Patton 8th edition

2. Skeletal Muscle: Myofilaments



Thin filament – actin, tropomyosin, troponin



Thick filament – myosin, myosin heads

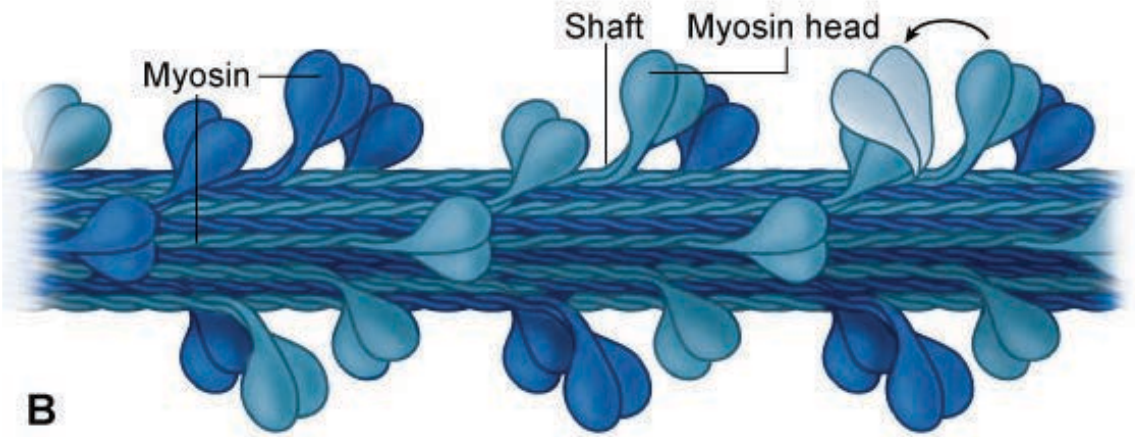
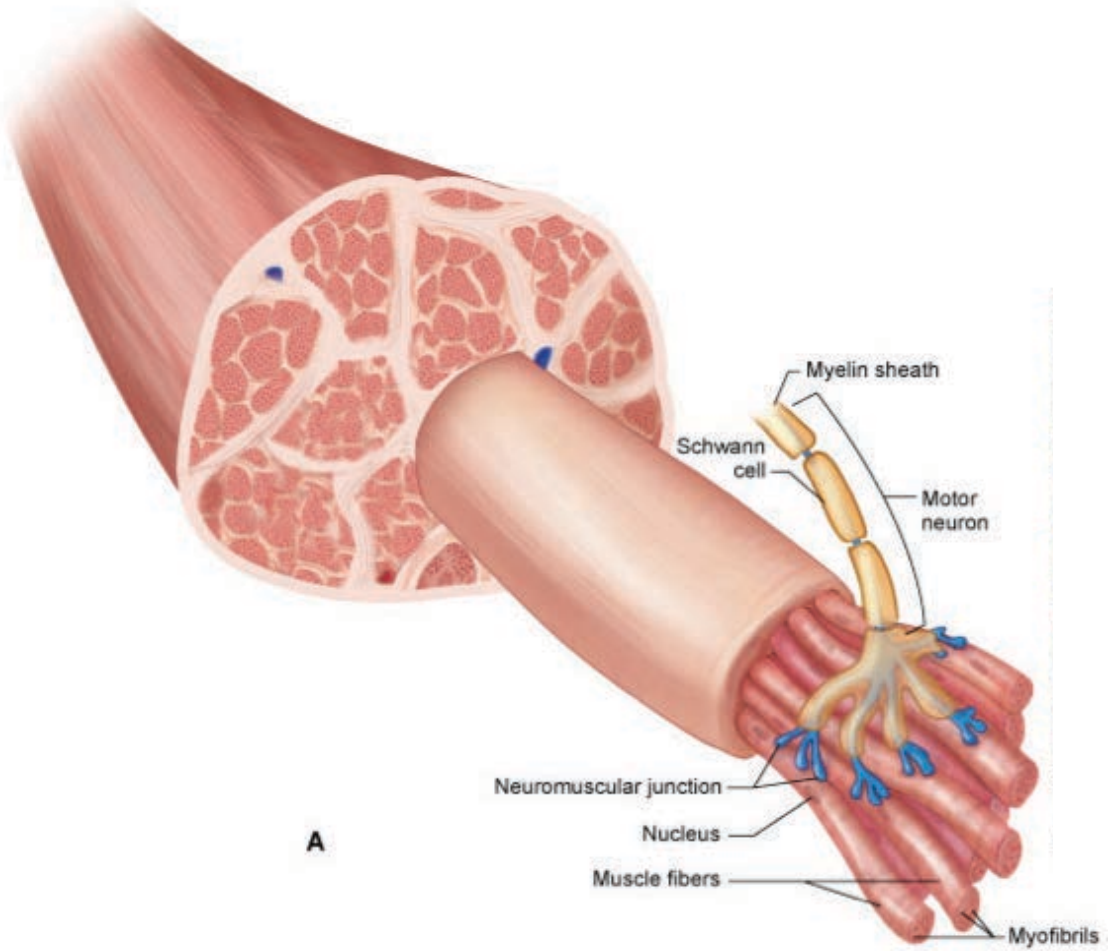
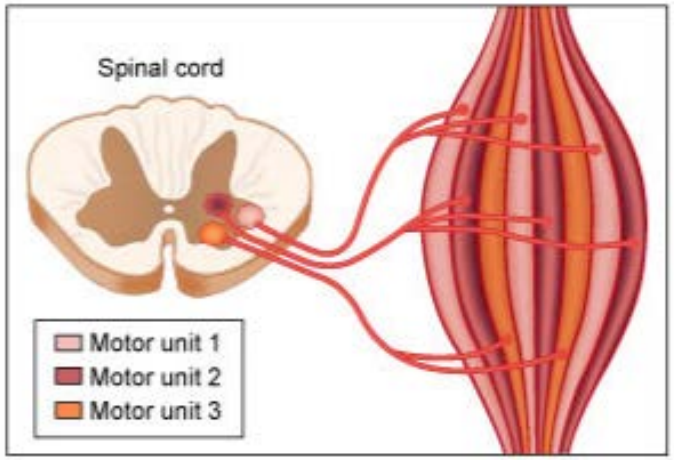


Fig 12-5, p. 352 Thibodeau & Patton 8th edition

3. The Motor Unit

Motor Unit: one somatic Motor Neuron and Muscle Fibres innervated by its branches



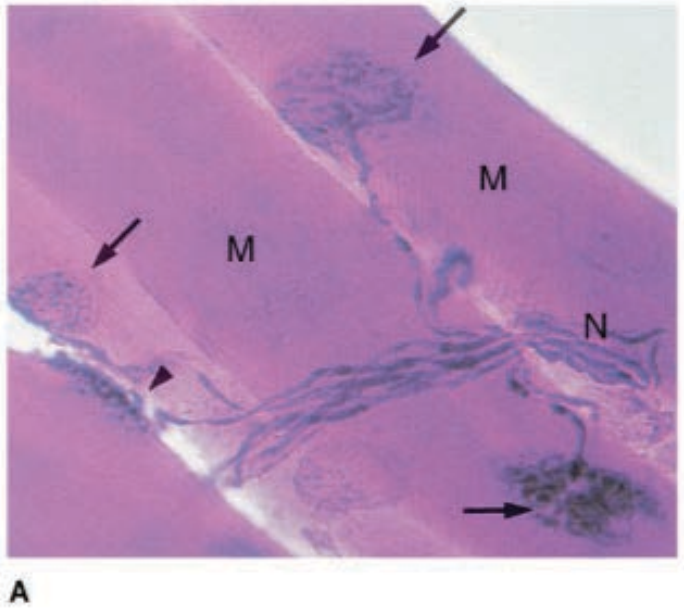


A Muscle Fibre is innervated by only one Motor Neuron

One Motor Neuron innervates multiple Muscle Fibers (# indicates precision of function)

Fig 12-18, p. 360 Thibodeau & Patton 8th edition

3. Motor Unit: NeuroMuscular Junction



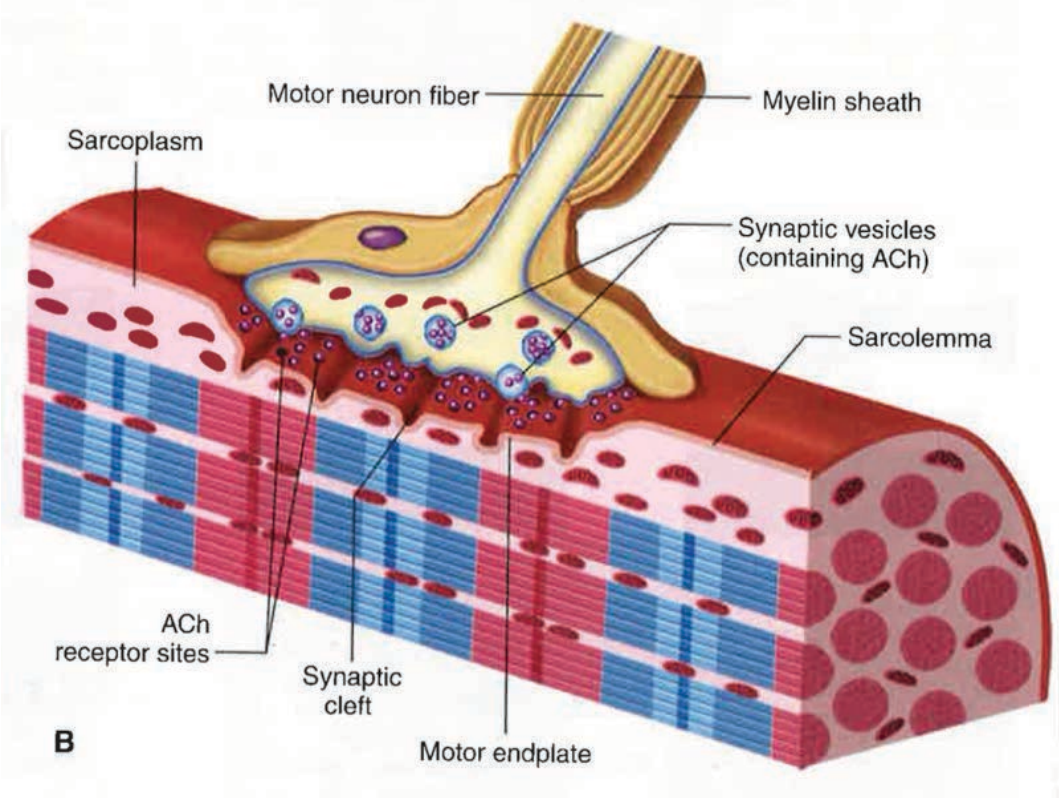
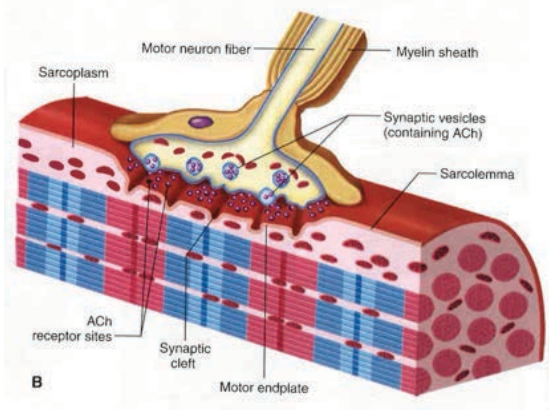


Fig 12-7, p. 352 Thibodeau & Patton 8th edition

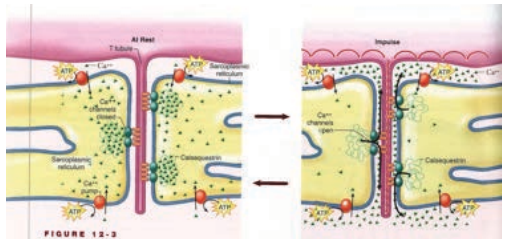
Example Question!

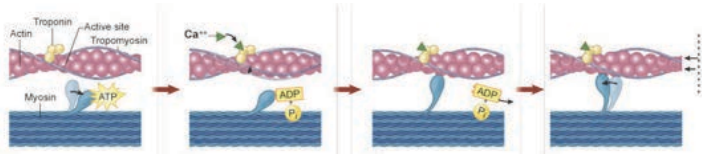
4. Mechanism of Contraction of Skeletal Muscle

1. Excitation
   - Neuronal Action Potential
   - Acetylcholine (Ach) release from nerve terminal
   - Action Potential on Muscle Fibre



2. Contraction
   - Ca^{2+} release from the internal Ca^{2+} store
   - Crossbridge formation of myofilaments
   - Contraction – Sliding filaments

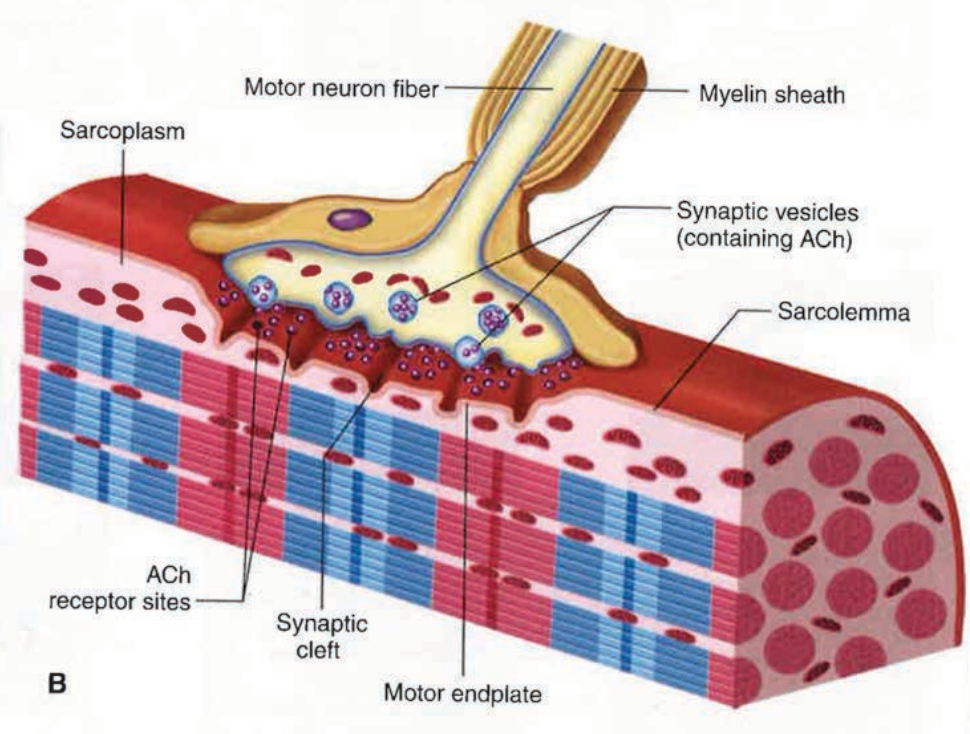


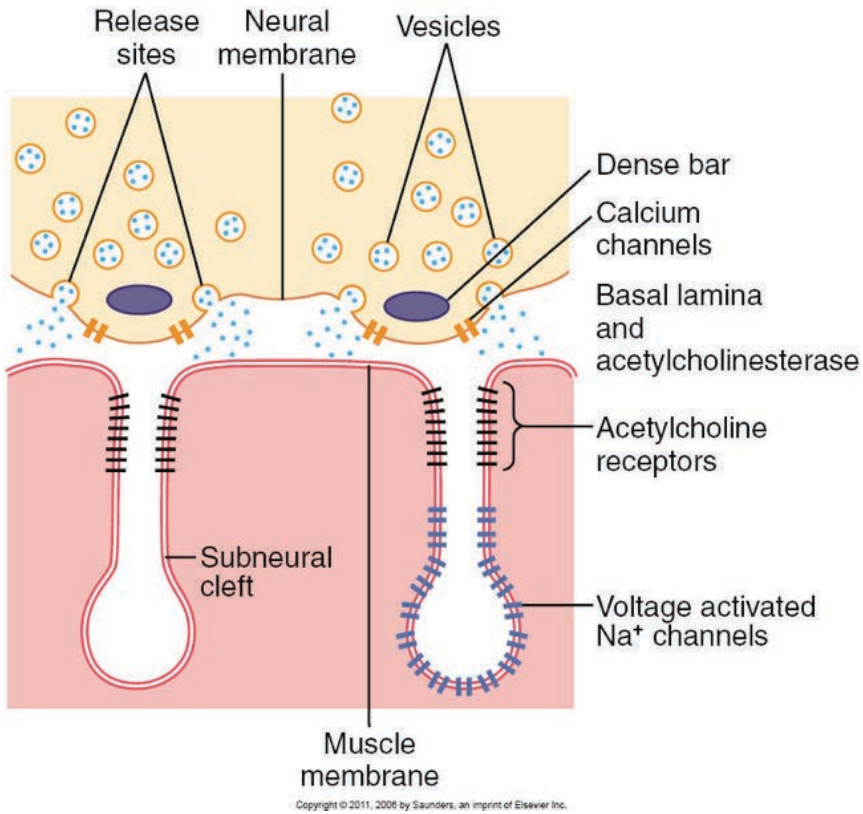


3. Relaxation
   - Ca^{2+} re-uptake into internal Ca^{2+} store
   - Uncoupling crossbridge

Fig 12-8, p. 354 Thibodeau & Patton 8th edition

4.1 Excitation



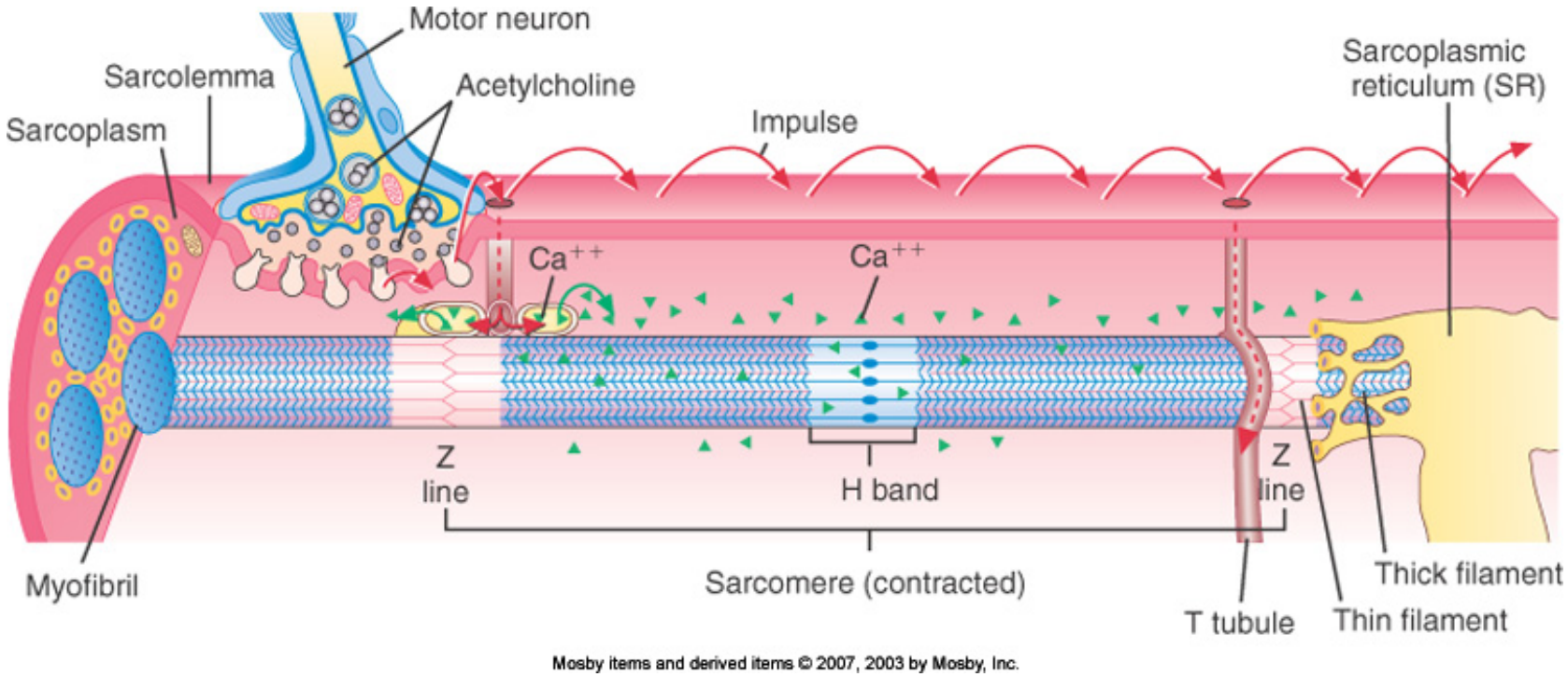


- AP reaches end of motor neuron, which causes Ca^{2+} entry into nerve terminal
- Synaptic vesicles release ACh, which diffuses into synaptic cleft
- ACh stimulates ACh-receptors on the adjacent muscle fibre
- Depolarisation of muscle sarcolemma, initiating an action potential
- Electro – Chemical – Electro coupling

Fig 12-7, p. 352 Thibodeau & Patton 8th edition

Fig 7.2, Guyton and Hall - Medical Physiology, 12th Edition

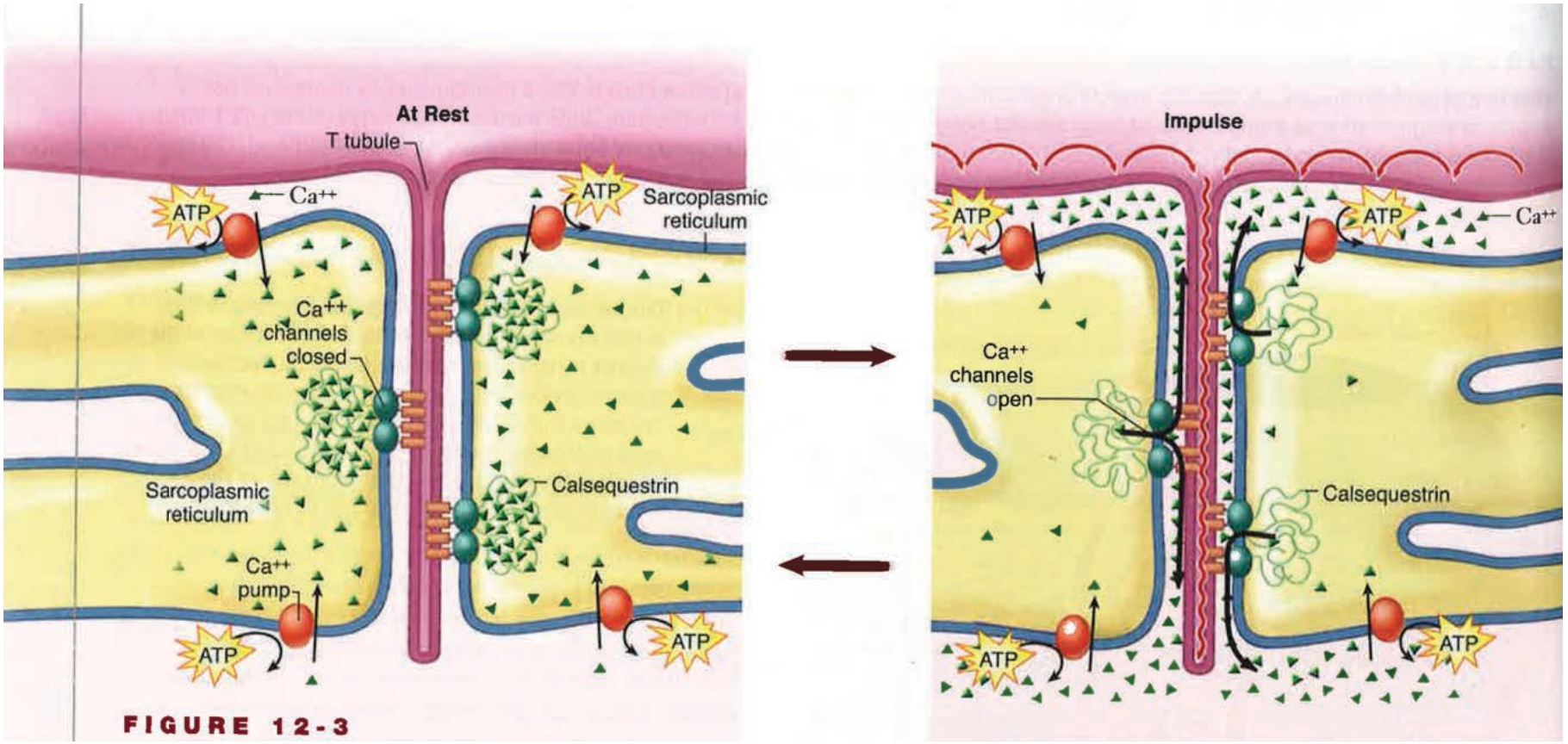
4.2 Excitation-Contraction



- AP travels over sarcolemma and T-tubules, triggering release of Ca^{2+} ions from the adjacent sarcoplasmic reticulum (SR)

Fig 12-8, p. 354 Thibodeau & Patton 8th edition

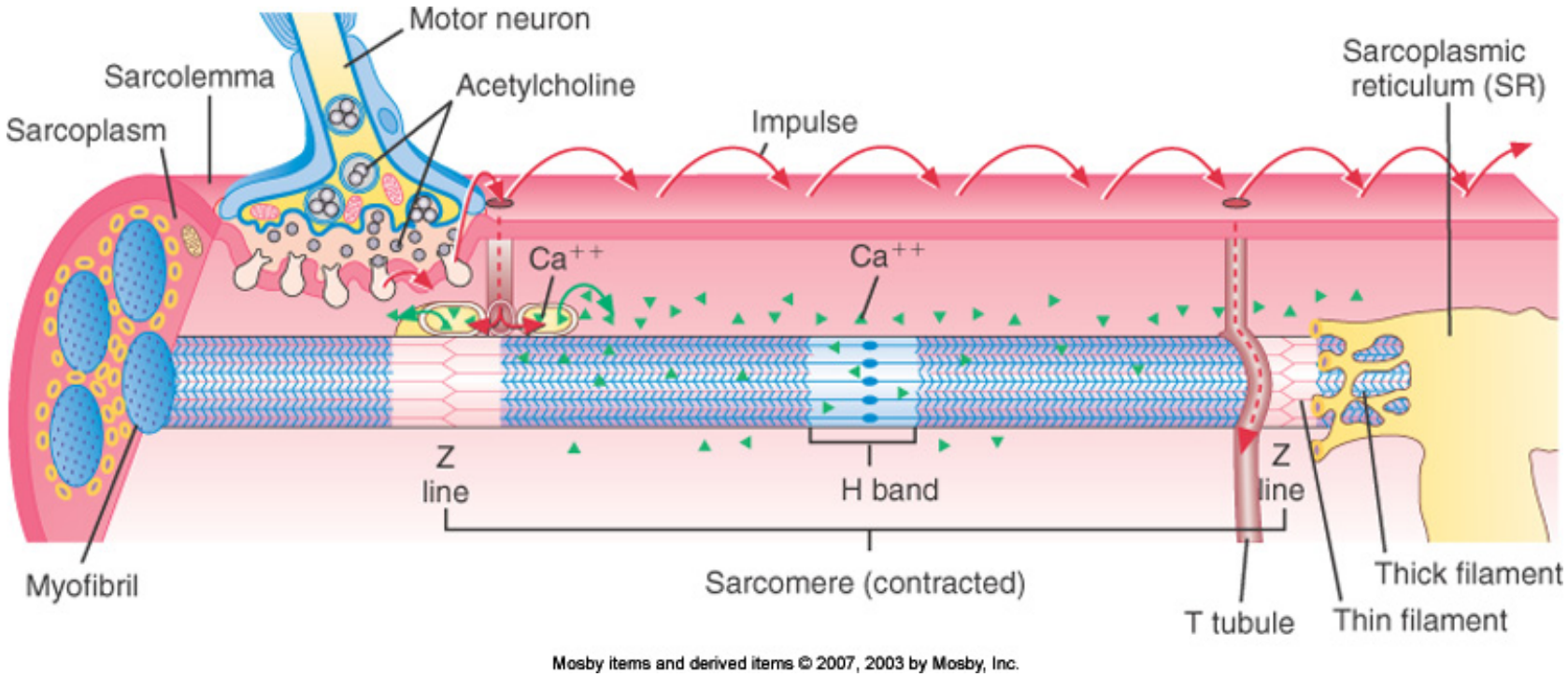
4.2 Contraction



- AP travels over the T-Tubules, triggering release of Ca^{2+} ions from the adjacent sarcoplasmic reticulum (SR)

Fig 12-3, p. 350 Thibodeau & Patton 8th edition

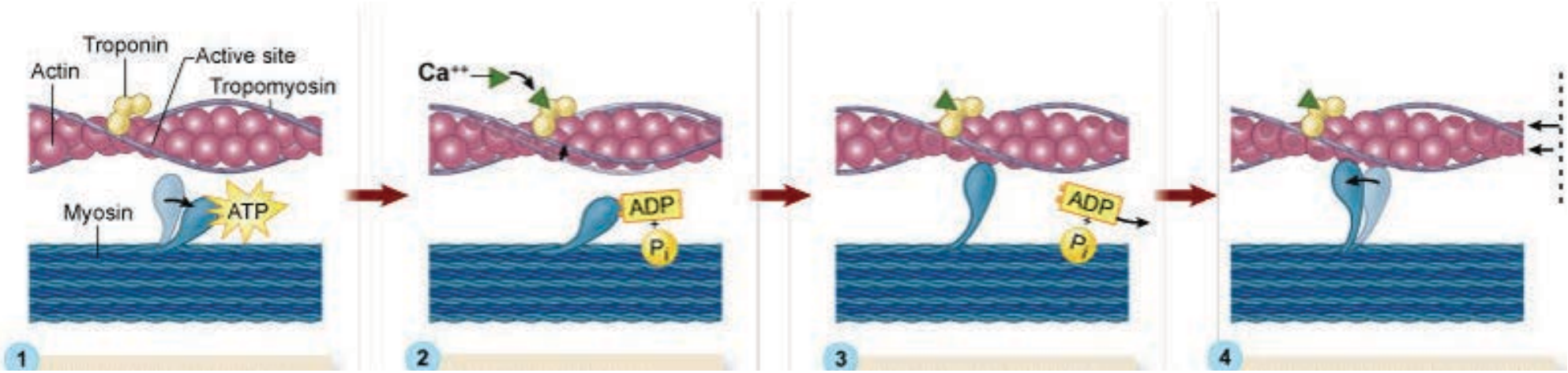
4.2 Contraction



- Ca^{2+} ions diffuse to the myofilaments to trigger crossbridge formation

Fig 12-8, p. 354 Thibodeau & Patton 8th edition

4.2 Contraction



Myosin head is in its ENERGISED state, with ATP bound

Ca^{2+}-troponin interaction exposes active sites

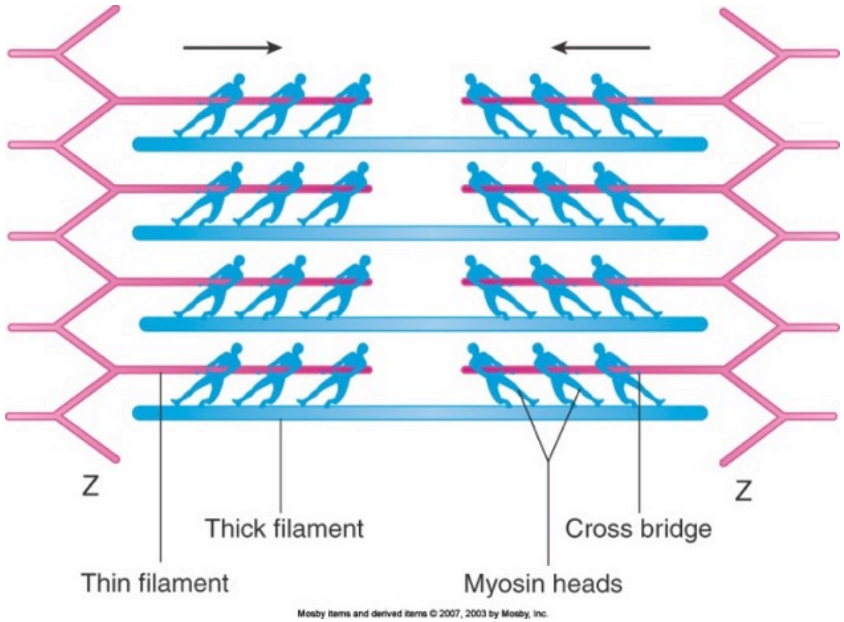
Actin and Myosin interact: CROSS-BRIDGE

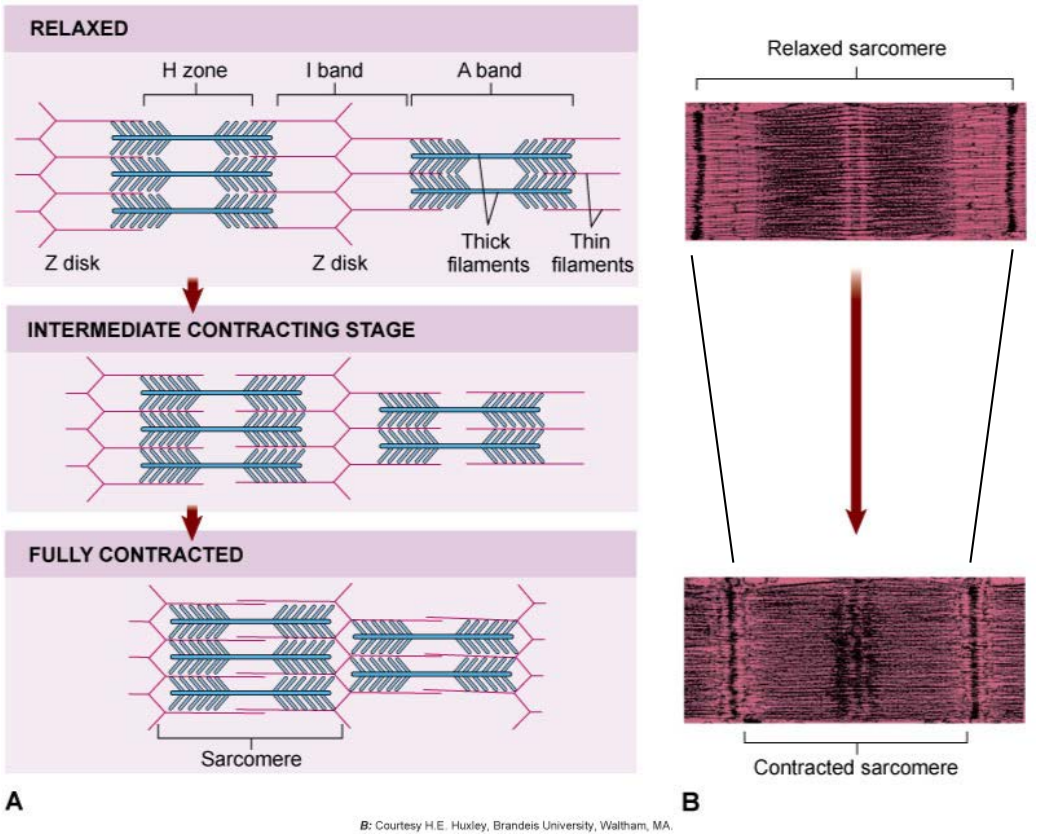
Energised myosin head pulls the actin POWERSTROKE

Each cycle is driven by high energy bonds of <u>adenosine triphosphate</u> (ATP)

Fig 12-9, p. 354 Thibodeau & Patton 8th edition

4.2 Contraction: Sliding Filament Model





Myofibril shortens (z-lines closer)

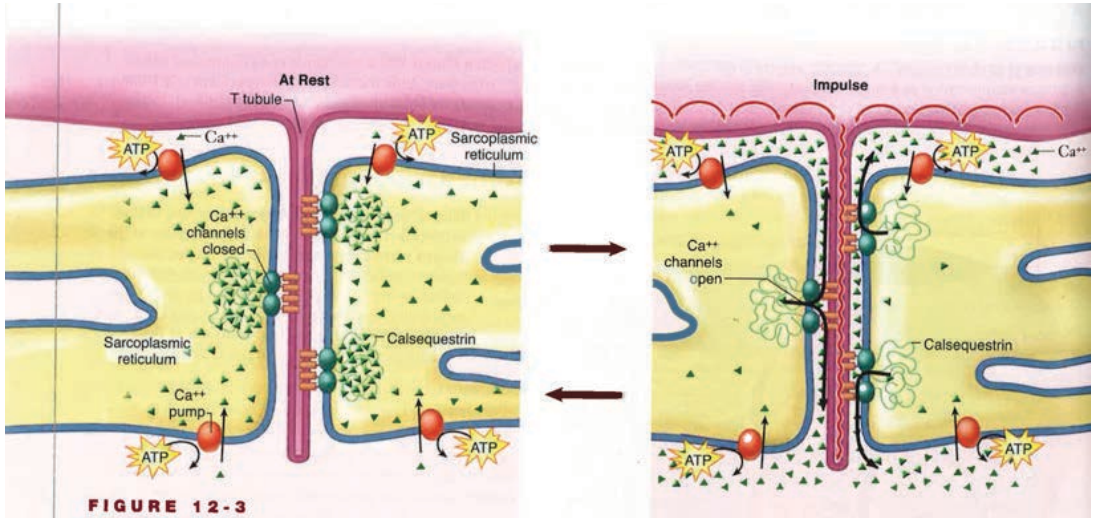
Myofilaments, actin and myosin, do not shorten!

Fig 12-13, p. 356 Thibodeau & Patton 8th edition

Fig 12-12, p. 355 Thibodeau & Patton 8th edition

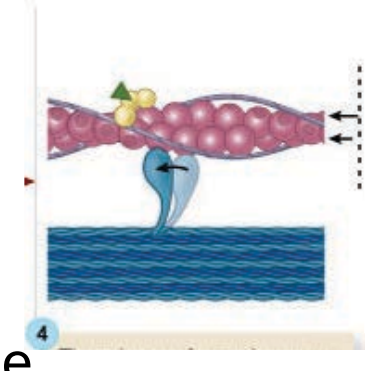
4.3 Relaxation

- No new AP - sarcolemma repolarises



- Ca^{2+} ions no longer bind to Troponin (reduced affinity)

- Actin and Myosin are still bound, but not enough Ca^{2+} ions to initiate new crossbridges



- ATP must bind, for Actin and Myosin to uncouple (uncoupling of crossbridge)

- Muscle Fibre returns to its resting state and …….

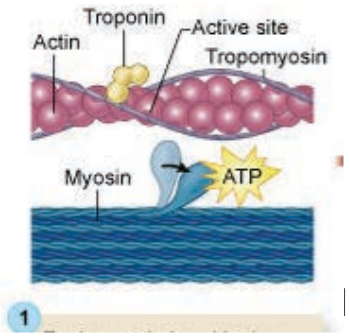


Fig 12-3, p. 350 Thibodeau & Patton 8th edition Fig 12-9, p. 354 Thibodeau & Patton 8th edition

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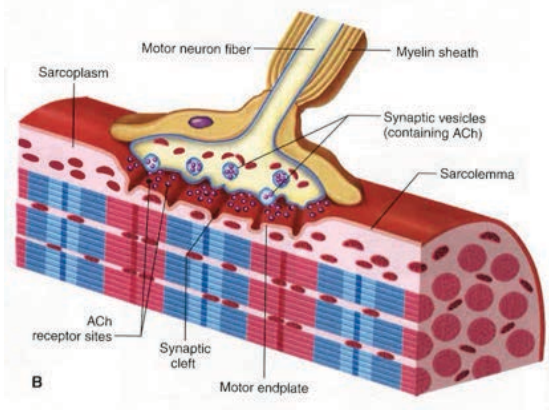

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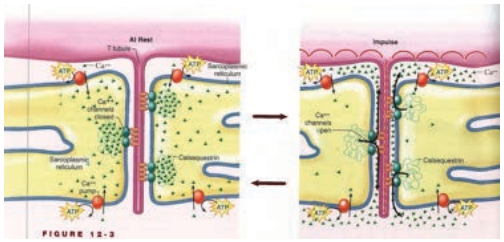

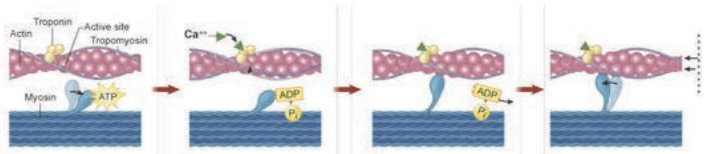

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Fig 12-8, p. 354 Thibodeau & Patton 8th edition

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