
ymca
awards

YMCA Awards

Level 3 Applied anatomy and physiology
2018

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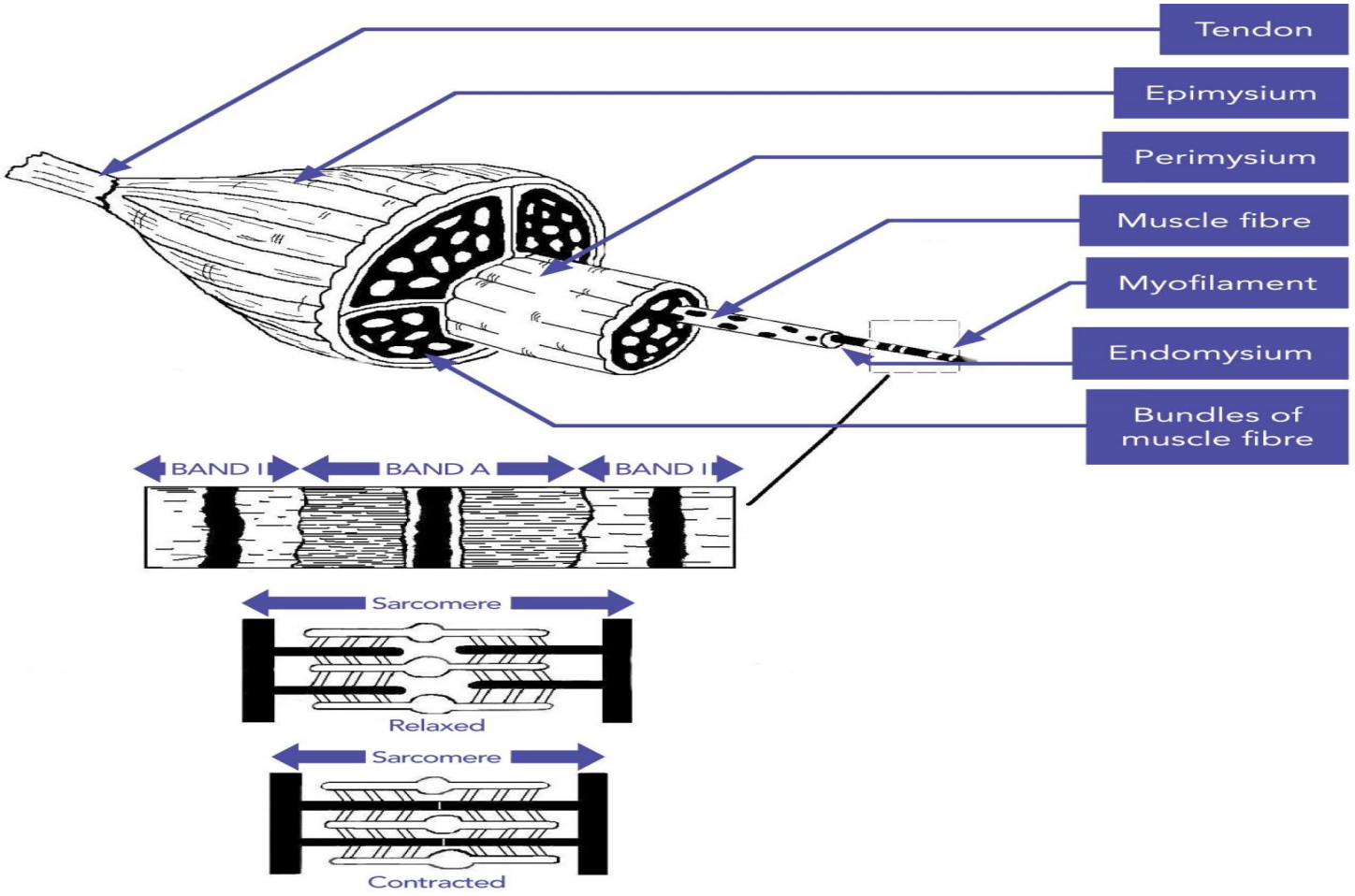
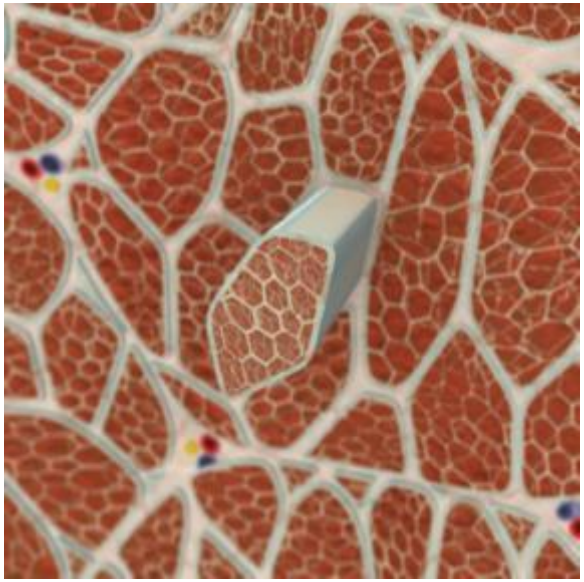
Muscle contraction

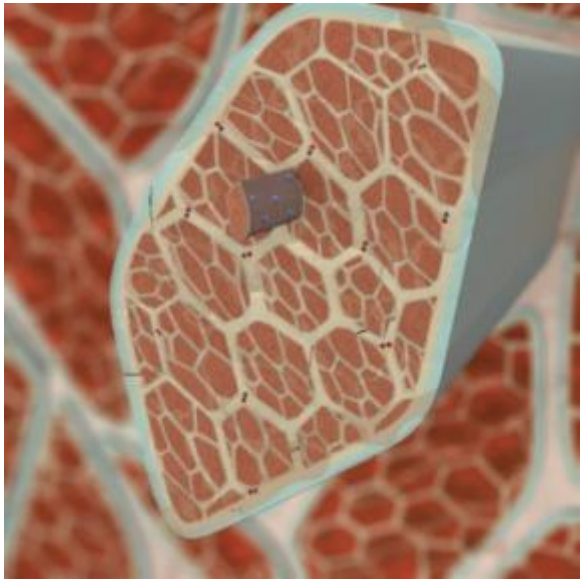
Muscle structure



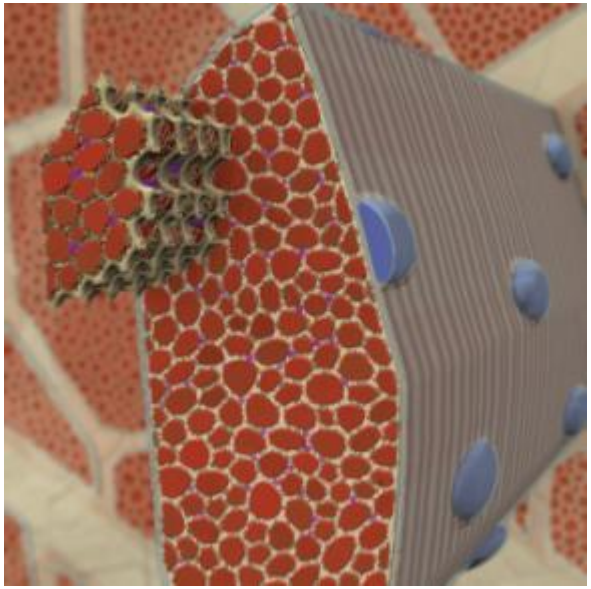
Muscle structure



Muscle fibre



Myofibril

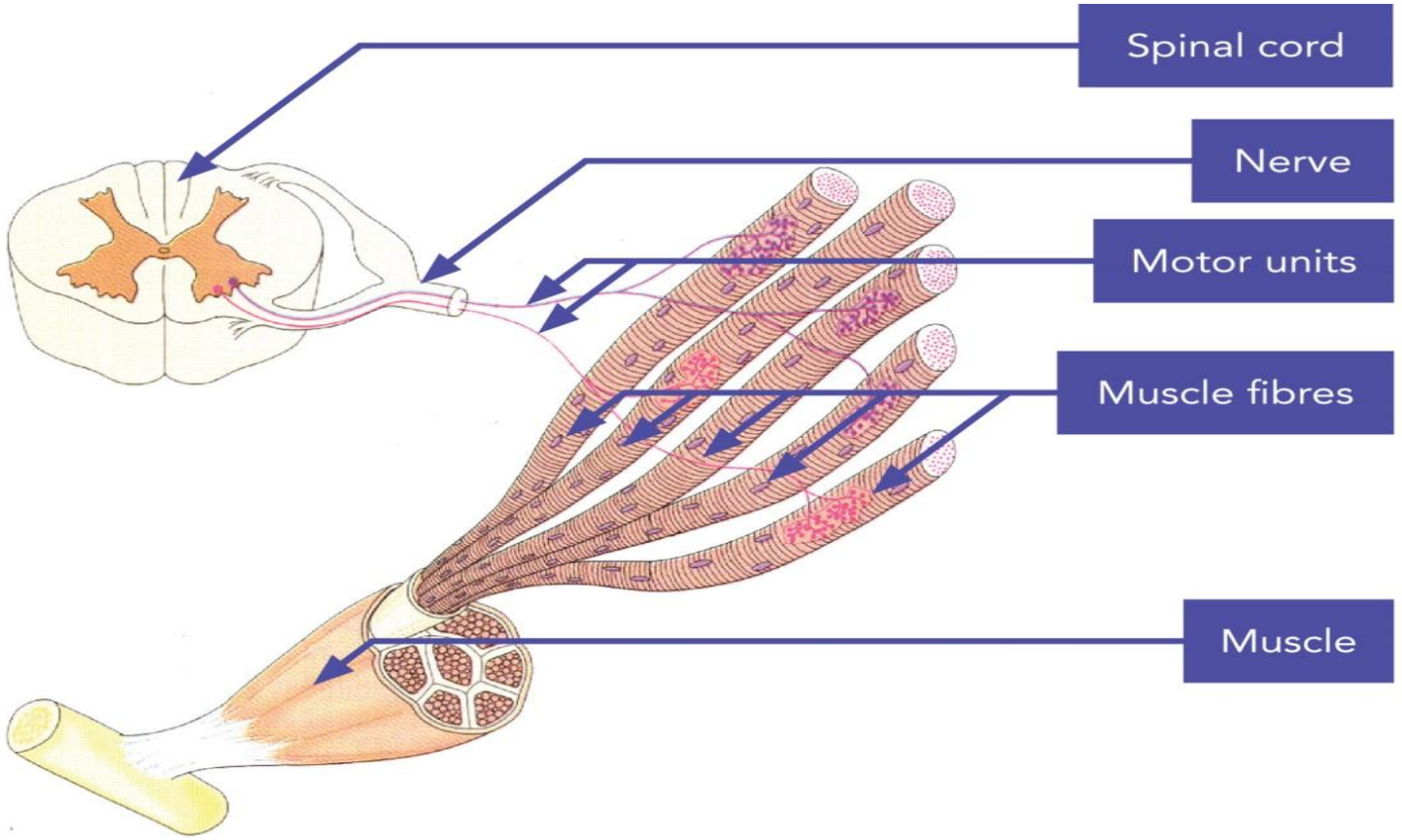


Myofilament

Sliding filament theory

- Occurs within the sarcomere, the ‘unit’ of muscular contraction
- Requires calcium and ATP
  - Nervous stimulus causes the myosin heads to attach to the actin forming cross bridges
  - Myosin heads pivot and pull actin towards the centre of the sarcomere
  - Process is repeated and myosin attaches further along the actin

Motor units and recruitment



Motor units and recruitment

- A motor unit is a motor neuron and the muscle fibres it innervates
- The strength of a muscular contraction will be affected by:
  - The frequency of nerve impulses coming into the muscle cell
  - The number of motor units activated

Motor units and recruitment

- Motor units are recruited in order of size
- Large motor units contain large numbers of type 2b fibres – strength, speed and power
- Small motor units contain large numbers of type 1 fibres – endurance and fine control
- Motor units can be recruited simultaneously to create a quick forceful contraction, or in an alternating sequence to provide longer, less intense contractions

Motor units and recruitment

To generate:

- A greater amount of force, the nervous system ‘recruits’ a larger number of motor units

- A lesser degree of force, the nervous system ‘recruits’ a smaller number of motor units

The ‘all or none’ law

- When an impulse is sent down a neuron all the muscle fibres within that motor unit will be innervated
- Firing a nerve within a motor unit generates the stimulus needed to fully contract all the associated muscle fibres
- The motor unit is either on or off
- There is no partial stimulation or contraction of a motor unit or its fibres

The sodium potassium pump

- The sodium-potassium pump maintains the electrical charge within a cell
- This is particularly important to muscle and nerve cells
- During nerve transmission and muscle contraction, sodium is pumped out of the cell and potassium is pumped in to the cell – at a ratio of 2:3 ions
- This results in a change in electrical charge that causes a nerve impulse or muscle contraction

The sodium potassium pump

- The sodium-potassium pump also maintains the acid-base balance as well as healthy kidney function in the body
- Energy is derived from pumping sodium outside the cell, where it becomes concentrated, wanting to push its way back in
- This energy is used to remove acid from the body

Muscle fibre types

Slow twitch fibres	Fast twitch fibres
Type 1	Type 2
Slow oxidative fibres	Fast glycolytic fibres
Red in colour	White in colour
Contain large numbers of mitochondria	Contain low numbers of mitochondria
Endurance type activities	Strength / anaerobic type activities

Muscle fibre types

The type 2 fibre types subdivide:

- Type 2a – Fast oxidative glycolytic (FOG)
- Type 2b – Fast glycolytic (FG)

The effects of exercise on the nervous system

- Strengthens existing connections and develops new connections
- Improves synchronisation of motor recruitment to achieve stronger muscular contraction
- Improves balance due to improved efficiency of proprioceptors
- Improves speed due to increased frequency and strength of nervous impulses
- Improves agility due to improved speed and frequency of signal and neural connections
- Improves muscle group coordination

What is plyometric exercise?

- Powerful and fast movements
- Rapidly lengthening (eccentric) and shortening (concentric) muscles in fast sequences, making use of stretch-shortening cycle, elasticity, innervations, strength of tissues and muscles that are involved in running faster, jumping higher, and throwing farther
- Raising the force and speed of muscle contractions, leading to higher explosive power that is needed in many sports activities

Plyometric exercises

Three phases of plyometric movements:

- Eccentric (rapid lengthening)
- Amortisation (resting – elastic energy wastage)
- Concentric (shortening)

Primary purpose: Enhanced power output during the concentric phase when compared to isolated concentric contractions

- Plyometric exercises increase muscular power by utilising the natural elasticity of the muscle and tendon, as well as the stretch reflex
- In a jump landing phase the quadriceps must contract eccentrically to slow the movement
- This increases the elastic energy in the muscle and tendon as the muscle lengthens
- This energy is then stored in the muscle
- Following the eccentric, landing phase, with an immediate concentric contraction (such as jumping up again), the stored energy is released
- This increases the total force produced

The stretch reflex

- The stretch reflex is the bodies response to a muscular stretch
- This involuntary response is initiated by the muscle spindles which detect the speed and intensity of a stretch and so during plyometrics, detect the rapid stretching of the quadriceps (when landing)
- Their response is to protect the muscle from over-stretching by increasing the activity of the quadriceps (the agonist muscles) and so the force the muscles produce