The Muscular System

AusDBF - eLearning Modules

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The Muscular System

Welcome to AusDBF eLearning module – The Muscular System.

This presentation contains texts, graphics, videos and an online survey questionnaire.

It is important that you read all the text and instructions before you proceed to the next page or option.

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The main functions of the Muscular System

To enable movement

- voluntary muscles, ones that we can consciously control, are able to generate force, provide locomotion and range of movements, through contracting and relaxing

  For example -fine motor skills, such as blinking, writing

  -gross motor skills, such as throwing a ball and paddling

To maintain posture

- muscles are responsible for maintaining and changing posture
- muscles of the upper back and core strongly influence posture maintenance

To enable essential bodily functions

- Involuntary muscles, ones we have little or no conscious control, continuously support and preserve the functioning of other essential organs and systems of the body

  For example – the heart, the lungs, digestive & endocrine systems

Common features of Muscles

Nervous control —nervous system controls muscle action

Contractility — can contract and become thicker

Extensibility —can stretch when a force is applied

Elasticity — can return to their original size and shape after action

Atrophy — can decrease in size due injury, illness or lack of activity

Hypertrophy — can increase in size (growth) with training

Characteristics of Muscles

MUSCLES ……

- are made of soft tissue
- are attached to bones via tendons
- contain protein filaments of actin and myosin that slide past one another, causing a change in the length of the muscle – eg. contraction &relaxation
- are classified as -
  - ✓ voluntary (eg. skeletal muscles-conscious control over contracting)
  - ✓ involuntary (eg. cardiac & smooth muscles-contract without conscious thought)

THERE ARE THREE TYPES OF MUSCLE

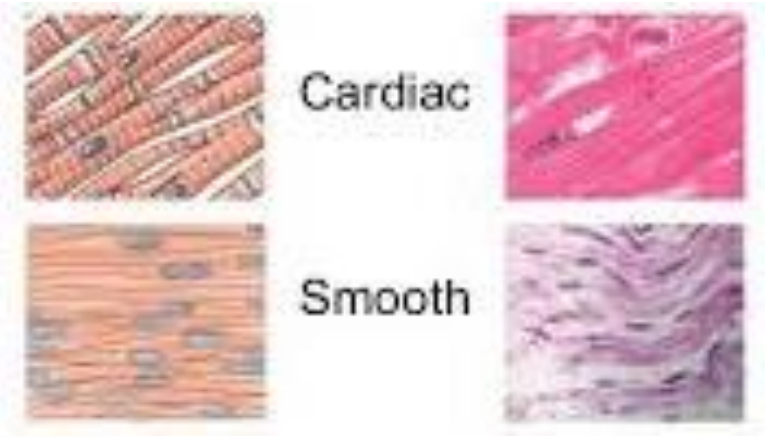
- smooth
- cardiac
- skeletal (or striated)

Types of Muscles

Smooth Muscle

- is found surrounding, and lining many organs, such as blood vessels, digestive tract, intestine and stomach, the bladder etc.
- is an involuntary muscle – contracts automatically with little conscious thought
- contract in usually slow, sustained and rhythmical manner
- non striated in appearance
- arranged in sheets or layers

Muscle Tissue Types



Cardiac Muscle (myocardium)

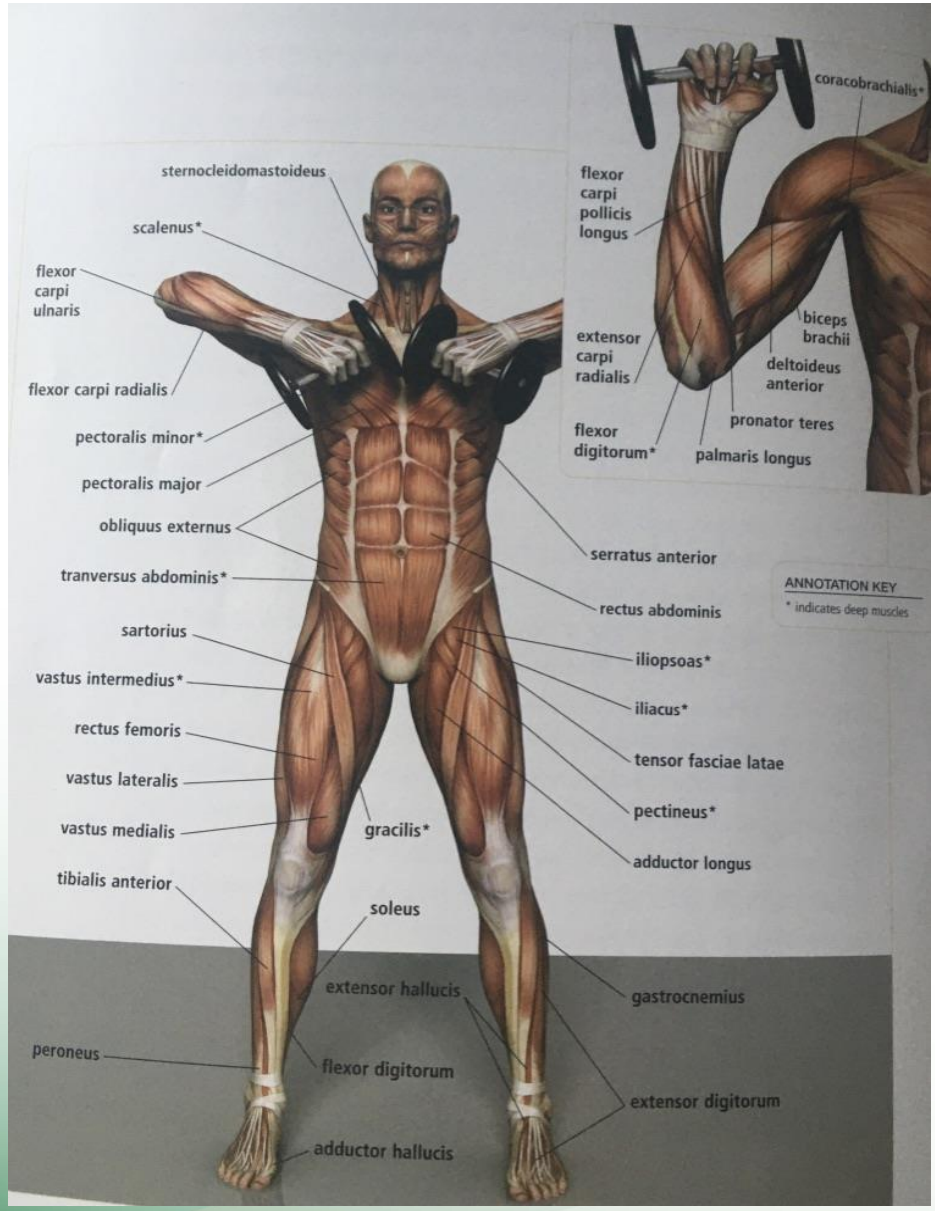
- is found only in the heart
- striated in appearance
- the muscle fibres are intertwined, in figure of eight bundles
- is an involuntary muscle
- contracts and relaxes rhythmically
- is difficult to fatigue

Types of Muscles

Skeletal Muscle

- is responsible for human movement
- is anchored to the skeleton, via tendons, to enable movement
- is striated, and has a striped appearance
- is a voluntary muscle, for example, your brain sends a message to the muscles concerned and the required physical action results
- can be classified as either slow or fast twitch muscles
- the muscle's attachment points on the skeleton (eg. origin & insertion) determines the major movement the muscle assists with
- work as pairs to enable movement around a joint

Muscle Tissue Types



Skeletal Muscles Anterior View

* denotes deep muscle

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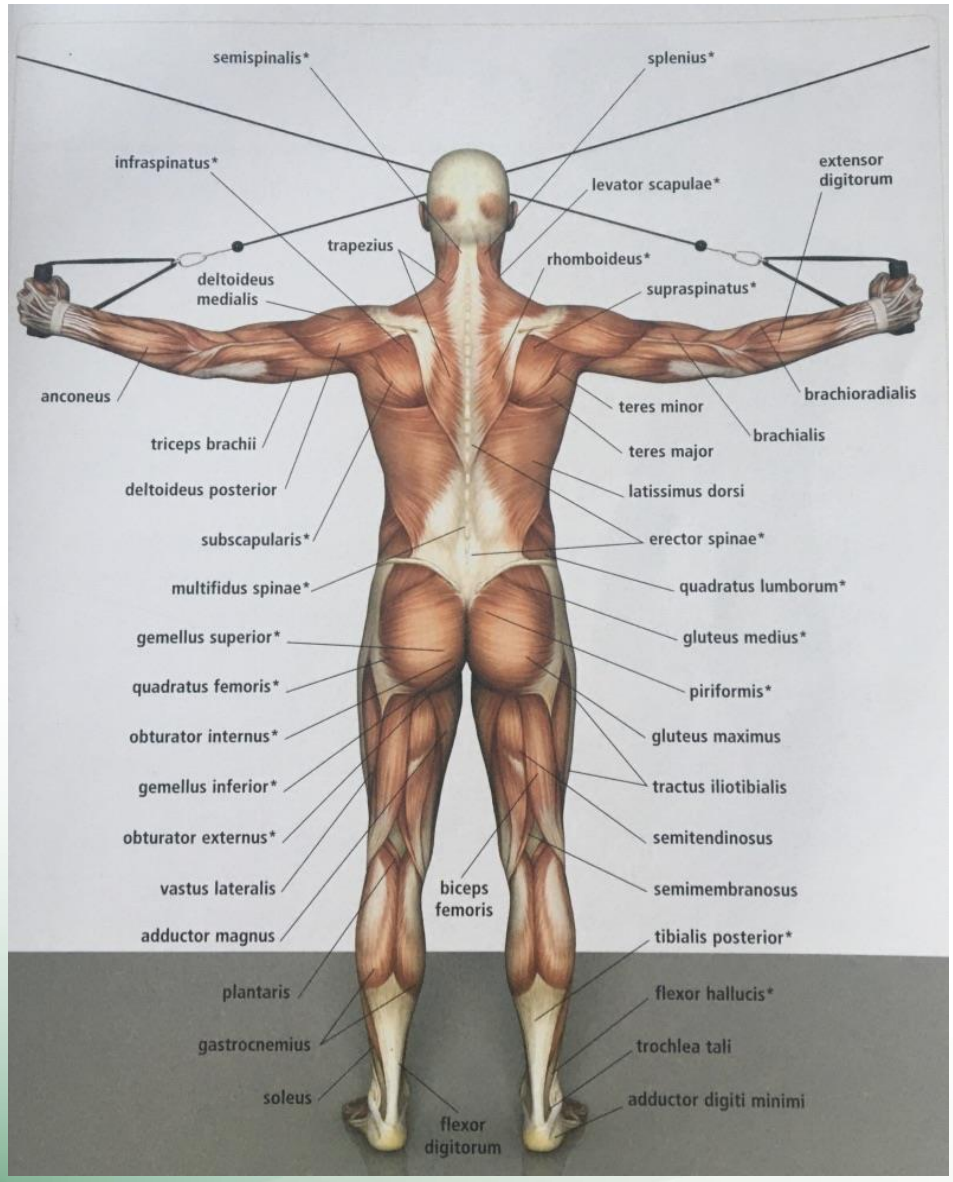

Skeletal Muscles Posterior View

* denotes deep muscle

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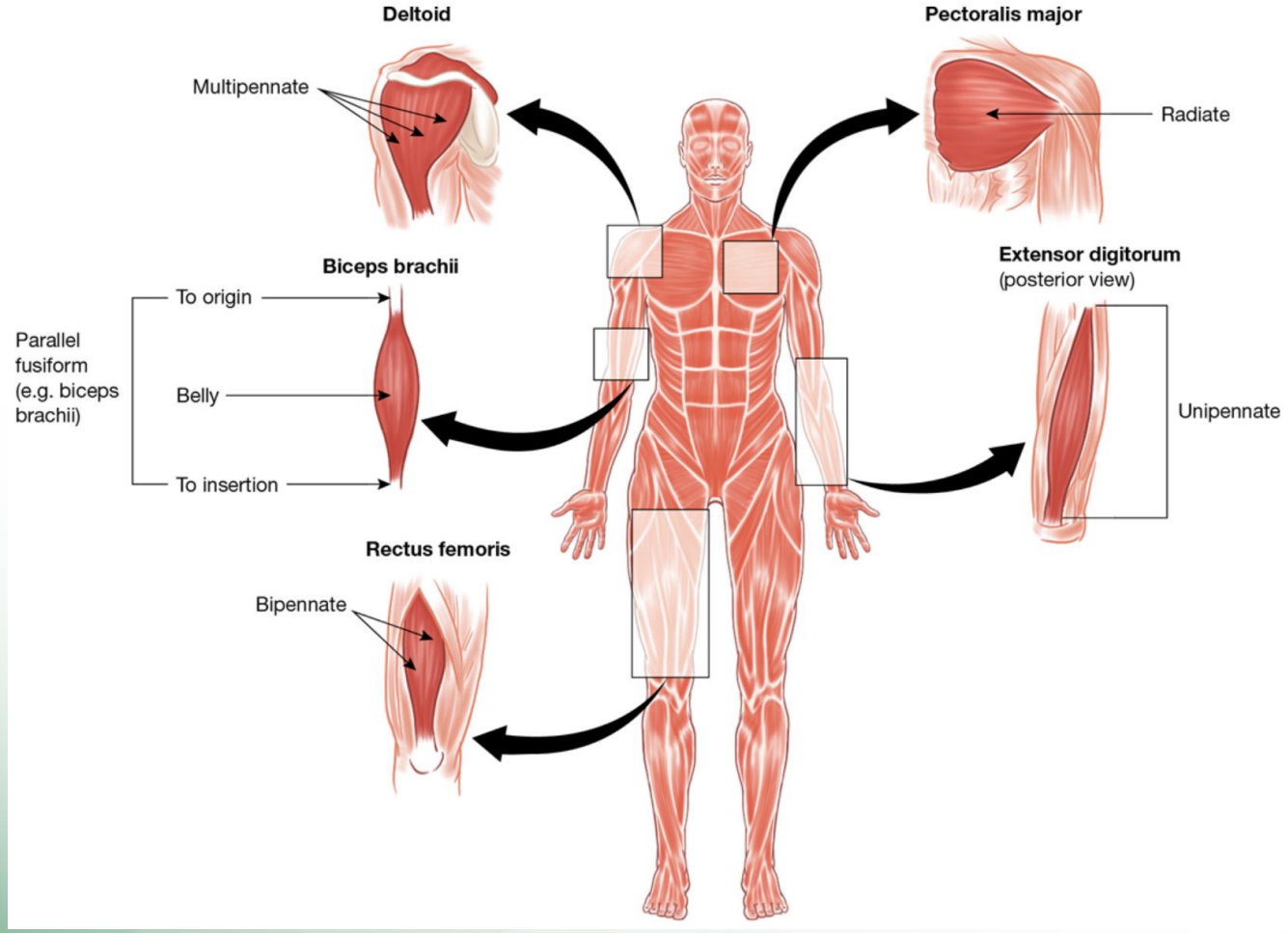
Muscle fibre arrangement

There are variations in the arrangement of the skeletal muscles in the body

- circular eg. muscles that surround the mouth and eyes
- convergent – triangular or fan shaped, eg. pectoralis major
- parallel – are strap like, eg. sartorius
- pennate – unipennate, bipennate, multipennate
  - these fibres are short and attach obliquely
- fusiform – similar to parallel, with an extend belly, eg. biceps

Muscle fibre arrangement



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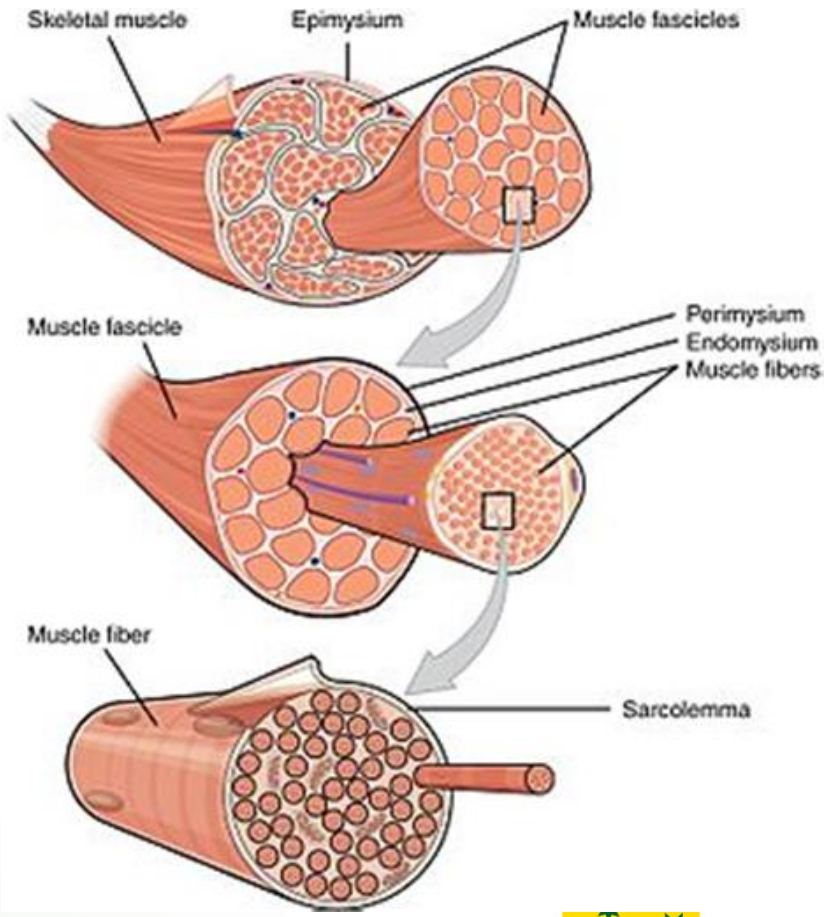
The microscopic structure of muscles

MUSCLE BELLY
- consists of thousands of muscle fibres that lie side by side
- is surrounded by the epimysium
- is made up of FASCICLES

FASCICLES
- are made up of smaller MUSCLE FIBRES
- are surrounded by the endomysium

MUSCLE FIBRES
- are made up of smaller MYOFIBRILS



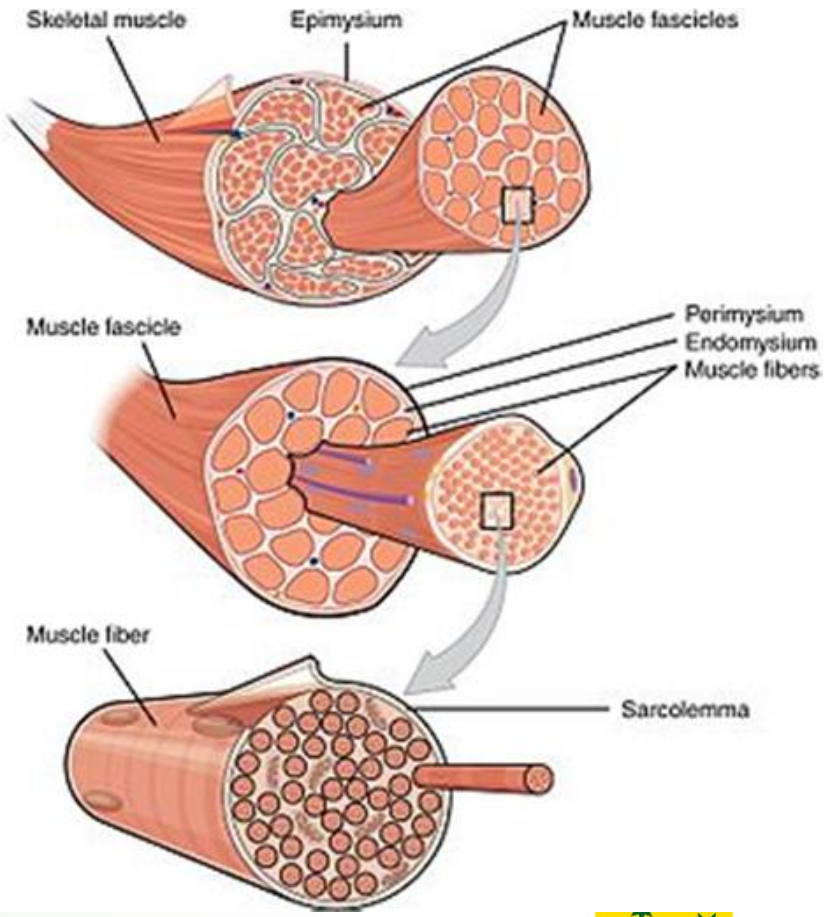
The microscopic structure of muscles

MYOFIBRILS

- are made up of many units along the length of the muscle,
- these units are known as SARCOMERES

SARCOMERES

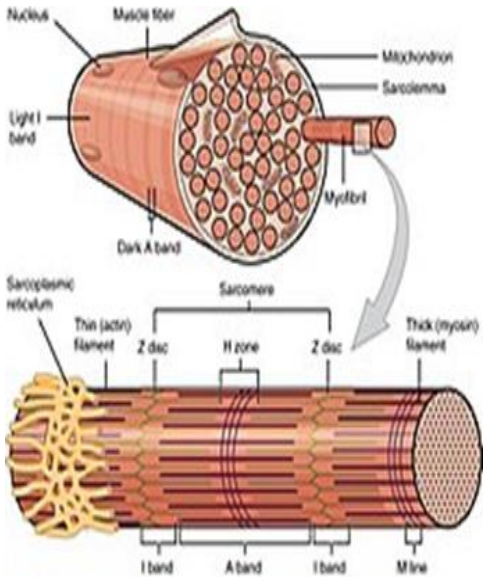
- are the contractile units of the muscles, each surrounded by sarcoplasm
- these units are arranged end to end along the entire length of the muscle
- each sarcomere is made up of smaller MYOFILAMENTS



The microscopic structure of muscles

MYOFILAMENTS

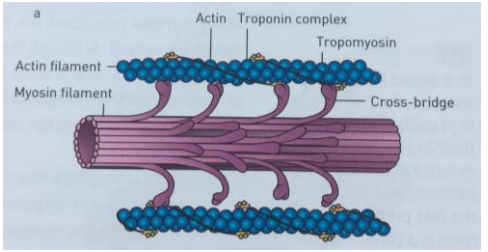
- there are two filaments – myosin and actin
- the overlap of these give the muscle it's striated appearance
- the sliding of these two filaments over each other, enables the muscle to contract and relax



MYOSIN - the thicker filament

ACTIN - the thinner filament

- attaches to the ends of the SARCOMERE, the Z Line



CROSSBIRIDGES

- attach the myosin filament to the actin filament

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The microscopic structure of muscles

- muscles fibres are surrounded by a cell membrane called the sarcomere

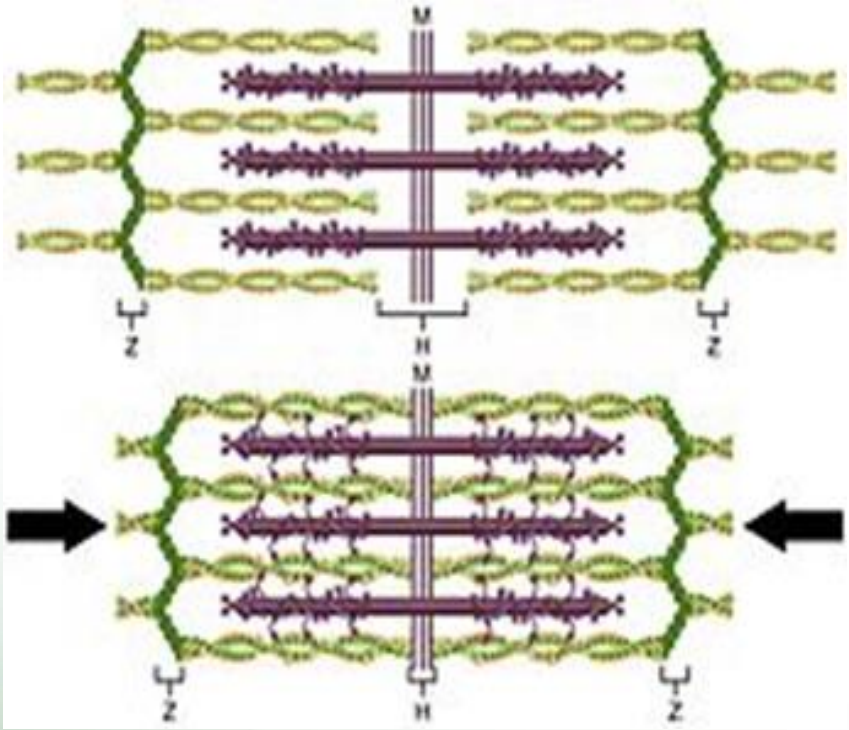
- underlying the sarcolemma, the contractile unit of the muscle, is a gel like fluid called the SACROPLASM

The SACROPLASM contains….

- mitochondria - the site of aerobic energy production
- myoglobin - carries oxygen to the mitochondria
- fat, carbohydrate and protein - energy nutrients
- adenosine triphosphate (ATP) an immediate energy source
- enzymes - chemicals that assist in speeding up energy production
- actin and myosin myofilaments - contractile proteins.

The microscopic structure of muscles

When a sarcomere contracts, the Z lines move closer together, and the I band becomes smaller. The A band stays the same width.
At full contraction, the thin and thick filaments overlap.
(see video clip at the end of the Module)



Characteristics of skeletal muscle fibre types

CHARACTERISTICS OF SLOW TWITCH FIBRES

- also known as Type I or RED muscle fibres
- are dense with capillaries (hence the red characteristic)
- are adapted to use oxygen efficiently
- are rich in mitochondria and myoglobin
- can sustain aerobic activity effectively for long periods of time, using fats and carbohydrates as fuel
- can contract for long periods of time but with little force.

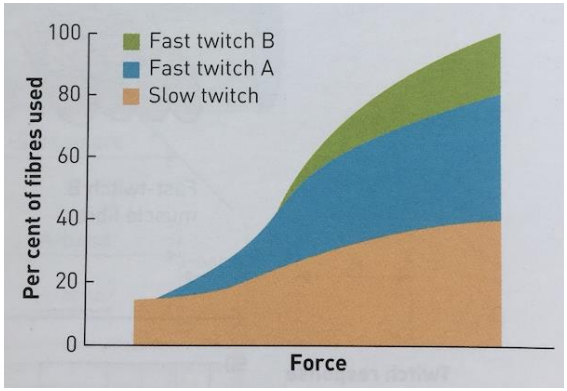
Characteristics of skeletal muscle fibre types

Characteristics of FAST TWITCH FIBRES

- also known as Type II (II a & II b) or WHITE muscle fibres
- these vary in both contractile speed and force generated
- these fibres contract quickly and powerfully
- can generate a greater force than slow twitch fibres
- fatigue rapidly & can only sustain short anaerobic bursts of activity
- anaerobic chemical reactions are used to provide energy
- energy is provided predominantly anaerobically (without O_2)
- glycogen (carbohydrate) is the preferred source of energy
- have greater contribution to muscular strength
- greater potential for increase in muscle mass

Characteristics of skeletal muscle fibre types

- slow twitch fibres cannot be changed/converted to fast twitch fibres
- fast twitch fibres cannot become slow twitch fibres, however, some fast twitch fibres can take on some characteristics of slow twitch fibres after aerobic and endurance training
- Fast twitch – Type II a – partially aerobic
- Fast twitch – Type II b – purely anaerobic



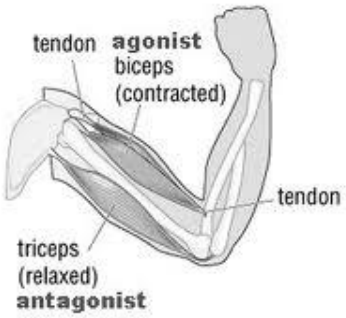
The recruitment of fibres increases as muscular force increases

Muscles work in opposing pairs

AGONIST MUSCLE

- also called the “prime mover”
- is responsible for the movement

example – biceps is the agonist in a biceps curl
- the biceps in this action contracts



ANTAGONIST MUSCLE

- the muscle responsible for the action OPPOSITE to the agonist

example – the triceps is the antagonist in the biceps curl
- the triceps in this action relaxes

WHILE ONE MUSCLE WORKS THE OTHER RELAXES

Motor unit activation & force production

- strength is reflected in being able to produce force, to overcome a load or to produce a movement.

THE DEVELOPMENT OF MUSCLE FORCE DEVELOPMENT IS DEPENDENT ON……

- number and type of motor units activated
- size of the muscle
- initial length of muscle that is being activated
- angle of the joint
- the muscle's speed of action.

STRENGTH OF MUSCULAR CONTRACTION

- for a contraction to occur, there must be a strong enough nerve impulse to stimulate the muscle fibres.

The “all or nothing” principle

The ‘all or nothing’ principle states that the nerve impulse will not stimulate the muscle fibres until it reaches a certain threshold level.

- once the nerve impulse reaches this threshold, all fibres of the motor unit will contract at the same time and maximally.
- if the impulse is too weak, no fibres will contract at all.

The intensity of muscular contractions can vary in two ways…..

- by varying the number of motor units stimulated
  eg. greater degree of strength required - the more nerve impulses that are sent, the more motor units are activated, therefore contracting more muscle fibres

- by varying the frequency at which the impulses arrive at the motor unit
  eg. a greater degree of strength required - then impulses will be sent at a faster rate to the muscles involved

Types of muscle actions

Muscles are able to contract (and relax) in differing ways.

ISOMETRIC ACTIONS

- involves muscle contraction against a force with no significant movement
- tension is produced but no joint movement or action is produced
- eg. standing in a doorway, with hands at shoulder higher, pushing out

ISOINERTIAL ACTIONS – concentric & eccentric actions

- these actions maintain a constant inertia, eg a weight is held and is moved through a range of motion

  - ✓ **CONCENTRIC** – when the muscles shortens under tension, eg. the upwards motion of a biceps curl, where the biceps muscle shortens
  - ✓ **ECCENTRIC** –when the muscle lengthens while still under tension, eg the quadriceps of the leg when sitting down, to control the rate of descent and work against gravity

ISOKINETIC ACTIONS

- is when the speed of the movement is constant regardless of the force applied by the resistance. eg. the use of machines eg. Cybex work the muscle maximally throughout the entire range of motion

Other terminology

ORIGIN of a muscle

- is the attachment of the muscle to the more STATIONARY end of the bone

INSERTION of a muscle

- is the attachment of the muscle to the more MOVABLE end of the bone

HYPERTROPHY

- used to describe a muscle when it INCREASES in size
- each single fibre increases in thickness

ATROPHY

- used to describe a muscle as it DECREASES in size
- often due injury, illness or lack of activity

SYNERGIST (or assistant)

- are muscles that assist the agonist to produce the required movement and reduce any excessive or unnecessary movements

STABILISER (or fixator)

- are muscles that ensure that the joint remains stable while the agonist and antagonists are working.

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Factors affecting muscle strength

Many factors affect the amount of force that a muscle can generate……

- muscle fibre arrangement
- muscle fibre recruitment
- muscle fibre type
- speed of contraction
- gender differences
- age differences

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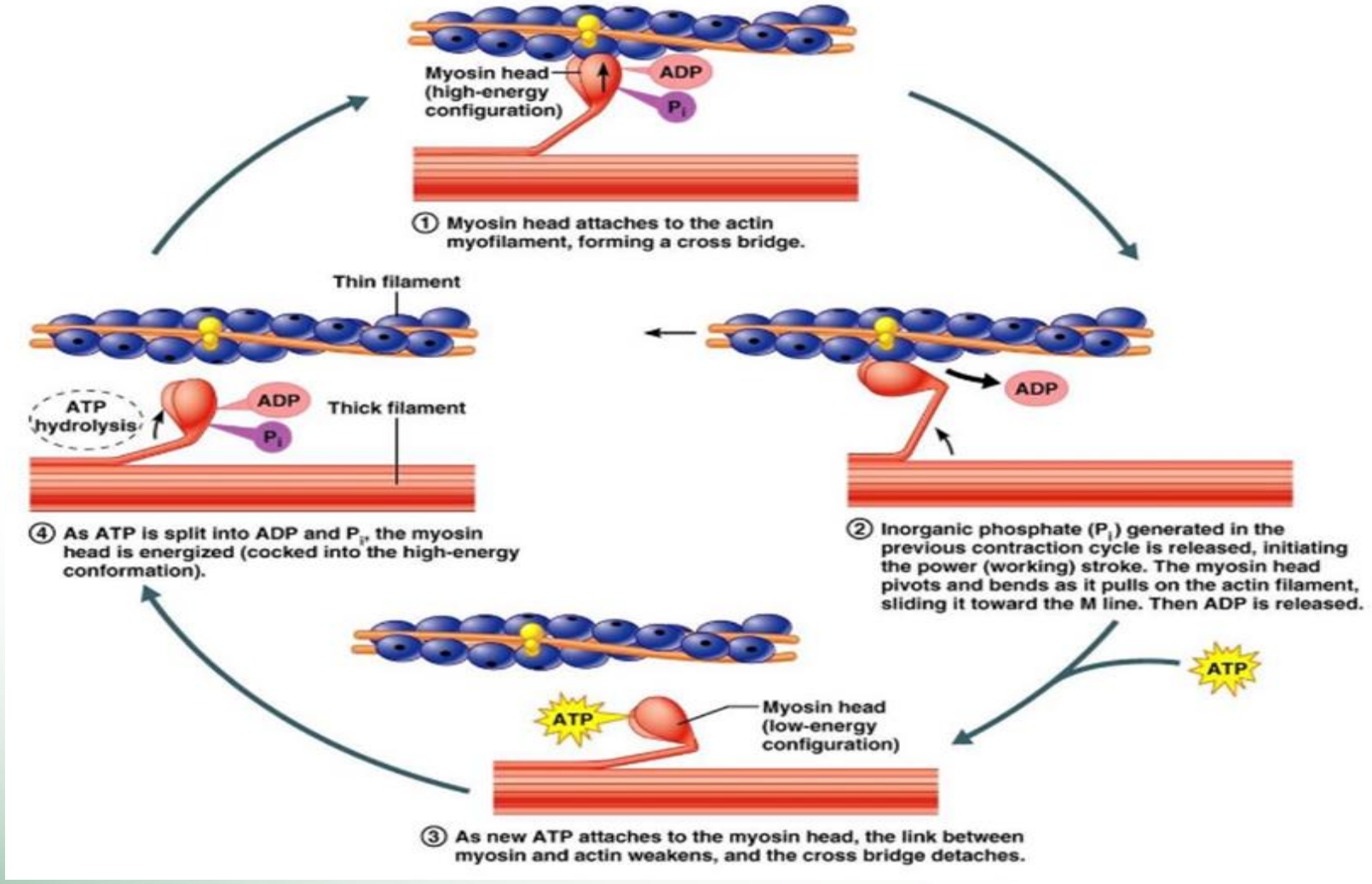
How do muscles contract?

- MOTOR NEURONS carry impulses from the brain via the central nervous system to the muscles
- these impulses stimulate muscular contraction and initiate movement
- the motor neuron only stimulates a small portion of the muscle
- the motor neuron and the muscle fibres it stimulates is known together as a MOTOR UNIT
- nerves connect to each myofibril at the neuromuscular junction, known as SYNAPSES (see The Nervous System module)
- when the signal is received, chemicals known as the neurotransmitters, (ACETYLCHOLINE) is released
- the neurotransmitter enables the nerve impulse to travel across the synapse and stimulate the muscle cells into action.
- calcium is also a vital element in the process of neurotransmitter release

How do muscles contract? ……

- in the presence of calcium, the myosin filaments can now attach to the actin.
- the breakdown of adenosine triphosphate (ATP) provides energy and enables the cross bridges to attach to the actin filaments and in a rowing like action pull them into the centre of the sarcomere, eg draws the ends of the sarcomere (Z lines) closer together
- the cross bridges continue to detach and reattach themselves from the actin filaments, shortening the sarcomere.
- the structural rearrangement of actin and myosin filaments change whereby Z lines move closer together
- every sarcomere along the muscle fibre shortens, leading the whole muscle to contract.
- the muscle will relax when the actin and myosin filaments lose contact with each other — that is, when the cross bridges detach from the actin.
- this is commonly known as the “the sliding filament” theory



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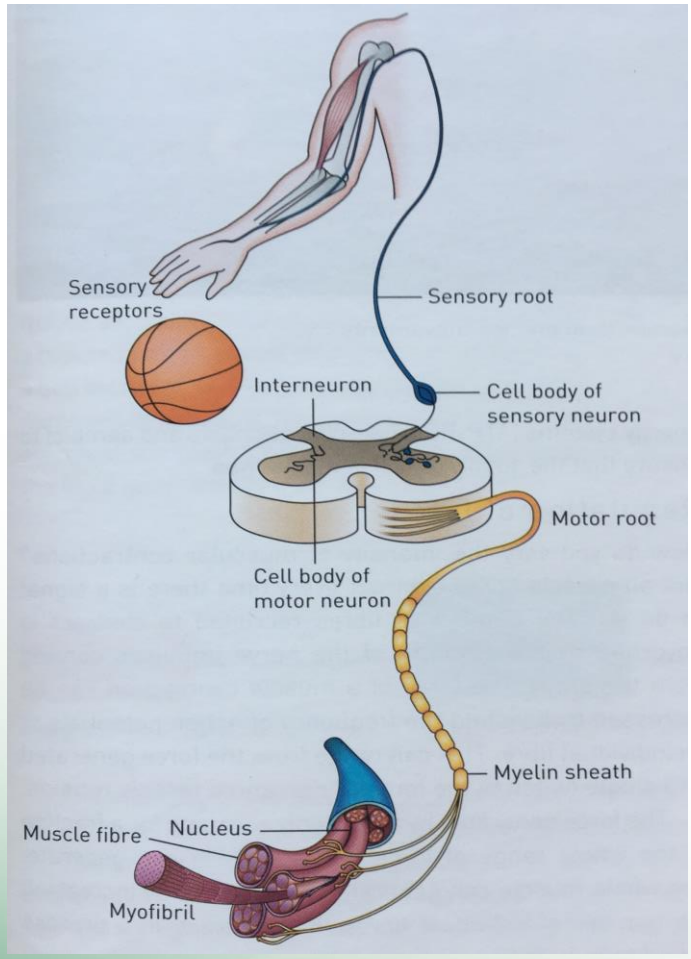
How do muscles contract?



Cardiac and smooth muscle

- contractions are stimulated by internal pacemaker cells which regularly contract, and propagate contractions to other muscle cells they are in contact with

- all skeletal muscle and many smooth muscle contractions are facilitated by the neurotransmitter acetylcholine.

DID YOU KNOW…..

- the term muscle is derived from the Latin musculus meaning little mouse perhaps because of the shape of certain muscles or because contracting muscles look like mice moving under the skin

MUSCLES ARE

- at lower intensities, are predominantly powered by aerobic chemical reactions (in the presence of O_2) using fats and carbohydrates
- anaerobic chemical reactions (without the presence of O_2) also provides energy, using carbohydrate, particularly by fast twitch fibres.

- both chemical reactions produce adenosine triphosphate (ATP) molecules
- ATP is used to provide energy for the movement of the actin & myosin

Please **turn up your volume**

then click on the URL link below to view a short video on the Muscular System.

When the video is completed please return and go to the next slide in this presentation.

https://youtu.be/q-NpqcWzmRA

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