Edexcel IAL Biology A-level

7.9-7.13 - Cardiac and Skeletal Muscle

Flashcards

What does the phrase ‘antagonistic pair of muscles’ mean?

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Muscles can only pull, so they work in pairs to move bones around joints

Pairs of flexors and extensors pull in opposite directions: Agonist contracts while antagonist relaxes.

What are extensors?

What are extensors?

Muscles which increase the angle at a joint and act to extend limbs

What are flexors?

What are flexors?

Muscles which decrease the angle at a joint and act to bend limbs

Describe the gross structure of the skeletal muscle system

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Tendons (inelastic tissue) connect muscles to incompressible skeleton

Ligaments (elastic tissue) join bones at joints (cartilage & fibrous connective tissue)

Describe the gross structure of skeletal muscle

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- Muscle cells are fused together to form bundles of parallel muscle fibres (**myofibrils**)
- Arrangement ensures there is no point of weakness between cells
- Each bundle is surrounded by **endomycium**: loose connective tissue with many capillaries

Where are slow and fast-twitch muscle fibres found in the body?

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Slow-twitch: sites of sustained contraction e.g. calf muscle

Fast-twitch: sites of short-term, rapid, powerful contraction e.g. biceps

Explain the structure and properties of slow-twitch muscle fibres

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- **Glycogen** store: many terminal ends can be hydrolysed to release glucose for respiration
- Contain **myoglobin**: higher affinity for oxygen than haemoglobin at lower partial pressures
- Many mitochondria: aerobic respiration produces more ATP
- Surrounded by many blood vessels: high supply of oxygen and glucose

Explain the structure and properties of fast-twitch muscle fibres

Explain the structure and properties of fast-twitch muscle fibres

- Large store of **phosphocreatine**
- More myosin filaments
- Thicker myosin filaments
- High concentration of enzymes involved in anaerobic respiration
- Extensive sarcoplasmic reticulum: rapid uptake and release of Ca^{2+}

Describe the microscopic structure of skeletal muscle

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Myofibrils: site of contraction

Sarcoplasm: shared nuclei and cytoplasm with lots of mitochondria and endoplasmic reticulum

Sarcolemma: folds inwards towards sarcoplasm to form transverse (T) tubules

Draw a diagram to show the ultrastructure of a myofibril

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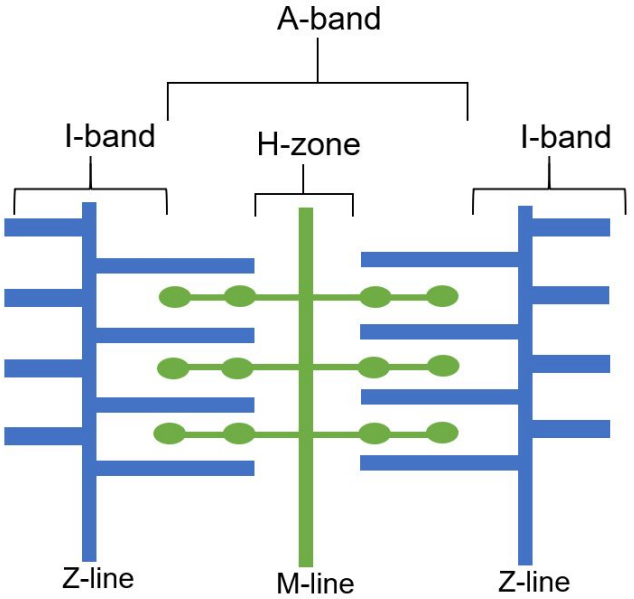
Z-line: boundary between sarcomeres

I-band: only actin

A-band: overlap of actin & myosin

H-zone: only myosin



How is muscle contraction stimulated?

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1. Neuromuscular junction: action potential = voltage-gated Ca^{2+} channels open
2. Vesicles move towards & fuse with presynaptic membrane
3. Exocytosis of acetylcholine (ACh), which diffuses across synaptic cleft
4. ACh binds to receptors on Na^{+} channel proteins on skeletal muscle cell membrane
5. Influx of Na^{+} = depolarisation

What does depolarisation of the sarcolemma cause?

What does depolarisation of the sarcolemma cause?

Depolarisation of the sarcolemma triggers the sarcoplasmic reticulum to release calcium ions. This stimulates muscle contraction

What is the sarcoplasmic reticulum?

What is the sarcoplasmic reticulum?

A type of endoplasmic reticulum found in muscle cells which is specialised to store and release calcium ions

What does Ca^{2+} binding to troponin cause?

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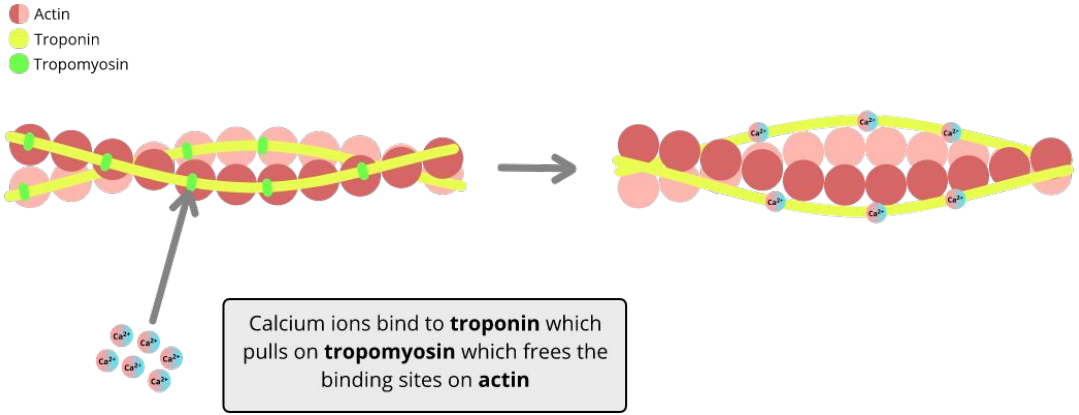
When calcium ions bind to troponin, it pulls on **tropomyosin** which moves and frees up the actin binding sites which allows myosin to bind.



Outline the sliding filament theory of muscle contraction

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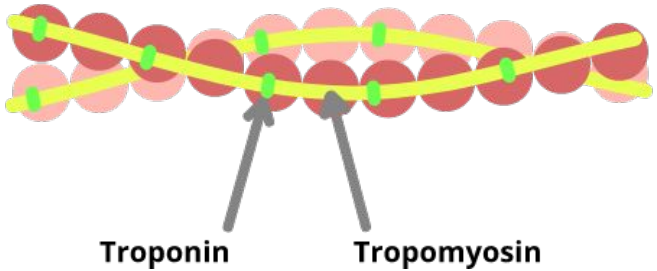
1) ATP bound to the myosin head is hydrolysed to ADP and P_i which causes the myosin head to move into a **primed** position
2) Ca^{2+} released from the sarcoplasmic reticulum binds to **troponin** which causes it to pull on **tropomyosin** which moves away and frees the myosin binding sites on actin.
3) The **myosin head binds** to the actin molecule
4) The myosin head then releases the bound ADP and P_i (from step 1) which triggers the '**power stroke**' where it pulls on the actin filament and causes sarcomere contraction
5) Another **ATP then binds** to the myosin head which causes it to detach from the actin and the cycle repeats.

What is the difference between troponin and tropomyosin?

What is the difference between troponin and tropomyosin?

- Troponin is the small protein bound to tropomyosin which **binds to Ca^{2+}** and **pulls on tropomyosin** to move it away from the binding sites on actin.
- Tropomyosin is the large protein composed of two **alpha helices** which **blocks the myosin binding sites** on actin.



What is an ATPase?

What is an ATPase?

An enzyme which catalyses the hydrolysis of ATP to ADP + P_i

Define the term myogenic

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A type of muscle which can initiate its own contraction without outside stimulation from nervous impulses.

What type of muscle is myogenic?

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Cardiac muscle

What is the sinoatrial node (SAN)?

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A group of cells in the wall of the right atrium that generate electrical activity, causing the atria to contract. The SAN is often referred to as the heart's pacemaker

What is the atrioventricular node (AVN)?

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A group of cells located between the atria that slow down the wave of excitation and pass it between the ventricles, along the bundle of His.

Describe the pattern of electrical stimulation in the heart which leads to contraction

Describe the pattern of electrical stimulation in the heart which leads to contraction

1) The sinoatrial node (SAN) produces a wave of excitation which passes down through the atria, causing them to contract
2) The impulse reaches the atrioventricular node (AVN) which provides a very short delay before passing the impulse along. This ensures that the atria finish contracting before ventricular contraction is stimulated.
3) The impulse is passed down through the bundles of His and then up through the Purkyne fibres which stimulates contraction of the ventricles from the apex (bottom) of the heart upwards.

What is an electrocardiogram (ECG)?

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A graph showing the electrical activity in the heart during the cardiac cycle

Explain the characteristic patterns displayed on a typical ECG

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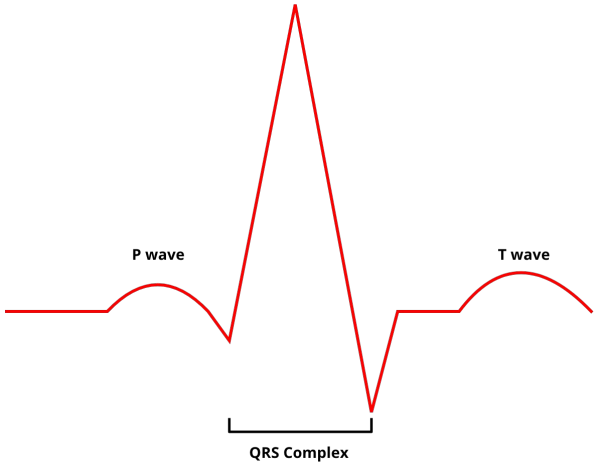
- **P wave** - depolarisation of atria during atrial systole
- **QRS wave** - depolarisation of ventricles during ventricular systole
- **T wave** - repolarisation of ventricles during ventricular diastole



Name some heart defects that ECGs can help to diagnose

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Symptoms of cardiovascular disease, including arrhythmia (irregular beat), tachycardia (heart rate too fast)

How can ECGs be analysed to determine heart defects?

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- The shape and size of the peaks on the graph provide useful information about the functioning of areas of the heart and the electrical conduction pathway
- The frequency of the peaks provides information about the frequency of stimulation which can be used to diagnose conditions like tachycardia (abnormally fast heart rate) or bradycardia (abnormally slow heart rate)

State the formula for cardiac output

State the formula for cardiac output

cardiac output (CO)

=

stroke volume (V) x heart rate (R)

What controls heart and ventilation rate?

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The autonomic nervous system

Why do heart and ventilation rate increase during exercise?

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To increase oxygen supply for respiring tissues & rapidly remove carbon dioxide

Name the receptors involved in changing heart rate and state their location

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Baroreceptors (detect changes in blood pressure): carotid body

Chemoreceptors (detect changes in pH e.g. due to increase in CO_2 concentration): carotid body and aortic body

Name the receptors involved in changing ventilation rate

Name the receptors involved in changing ventilation rate

- Chemoreceptors
- Stretch-mediated receptors in muscles and tendons

How does the body respond to an increase in blood pressure?

How does the body respond to an increase in blood pressure?

1. **Baroreceptors** send **more impulses to cardioinhibitory centre** in the **medulla oblongata**
2. More impulses to SAN down vagus nerve via **parasympathetic nervous system**
3. Stimulates release of **acetylcholine**, which decreases heart rate

How does the body respond to a decrease in blood pressure?

How does the body respond to a decrease in blood pressure?

1. **Baroreceptors** send **more impulses to cardioacceleratory centre** in the **medulla oblongata**
2. More impulses to SAN via **sympathetic nervous system**
3. Stimulates release of **noradrenaline**, which increases heart rate and strength of contraction

How does the body respond to an increase in CO_2 concentration?

How does the body respond to an increase in CO_2 concentration?

1. **Chemoreceptors** detect **pH decrease** and **send more impulses to cardioacceleratory centre & ventilation centre** of **medulla oblongata**
2. More impulses to SAN via **sympathetic nervous system**.
3. **Heart rate** increases, so rate of blood flow to lungs increases= rate of **gas exchange** and **ventilation** rate increase