Edexcel (A) Biology A-level

Topic 7: Run For Your Life

Notes

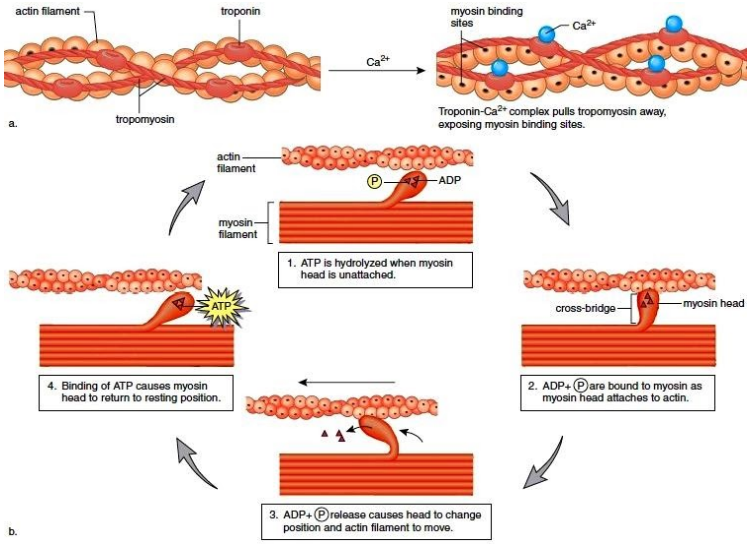
Movement

Key words:

- **Tendons –** non-elastic tissue which connects muscles to bones
- **Ligaments –** elastic tissue that joins bones together and determines the amount of movement possible at a joint
- **Joints –** the area where two bones are attached for the purpose of permitting body parts to move, they're made of fibrous connective tissue and cartilage
- **Skeletal muscles-** muscles attached to bones, they are arranged in antagonistic pairs
- **Antagonistic muscle pairs-** pairs of muscles which pull in opposite directions – as one muscle contracts, the other relaxes. **Extensors** act to straighten the joint while **flexors** act to bend the joint. For example triceps and biceps in the arm: when the triceps relaxes, the biceps contracts to lift the arm.

Muscle Contraction

Sliding Filament Theory



1. Calcium ions released from sarcoplasmic reticulum upon nervous stimulation. Bind to troponin molecule - changing its shape.
2. Myosin binding sites exposed, head moves forward to form an actomyosin bridge.
3. ADP + Pi released, myosin head moves forwards - shortening the sarcolemma.
4. Free ATP binds, myosin head changes shape - moving back to original position.
5. ATPase in myosin head breaks ATP back into ADP + Pi to restore the original state.

6. Repeated stimulation causes continued contraction. If stimulation is stopped, ATP released is used to actively transport calcium ions back into sarcoplasmic reticulum.

Aerobic Respiration

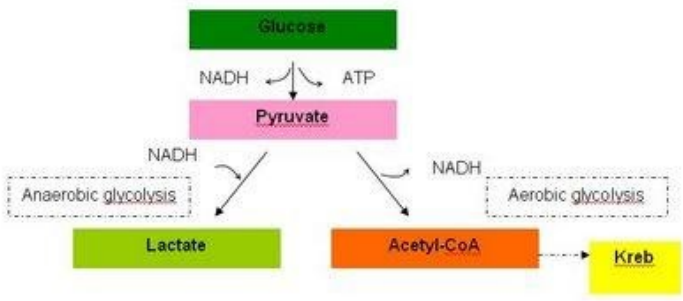
Aerobic respiration is the splitting of a **respiratory substrate** reuniting hydrogen with atmospheric oxygen to release a large amount of energy and carbon dioxide as a waste product. **Anaerobic respiration** occurs in the absence of oxygen. Respiration is a multi-step process with each step controlled and catalysed by a specific intracellular enzyme. It yields ATP, which is used as a source of energy for metabolic reactions, and generates heat.

It has four stages:

- Glycolysis
- Link Reaction
- Kreb's Cycle
- Oxidative Phosphorylation

Glycolysis

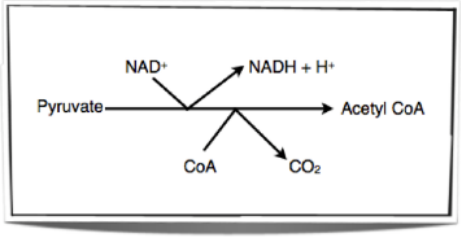
Glycolysis is the first process of both aerobic and anaerobic respiration. It occurs in the cytoplasm.



In this process glucose is **phosphorylated** to produce 2 molecules of **pyruvate,** 2 molecules of ATP and 2 molecules of NADH. In anaerobic respiration the pyruvate is reduced into lactate with the help of NADH. **Lactate** must be oxidised back to pyruvate in the liver. This creates an oxygen debt. Lactate **decreases blood pH** which can affect enzyme activity, causing muscle fatigue.

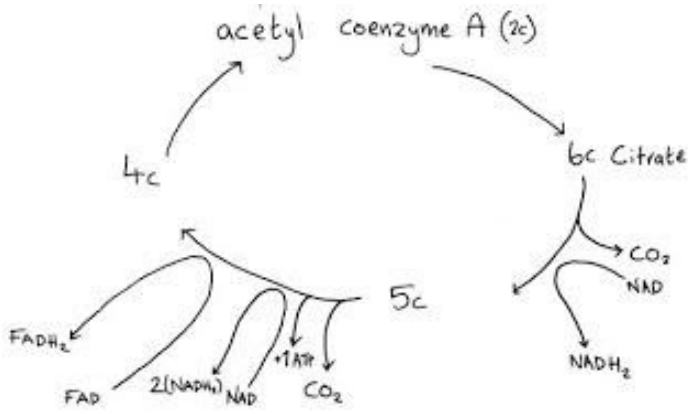
Link Reaction and Kreb's Cycle

The next step of aerobic reaction is **the link reaction,** where pyruvate is bound to coenzyme A producing **acetyl coenzyme A** with the release of **NADH.**



Acetyl-CoA then enters the **Krebs cycle,** where it donates 2 carbons to the 4 carbon compound oxaloacetate, producing

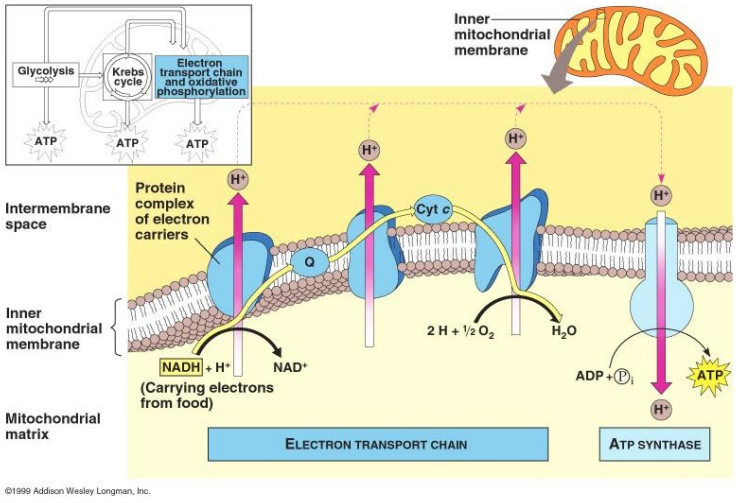
citrate. CoA is restored for use in the link reaction. Citrate is oxidised and carbon dioxide, ATP, **reduced NAD and reduced FAD** are produced.



Both the Link reaction and Kreb's cycle occur in the **mitochondrial matrix**.

Oxidative Phosphorylation

Oxidative phosphorylation is the process in which ATP is synthesised via **chemiosmosis** in the **electron transport chain** in mitochondria. This process generates the majority of ATP in aerobic respiration and it occurs as following:



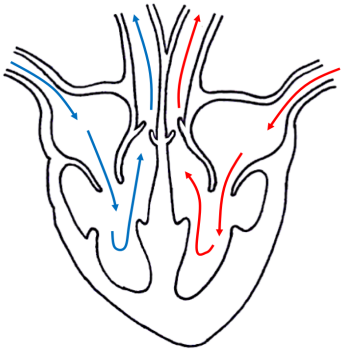
- Reduced coenzymes carry **hydrogen ions** and electrons to the electron transport chain, which occurs on the **inner mitochondrial membrane.**
- Electrons are carried from one electron carrier to another in a series of **redox reactions: the electron carrier** which passes the electron on is oxidised, whereas the electron carrier which receives it is reduced.
- **Hydrogen ions** are actively transported across the membrane into the **intermembrane space** – using the energy released from redox reactions. As a result, the concentration of the hydrogen ions in the intermembrane space is high.
- Hydrogen ions diffuse back into the **mitochondrial matrix,** down the **electrochemical gradient** through the protein ATP synthase.

- ATP is produced on **stalked particles** using ATP synthase.
- The **hydrogen ions and electrons are then combined with oxygen to produce water.**

Cardiac Cycle

Due to the heart's ability to initiate its own contraction, it is referred to as **myogenic:**

1. Depolarisation originates in the **Sinoatrial Node**.
2. Depolarisation spreads through the atria - causing atrial systole. .
3. Bundle of His splits into two branches c
4. It cannot spread directly to the ventricles due to the region of nonconductive tissue - the annulus fibrosus.
5. Instead, it stimulates another region of conducting tissue known as the **Atrioventricular Node**.
6. A slight delay occurs between atrial systole and atrial diastole / ventricular systole (in which the ventricles fill with blood).
7. The AVN passes depolarisation into the conducting fibres known as the **Bundle of His**alled **Purkyne Fibres**. These spread up through the ventricles to initiate ventricle systole.



Electrical changes in the heart are caused by the spread of a **wave of depolarisation** which can be measured and detected with an **electrocardiogram (ECG)**. Some diseases affect the wave of depolarisation within the heart thus affecting the **ECG pattern** therefore ECG can be used in the diagnosis of various heart diseases including cardiovascular heart diseases.

Cardiac output = stroke volume x heart rate

Cardiac output can be regulated by controlling the heart rate.

Factors which increase the heart rate include:

- **Low pH** caused by high carbon dioxide concentration, detected by chemoreceptors located in carotid arteries, aorta and the brain. The receptors send impulses to the medulla oblongata where the cardiovascular centre is located
- **Stretch receptors** respond to muscle movement, for instance during exercise
- **Decrease** in blood pressure
- **Adrenaline** is a hormone released to stimulate the fight or flight response

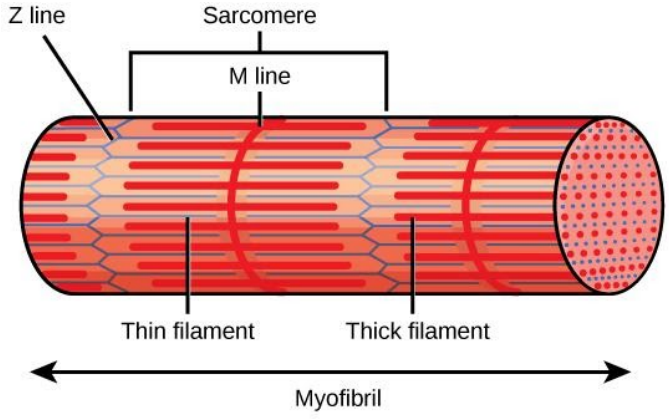
The relevant receptor sends an impulse to the **Cardiac Control Centre in the medulla oblongata**. An impulse is then sent to the **Sinoatrial Node** along a **sympathetic neurone**, depolarisation occurs and **noradrenaline is released** at the SAN. This results in increased heart rate.

Ventilation rate = tidal volume x number of breaths per minute

Ventilation rate is controlled via the same mechanism in response to the following changes to conditions:

- **Increase in carbon dioxide concentration** in blood which causes pH to drop
- **Impulses from stretch receptors** in muscles and tendons caused by exercise
- Voluntary control

Muscles



- **Slow twitch fibres** are specialised for **slow contractions** and are adapted to **long periods of exercise,** such as marathon running and therefore **do not fatigue quickly. Fast twitch fibres** are adapted for **rapid release of energy** during intense exercise such as sprinting – **the contractions are intense and in short bursts.**

- Slow twitch fibres contain many **mitochondria** and a lot of **myoglobin** which results in slow twitch fibres being dark in colour. Fast twitch fibres have very few mitochondria and thus they are lighter in colour.
- Moreover, slow twitch fibres have low levels of **creatine phosphate** and **glycogen,** whereas fast twitch fibres have high levels of both creatine phosphate and glycogen.

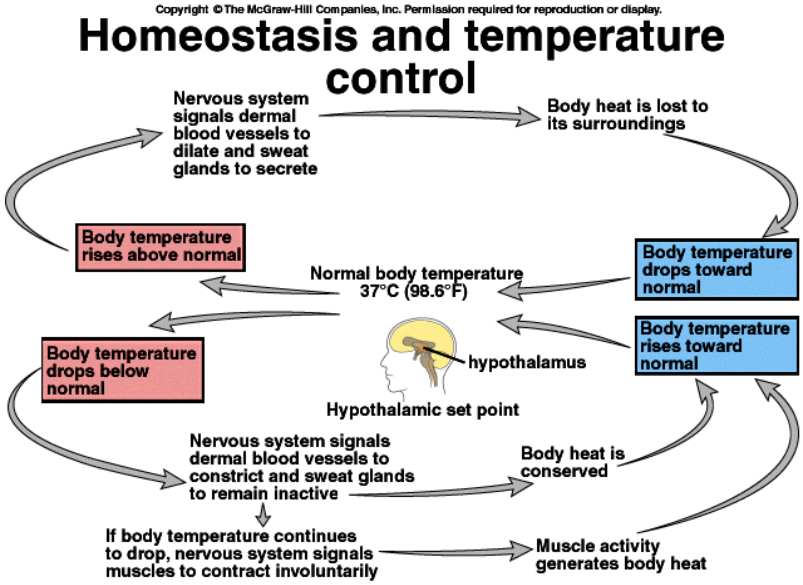
Negative and Positive Feedback

Negative feedback which counteracts any change in internal conditions. This means that all changes are **reversed to restore the optimum conditions**. Another example of a control pathway is **positive feedback,** which doesn't occur as often as negative, and has an opposing effect and increases the original change in the conditions. An example of positive feedback is **dilation of the cervix during childbirth**.

Homeostasis and Exercise

Homeostasis is the control of internal conditions such as temperature. A homeostatic system consists of **receptors, a control mechanism and effectors** which interact together. Homeostasis maintains the body in a state of dynamic equilibrium during exercise, the process occurs as following:

- Firstly the changes in temperature are detected by **thermoreceptors** in the skin, or thermoreceptors in the **hypothalamus,** which detect changes in blood temperature.
- Hypothalamus **stimulates** effectors to either decrease or increase the body temperature.



Exercise

Disadvantages of exercising too much include:

- **Wear and tear** on joints

- Suppression of the **immune system**

Disadvantages of exercising too little:

- Increased risk of **obesity**
- Increased risk of **CVD**
- Increased risk of **diabetes**
- Suppression of the **immune system**
- Increased levels of **LDLs**

Medical Technology

Keyhole surgery is a non-invasive method which uses **fibre optics** to repair damaged joints quickly. It is also much cheaper than conventional methods as it doesn't require as many members of stuff and the recovery time is shorter.

A **prosthesis** is an artificial body part which enables those with injuries and disabilities to regain the appearance or function of a particular body part as well as participate in sports and may be connected either internally or externally.

Doping

Many drugs act as hormones to increase muscle mass or endurance to enhance physical capacities in sport. Hormones act through the control of transcription factors… **Transcription factors** are proteins that bind to DNA.

Transcription factors bind to specific base sequences and either stimulate or prevent transcription of the gene.

- **Promoter** Sequences
  - Found upstream of the gene they act on - enable the binding of RNA polymerase and therefore promote transcription.
- **Enhancer** Sequences
  - Regulate DNA activity by changing chromatin structure - making it more or less open to RNA polymerase. Open = active gene expression, closed = gene inactivity .

Steroid hormones are lipid soluble, for example **testosterone**. They can enter through the plasma membrane to form a hormone-receptor complex; this initiates the changes in the nucleus. Peptide hormones are not lipid soluble, for example **EPO.** They cannot enter the cell directly and trigger the release of a second messenger molecule from the cell membrane, this can enter the nucleus to bring about a change.

There are numerous **ethical issues** to the use of drugs in sport.

- It is acceptable: athletes have the right to decide for themselves + it may allow disadvantaged to compete at a higher level
- It is not acceptable: athletes do not always know the risks + it makes the competition unfair