Unit 1 - Anatomy and Physiology

Assessment Outcomes

AO1 – Demonstrate knowledge of body systems, structures, functions, characteristics, definitions and other additional factors affecting each body system.

AO2 – Demonstrate understanding of each body system, the short- and long-term effects of sport and exercise on each system and additional factors that can affect body systems in relation to exercise and sporting performance.

AO3 – Analyse exercise and sports movements, how the body responds to short-term and long-term exercise and other additional factors affecting each body system.

AO4 – Evaluate how body systems are used and how they interrelate in order to carry out exercise and sporting movements

AO5 – Make connections between body systems in response to short-term and long-term exercise and sport participation. Make connections between muscular and all other systems, cardiovascular and respiratory systems, energy and cardiovascular systems.

Learning Aim D – The effect of exercise & sports performance on the cardiovascular system

Learning objectives

D1 – To understand the structure of the cardiovascular system

D2 – To be able to describe the function of the cardiovascular system.

D3 – To understand the control of the cardiac cycle and how it changes during exercise and sports performance.

D4 – To be able to describe the responses of the cardiovascular system to exercise.

D5 + D6 – To understand the adaptations of the cardiovascular system to exercise and other additional factors.

The cardiovascular system

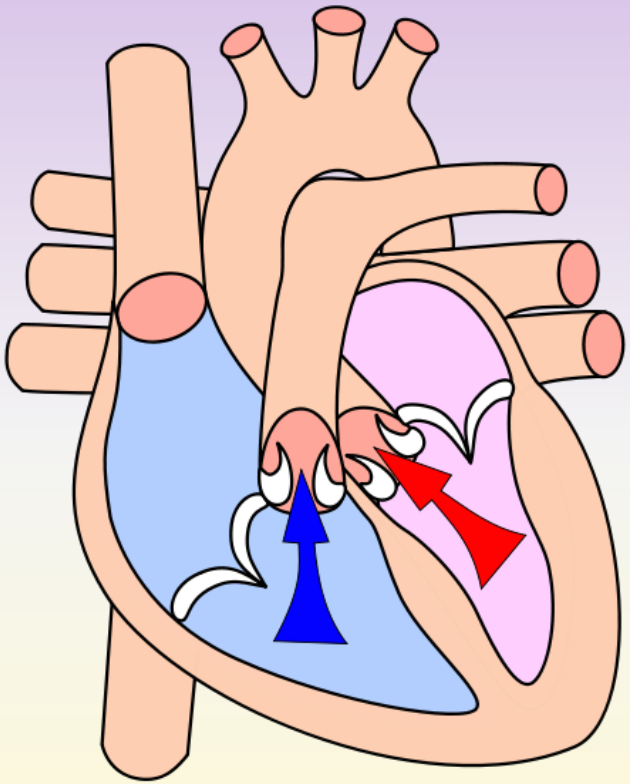
Watch me

The circulatory system and it's components

Cardiovascular System

The cardiovascular system refers to the heart, blood vessels and the blood. The heart (cardiac muscle) operates a double circulatory system in which blood flows through the heart twice.

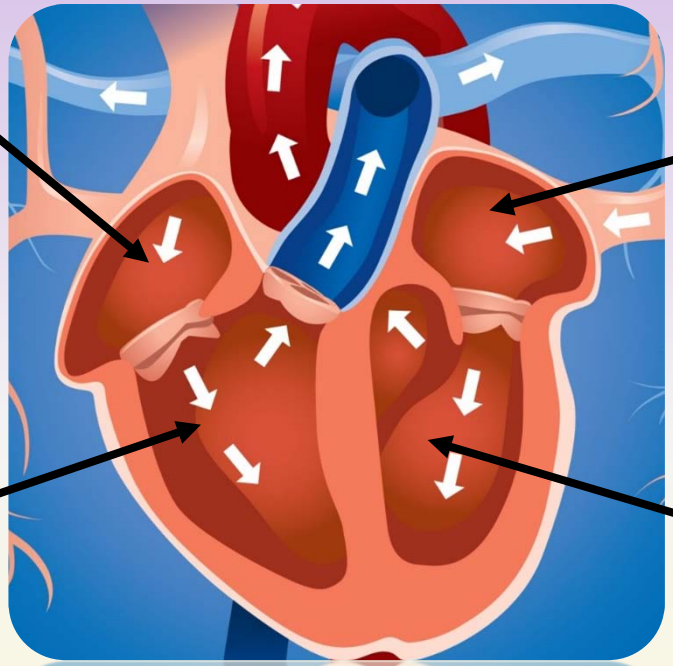
1. **Pulmonary circulation** - *i.e. flow of deoxygenated blood bto the lungs and oxygenated blood back to the heart.*
2. **Systemic circulation** - *i.e. movement of oxygenated blood from the heart through the rest of the body and deoxygenated blood back to the heart.*



Structure of the heart

The left side of the cardiac muscle has a thicker wall to allow the heart to contract with more force on the oxygenated side.

RIGHT ATRIUM - An upper chamber receiving de-oxygenated blood.



LEFT ATRIUM - An upper chamber receiving oxygenated blood from the lungs.

RIGHT VENTRICLE - A lower chamber containing de-oxygenated blood.

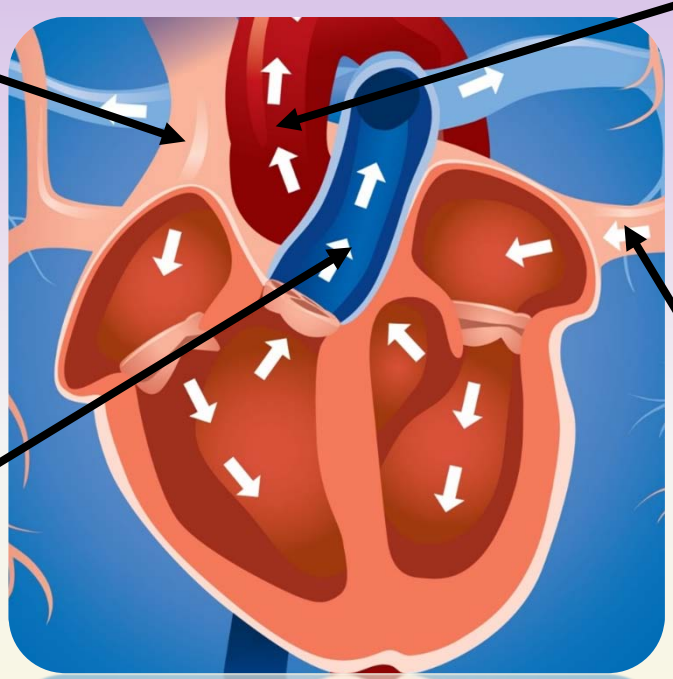
LEFT VENTRICLE - A lower chamber containing oxygenated blood.

Structure of the heart

The more the efficient the heart the greater the capacity to transport oxygen.

VENA CAVA- Returns deoxygenated blood to the heart either via the superior or inferior vena cava.

AORTA - Oxygenated blood is pumped at high pressure from the heart to the body.



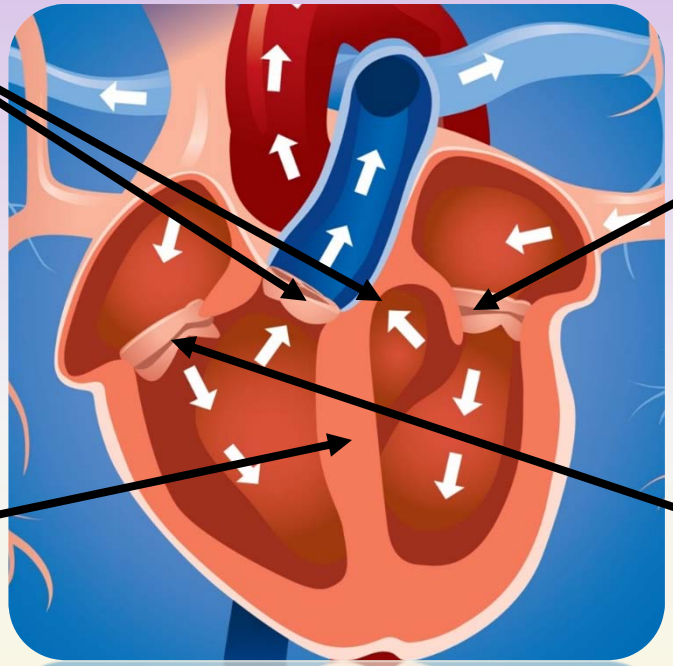
PULMONARY ARTERY - Carries deoxygenated blood from the heart to the lungs.

PULMONARY VEIN - Returns oxygenated blood to the heart.

Structure of the heart

Other structures of the heart that enable a smooth functioning include:

SEMI-LUNAR VALVES - Prevent expelled blood flowing back into the heart.



BICUSPID - Prevent blood flowing back into the left atrium.

SEPTUM - The wall dividing the left and right sides of the heart.

TRICUSPID - Prevent blood flowing back into the right atrium from the ventricle.

Structure of blood vessels

Once blood leaves the heart, it is transported around the body in three main types of blood vessels:

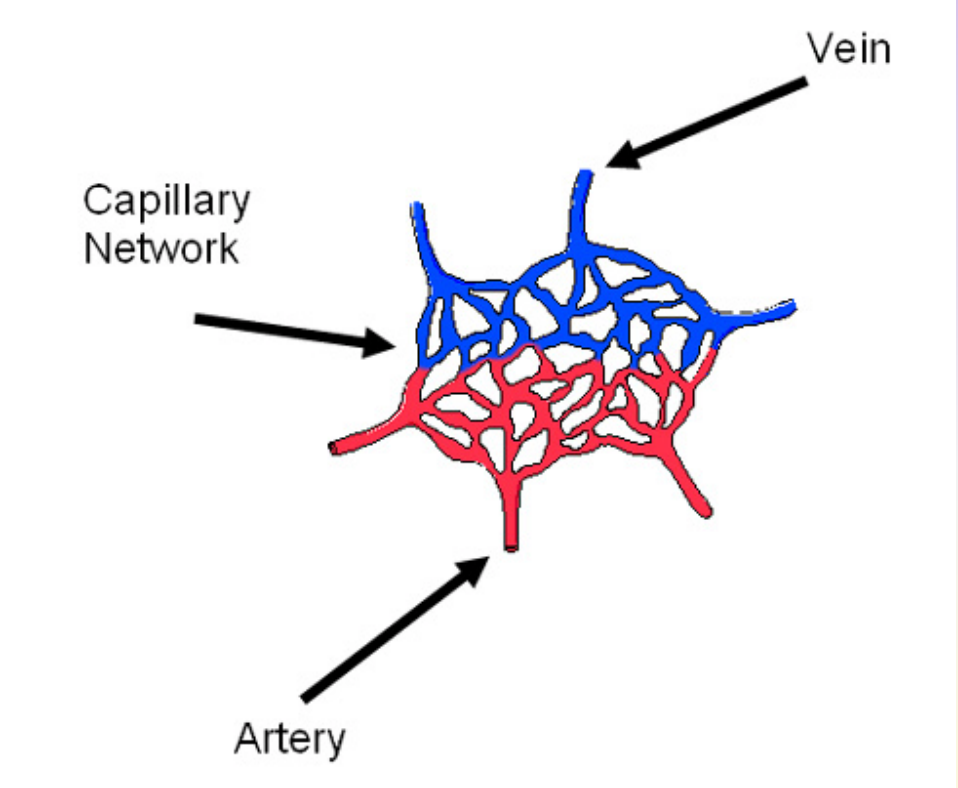
- **Arteries**
- **Veins**
- **Capillaries**

Structure of blood vessels

Arteries/Arterioles transport the oxygenated blood away from the left side of the heart under a **high pressure**.

The largest artery in the body, connected directly to the heart, is the **Aorta**.

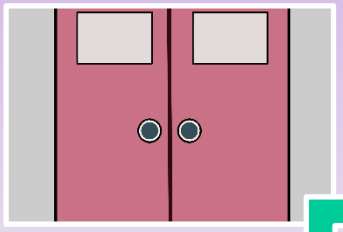
Arterioles have a ring of smooth muscle surrounding the entry to the capillary called **pre-capillary sphincters**. These dilate and constrict to control blood flow.



Structure of blood vessels

Veins/Venules transport blood from all over the body **back** to the heart and lungs for **re-oxygenation** under a **low pressure**.

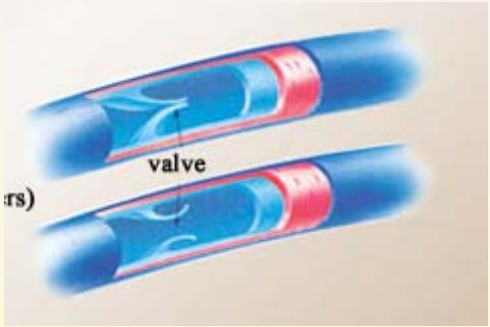
An unique feature of **veins** is that they have **valves**.



Like the valves in the heart, they are there to **prevent a backflow** of blood.

Remember = **V**eins have **V**alves

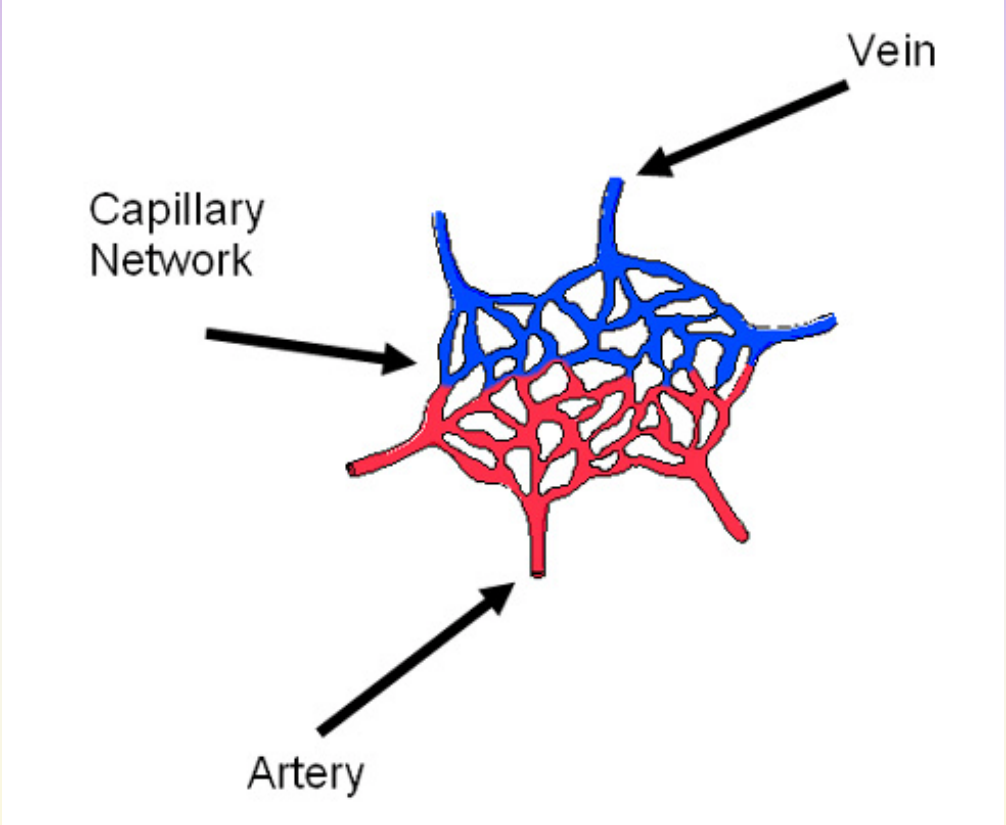
The blood must flow in one direction only, against gravity in most cases, back to the heart.



Structure of blood vessels

Capillaries are small blood vessels that carries blood to and from the body's cells.

They are **one cell thick** and are exchange points where oxygen and carbon dioxide cross into the tissue cells (muscles) from the arterioles.

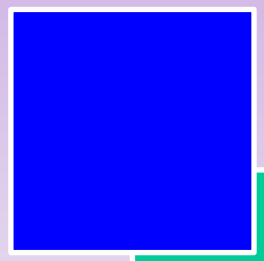


Structure of blood vessels

Below is a summary of the differences between arteries and veins:

Arteries

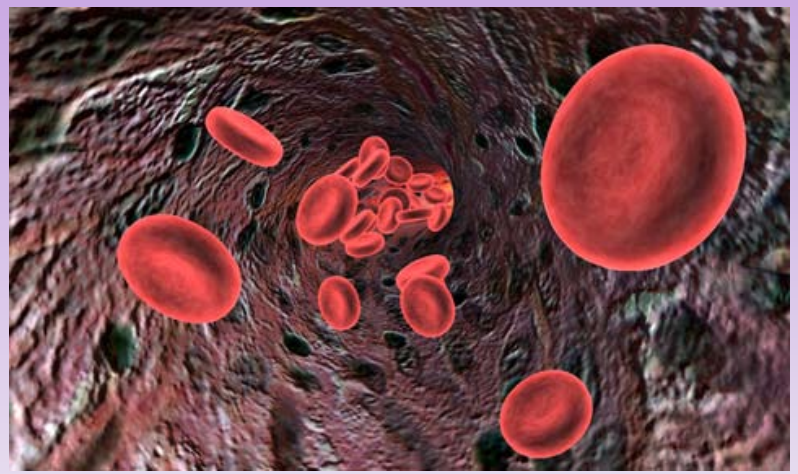
- Take blood away from the heart
- Walls are thick and elastic
- Transports oxygenated blood
- Has small lumen
- Has a pulse and blood travels in spurts
- Has no valves



Veins

- Take blood to the heart
- Walls are thin
- Transports de-oxygenated blood
- Has large lumen
- Has no pulse and blood travels smoothly
- Has valves

Composition of blood



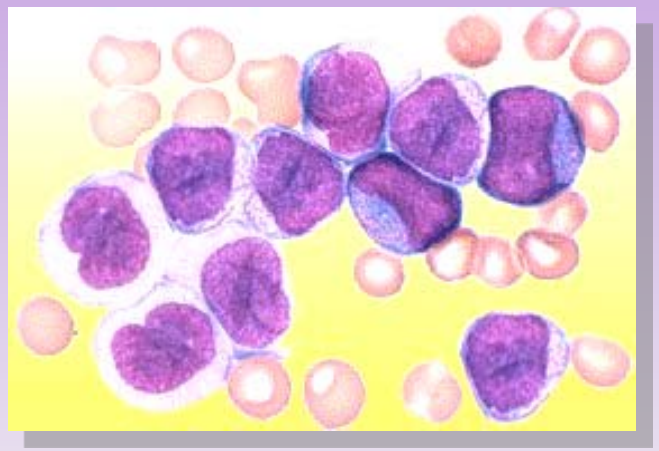
1. Red blood cells carry oxygen from the lungs to the muscles + Removes CO_2 from muscles to lungs.

Contain a red-coloured compound called haemoglobin which bonds with oxygen to form oxyhaemoglobin

Think.Pair.Share - How do red blood cells help a sports performer?

These cells are responsible for carry oxygen to working muscles. Without these cells performers would fatigue and stop.

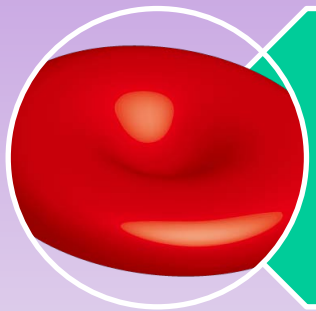
Composition of blood



2. White blood cells defend against disease. They are vital to health and preventing infection after injury.

3. Platelets and plasma clot the blood to stop bleeding. Platelets are important in healing injuries.

Functions of the Cardiovascular System



1.Transporting substances around the body. These include oxygen, glucose, carbon dioxide and waste products.

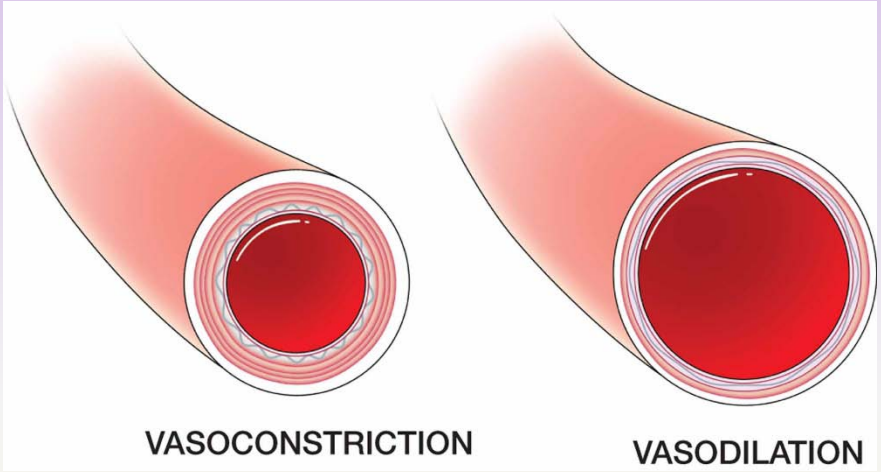
2.Controlling body temperature (Thermoregulation) This ensure that athletes do not overheat during exercise.

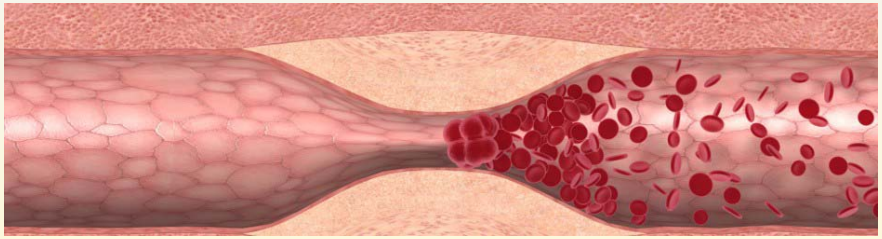
3.Protecting the body. Blood contains cells and anti-bodies that fight infection (Leucocytes) and coagulation factors that clot the blood when damage occurs to vessel walls.

Vasodilation and Vasoconstriction

Arterioles will increase diameter through **vasodilation** (increase blood flow, nutrients and gaseous exchange) or decrease through **vasoconstriction.**

It is through **constriction** and **dilation** that the vessels can regulate blood pressure and ensure the tissues are receiving sufficient blood — particularly during exercise.





Cardiac conduction system

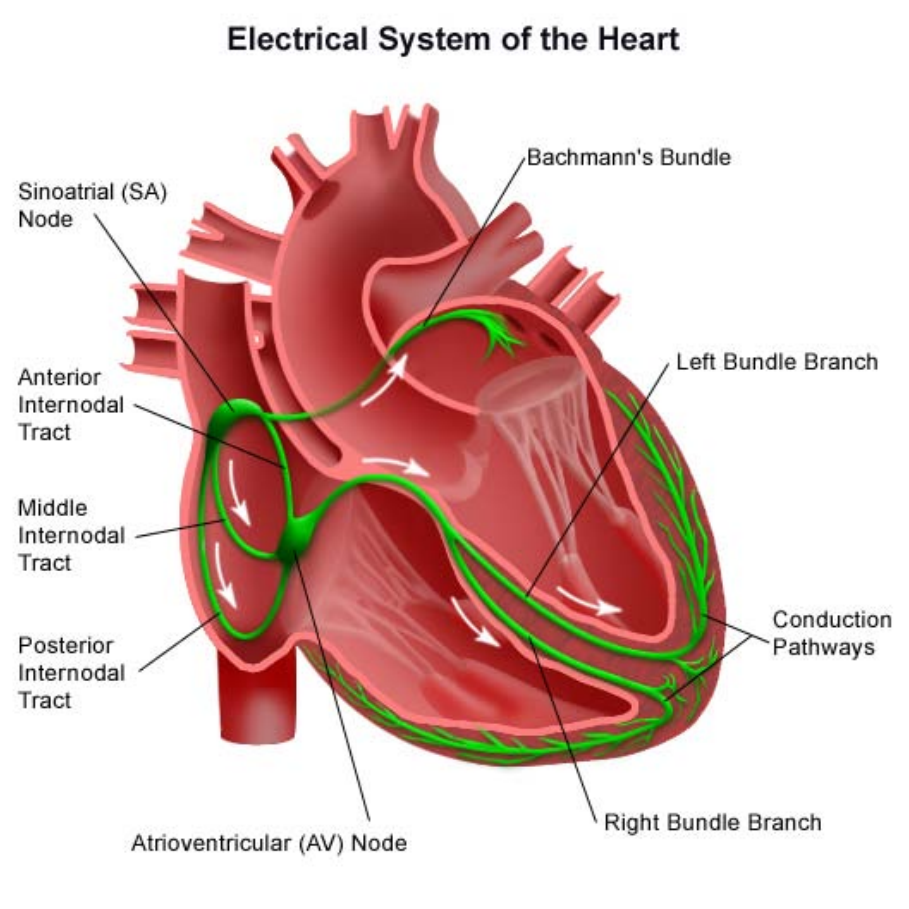
The **cardiac conduction system** is a group of specialised cardiac muscle cells in the walls of the heart that send signals to the heart muscle causing it to contract.

The main components of the **cardiac conduction system** are the **SA node, AV node, bundle of his, bundle branches, and purkinje fibres.**

Cardiac conduction system

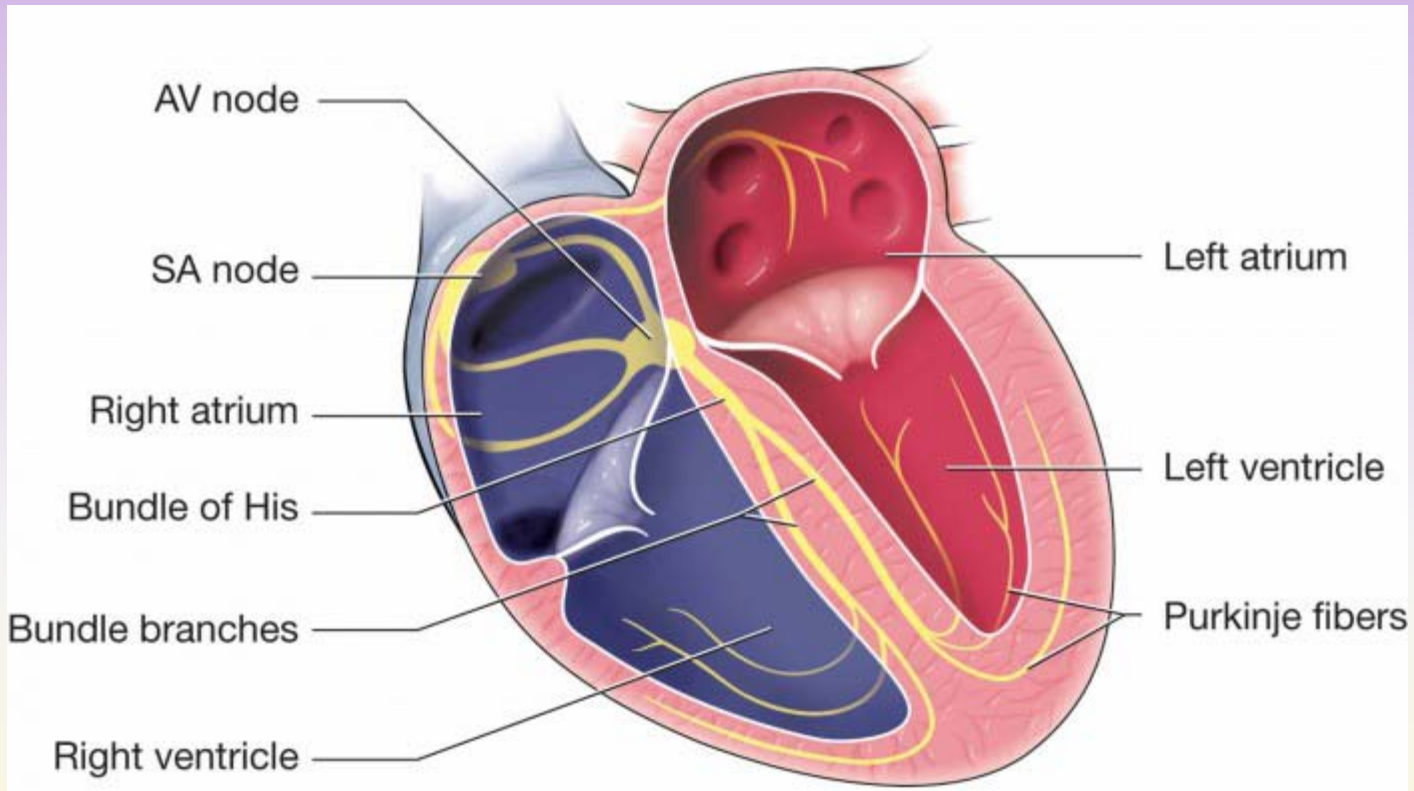
The electrical impulse begins at the pacemaker: a mass of cardiac cells known as the **sino-atrial node (S.A. node).**

As the impulse is emitted, it spreads to adjacent interconnecting fibres of the atrium, which causes the atria to contract.



Cardiac conduction system

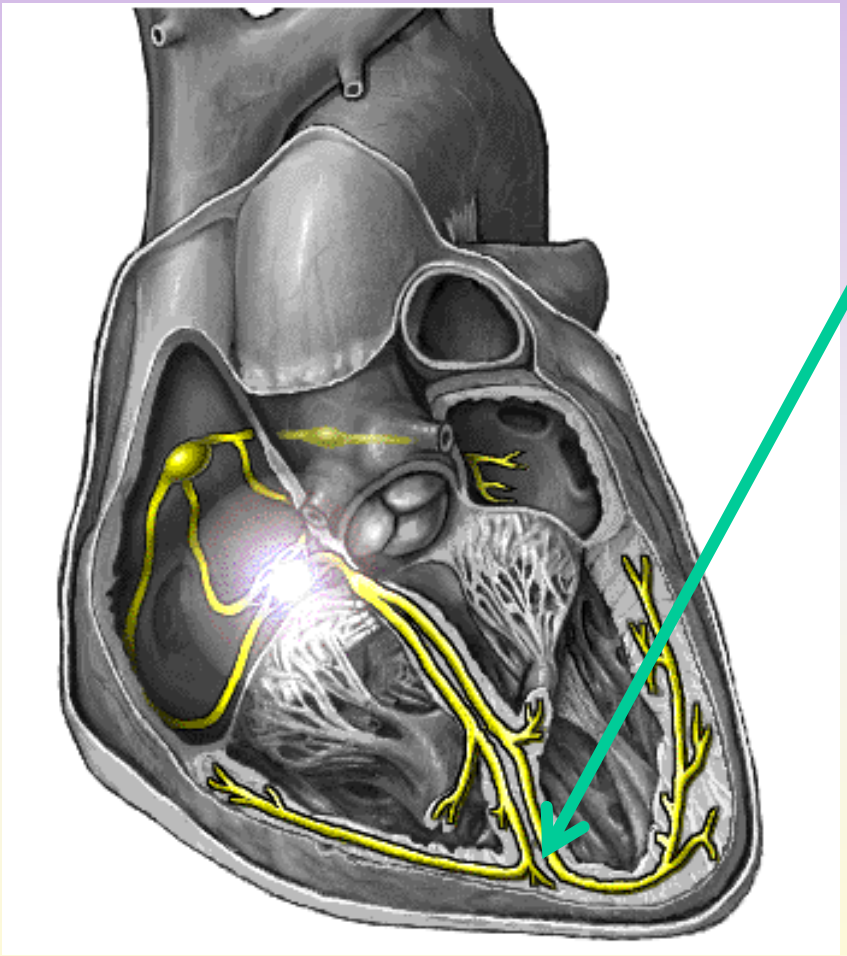
It then passes to another specialised mass of cells called the **atrioventricular node (A.V. node)**



The A.V. node acts as a distributor and passes the action potential to the **Bundle of His**.

Cardiac conduction system

This action potential filters to the branching **Purkinje fibres**, spread the excitation throughout the ventricles.



There is a delay of about 0.1 second from the time when the A.V. node receives stimulation, to when it distributes action potential through the ventricles.

Cardiac conduction system - summary

- Heart generates own electrical impulses at the **sino-atrial node** (pacemaker)
- Impulse spreads through cardiac tissue in the atria.
- This causes contraction of the atria.
- The impulse carries on to **Atrio-ventricular node.**
- The action potential moves into **Bundle of His** and spreads throughout the **Purkinje fibres** via the **bundle branches** causing the ventricle to contract.

Effect of the nervous system

The **Cardiac Control Centre (CCC)** in the medulla oblongata of the brain receives three sources of information through control systems.

The **nervous system** comprises the **sympathetic system** and the **parasympathetic system**.

The sympathetic system stimulates **SA node** to cause the heart to beat faster and the parasympathetic system returns the heart to its resting level.

Responses of the cardiovascular system during exercise

Exercise requires a number of responses from the cardiovascular system to maintain the needs of the body.

1. **Anticipatory rise:**
This **increase in heart rate** is caused by an increase in activity of the sympathetic nervous system causing the adrenal glands to release **adrenaline** into the blood stream.

Responses of the cardiovascular system during exercise

2. **<u>Increase in heart rate:</u>**

Once stimulated, the sympathetic nerves cause the release of **adrenaline**. This hormones cause an increase in heart rate and therefore an increased oxygen supply.

Responses of the cardiovascular system during exercise

The **short term effects** of exercise on the cardiovascular system also include:

3. Increase in stroke volume
4. Increase in cardiac output

Responses of the cardiovascular system during exercise

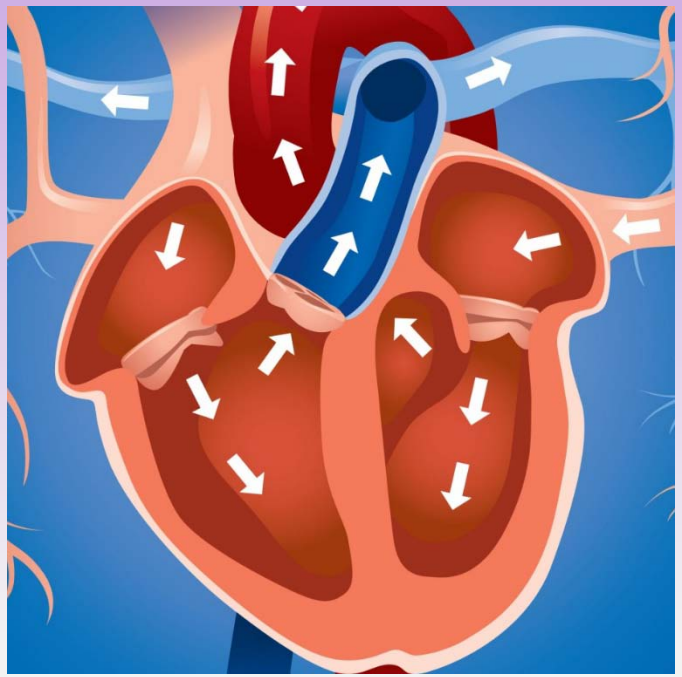
5. Blood pressure is the force of the blood against the walls of the arteries.

Blood Pressure increases as a result of exercise.

More blood is pumped around the body which increases the pressure on the blood vessel walls.

Responses of the cardiovascular system during exercise

Systolic Pressure:
This is the maximum pressure in the arteries when the heart contracts.



Diastolic Pressure:

This is the pressure of blood during the relaxation phase between beats.

Responses of the cardiovascular system during exercise

Blood pressure is a measure of how well the heart is pumping and vessel are working. The harder they work the more contractions needed.

A blood pressure reading shows:

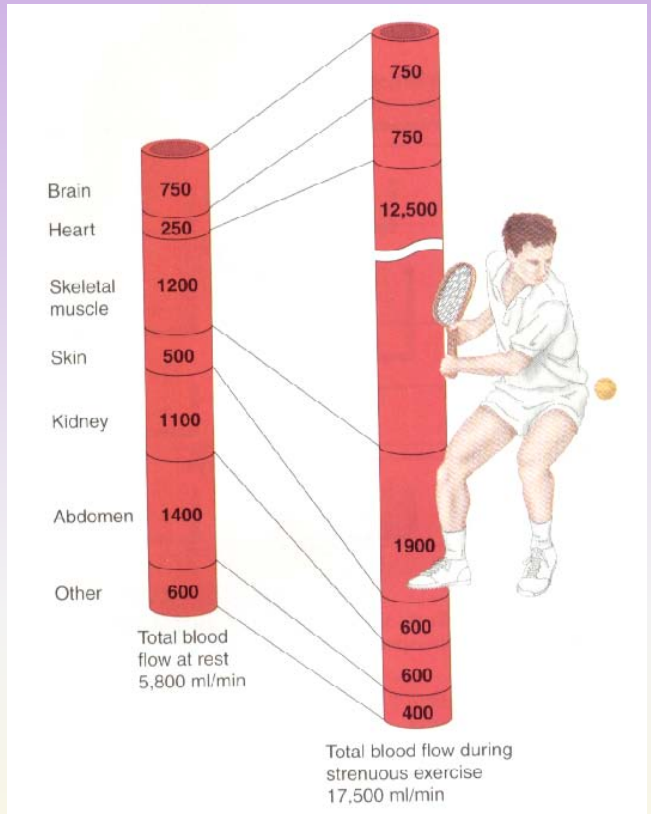
Systolic Pressure Diastolic Pressure

Average blood pressure: 120 80

Responses of the cardiovascular system during exercise

6. **<u>Redistribution of blood flow:</u>** At rest, the body mainly serves oxygen rich blood to the body's organs (around 75%) This changes dramatically during exercise.

   Constriction of some blood vessels causing blood to be redistributed to where it is needed *i.e. the working muscles*



Think. Pair. Share - Look at the changes in blood redistribution in the diagram shown. What do you notice and why does this 'shunt' take place?

Responses of the cardiovascular system during exercise

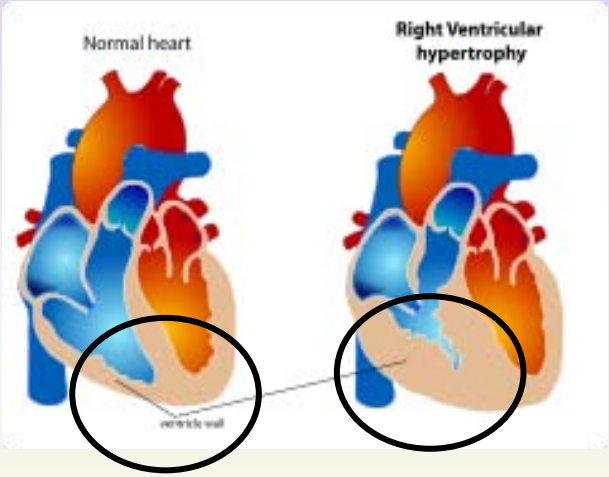
During exercise, blood flow to the skeletal muscles increases to meet the increase in oxygen demand. This redirection of blood flow to the areas where it is most needed is known as a **vascular shunt**.

Adaptations of the cardiovascular system due to exercise

A carefully planned training regime will result in the cardiovascular system adapting over time to cope with the increased demands of exercise.

Cardiac Hypertrophy:

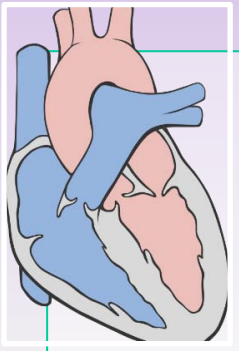
The enlargement of the heart is due to training causing the walls of the heart to thicken. An increase in left ventricle strength causes the heart to become more efficient.



Think. Pair. Share – How will cardiac hypertrophy affect performance?

Adaptations of the cardiovascular system due to exercise

The following cardio-respiratory system changes can take place after as little as 4-6 weeks training.



Increased **maximum cardiac output** means more blood is pumped out of the left ventricle of the heart per minute.

Increased resting and exercise **stroke volume** means more blood is pumped out of the left ventricle per beat.

Adaptations of the cardiovascular system due to exercise

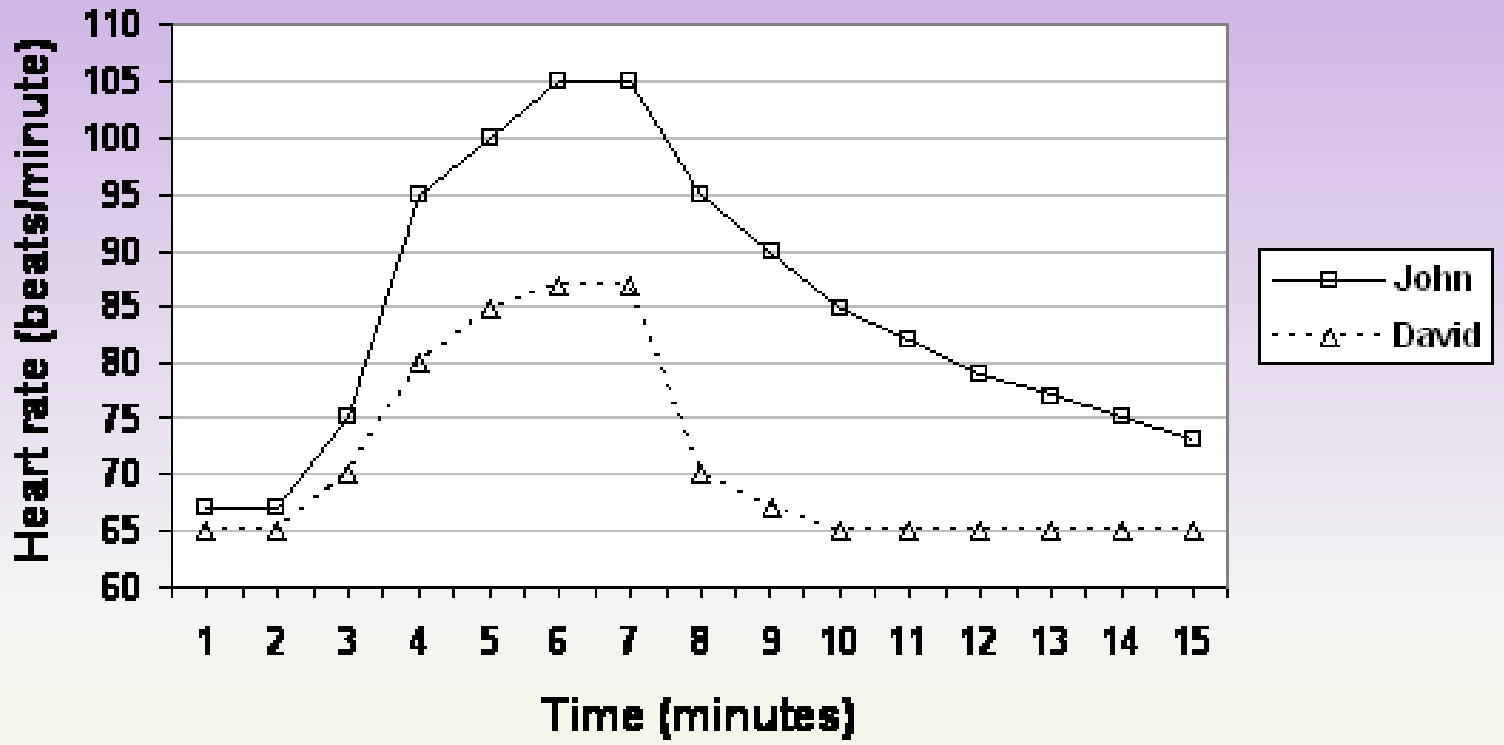
Decreased resting heart rate:

Cardiac hypertrophy and an increase stroke volume causes resting heart rate to drop.

Decreased resting blood pressure:

Physical activity causes blood pressure to rise and returns to normal post exercise. Research shows that regular exercise can contribute to reducing blood pressure particularly those suffering from **hypertension**.

Adaptations of the cardiovascular system due to exercise



Think. Pair. Share - Describe what you see from these graphs. Which athlete is trained and which is one is untrained?

Adaptations of the cardiovascular system due to exercise

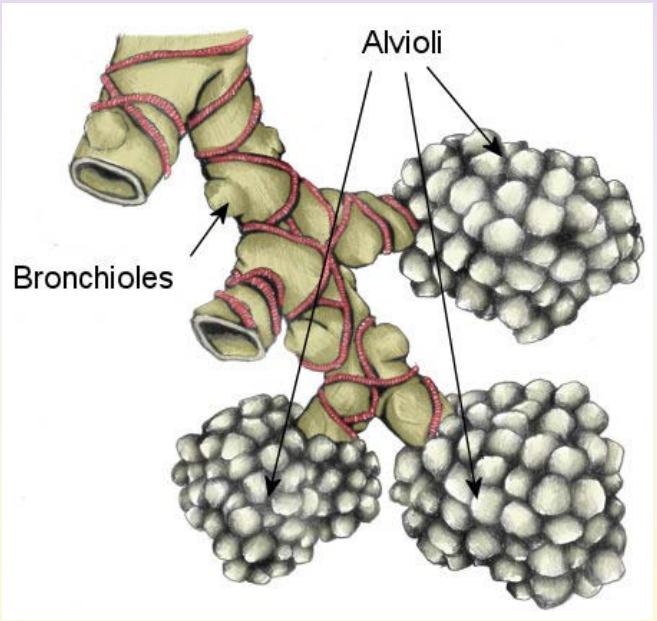
Decreased heart rate recovery time:

Training will result in heart rate recovering quicker after exercise. Fitter athletes will bring their heart rate down much quicker than untrained individuals.

Adaptations of the cardiovascular system due to exercise

Capillarisation of skeletal muscle and alveoli:

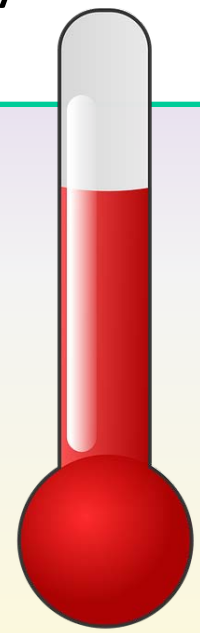
A better capillary network in the body will increase blood flow to working muscles. This allows for a more effective transport of oxygen and nutrients.



Adaptations of the cardiovascular system due to exercise

Increased blood volume:

Blood volume increases as a result of capillarisation and means the body can deliver more oxygen to working tissues. In addition, this increase in blood volume will regulate body temperature more efficiently.



Additional factors affecting the cardiovascular system

Watch me

What happened to Fabrice Muamba in 2012? What is Sudden Arrhythmic Death Syndrome? (SADS)

Additional factors affecting the cardiovascular system

Sudden arrhythmic death syndrome (SADS) is an inherited cardiac condition that can cause death in young and well trained individuals. The heart's natural rhythm becomes disrupted and can stop beating altogether.

High profile cases such as Fabrice Muamba have raised awareness of the syndrome.

Think. Pair. Share – What is being done to help protect sportspeople from SADS?

Additional factors affecting the cardiovascular system

Exercise causes the heart to work harder than normal and blood is ejected around the body under a greater force. Individuals suffering from **high blood pressure (hypertension)** risk placing excessive strain on the heart with vigorous exercise.

Those suffering from hypertension should seek medical advice before starting an exercise programme.

Additional factors affecting the cardiovascular system

Low blood pressure (hypotension) indicates that blood is moving slowly around the body and can restrict the volume of blood reaching vital organs and muscle tissues.

Symptoms include dizziness, tiredness and fainting.

Low blood pressure will affect cardiovascular performance as insufficient delivery of oxygenated blood to working muscles will cause early fatigue.

Additional factors affecting the cardiovascular system

In hot conditions **thermoregulation** is vital. This is the process of maintaining core body temperature. It is important to **acclimatise** and enable the body to modify the control systems that regulate blood flow to the skin.

The 2022 World Cup in Qatar has been forced to move the date of the competition to the cooler months of December rather than the 50◦C heat in the summer months on the grounds of player health and safety.

Additional factors affecting the cardiovascular system

A rise in core body temperature of several degrees can greatly affect performance and is known as **hyperthermia**. This is common if an athlete pushes themselves too fast, for too long or in **hot humid conditions**.

The body regulates temperature through **vasodilation** so heat can dissipate.

It is also important to wear the **correct clothing** to encourage evaporation.

Additional factors affecting the cardiovascular system

Hypothermia is when body temperature falls below 35oC. Hypothermia may occur when training in a **cold environment** without adequate clothing.

Symptoms include:

- Shivering
- Confusion
- Heart irregularities.

Apply it!

What has stuck with you?

The Cardiovascular system

Explain to the person next to you three responses of the cardiovascular system to exercise.

Describe how vascular shunt is created once exercise begins.

Explain difference between veins, venules, arteries, arterioles and capillaries.

How does the nervous system control the heart pumping?

Practice it!

Exam questions

1. (i) Blood is circulated around the body. Name the type of blood vessel that returns blood to the heart. (1)

.....

(ii) This type of blood vessel contains valves. What is the function of these valves? (1)

.....

.....

.....

Practice it!

Exam questions

2. Blood is made up of different components. Complete the table below by identifying the: (6)

(i) components;

(ii) function of each component;

(iii) importance to the sports performer.

Component of blood	Function of each component	Importance to sports performer
		Oxygen delivery for activity
White blood cells		
		Stops blood loss so the performer can continue to play

Practice it!

Exam questions

3. Describe how the capillaries aids the process of gaseous exchange. (3)

4. Describe the functions of the right atria. (2)

5. Explain the role of the Atrio-ventricular node (AVN) in the nervous control of the heart when exercising. (3)

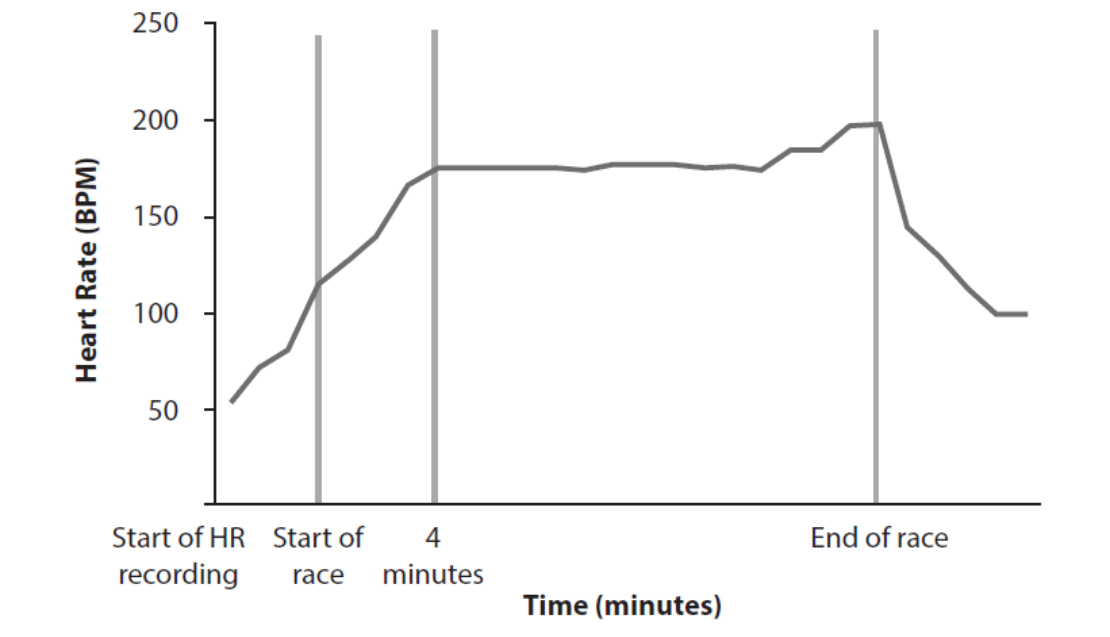
Practice it!

Exam questions

6. Joe has been taking part in a 6 week endurance training programme to try to improve his 5000m time. He used a heart rate monitor to record his heart rate during his first 5000m race.

Explain, using Figure 5, how Joe's heart rate increases from the start of the Heart Rate (HR) recording to 4 minutes into the race.

(4)



Practice it!

Marks Scheme:

1. (i) Veins/vena cava/ pulmonary vein.

   (ii) Stop backflow of blood/stop blood going backwards/stop blood going the wrong way

2.

Component of blood	Function of each component	Importance to sports performer
Red blood cells	Carry/ collect/ transport oxygen/O2	
	Fight disease/help immune system/	Keep the performer **healthy** so they can **compete**
Platelets	Aid clotting/form a scab	

Practice it!

Marks Scheme:

3.

- Connective blood vessel between an arteriole and venule (1)
- A network of capillaries providing a large surface area that surrounds the muscle/alveoli (1)
- It has a 1 cell thick/endothelial/semi permeable membrane (1)

4. To receive deoxygenated blood returning to the heart from the vena cava (1) Facilitates circulation by contraction of the atrial walls sending blood to the right ventricle (1)

5. The AV node (AVN) receives increased stimulation of impulses from the sinoatrial node (SAN) (1) the AV node slows down the impulse to allow for complete contraction of the atria (1) relays the impulse down the bundle of His/sends impulse to allow ventricular contraction (1)

Practice it!

Marks Scheme:

6.
(Start of Heart Rate Recording)
Anticipatory rise of HR immediately prior to the race starting (1) due to the release of adrenaline which acts on the sinoatrial node (SAN) to increase HR. (1)

(Start of Race)
Sharp increase in heart rate due to an increased stimulation of the sympathetic nervous system (1) due to decreased concentration/partial pressure of oxygen in the blood/muscles/increased concentration/partial pressure of CO2/acidity in the blood/muscles (1)