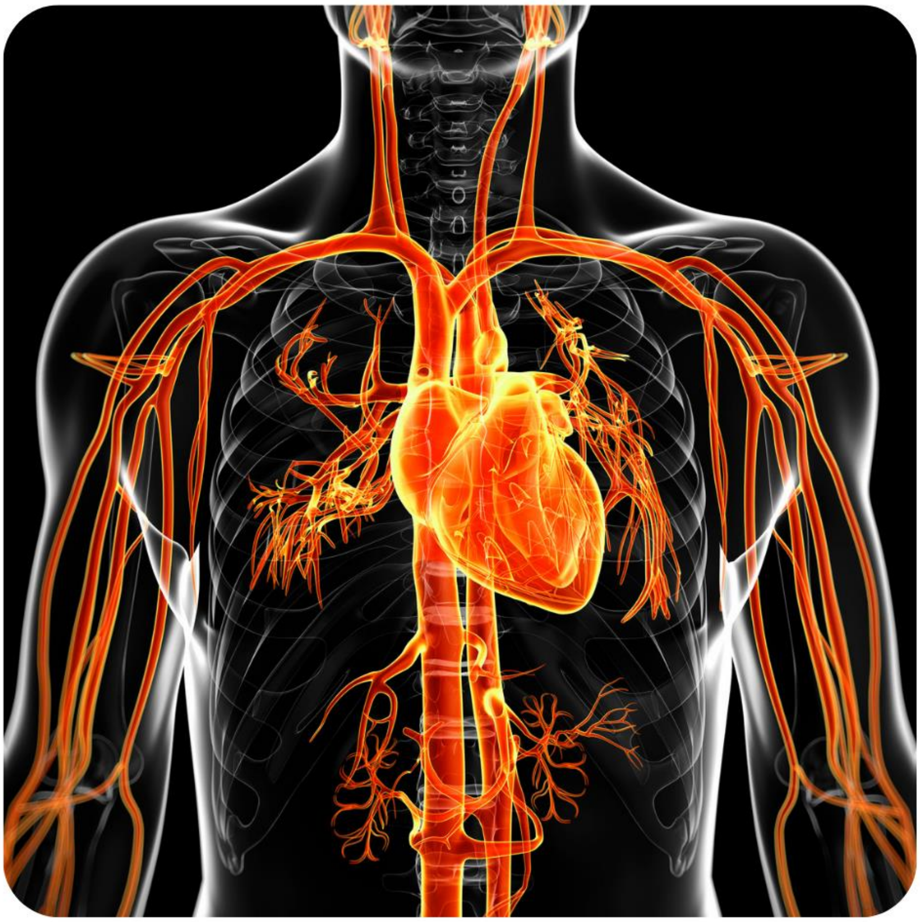
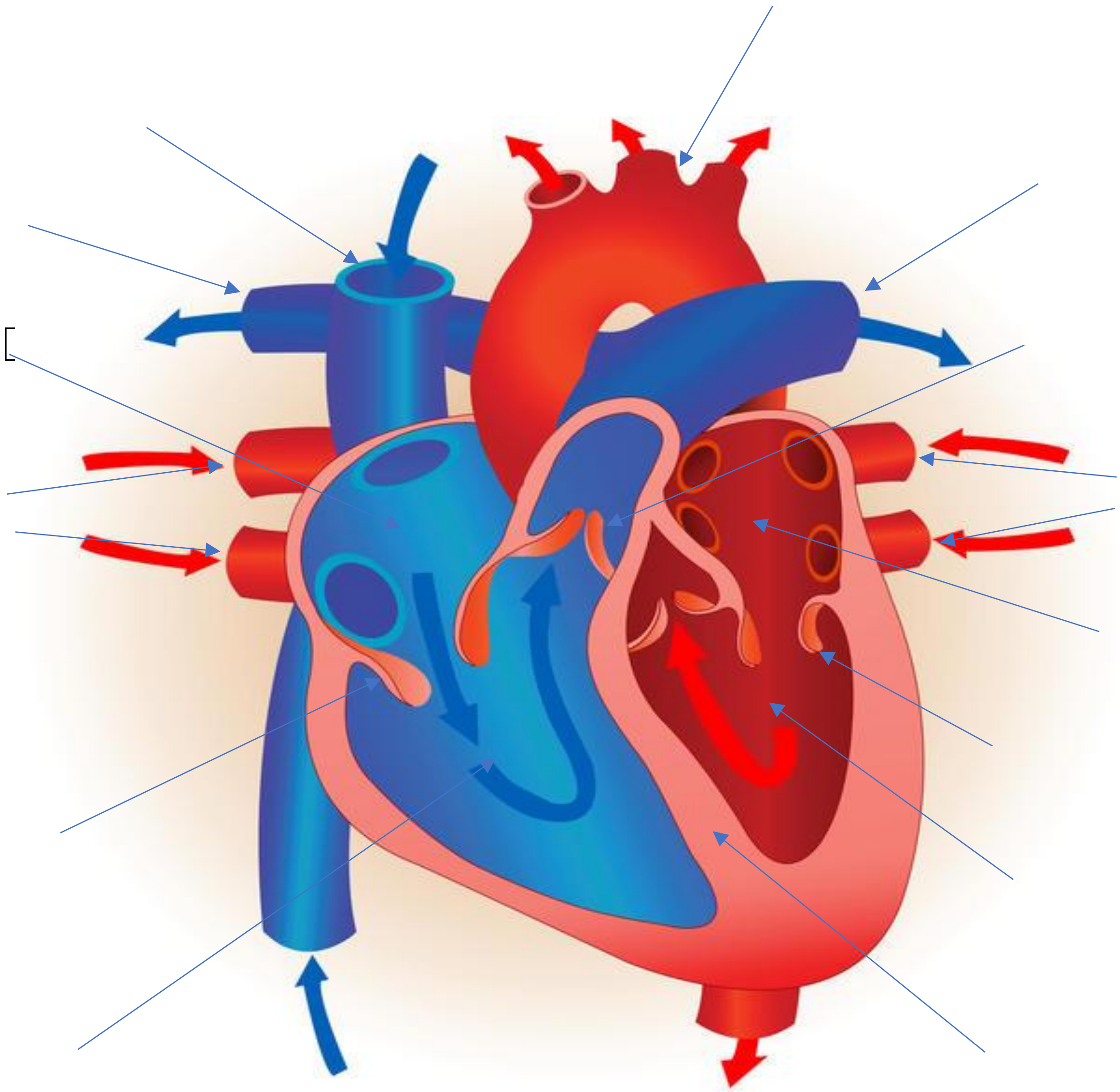
1.1.b The Cardiovascular System

Name	
Class	



The Heart – Chambers, Arteries, Veins & Valves



The **Pulmonary Circuit** carries deoxygenated blood to the lungs and oxygenated blood back to the heart. This circuit is made up of the pulmonary artery and ________________________.

The **Systemic Circuit** carries oxygenated blood to the body and deoxygenated back to the heart. This circuit is made up of the _____________ and ________________ .

<u>The Cardiac Conduction System</u>

The cardiac conduction system is a group of cells found in the wall of the heart which are responsible for the electrical impulses that cause the atria/ventricles to contract.

The heart is '**myogenic**'. This means that it is capable of generating its own electrical impulses, forcing the cardiac muscle to **contract**.

It is important that you understand the order of events that occur in the Conduction System:

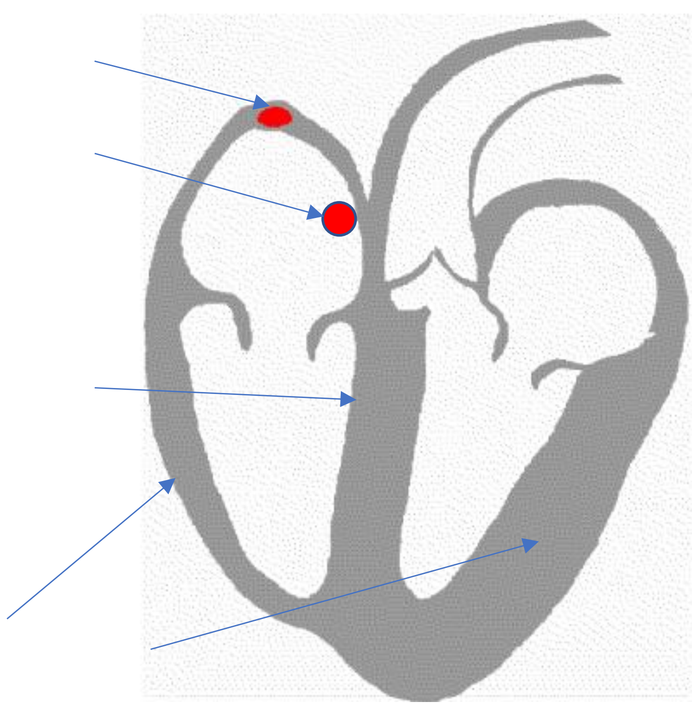
Electrical signal begins in the **Sinoatrial Node (SAN)** aka the **pacemaker**

The electrical impulse travels through the atria, causing them to contract and pass blood into the ventricles, before reaching the **Atrioventricular Node (AVN)**

A delay of 0.1secs then occurs whilst the atria fully contract.

The electrical impulse then travels down the **bundle of his,** located in the septum.

The **bundle of his** then separates into smaller branches called **purkyne fibres.** These spread the impulse around the ventricles, causing contractions



<u>The Cardiac Cycle</u> – refers to the cardiac muscle contraction and the movement of blood within the chambers. The following occurs in the atria first, then ventricles.

The **cardiac diastole** is the <u>relaxation</u> of the cardiac muscle

The atria and ventricles relax and expand to draw blood into the atria.

The increased pressure in the atria opens the AV valves, allowing blood to enter the ventricles.

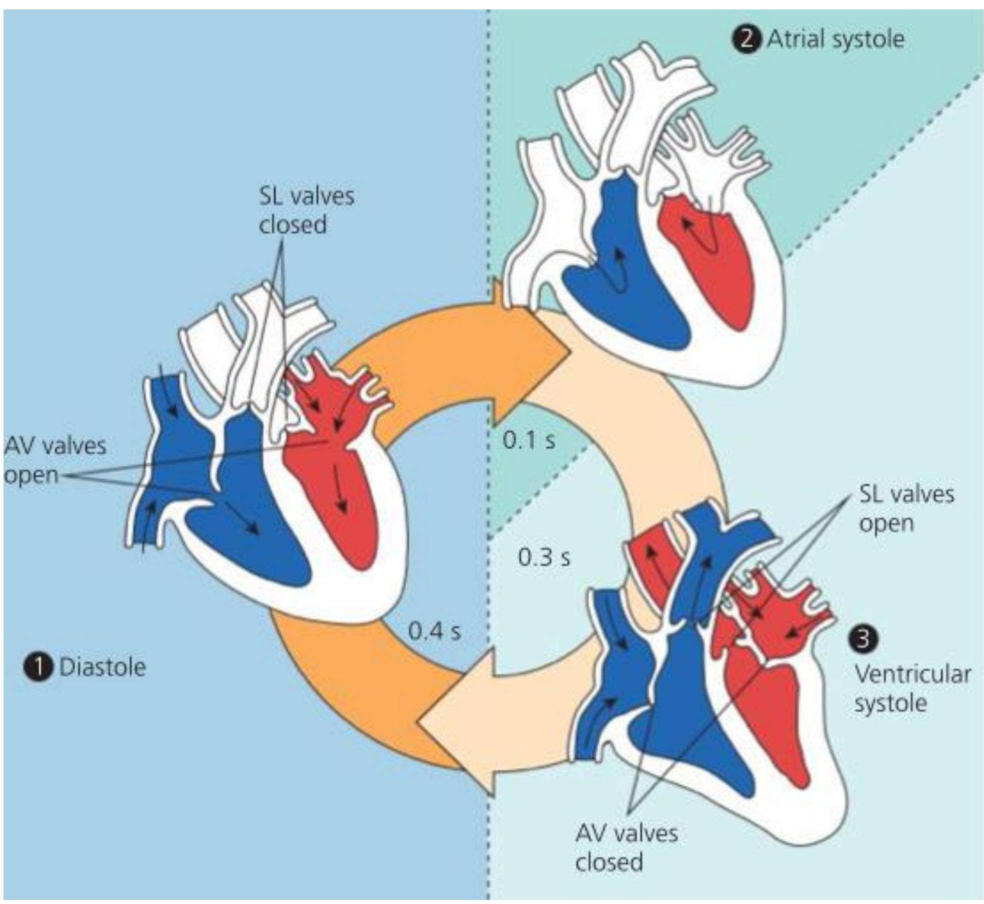
SL valve close to prevent blood from leaving the heart.

The **cardiac systole** is the <u>contraction</u> of the cardiac muscle.

Atrial Systole – As the atria contract, remaining blood is forced into the ventricles.

Ventricular systole – As the ventricles contract, pressure increases and AV valves close to prevent backflow into the atria.

SL valves are forced open as blood is ejected into the aorta and __________________.



In order to assess a performer's cardiac muscle, we look at heart rate, stroke volume and cardiac output.

Heart rate = The number of cardiac cycles (beats) per minute (lower = more efficient)

A heart rate lower than 60bpm is known as **bradycardia**, resulting from cardiac ________________.

MAX HR = 220 – age

Stroke Volume = The ____________ of blood pumped out by the heart ________________ in each contraction. It depends on two factors:

Venous Return: the volume of blood returning to the heart

(greater volume returned = greater volume ejected)

Ventricular elasticity and contractility: the degree of stretch in cardiac muscle fibres.

(greater stretch = greater force of contraction = raises SV)

Cardiac Output, Q = The _______________(litres) of blood pumped out by the heart __________ per__________. (Heart Rate x Stroke Volume)

Ventricles	Volume	Minute	Volume	Ventricles	Hypertrophy

Explain what you believe will happen to stroke volume and cardiac output as a result of exercise.

____

We will now look into whether this is completely true…..

Exercise can be done at maximal or sub-maximal intensity. What is the difference between the two?

Maximal –

____

Submaximal –

____

Sub-Maximal Exercise:

The following table shows the stroke volume (ml) of a performer exercising at sub-maximal intensity.

Table 1

Time	Stroke Volume (ml)	HR Estimate
1min (30% max effort)	80	
2min (40% max effort)	120	
3min (50% max effort)	140	
4min (60% max effort)	160	

The performer in the table above is 18 years old. Use the column to state how high you think their HR was for each minute of exercise. Explain your estimates below.

____

____

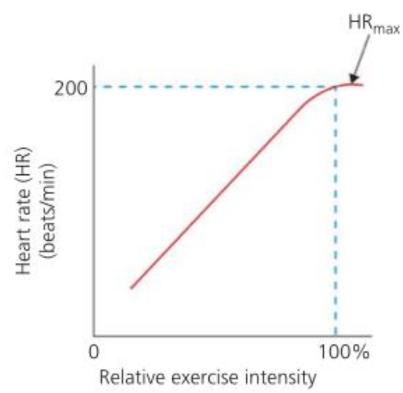
____

Like stroke volume, Cardiac output continues to increase in line with intensity, until maximal exercise is reached.

Anticipatory Rise

This is the increase in heart rate that occurs just before taking part in exercise. It is caused by an increase in activity from the **sympathetic nervous system.**

During sustained sub-maximal exercise, heart rate plateaus as the supply of oxygen meets the demand.



Maximal Exercise:

When exercising at maximal levels, things start to change for stroke volume. A performer's stroke volume will only continue to rise up to around 60% of maximal effort. At this point the heart rate is too high for the ventricles to have enough time to fill up with blood, meaning that there is a **plateau** in stroke volume.

Table 2

Time	Stroke Volume (ml)	HR	Cardiac Output (litres/min)
1min (30% max effort)	80		
2min (40% max effort)	100		
3min (50% max effort)	120		
4min (60% max effort)	160		
5min (70% max effort)			
6min (80% max effort)			
7min (90% max effort)			

Using the information above, fill in the table to show what you would expect to happen to stroke volume, cardiac output and HR as a result of maximal exercise.

So if stroke volume does not increase at maximal exercise, how do your working muscles continue to get the oxygen they require as exercise intensity increases?

____

____

Heart rate does not plateau during maximal exercise as the intensity is constantly increasing, which means a growing demand for oxygen.

What do you think happens to cardiac output during maximal exercise?

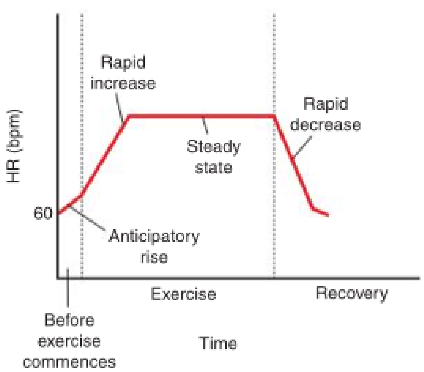
After completing the table above, explain what happens to Cardiac Output when exercising at **sub-maximal and maximal** levels.

Now use graph paper in order to plot one line graph showing the results from table 2, and a separate graph to show your results from table 3.

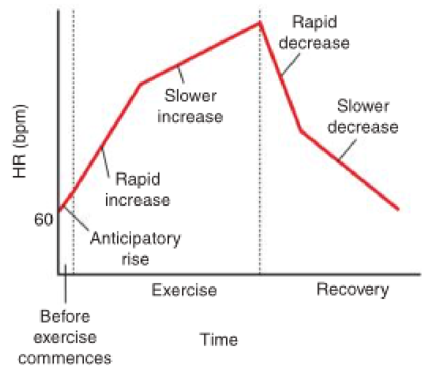
<u>Recovery</u>

There is a gradual decrease in Heart rate during recovery.

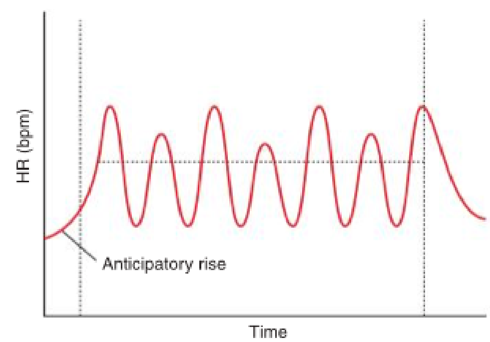
Sub-maximal Exercise



Maximal Exercise



Fluctuating intensities of exercise



During recovery, the body needs to maintain blood/oxygen supplies and the removal of _______

. To do so, what do you think is maintained during the earlier stages of recovery? ____________

Cardiac output decreases rapidly at first, then more slowly back to resting levels.

<u>Redistribution of Blood Flow:</u>

During exercise blood must be distributed to areas of the body that require an increased level of oxygen. This redistribution of blood flow is known as **vascular shunting.**

How would the following performers benefit from the **vascular shunt mechanism**? Which muscle groups will require more oxygen?

How does eating just before exercising have an effect on **vascular shunting?**

Key Point – The brain requires the same amount of oxygen at rest and exercise

As you exercise and vascular shunting occurs, your blood vessels help with the process of redistributing blood. This process if known as vasodilation and vasoconstriction.

VasoDILATion – blood vessels DILATE (get bigger) – allows more blood for the active muscles
VasoCONSTRICTion – blood vessels CONSTRICT (get smaller) – takes blood away from inactive areas and the organs

How is vasodilation used by the body during exercise?

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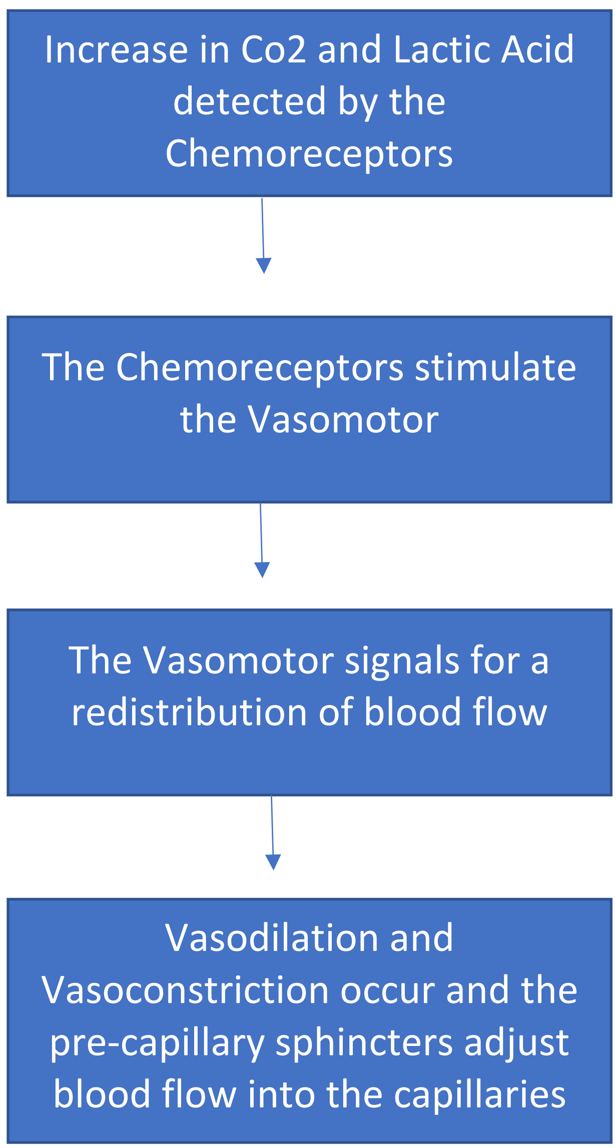
____

How is vasoconstriction used by the body during exercise?

____

____

<u>The Process of Vascular Shunting:</u>



How does vascular shunting occur in order to benefit a netball player during a match?

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____.

<u>Pre-capillary sphincters</u> help direct blood flow into capillaries, into tissue that need it the most. This, like the arterioles, reduces flow to _____________ tissues, and increases flow to active ones.

What is the **Vasomotor** and where is it located?

____

____

What are the chemoreceptors and where are they located?

____

____

Heart Rate Regulation

During exercise, the heart rate of an individual needs to change to meet certain demands. To do this, the **Cardiac Control Centre (CCC)** in the medulla oblongata in the brain receives information from sensory nerves and sends information to motor nerves.

1. Neural Control

Sympathetic v Parasympathetic Systems:

The sympathetic system can speed up the cardiac impulses given out by the cardiac conduction system, whereas the parasympathetic system can decrease these impulses and heart rate.

Both of these control mechanisms are controlled by the **medulla oblongata** in the brain.

If **sympathetic** nervous impulses are sent from the brain to the SAN, what will happen? What might an individual be doing at this point?

____

If **parasympathetic** nervous impulses are sent from the brain to the SAN, what will happen? What might an individual be doing at this point?

____

Chemoreceptors:

During _____________ the **chemoreceptors** detect an increase in _____________. Nerve _____________ are therefore sent to the ___________________ in the brain and the _______________________ system is activated and impulses are sent to the SA _____________ in order for contractions to increase. This will lead to an increase in heart rate and the supply of _____________ for the body. This is also similar for increased levels of lactic acid.

Impulses	Medulla Oblongata	Exercise	Oxygen	Carbon Dioxide	Node	Sympathetic Nervous

Baroreceptors:

The **baroreceptors** detect an increase or decrease in ___________________ by detecting the stretching of the _____________ wall. An increase in arterial pressure will result in the baroreceptors sending a _____________ to the _____________________ in the brain. The _______________ system will then be activated and impulses are sent to the ________ node for contractions to decrease. However during exercise the baroreceptor __________ point increases, so that heart rate does not __________ down.

Arterial	Set	Blood Pressure	Message	Parasympathetic	Medulla Oblongata	Slow	SA

2. Intrinsic Control

Temperature changes will affect the _______________ (thickness) of the blood therefore the _______________ of nerve impulse transition.

Venous return changes affect the _______________ in the ventricle walls, force of _______________ and stroke volume.

Speed	contraction	stretch	viscosity

3. Hormonal Control

Adrenaline and nonadrenaline are released from the adrenal glands, increasing the force of ventricular contraction (therefore SV) and the speed of electrical activity through the heart (therefore HR)

Sympathetic nervous system = increases HR

Parasympathetic nervous system = decreases HR

<u>Venous return mechanisms</u> –mainly against gravity.

Venous return is the flow of blood back to the heart, via the veins and specifically the vena cava. During exercise, **venous return** increases. As a result of this, more blood will also be ejected from the heart (stroke volume).

Venous Return Mechanisms:

The blood in the veins is at a much lower pressure than in the arteries, particularly as it goes through the Vena Cava and into the heart. Why do you think this is?

____

____

____

____

Due to this low pressure of blood in the veins, the **venous return mechanisms** are required in order to help Venous Return. These are as follows:

1. **The Skeletal Muscle Pump –** Muscles _____________ and relaxing are constantly changing shape. This results in muscles pressing on nearby _____________. This causes a pumping action, which pushes blood back towards the heart.

2. **The Respiratory Pump**

Breathing in and out causes _____________ in many muscles, as well as the diaphragm. This causes a constant change in the _____________ of the thoracic (chest) cavity, compressing the veins and causing venous return.

3. **Pocket Valves**

Veins are full of pocket valves. As blood passes through these valves, they _____________ in order to prevent the _____________ of blood

contractions	close	contracting	pressure	veins	backflow

Venous return is also aided by 'smooth muscle', 'gravity' and the 'suction pump' of the heart. Do some of your own research to find out about these factors within venous return.

____

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How would swimming effect the venous return mechanisms?

____

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Tip – Don’t just repeat what you have learned about the mechanisms. Make sure that your are relating your answer to exercise

As exercise is coming to an end, cardiac output remains _____________. But, sometimes not _____________ blood is returned back to the heart in comparison to that being ejected, causing feelings of _____________.

Also, blood _____________ can occur, aka ‘heavy legs’. Therefore, an active recovery is needed to prevent this, which Type equation here.includes _____________________ exercise to _____________ muscle and respiratory pump.

Enough	pooling	low	maintain
high	low-intensity	high-intensity	

<u>Starling's Law:</u>

Starling's law of the heart states that **stroke volume** increases in response to an increase in **venous return.**

This process, outlined by Starling, follows six key steps.

There is an increase in venous return

Therefore greater diastolic filling of the heart occurs

This causes the cardiac muscle to be stretched

Resulting in a more powerful contraction

And an increased ejection fraction (stroke volume)

Sample Exam Questions

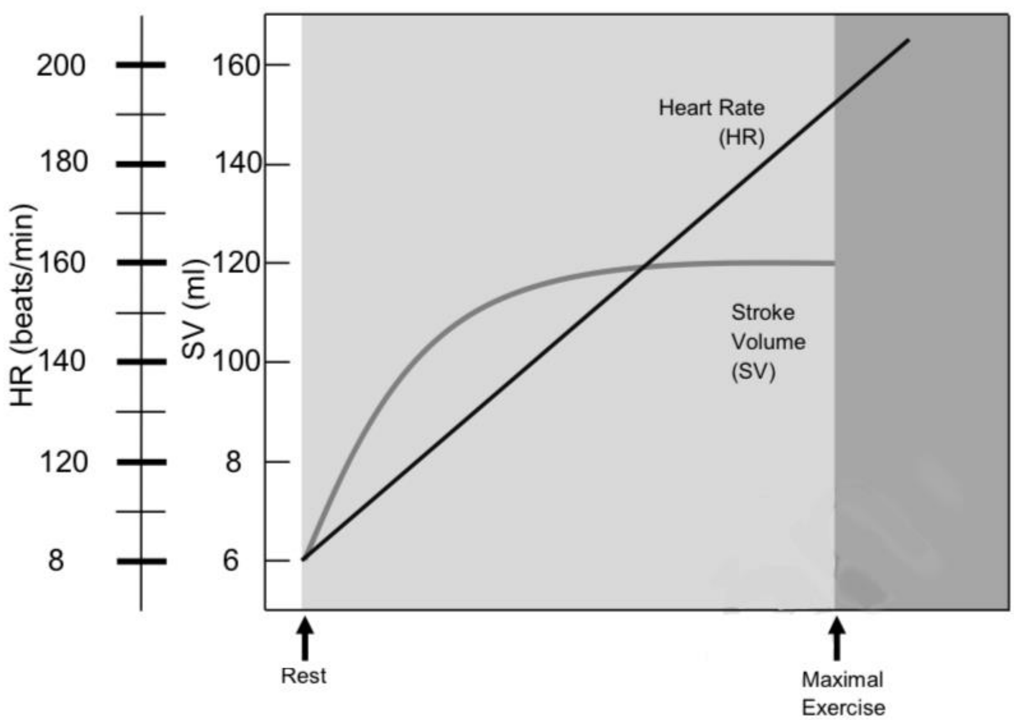
1. At the start of an endurance cycling event, a cyclist will experience a redistribution of cardiac output.
Explain how and why the vascular shunt mechanism redistributes blood in a cyclist as they begin cycling at the start of the event. (5)

____

2.

Fig.2 shows the changes in stroke volume and heart rate from rest to maximal exercise.

Fig.2



A) calculate the cardiac output when the heart rate is 180bpm. Show your working. (2)

B) Explain the changes to stroke volume during sub maximal exercise. (3)

When a performer is running, blood is redirected to the working muscles.
Explain how this redistribution of blood is achieved. (3)

Key Terms

Stroke Volume – The volume of blood pumped out of the ventricles during each contraction

Cardiac Output – The volume of blood pumped out of the ventricles per minute (HR x Stroke Volume)

Cardiac systole - the contraction of the cardiac muscle

Cardiac diastole - the relaxation of the cardiac muscle

Sympathetic Nervous System – Part of the ANS and can activate an increase in HR

Parasympathetic Nervous System – Part of the ANS and can activate a decrease in HR

Vascular Shunting – The redistribution of blood flow around the body

Myogenic – The heart's ability to create its own contraction

Chemoreceptors – Responsible for detecting an change in C02/Lactic Acid/Blood Acidity

Baroreceptors – Responsible for detecting a change in blood pressure

Venous Return – The flow of the blood back to the heart via the veins and specifically the vena cava

Starling's Law – Stroke volume increases due to an increase in venous return