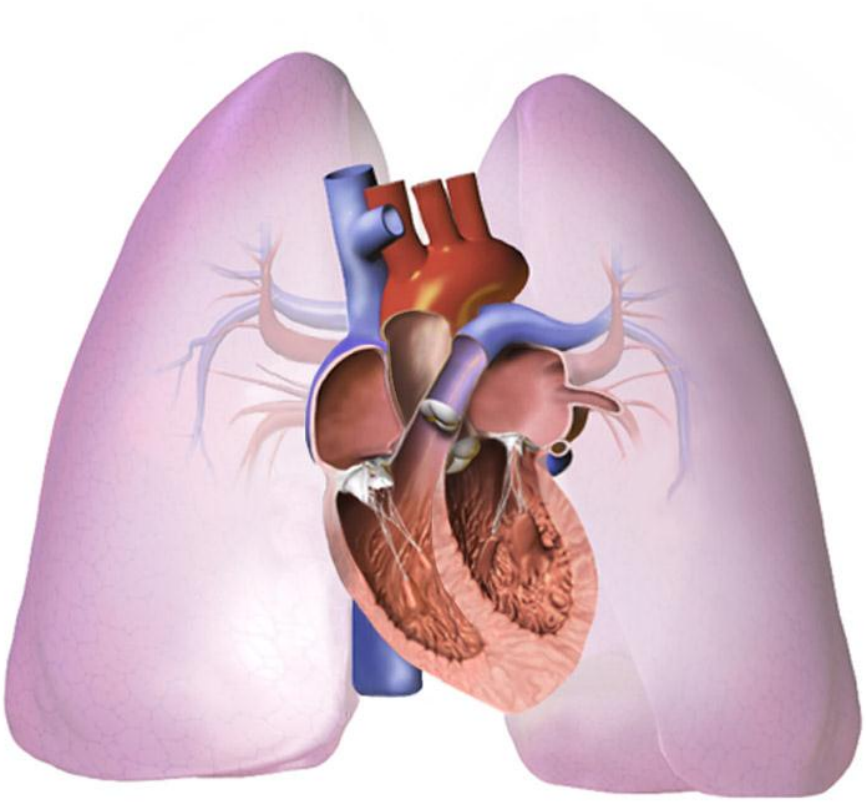
1.2 The Structure and Functions of the Cardio-Respiratory System

Name _____

Class_____

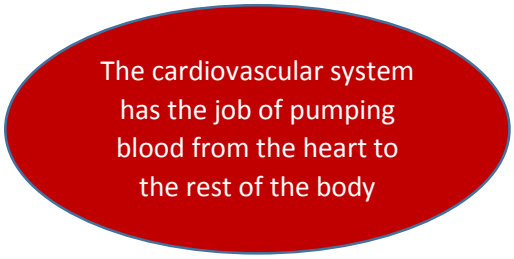


Topic	Description from Specification	Pupil comments – How confident do you feel on this topic?
Identification of the pathway of air (limited to):	Mouth/nose, trachea, bronchi, bronchioles, lungs, alveoli.	
Gaseous exchange Gas exchange at the alveoli features that assist in gaseous exchange	Large surface area of alveoli, moist thin walls (one cell thick), short distance for diffusion, lots of capillaries, large blood supply, movement of gas from high concentration to low concentration. Oxygen combines with haemoglobin in the red blood cells to form oxyhaemoglobin. Students should also know that haemoglobin can carry carbon dioxide.	
Structure of arteries, capillaries and veins	Size/diameter, wall thickness, valves in veins.	
How the structure of each blood vessel relates to the function:	Carrying oxygenated/deoxygenated blood to/from the heart, gas exchange, blood pressure, redistribution of blood during exercise (vasoconstriction and vasodilation). Students should be taught the names of the arteries and the veins associated with blood entering and leaving the heart.	
Structure of the heart:	Atria (left and right atria). Ventricles (left and right ventricles).	
The cardiac cycle and the pathway of the blood	The order of the cardiac cycle, including diastole (filling) and systole (ejection) of the chambers. This starts from a specified chamber of the heart, eg the cardiac cycle starting at the right ventricle. Pathway of the blood: Deoxygenated blood into right atrium then into the right ventricle the pulmonary artery then transports deoxygenated blood to the lungs. Gas exchange occurs (blood is oxygenated). Pulmonary vein transports oxygenated blood back to the left atrium then into the left ventricle, before oxygenated blood is ejected and transported to the body via the aorta. Valve names are not required but students should be taught that valves open due to pressure and close to prevent backflow.	

Cardiac output, stroke volume and heart rate	Cardiac output, stroke volume and heart rate, and the relationship between them. Cardiac output (Q) = stroke volume x heart rate. Students should be taught how to interpret heart rate graphs, including an anticipatory rise, and changes in intensity.	
Mechanics of breathing – the interaction of the intercostal muscles, ribs and diaphragm in breathing. Inhaling (at rest) with reference to the roles of the:	Intercostals, rib cage, diaphragm. Exhaling (at rest) with reference to the roles of the intercostals, rib cage, diaphragm. Lungs can expand more during exercise (inspiration) due to the use of pectorals and sternocleidomastoid. During exercise (expiration), the rib cage is pulled down quicker to force air out quicker due to use of the abdominal muscles. Changes in air pressure cause the inhalation and exhalation.	
Interpretation of a spirometer trace Identification of the following volumes on a spirometer trace and an understanding of how these may change from rest to exercise	Tidal volume, expiratory reserve volume, inspiratory reserve volume, residual volume. Interpretation and explanation of a spirometer trace (and continue a trace on paper) to reflect the difference in a trace between rest and the onset of exercise.	

The cardio-respiratory system refers to two different body systems which work very closely together in order to transport oxygen from the lungs to the heart and on to various muscles around the body. These systems are the **cardiovascular system** and the **respiratory system.**

What type of athlete do you think of when you hear the term 'cardiorespiratory system'? Why?



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<u>The Pathway of Air:</u>

What is the main organ involved in respiration? _____

Unscramble the words below to uncover which other parts of the body are involved in respiration…

RAHCAET _____

VLAOILE _____

PRADIGMH _____

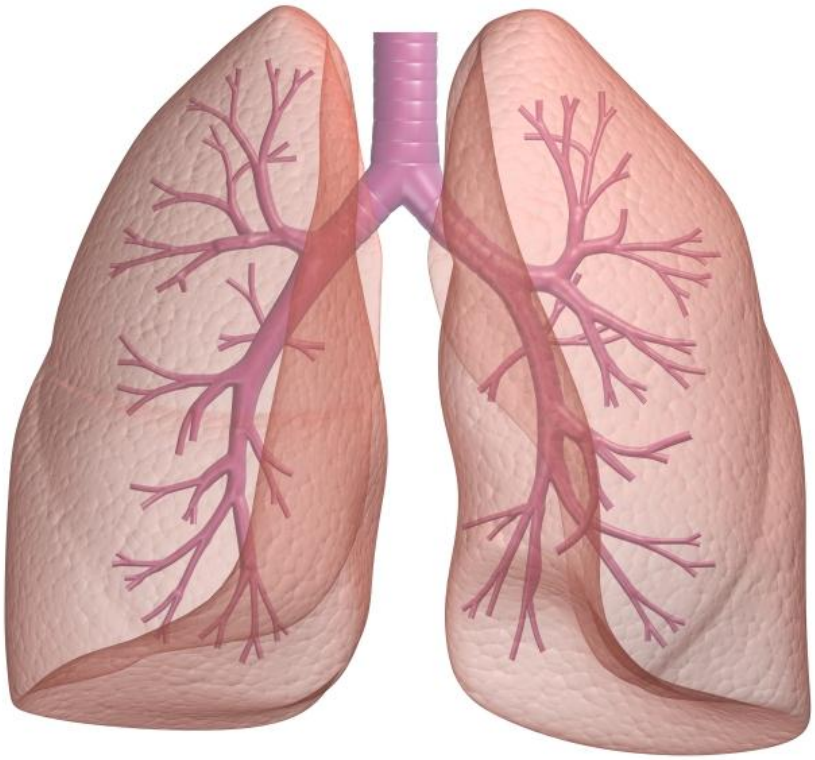
RNIHBCO _____

RNIHBCOSLOE _____

When inhaling the _____ tightens, changing from a dome shape to a flatter shape. This action opens up the _____ and allows air to rush in. When we exhale the _____ relaxes, moving up and back to a dome shape.

When breathing in, air passes through the wind pipe, which is also known as the _____. From here, the air enters one of two branches called the _____, through which air passes into each _____. Smaller branches called _____ extend out from the _____ and at the very end of these there are millions of tiny sacs called _____. Here is where gaseous exchange takes place and oxygen is passed into the blood so that is can supply the body.

Label the diagram below and also outline the position of the diaphragm when inhaling.



<u>The Mechanics of Breathing:</u>

When exercising the pectorals help the lungs to expand during inhalation. When exhaling, the abdominals pull the rib cage down quicker in order to force out the air.

The **intercostal muscles** are internal muscles that lie between the ribs. They also play an important role in expanding and shrinking the chest so that breathing can occur.

Recap:

Put each of the following headings into each of the boxes on the right. Below each heading add in as much detail as possible about what happens at this stage of **respiration.**

Alveoli

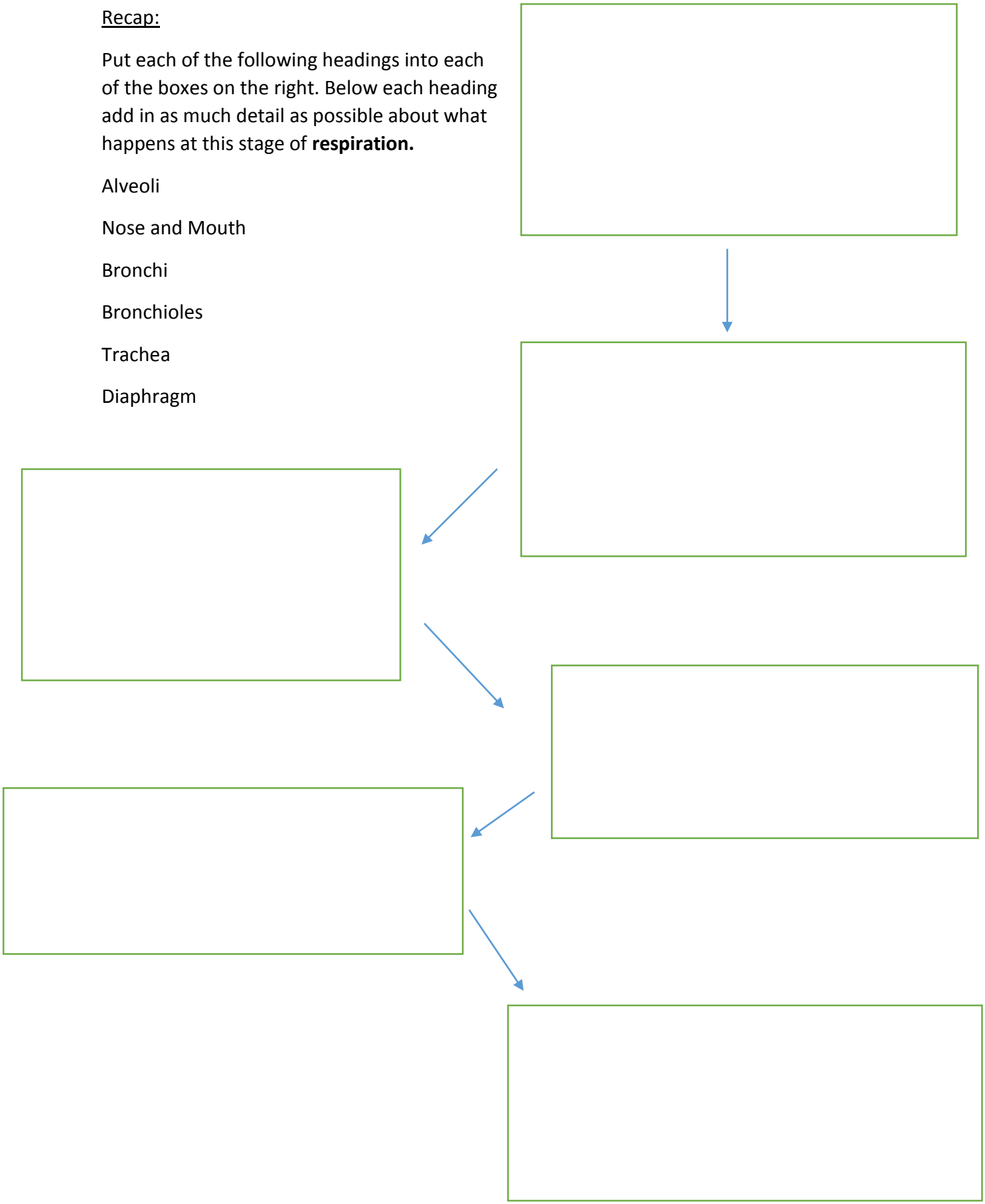
Nose and Mouth

Bronchi

Bronchioles

Trachea

Diaphragm



Gas Exchange at the Alveoli:

Use the words below in order to fill in the gaps and learn about the alveoli and capillaries.

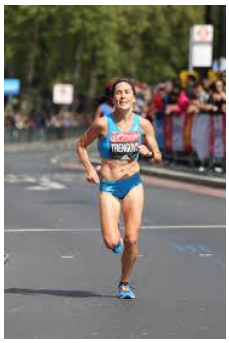
High Large Oxygen Thin Capillaries Sacs Breathing

The alveoli are tiny _____ of air that are important for gas exchange. There is a high concentration of _____ in the alveoli after _____ in. This oxygen diffuses through the moist, _____ walls of the alveoli (which are one cell thick) and into the blood stream. This happens as gases wish to move from areas of _____ concentration, into areas of low concentration. The alveoli have a _____ surface area and are surrounded by _____, helping gas exchange. The short distance for diffusion means that lots of oxygen can get into the bloodstream.

Carbon Dioxide Thin Oxygen

Capillaries are small blood vessels which link up the arteries and veins with muscles. They also surround the **alveoli** in the lungs, allowing _____ and _____ to diffuse into and out of the blood stream. The walls of the capillaries are very _____, allowing diffusion to take place.

If somebody regularly takes part in cardiovascular exercise they can create more capillaries – known as 'increased capillarisation'. Why would this benefit a long distance runner during and after the race?



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Helen Glover is an Olympic rowing champion. She will often row for long periods without having a rest. How would the features of her respiratory differ to a sprinter who only exercises in short bursts?

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The **alveoli** work best when they are moist and clean. How does your body ensure moisture and cleanliness?

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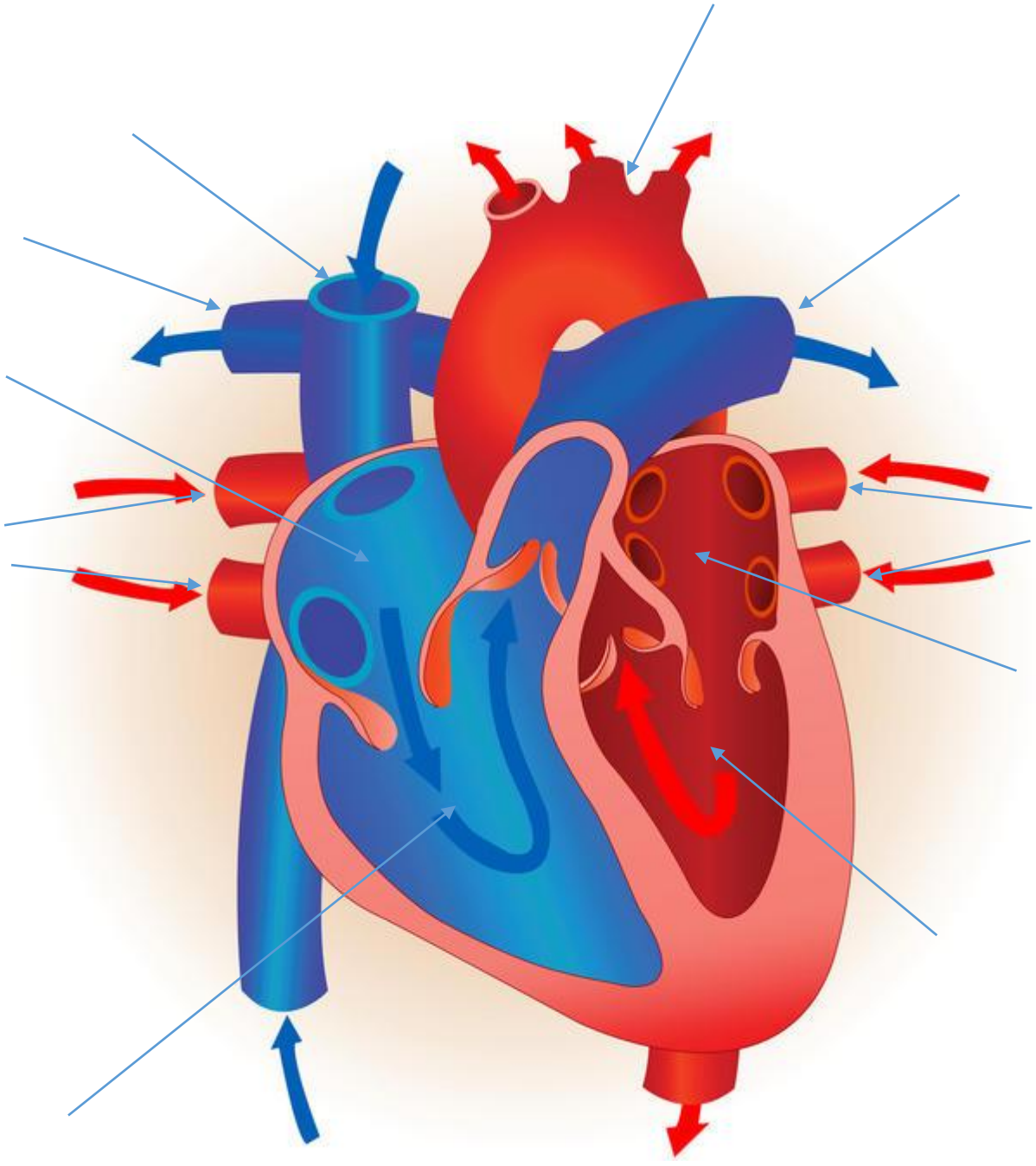
Think about what happens when you breathe in

<u>Key Point:</u> Haemoglobin is an iron containing protein in red blood cells. It combines with oxygen to form oxyhaemoglobin.is responsible for carrying oxygen around the body and can also transport carbon dioxide

The Heart



Which side of the heart is the right side and which is the left side?

Which side of the heart pumps oxygenated blood and which side pumps deoxygenated blood?

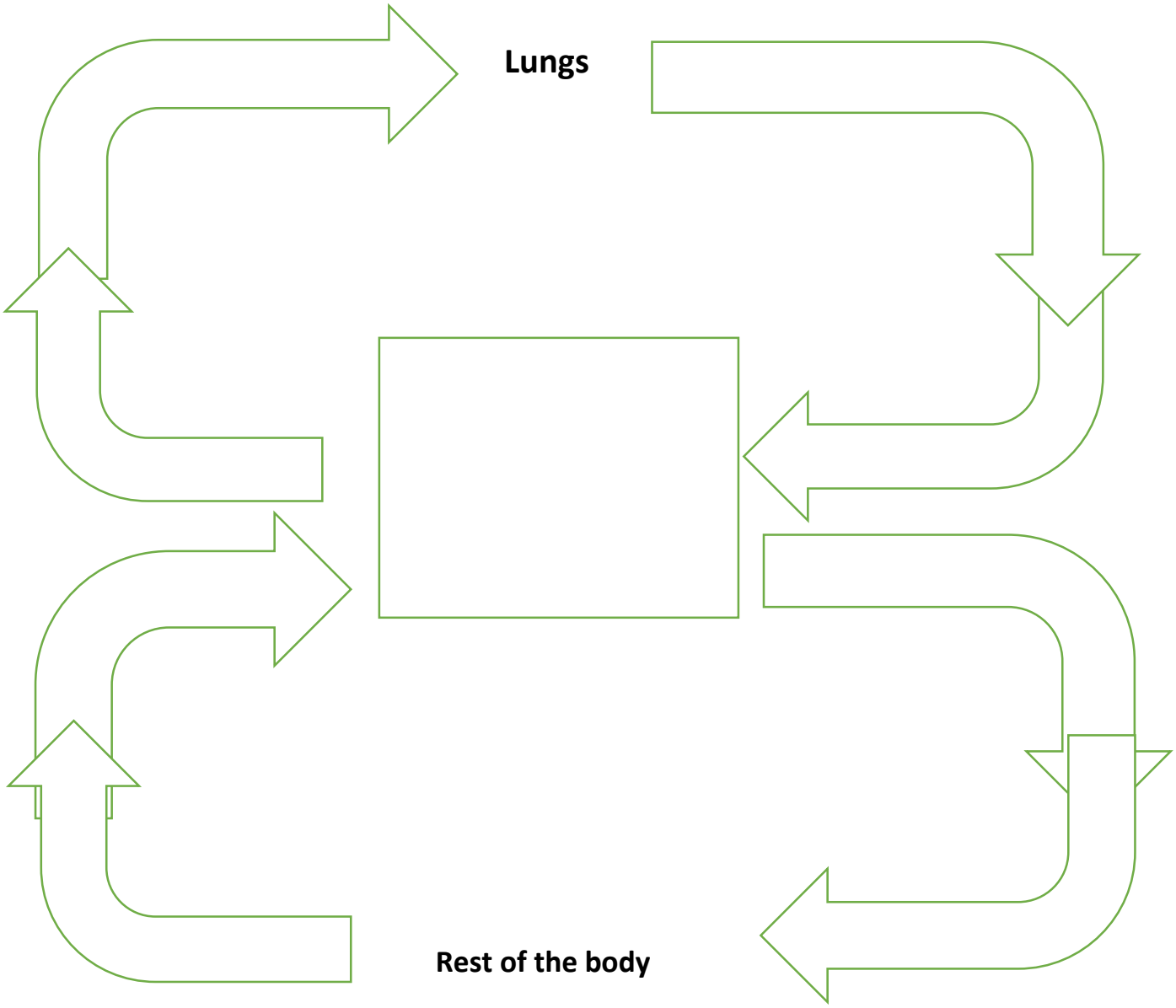
Valves in the heart open due to pressure and close to prevent the backflow of blood. Can you point out the valves in this diagram?

What goes on in the heart?

Deoxygenated blood enters the heart through the _____ _____ where it collects in the right _____. The deoxygenated blood then travels into the right _____. The blood then leaves the heart through the pulmonary _____. The deoxygenated blood then travels to the lungs where it will collect _____.

Oxygenated blood makes it way from the _____ and enters the heart through the pulmonary _____. Having entered the left _____ the oxygenated blood travels into the left _____. The blood then leaves the heart through the _____. The oxygenated blood will then travel around the body in order to supply the _____ with _____.

Label the below diagram with the vena cava, pulmonary artery, pulmonary vein and aorta. Also label the atrium and ventricles. Colour in your diagram correctly (blue and red!).



Ellie Symonds is a Paralympic swimmer over the distance of 400m. What happens to her Heart rate as she swims and why? What do you think would happen to her resting heart rate if she was to increase the amount of cardiovascular training she was undertaking?

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Blood vessels are responsible for supplying your body with oxygenated and carrying away deoxygenated blood. The blood vessels that are responsible for this job are **veins, arteries and capillaries.**

Arteries carry blood away from the heart. This is usually in the form of _____ blood travelling to various muscles. However one artery carries deoxygenated blood to the lungs, this is the _____. Arteries have thick walls and carry blood which is at high pressure.

A = Artery

A = Away from the heart

Veins return blood to the heart. This is usually in the form of _____ blood from various muscles. However one vein carries oxygenated blood to the heart from the lungs, this is the _____. Veins have thin walls and carry blood which is at low pressure.

As we learned earlier, **capillaries** are small blood vessels which link up the arteries and veins with muscles.

Structure of the blood vessels:

	Size/Diameter	Wall Thickness	Valves
Arteries	Up to 10mm	Thick & Muscular	No
Veins	Up to 10mm	Thin	Yes
Capillaries	5-10 micrometers (Tiny!)	Thin	No

Why do the capillaries have a smaller diameter than the arteries and veins?

_____

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_____

Why do the arteries have thicker walls than the veins and capillaries?

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Why do the veins contain valves?

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Redistribution of Blood during Exercise:

During exercise the **cardiovascular system** is capable of increasing the blood flow to active areas and diverting blood away from inactive areas.

If you were taking part in a marathon, where are the most active areas of your body that would require increased blood flow?

_____

Where would the inactive areas be, which require less blood flow?

_____

If you have eaten just before you exercise, why can this make the process of blood redistribution more difficult for your body?

_____

_____

How the redistribution of blood occurs:

Blood vessels are able to change in size in order to allow the redistribution of blood to happen during exercise.

Vasodilation means that the blood vessels become wider, enabling more blood to be delivered to active areas.

Vasoconstriction means that the blood vessels become narrower, restricting the amount of blood that is delivered to inactive areas.

Vasodilation and vasoconstriction also play an important role in regulating body temperature. Can you fill in the gaps below?

Vasodilation occurs when the _____ is too hot and it involves the blood vessels close to your skin dilating (getting _____).The blood gets closer to the skin, enabling more heat to escape and the body cools down.

Vasoconstriction occurs when the _____ is too cold and it involves the blood vessels constricting (getting smaller). The blood gets further away from the _____ of the skin and less _____ is lost.

How could your cardiovascular system regulate your body temperature throughout a day of skiing?

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How would the redistribution of blood benefit a netball player during a match?

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Useful Hint:

VasoDILATion – blood vessels DILATE (get bigger which cools you down)

VasoCONSTRICTion – blood vessels CONSTRICT (get smaller which warms you up)

Blood Pressure

Just like any other muscle, the heart spends it's time **contracting** and **relaxing**. As the heart contracts (beats) blood is ejected and this stage is known as **systole.** The heart will then relax and begin to fill with blood once again, this stage is known as **diastole**.

Blood pressure is a measure of the force that the heart uses to pump the blood around the body. When having your blood pressure measured you are given two numbers. The first number refers to your **systolic blood pressure,** which is the highest pressure that is created when your heart is contracting. The second number is your **diastolic blood pressure,** which is the lowest pressure created when your heart is relaxing. An average blood pressure reading is 130/85.

Arteries carry blood at a higher pressure than veins. Why do you think this is the case?

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Why do you think that severely high blood pressure could lead to a heart attack?

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Interpreting Graphs:

For the exam you will need to be able to interpret data on graphs. This data could include information on heart rate, stroke volume, cardiac output and anticipatory rise.

What is heart rate?

What is stroke volume?

What is cardiac output?

What is anticipatory rise?

Task 1 - Practical:

With the help of a partner, complete the following task in order to create some data on your working HR.

1. Take your RHR
2. Take your HR every minute for 3 minutes prior to beginning the exercise task (in order to measure any anticipatory rise
3. Set a treadmill to level 8 and begin running
4. Take your HR every minute and record the score
5. Every 2 minutes increase the treadmill by 2 levels (e.g. from 8 to 10)
6. Continue until you have reached your maximum capacity and need to stop
7. Continue to record your HR for five minutes into your recovery (every minute)

Plot out a line graph using your results. On the graph you should be able to highlight your resting HR, working HR and recovery HR. Draw out a line on the graph to represent somebody who is fitter than you and also somebody who is not as fit as you.

Maximum HR is 220-Age. How close to this did you get during the test? What does this say about your fitness levels?

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What are the differences in the line showing your fitness levels and the line showing a person who is not as fit as you?

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What caused you to eventually stop exercising?

_____

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Task 2

Using the table below, create a bar chart to show the average **cardiac output** when moving at different speeds.

Cardiac Output (litres per minute)		
Running	Jogging	Walking
20	10	5

Using your bar chart, explain why cardiac output differs when exercising at different speeds.

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Interpretation of a Spirometer Trace:

A **spirometer** is an implement that can be used to show the amount of air inhaled and exhaled.

A **spirometer trace** is the data reading being shown as part of a graph.

In order to understand a spirometer trace, you must first be able to define the following terms:

Tidal Volume

_____

_____

Expiratory Reserve Volume

_____

_____

Inspiratory Reserve Volume

_____

_____

Residual Volume

_____

_____

Vital Capacity

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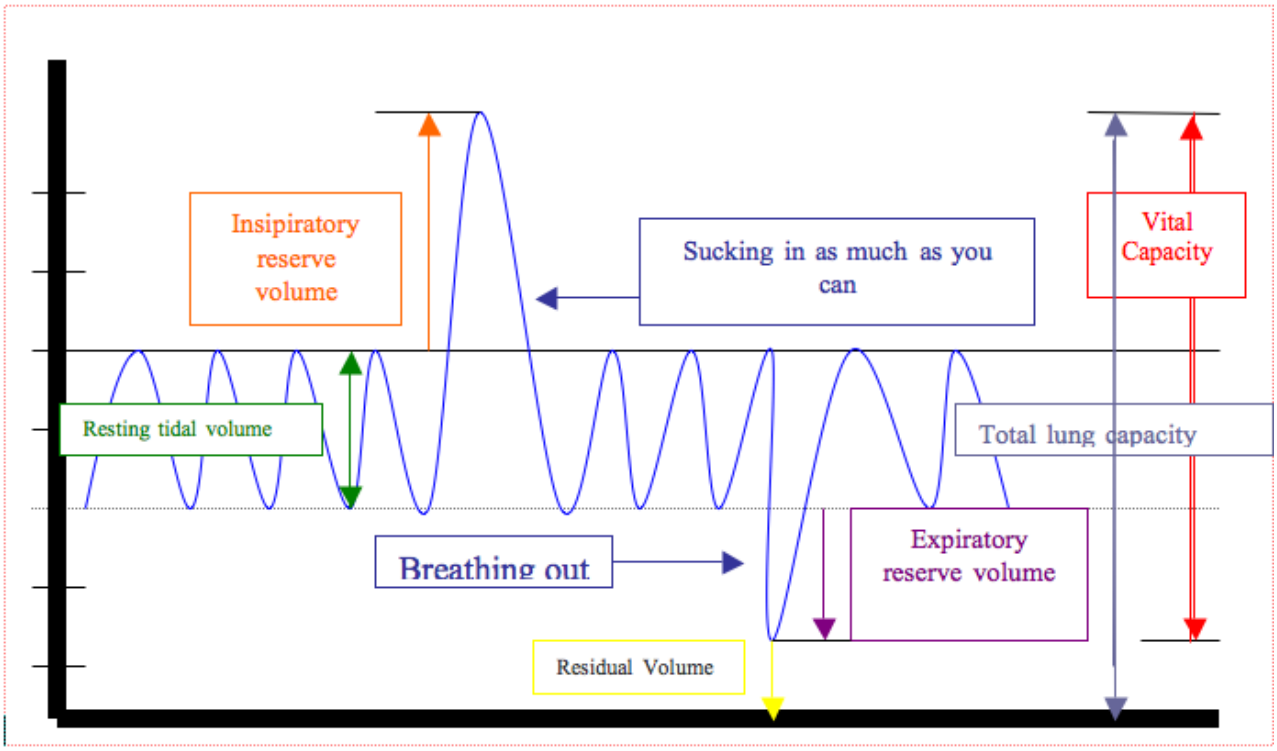
The image below shows how each of these terms can be displayed on a graph. This graph is showing the values for a person **at rest.** Take some times to understand this graph before having a go at the questions below.



Tidal volume increases during exercise. Why does this occur?

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_____

Does your **vital capacity** increase during exercise?

_____

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Hint: Think carefully before answering this question

It is important that you are able to understand how the graph shown above will vary at exercise.

Task – Think carefully before using a separate piece of paper to draw out the same graph to show a trace for a 1500m runner towards the end of a race.

Hint: Think about both **breathing rate** and **breathing depth** and how each of these will affect the tidal volume readings

Recap:

Using any of the knowledge you have gained from this topic, name four ways that your cardio-respiratory system helps you to get oxygen to your muscles during exercise:

1. _____

2. _____

3. _____

4. _____

Key Terms:

Cardio-respiratory system: The interaction of the heart and lungs to supply oxygen to the muscles.

Blood Vessels: Responsible for transporting blood; arteries, veins and capillaries.

Blood Pressure: The pressure of the blood against the walls of the walls of the blood vessels.

Systole: The phase of the heartbeat when the heart contracts and pumps blood from the chambers into the arteries.

Diastole: The phase of the heartbeat when the heart relaxes and lets the chambers fill with blood.

Arteries: Blood vessels that takes blood away from the heart.

Veins: Blood vessels that takes blood back to the heart.

Capillaries: Tiny blood vessels that link arteries with veins.

Redistribution of blood: The process that increases blood flow to active areas during exercise by diverting blood away from inactive areas.

Vasodilation: When blood vessels get bigger (dilate)

Vasoconstriction: When blood vessels get smaller (constrict)

Vital Capacity: The greatest amount of air that can be made to pass into and out of the lungs.

Tidal Volume: The amount of air inspired and expired with each normal breath.

Expiratory Reserve Volume: The additional amount of air that can be expired from the lungs by determined effort after normal expiration

Inspiratory Reserve Volume: The maximal amount of additional air that can be drawn into the lungs by determined effort after normal inspiration

Residual Volume: The amount of air that remains in a person's lungs after fully exhaling.

Respiration: The movement of air from outside the body into the cells within tissues.

Diaphragm: A dome-shaped muscle that separates the chest from the rest of the body.

Trachea: The tube that takes air into the body. AKA the windpipe.

Bronchus: Tube along which air passes from the trachea to the lungs.

Bronchioles: Smaller branches coming off the bronchi.

Alveoli: Tiny sacs at the end of the bronchioles, where gas exchange takes place.

Intercostal Muscles: Internal muscles that run between the ribs and help the chest to expand and shrink during breathing

Haemoglobin: A type of protein found in every red blood cell. Attaches to oxygen and transports it around the body.