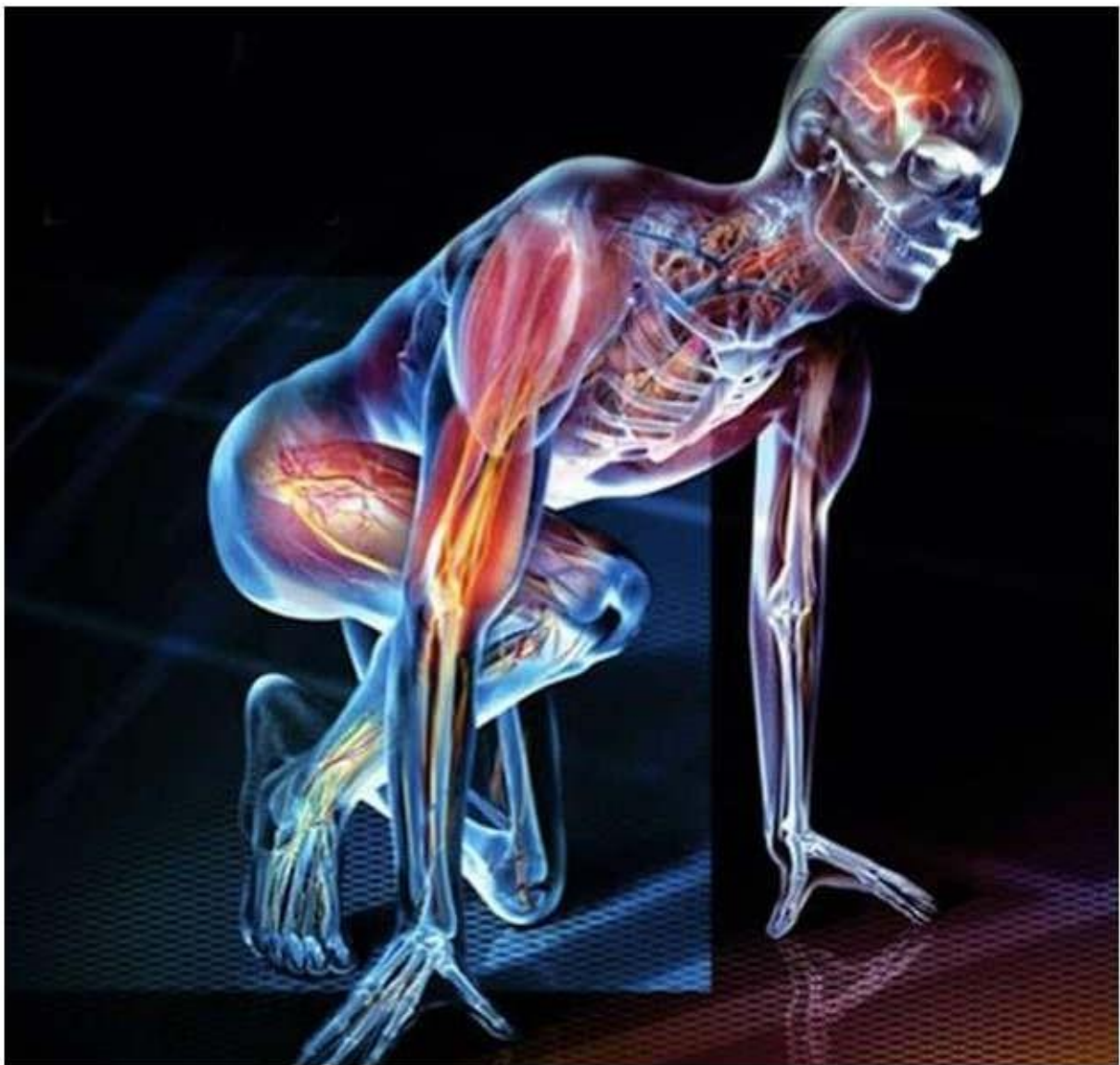


YR 12- Unit 1
Anatomy and Physiology
Revision booklet



Name:

Section 1: Learning Aim A- Skeletal System (Pages: 3-10).

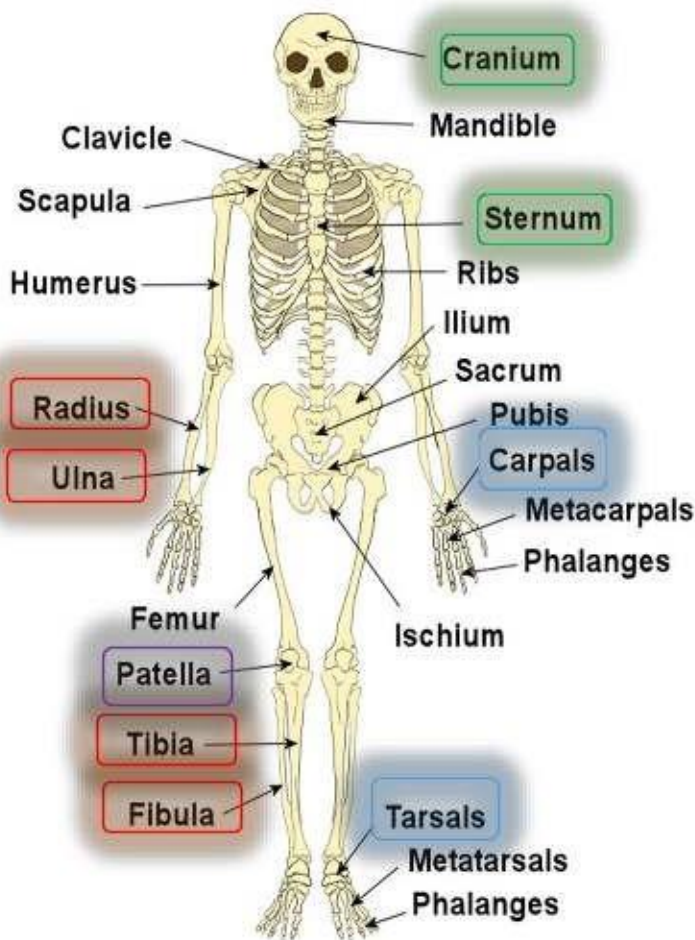
Section 2: Learning Aim B- Muscular System (Pages: 11- 14).

Section 3: Learning Aim C- Respiratory system (Pages 15- 17).

Section 4: Learning Aim D- Cardiovascular system (Pages 18-23).

Section 5: Learning Aim E- Energy Systems (Pages 24-27).

Learning aim A- The effects of exercise and sports performance on the skeletal system.



Types of bone:

- **Long bones**- found in limbs. They have a shaft known as the **diaphysis** and two expanded ends known as the **epiphysis**.
- **Short bones**- small, light, strong, cube-shaped bones consisting of **Cancellous bone** surrounded by a thin layer of compact bone.
- **Flat bone**- thin, flattened and slightly curved, with a large surface area.
- **Irregular bones**- Have complex shapes that fit none of the categories above- examples included spinal column.
- **Sesamoid bones**- Specialised function and are usually found within a tendon- provide smooth surface for tendon to slide over.

Areas of the skeleton

- The skeleton can be divided up into two parts:
 - Axial skeleton (the long axis of your body).
 - Appendicular skeleton (Bones attached to the axis).
- Axial skeleton main core of your skeleton and consists of:
 - The skull (Cranium and facial bones).
 - The thoracic cage (sternum and ribs).
 - The vertebral column.
- Appendicular skeleton consists of the bones attached to the axial skeleton and consists of:

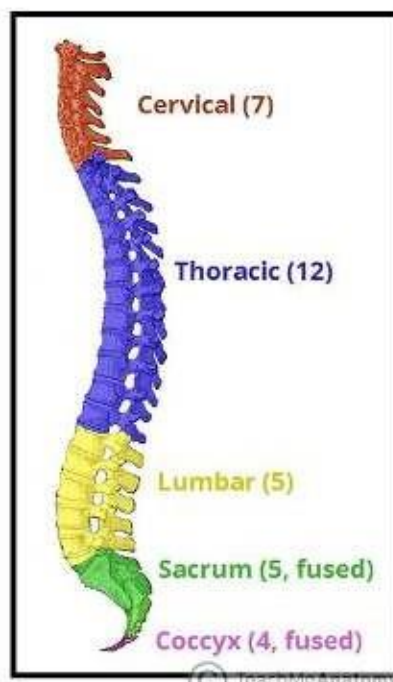
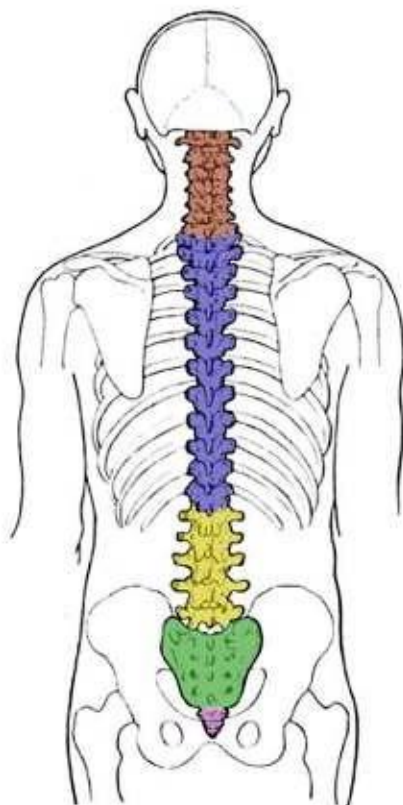
- The upper limbs (including humerus, radius, ulna, carpals, metacarpals and phalanges).
- The lower limbs (including femur, tibia, fibula, patella, tarsals, metatarsals and phalanges).
- The shoulder girdle consists of four bones (two clavicles and two scapulae).
- The pelvic girdle consists of three bones: The ilium, pubis and ischium.

Spine/ vertebral column

Extends from the base of the cranium to the pelvis, providing a central axis for the body.

Made up of 33 irregular bones called vertebrae and is held together by powerful **ligaments**.

Five sections of the vertebrae column:



The vertebral column:

The vertebral column has many functions. It protects the spinal cord and supports the ribcage. The larger vertebrae of the lumbar region support a large amount of body weight. The flatter thoracic vertebrae offer attachment for the larger muscles of the back. These along with the intervertebral discs, receive and distribute impact associated with sporting performance, reducing shock.

Postural deviations:

The spine has a distinctive shape when stacked on top of one another. The normal shape consists of a curve in the cervical (neck), thoracic (mid back) and lumbar (low back) regions when viewed from the side.

A neutral spine refers to good posture with the correct position of the three natural curves. When viewing the spine from the front (anterior), it should be completely vertical.

Kyphosis- Excessive outward curve of the thoracic region of the spine, resulting in a hunchback appearance.

Scoliosis- Abnormal curvature of the spine either left or right (lateral curvature). Most likely to occur in the thoracic region. Often found in children but can be found in adults.

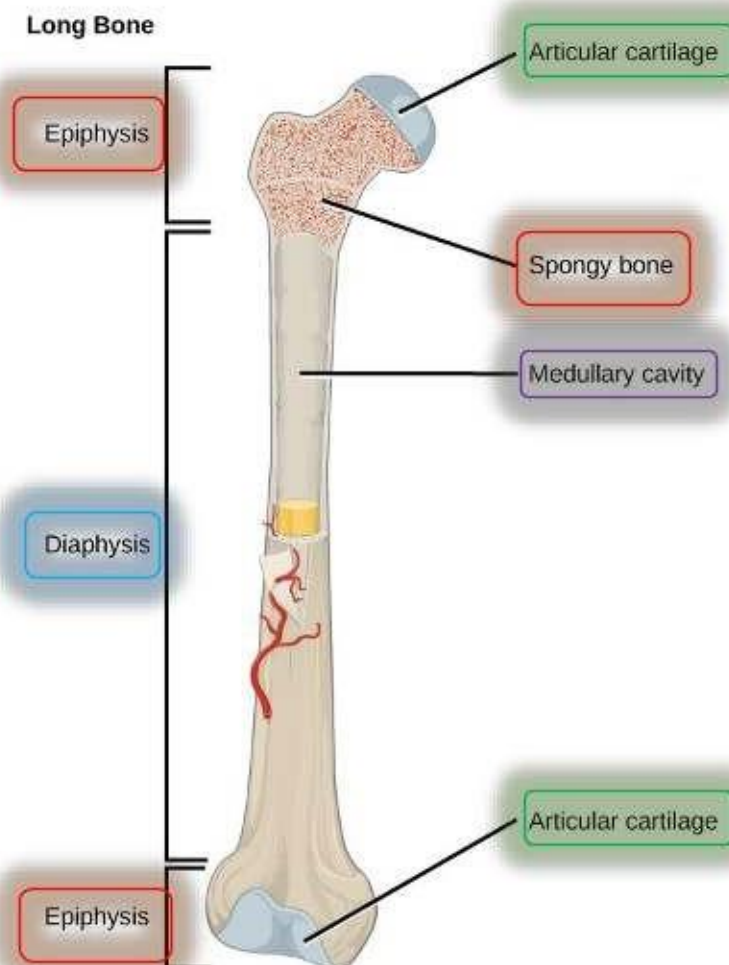
Process of bone growth

Bone is a living organ that is continuously being reshaped through a process called remodelling. **Ossification** is the process in which bones are formed. Throughout this process parts of the bone are reabsorbed so that unnecessary calcium is removed (via cells called **osteoclasts**) while new layers of bone tissue are created.

Cells that bring calcium to your bones are osteoblasts- responsible for creating bone matter. Osteoblast activity increases when you exercise, so your bones will become stronger the more exercise you do. A result from this is your bone calcium store increases to cope with the demand for calcium, so exercising reduces the risk of osteoporosis. Activities that can build stronger bones include: Tennis, netball, basketball, aerobics.

At the end of long bones there are growing plates, which allow the bone to grow longer. This continues throughout childhood until maturity. These areas are called the **epiphyseal plates**. Once a long bone is fully formed, the head (or each end of the bone) fuses with the main shaft (**diaphysis**) to create the **epiphyseal line**.

Diagram of long bone



Epiphysis- This is the name given to the two ends of the bone. It is covered in articular cartilage to allow bones to slide past one another more easily. The interior of epiphyses is filled with spongy bone/Cancellous bone, and is differentiated from the interior of the diaphysis by the epiphyseal line (in adults) or plate (in children).

Diaphysis- This is the shaft of the long bone, and makes up the length of the bone. It is roughly cylindrical in shape, and is composed of a thick layer of compact bone surrounding the medullary cavity.

Articular cartilage- This cartilage covers the end of the long bones, to allow smooth articulation at the joint and protect the bone from friction damage.

Medullary cavity- This is the space inside the diaphysis, and can also be called the yellow marrow cavity. In infants it is called the red marrow cavity, as it is filled with newly forming red blood cells.

Function of the skeletal system

- **Support-** collectively, your bones give your body shape and provide the supporting framework for the soft tissue of your body.
- **Protection-** Bones of your skeletal surround and protect vital tissues and organs in your body.
- **Attachment for skeletal muscle-** Parts of your skeleton provide a surface for your skeletal muscles to attach to, allowing you to move.
- **Source of blood cell production-** your bones are not completely solid, as this would make your skeleton heavy and difficult to move. Blood vessels feed the centre of your bones, and are stored within the bones is bone marrow. The marrow of your long bones is continually producing red and white blood cells.
- **Store of minerals-** Bone is a reservoir for minerals such as calcium and phosphorus, which are essential for bone growth and the maintenance of bone health.
- **Leverage-** the bones provide a lever system against which muscles can pull to create movement.
- **Weight bearing-** Your bones are very strong and will support the weight of your tissue including muscles.
- **Reducing friction across joints-** The skeleton has many joints of different types. Synovial joints secrete fluid that prevents bones from rubbing together, reducing friction between the bones.

► **Table 1.3:** Function of different bones types

Type of bone	Function	Examples
Long	Movement, support, red blood cell production	Femur, humerus, tibia, radius, ulna
Short	Fine or small movements; shock absorption, stability, weight bearing	Carpals, tarsals
Flat	Attachment for muscles; protection	Sternum, scapula, pelvis, cranium
Sesamoid	Protection; reduction of friction across a joint	Patella, pisiform (wrist)
Irregular	Protection (spinal cord); movement	Vertebrae

Joints

For movement to occur, bones must be linked. A joint is formed where two or more bones meet, this is known as **articulation**.

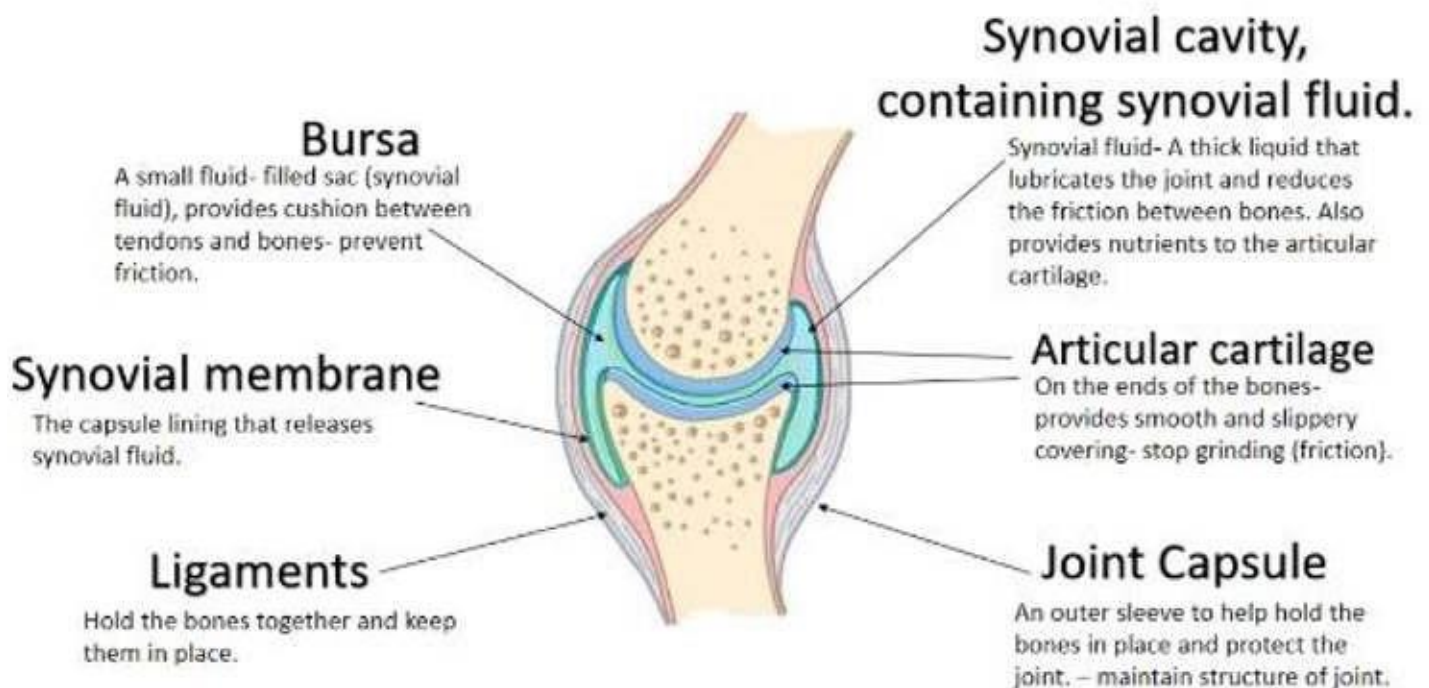
Joint classification:

Fixed joints- Or fibrous/ immovable joints, do not move. Fixed joints form when the bones interlock and overlap during childhood. Held together bands of tough fibrous tissue and are strong with no movement between bones. Example of this is your cranium.

Slightly moveable joints- Or cartilaginous joints allow slight movement. The ends of the bone are covered in a smooth, shiny covering, known as articular or hyaline cartilage, which reduces friction between the bones. The bones are separated by pads of white fibro cartilage. Slight movement at these joining surfaces is made possible because the pads of cartilage compress, for example between most vertebrae.

Synovial joints- Or freely moveable joints offer the highest level of mobility at a joint and are vital for sporting movements. Most joints in your limbs are synovial.

Synovial joints



Types of synovial joints

Hinge Joint	Ball and Socket Joint	Condyloid Joint	Gliding Joint	Pivot Joint	Saddle Joint
Elbow joint, knee joint.	Shoulder joint, hip joint.	Wrist joint.	Ankle joint.	Neck joint (atlas and axis).	Thumb joint.

Range of movement at synovial joints:

The range of motion is the amount of movement at a joint and is often referred to as joint flexibility.

- **Flexion**- Reducing the angle between the bones of a limb at a joint.
- **Extension**- Straightening a limb to increase the angle at the joint.
- **Dorsiflexion**- An upward movement, as in moving the foot to pull the toes towards the knee in walking.
- **Plantar flexion**- A movement that points the toes downwards by straightening the ankle.
- **Lateral flexion**- the movement of bending sideways, for example at the waist.
- **Horizontal flexion and extension**- bending the elbow (flexion) while the arm is in front of your body; straightening the arm at the elbow (extension).
- **Hyper-extension**- Involves movement beyond the normal anatomical position in a direction opposite to flexion.
- **Abduction**- Movement away from the body's vertical midline.
- **Adduction**- Movement towards the body's vertical midline.
- **Horizontal abduction and adduction**- this is the movement of bringing your arm across your body (flexion) and the back again (extension).
- **Circumduction**- This is a circular movement that results in a conical action.
- **Rotation**- Circular movement of a limb.

Responses of the skeletal system after a single sport/ exercise session

Short term (acute) responses:

- Produce more synovial fluid to lubricate joints.
- The fluid will become less viscous to allow a greater range of movement.
- Release of synovial fluid will also provide increase nutrients to the articular cartilage.
- Increased mineral uptake within the bones, increasing strength and density of the bone.

Long term (chronic) responses:

- Increase bone mineral density, overtime resulting in stronger bones.
- Increase strength in ligaments, meaning they can stretch more, making them more pliable and will increase flexibility.

Additional factors effecting the skeletal system

Arthritis- A condition where there is an inflammation within a synovial joint, causing pain and stiffness in the joint. Most common type of arthritis is osteoarthritis. This is caused by general wear and tear over a long period of time, resulting in reduced cartilage tissue which can cause the bones to rub. However, regular exercise can help prevent arthritis because during physical activity your joints produce more synovial fluid which helps improve ‘

Osteoporosis- The weakening of bones caused by a loss in calcium or lack of vitamin D. Age will affect your bone density naturally becoming more brittle and fragile. However, physical activity can prevent this as during physical activity there is an increase in the uptake of minerals within the bones, resulting in an increase of bone mineral density. Resistance training is good method of training to prevent osteoporosis.

Age- The skeletal system is a living tissue that is constantly growing and repairing itself so that it can provide support and protection. Generally, exercise is good for you, other than one exception. This is resistance training in children. This is because children’s bones are still growing and putting too much force on them can cause damage to the epiphyseal plate (where bone growth takes place), found at the end of each long bone. Damage to this could stunt their growth.

Other important information and key words

► Table 1.2: Terms used to describe the location of bones

Term	Meaning
Anterior	To the front or in front
Posterior	To the rear or behind
Medial	Towards the midline or axis, an imaginary line down the centre of the body
Lateral	Away from the midline or axis
Proximal	Near to the root or origin (the proximal of the arm is towards the shoulder)
Distal	Away from the root or origin (the distal of the arm is towards the hand)
Superior	Above
Inferior	Below

Cancellous bone- Light and porous bone material that has a honeycomb or spongy appearance.

Ligaments- Short bands of tough and fibrous flexible tissue that holds bones together.

Tendon- Strong fibrous tissue that attaches muscle to bone.

Calcium- A mineral essential for bone growth and found in a wide range of foods.

Articulation- Where two or more bones meet.

Flexibility- Range of movement around a joint or group of joints.

Soft tissue- The tissue that connects, supports and surrounds structures such as joints or organs (E.G- Tendons and ligaments).

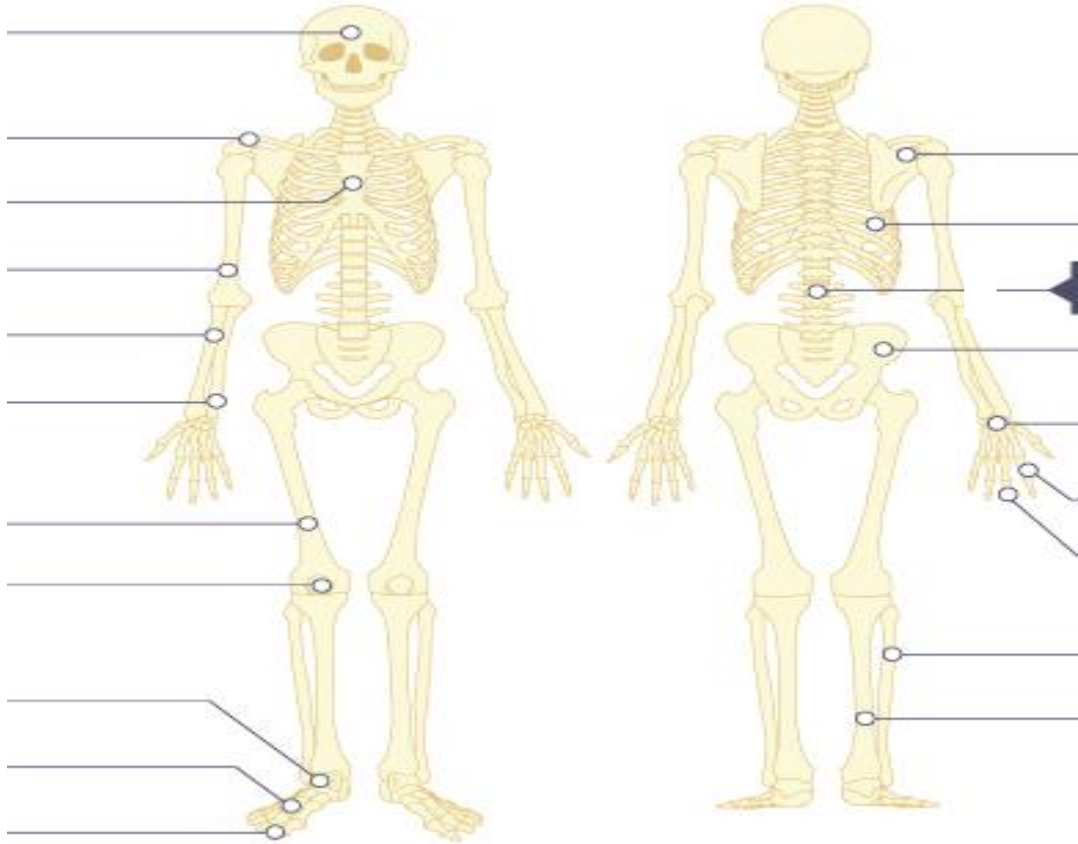
Viscous- Describes how thick a fluid is.

Acute response- Immediate.

Chronic response- Takes place over a period of time.

Learning Aim A – the effects of exercise and sports performance on the skeletal system

TASK 1 – Label the bones on the diagram below



Discussion: Are all bones the same? How are they different?

Functions of the Skeletal System (WATCH: <https://youtu.be/ltFutvTye8c?si=82KCsDdHU--8kSTd>)

What I think	What I want to know	What I know now (after research)

Classifying Bones

Task 1 – identify the odd one out (discuss why)

1. Ulna & Radius Femur Vertebral Column Tibia

2. Scapula Tibia Cranium Pelvis

Task 2 – Classifying the Bones (WATCH: https://youtu.be/B2Uxg_C14d4?si=PD0w9xsG1_6QHI-6)

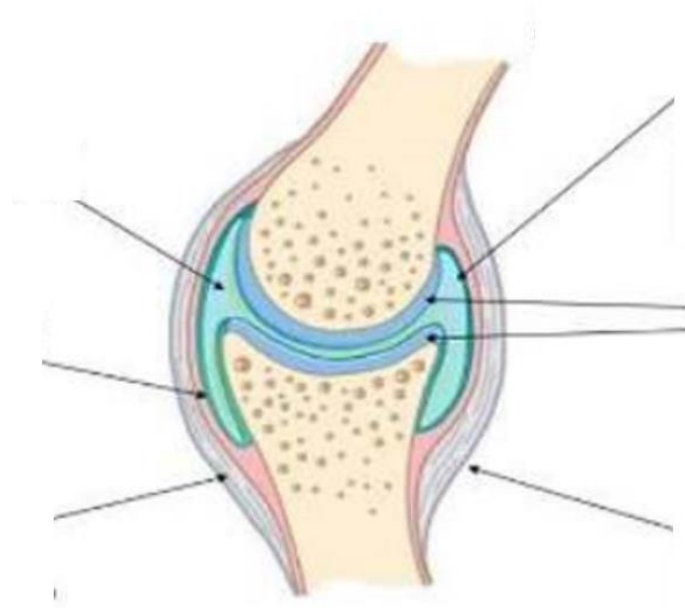
Type of Bone		Function	Examples
Long Bones		Enable movement	Scapula, Cranium, Mandible, Pelvis
Short Bones		For protection	Vertebrae, Tarsals, patella
Flat Bones		Protection/Attachment points for muscles	Femur, Ulna, Radius, Tibia
Irregular Bones		Levers for movement	Carpals, Phalanges

Exam Question

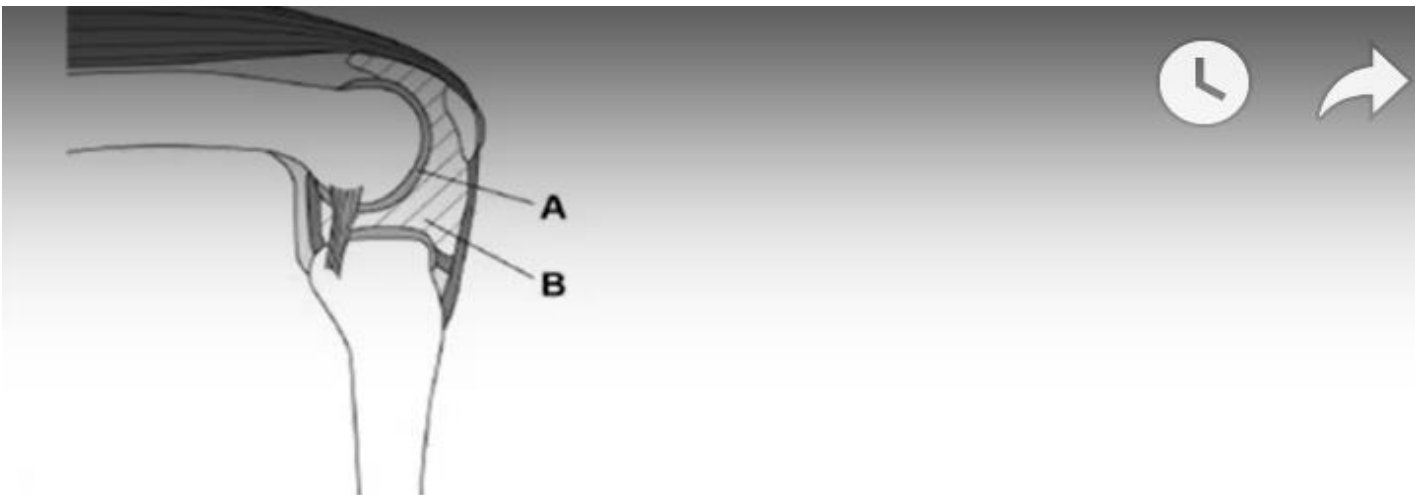
4) Aside from 'protection', explain how one other function of the skeletal system allows a netball player to produce an effective performance. **3 Marks**

Joints

Task 1 – Label the Synovial Joint below:



Task 2 – Answer the exam questions below (WATCH: <https://youtu.be/Ks6c6gX5oig?si=9w1o3rUxhyvpS634>)



(a) Identify structures **A** and **B** from the diagram.

Structure A _____

Structure B _____

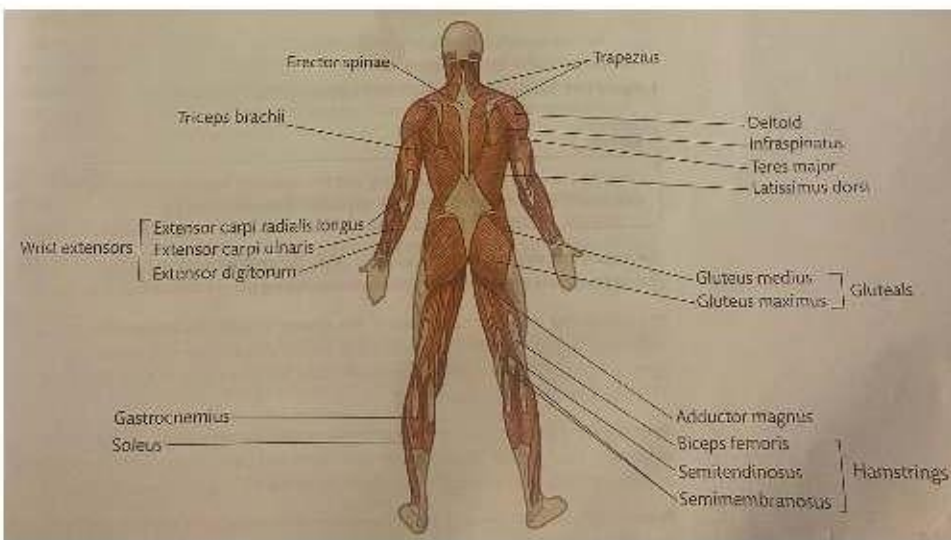
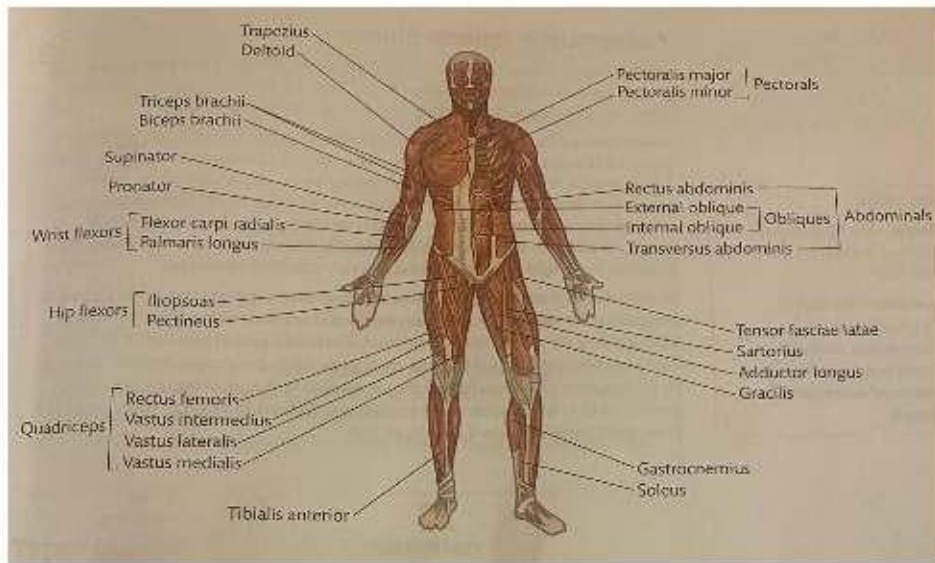
(2)

(b) For **one** of the structures identified in part(a), describe its function in the prevention of injury.

Structure _____

Function _____

Learning Aim B- The effects of exercise and sport performance on the muscular system.



Types of muscle-

Skeletal muscle- this type of muscle works voluntarily, meaning under conscious control. Critical for sporting movements as they are connected to the skeletal system via tendons and are primarily responsible for movement. They can fatigue during exercise.

Cardiac muscle- muscle found in the wall of your heart and works continuously. It is involuntary, meaning it is not under conscious control. This muscle does not fatigue, which means it does not get tired during exercise.

Smooth muscle- an involuntary muscle that works without conscious thought, functioning under the control of your nervous system. Located in the walls of your digestive system and blood vessels to help regulate digestion and blood pressure.

Antagonistic muscle pairs

Origin- the fixed end of the muscle that remains stationary.

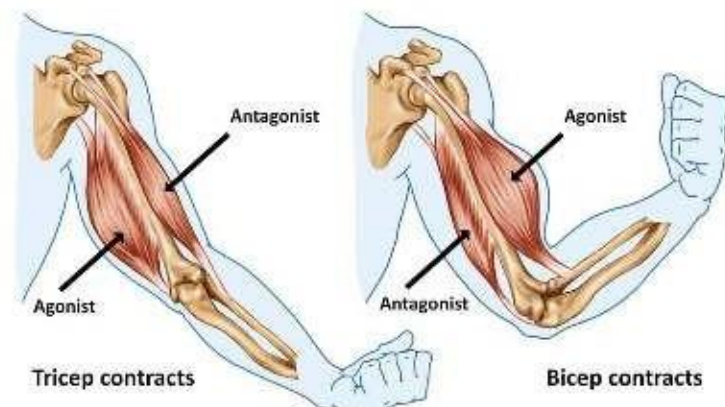
Insertion- end of the muscle that moves- usually crosses over a joint.

Agonist- the muscle that shortens/ the prime mover.

Antagonist- the muscle that relaxes to allow the movement to take place and exerts a braking control over the movement.

Synergist- muscles that work together to enable the agonist to operate effectively.

Fixator- muscles that stop unwanted movement throughout the body by stabilising the joints involved.



Types of skeletal contraction

- **Isometric**- The length of the muscle does not change and the joint angle does not alter. However, the muscles are still actively engaged, holding a static position. Examples- abdominal plank, gymnastics crucifix on the rings, holding the wall in rock climbing.
- **Concentric**- When the length of the muscle shortens under tension, reducing the angle at the joint. Also known as the positive phase of a muscle contraction. Example- Bicep curl, kicking a ball.
- **Eccentric**- When the muscle returns to normal length after shortening against resistance. The straightening of the arm in a bicep curl can be an example of this, or the straightening of your leg when kicking a football. At this point your muscles work against gravity and act like a braking mechanism. Easier to perform, but can cause muscle soreness. Also known as the negative phase of a muscle contraction.

Fibre types

Fibre Name/ Type	Characteristics	Sporting examples
Type 1 (Slow twitch fibres)	-Contract slowly and with less force. -Slow to fatigue and suited to longer-duration aerobic activities. -Have rich blood supply and contain many mitochondria to sustain aerobic metabolism. -Have high capacity for aerobic respiration. -Recruited for lower-intensity, longer-duration activities.	-Long distance running. -Swimming.
Type 2 (Type IIa- Fast twitch).	-Fast contracting and produce great force. -Resistant to fatigue. -These fibres are less reliant on oxygen for energy supplied by blood and therefore fatigue faster than slow-twitch fibres. -Suited to speed, power and strength activities.	-Strength activities like weight training (10-12 reps). -Speed and power activities. -Fast running events like 400M.
Type 2 (Type IIX- fast twitch).	-Contract quickly and produce large amounts of force. -Fatigue more readily, making them better suited to anaerobic activities. - Depend on anaerobic respiration and are recruited for higher-intensity, shorter-duration activities. -Stop- go activities (like rugby).	-Higher intensity, shorter duration activities like 100M sprint. -Stop- go or change-of-pace activities like football, rugby or netball.

Responses of the muscular system to a single sport or exercise session

Acute response- Immediate response.

Increased blood supply- Short term effect includes increase in metabolic activity (rate in which muscles produce and release energy so that movement can take place). Due to this increase, there is an increase demand for oxygen and glucose, which is met by an increased blood supply. Blood vessels expand/ get wider to allow more blood to enter your muscles (known as **vasodilation**).

Increased muscle temperature- When you exercise you get warmer. This is because your muscles need energy, so the body breaks down fats and carbs to provide that energy, a waste product of this reaction is heat. The more energy you need, the more heat produced.

Increase muscle pliability- Warming of your muscles during activity makes them more pliable and flexible. This means the muscles are less likely to suffer injuries or strains. It also improves joints flexibility as warm muscles are more pliable and able to stretch further.

Lactate- Uncomfortable burning sensation in your muscles during high-intensity exercise. This is most likely caused by a build of lactic acid, which is waste product produced during anaerobic exercise. This will result in rapid fatigue and impede muscle contractions.

Micro-tears- During resistance training, your muscles are put under stress, to the point that tiny tears occur in your muscle fibres. These cause swelling in the muscle tissue, causes pressure on the nerve endings and pain. Training improvements will only be made if the body has rest to repair these micro-tears, making your muscles a little stronger and bigger than it was before.

DOMS (Delayed onset muscle soreness)- The pain felt 24-48 hours after strenuous exercise. Usually occurs a day after exercise and can last up to 3 days. DOMS is caused by the micro-tears. DOMS is also associated with exercises where eccentric muscle contractions occur.

Adaptations of the muscular system to exercise

Chronic responses- long term effects.

Hypertrophy- regular resistance training where the muscles are overloaded will increase muscle size and strength. This is from the muscle fibres becoming larger due to increase in protein in the cells; this is known as hypertrophy.



Increased tendon strength- Tendons and ligaments will increase in flexibility and strength with regular exercise.

Increase in number and size of mitochondria- When muscles become bigger (hypertrophy), the muscle fibres also get larger. Within the muscle fibres are mitochondria which are responsible for energy production. Due to the increased fibre size, there is room for more and larger mitochondria. This results in muscles being able to produce more aerobic energy, improving aerobic performance.

Increase in myoglobin stores- Myoglobin is a type of haemoglobin (red protein found in blood transporting oxygen) found exclusively in muscles. Responsible for binding and storing oxygen in the blood within skeletal muscles. Exercise can increase the amount of myoglobin stored in the muscles. The myoglobin transports oxygen to the mitochondria which produces energy. Therefore, the more myoglobin you have the more energy that can be produced.

Increase in storage of glycogen- Stored form of glucose. If you can store more glycogen, you can train at higher intensities for longer, as muscles glycogen does not require oxygen to produce energy.

Increase in storage of fat- Fat stores to produce energy through aerobic glycolysis. Breaking down fatty acids and using oxygen to make energy.

Increased tolerance to lactate- Anaerobic training stimulates the muscles to become better able to tolerate lactic acid, and clear it away more efficiently.

Additional factors affecting the muscular system

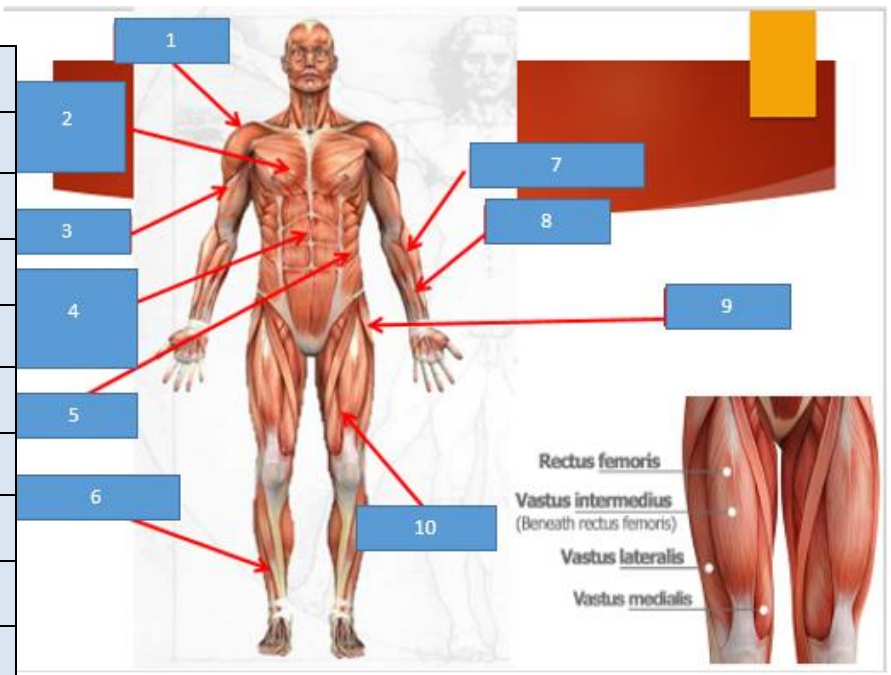
Age- As you get older your muscle mass will decrease. Muscles become smaller, resulting in a decrease in muscle strength and power.

Cramp- Cramp is the sudden involuntary contraction of your muscle. The sensation of muscle spasm where you have no control of the tightening of your muscle fibres, can be painful and prompted by exercise. Can last seconds up to 10 minutes.

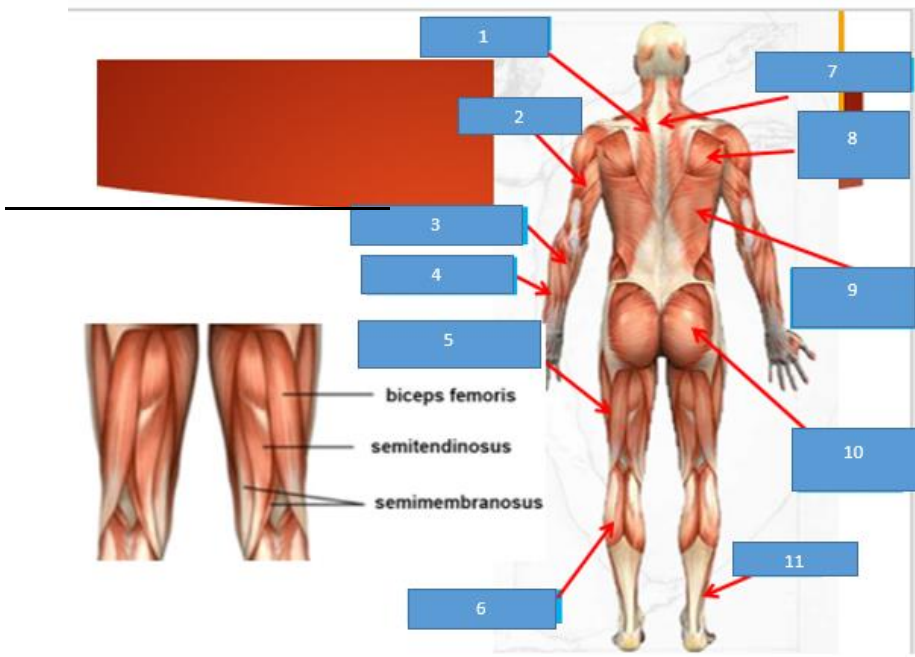


Learning Aim B – the effects of exercise and sports performance on the muscular system
Task 1 – Label the muscles below

1	
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Types of muscle

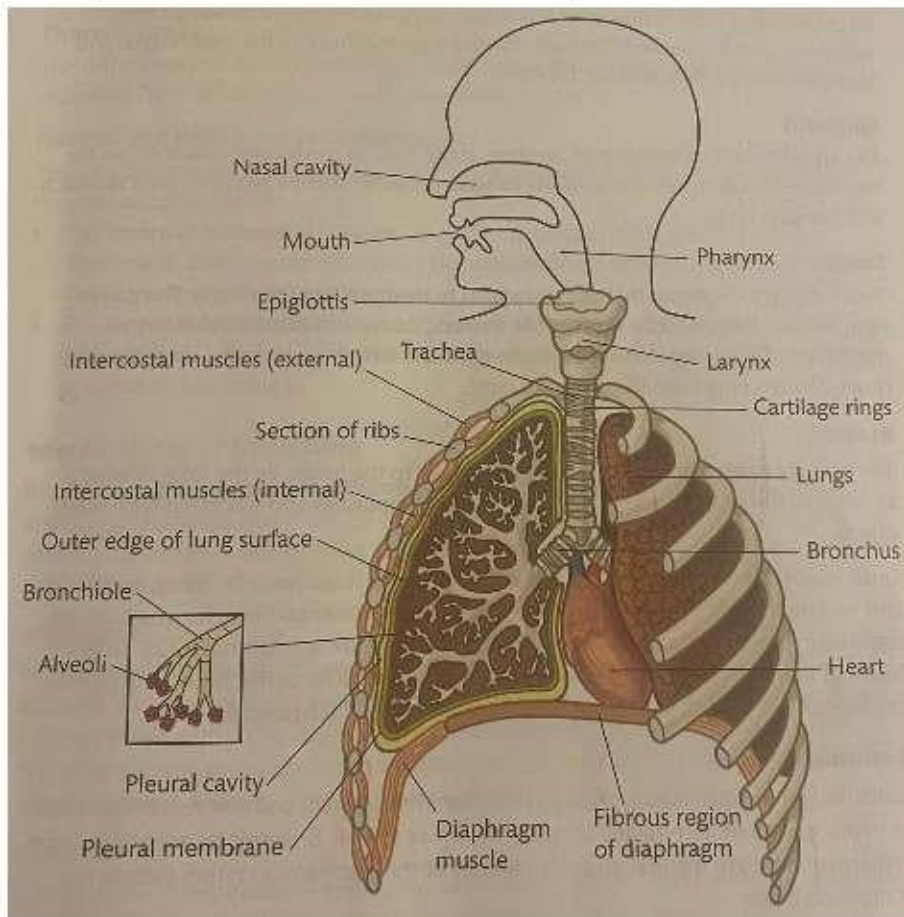
	Skeletal Muscle	Smooth Muscle	Cardiac Muscle
Voluntary or Involuntary? Give a description of why			
Definition / Description of this type of muscle Give an example			
Characteristic x2 What does it look like?			
Function What does it do?			

Different Types of Muscle Contraction

	Isometric	Concentric	Eccentric
Definition			
Key Function (what does it do?)			
Example			

Learning Aim C- The effects of exercise and sports performance on the respiratory system.

Structure of the Respiratory system:



Nasal Cavity- When you breathe in, air enters the nasal cavity passing the nostrils. Hairs within the cavity filter out dust, pollen and foreign particles.

Pharynx- Commonly called the throat. Connects the nasal cavity and the larynx.

Larynx- Also known as the voice box.

Trachea- Also known as the windpipe, start of the lower respiratory tract. Travels in front of the oesophagus and branches into the right and left bronchi.

Epiglottis- Small flap of cartilage that closes the top of the trachea when you swallow.

Lungs- Organ that allows oxygen to be drawn into the body.

Bronchi- Bronchi subdivides into smaller tubes, branching off into the lungs (Bronchial tree).

Bronchioles- small airways that extend from the bronchi and connect to the alveoli.

Alveoli- Responsible for the transfer of oxygen into the blood and removal of CO₂ out of the blood (gaseous exchange).

Diaphragm- Flat muscle that is located beneath the lungs within the thoracic cavity and separates the chest from the abdomen. Controls the breathing.

Thoracic cavity- Chamber of the chest protected by the thoracic wall (rib cage).

Internal and external intercostal muscles- Muscles that lie between the ribs. Help with inhalation and exhalation, they extend and contract.

Mechanisms of breathing

Pulmonary ventilation/ breathing is the process by which air is transported into and out of the lungs. It has two phases:

Inspiration- Breathing air into the lungs. Intercostal muscles between the ribs contract to lift the ribs upwards and outwards, while the diaphragm is forced downwards. Atmospheric pressure is higher than in the lungs which encourages air to be drawn in. (pressure goes from high to low).

Expiration- Opposite of inspiration. Intercostal muscles relax, the diaphragm relaxes (moving upwards). The chest moves downwards and inwards. Pressure in the lungs is high so it is pushed out of the body.

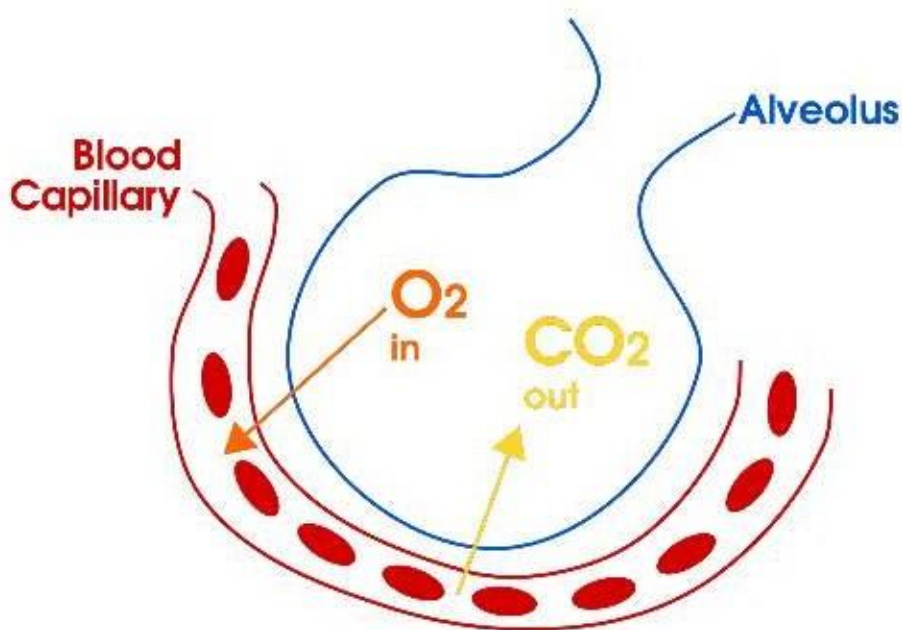
Control of breathing

Neural control- Breathing is a complexed process which is largely under involuntary control. Inspiration is an active process (muscles are contracting), whereas expiration is passive (muscles relax). This process is controlled by neurones (cells that conduct nerve impulses) in the brain stem. Involuntary breathing is controlled by the **medulla oblongata** (located in the middle of your brain, responsible for involuntary functions).

VRG (Ventral respiratory group) responsible for generating the rhythm of your breathing.

Chemical control- Continually changing levels of oxygen and CO₂ in the blood also control breathing. Sensors called chemoreceptors respond to chemical fluctuations within our blood. They detect changes in blood CO₂ levels and send signals to the medulla that will make changes to breathing rates.

Gaseous exchange



Gaseous exchange- process by which one type of gas is exchanged for another. In the lungs gaseous exchange occurs by diffusion between the air in the alveoli and blood in the capillaries surround the alveoli wall.

The alveoli delivers oxygen from the lungs to the bloodstream and removes CO₂ from the bloodstream to the lungs to be exhaled.

Key words

Respiratory rate- The amount of air you breathe in one minute.

Tidal volume- Volume of air breathed in and out with each breath.

Residual volume- Air that remains in your lungs after maximal expiration.

Vital capacity- The amount of air that can be forced out of the lungs after maximal inspiration.

Inspiratory reserve volume- Breathing deeply to take in more air than usual so that more oxygen can reach the alveoli. Especially important when exercising.

Expiratory reserve volume- Amount of additional air that can be breathed out after normal expiration.

Total lung volume- Total lung capacity after you have inhaled as deeply and as much as you can, after maximal inspiration.

Responses of the respiratory system to a single sport or exercise session

Increased breathing rate- During exercise muscles need more oxygen and the corresponding increase in CO₂ production stimulates faster and deeper breathing. Capillary network surround the alveoli expands, increasing blood flow to the lungs and pulmonary diffusion.

Increased tidal volume- During exercise tidal volume increases to allow more air to pass through the lungs. Tidal volume is elevated by both aerobic and anaerobic exercise.

Adaptions of the respiratory system to exercise

Increased vital capacity- Increases to provide an increased and more efficient supply of oxygen to working muscles.

Increased strength of respiratory system- The diaphragm and intercostal muscles increase in strength, allowing greater expansion of the chest cavity. Making it easier to take deeper breaths as they are stronger and more pliable.

Increase in oxygen and carbon dioxide diffusion rate- Allowing oxygen and CO₂ to diffuse more rapidly. Meaning tissues can train longer and harder, as your muscles will be supplied with more oxygen and the increased CO₂ will be removed more quickly.

Additional factors affecting the respiratory system

Asthma- Common condition where the airways of the respiratory system can become restricted, making it harder for air to enter the body, resulting in coughing, wheezing or shortness of breath.

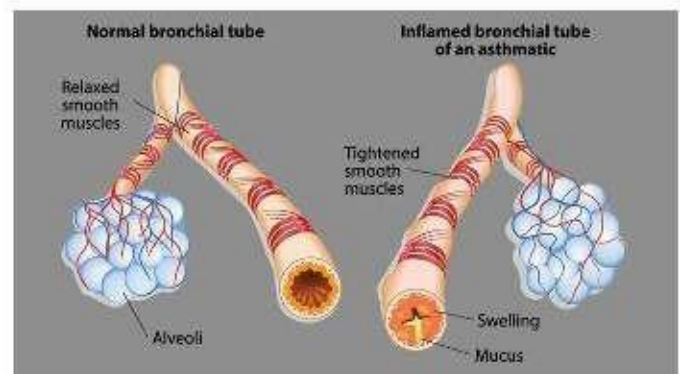
Normally the bands of muscle surrounding the airways are relaxed and allows air to move more freely. Asthma makes the banks of muscle contract and tighten, so air cannot move freely in and out of the body.

Altitude/ partial pressure

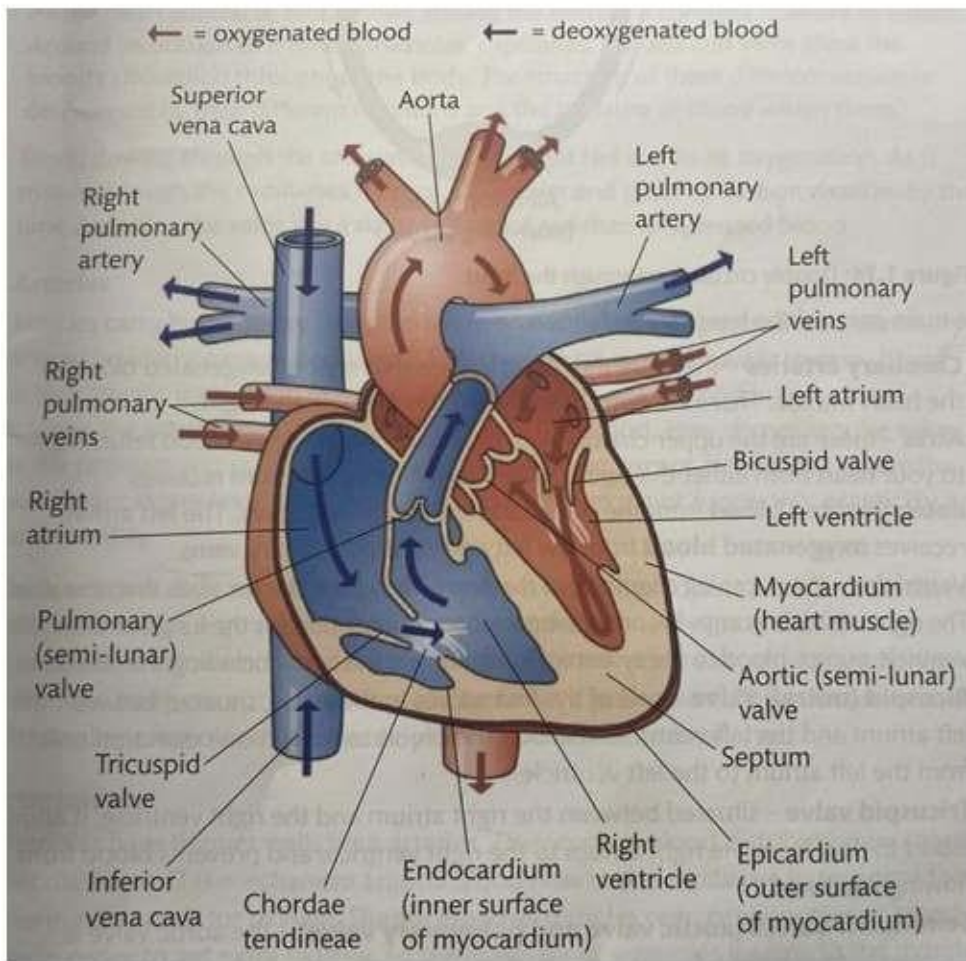
Many elite athletes like to train at high Altitudes as the air pressure is lower and The oxygen particles are farther apart. Overtime athletes' respiratory system

Adapts to the lower pressure and becomes

More efficient. Short term effects of altitude training can include: Shortness of breath, dizziness, headaches and difficulties concentrating.



Learning Aim D- The effects of exercise and sports performance on the cardiovascular system



Key info:

The Word Pulmonary always links to the lungs. Pulmonary Artery- takes blood to the lungs. Pulmonary veins- takes blood from the lungs to the heart.

Right side of the heart carries deoxygenated blood, left side carries oxygenated.

Valves prevent blood flow going backwards/ in the wrong direction.

Ventricles are the pumping chambers. Thicker walls of muscle. The right ventricle pumps blood to the pulmonary circulation for the lungs, the left ventricle pumps blood to the body (systemic circulation), so has a thicker muscle wall.

Pulmonary artery- only artery to carry deoxygenated blood.

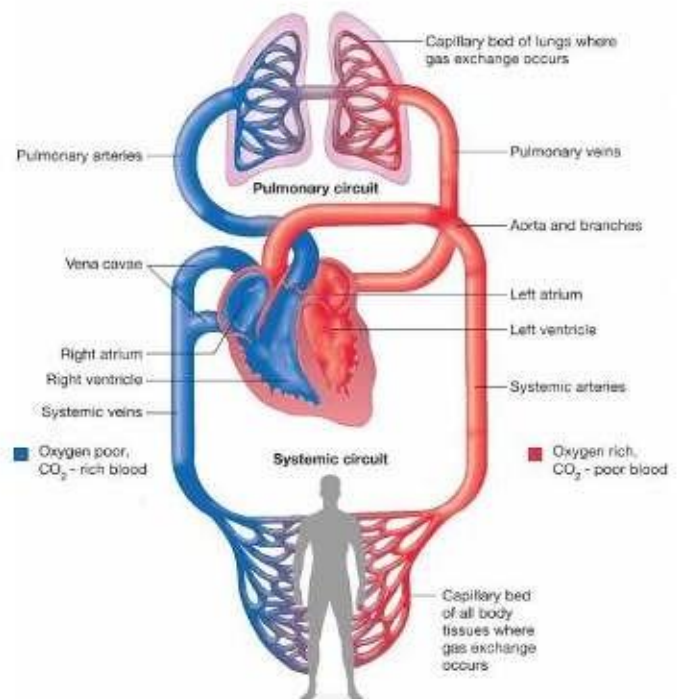
Blood flow through the heart:

Sometime in an exam it will give you a starting place and ask you to describe the blood flow through the heart. For example, from the left atrium:

Left atrium – Bicuspid valve- left ventricle- Aortic semi-lunar valve- Aorta- Body- Vena Cava- Right atrium- Tricuspid valve- Right Ventricle- Pulmonary semi-lunar valve- Pulmonary artery- Lungs- Pulmonary veins- Back to the left atrium.

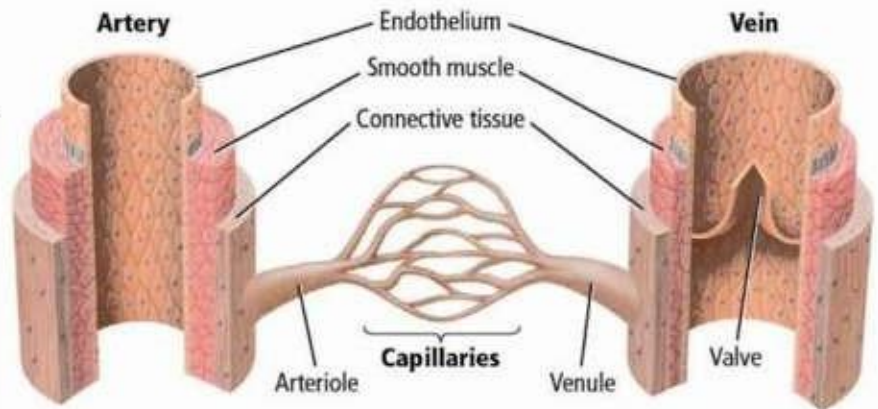
Red- Oxygenated blood.

Blue- Deoxygenated blood.



Structure of blood vessels

Arteries- Carry blood away from the heart. They have thick muscular walls to cope with high pressure and speed of blood flow. When the heart ejects blood into the arteries, they expand to accommodate for the blood. They have 2 key properties: Elasticity and contractility.



Arterioles- Thinner walls than arteries. Control blood distribution by changing their diameter. During exercise where muscles require an increased blood flow, the diameter increases. To compensate for the increased demand for blood by the muscles other areas like the gut have their blood flow temporarily reduced by decreasing the diameter. Connect arteries to capillaries and are responsible for controlling blood flow to the capillaries.

Capillaries- Smallest blood vessel, narrow and thin. Number of capillaries in a muscle can be increased through frequent exercise. Essential part of the cardiovascular system as they allow diffusion of CO₂ and Oxygen. Capillaries surround muscles to make sure they get oxygen to produce energy. Walls of capillaries are only one cell thick to make diffusion easier. Pressure in capillaries is higher than in veins, but lower than in arteries.

Veins- Facilitate venous return- return of deoxygenated blood to the heart. They have thinner walls than arteries and larger diameters. Blood pressure in veins is low and therefore uses contracting muscles to help push the blood through towards the heart. Veins also have valves to prevent backflow of blood when muscle relax.

Venules- Small vessels that connect the capillaries to the veins. Take blood from the capillaries and transport this deoxygenated blood under low pressure to the veins which, in turn, will lead back to the heart.

	Artery	Vein	Capillary
Function	It carries oxygenated blood away from the heart, except for the pulmonary artery	It carries deoxygenated blood from body parts to cells except for the pulmonary vein	It takes care of the diffusion of gases and nutrients from blood to cells of the body.
Lumen	Small and narrow	Large	Very small
Wall	Thick	Thin	Very thin
Other Features	Presence of muscular walls Largest artery - aorta	Presence of valve to avoid backflow of blood	Semi permeable walls for the transportation of gases and nutrients.

Composition of blood

- **Red blood cells (erythrocytes)**- Carry oxygen to all living tissue. They contain a protein called haemoglobin which gives blood its red colour and when combined with oxygen forms oxyhaemoglobin. Red blood cells are round, flattened discs with an indented shape which gives them a large surface area and allows them to flow easily through plasma.
- **Plasma**- Straw-coloured liquid in which all blood cells are suspended. Made up of approximately 90% water as well as electrolytes such as sodium, potassium and proteins. The plasma also carries CO₂, dissolved as carbonic acid.
- **White blood cells (leucocytes)**- Components of blood that protect the body from infections. White blood cells identify, destroy and remove pathogens such as bacteria or viruses from the body. White blood cells originate in the bone marrow and are stored in your blood.
- **Platelets (thrombocytes)**- Disc-shaped cell fragments produced in the bone marrow. The primary function of platelets is clotting to prevent blood loss.

Functions of the Cardiovascular System

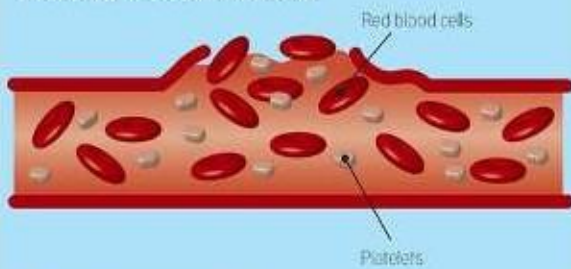
- **Delivering oxygen and nutrients**- Key function is to supply oxygen and nutrient to the tissues of the body via the bloodstream. During exercise the body needs more of these, so the cardiovascular system responds to meet the increased demands. When the cardiovascular system can no longer meet the demands, fatigue will occur and performance will drop.
- **Removal of waste products (CO₂ and lactate)**- Carries waste products from the tissues to the kidneys and the liver, and returns CO₂ from the tissues to the lungs.
- **Thermoregulation**- Responsible for the distribution and redistribution of heat within your body to maintain thermal balance during exercise. To ensure you don't overheat during exercise. It can do this in two ways:



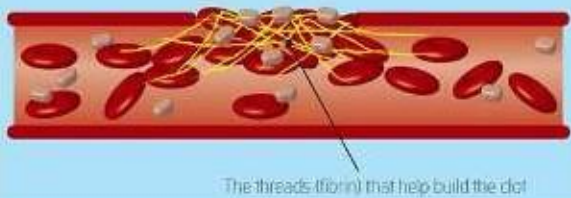
- **Vasodilation**- Caused by the relaxation of the involuntary muscle fibres in the walls of blood vessels and causes an increase in the diameter of blood vessels. This decreases resistance to the flow of blood, this will result in a decrease in body temperature, as heat in the blood can be carried to the skin surface.
 - **Vasoconstriction**- Blood vessels can also temporarily shut down or limit blood flow to tissues. Vasoconstriction causes the diameter of blood vessels to decrease. This will result in an increase in body temperature, as heat loss is reduced as blood is moved away from the surface.
- **Fighting infection**- White blood cells are constantly produced inside bone marrow. They are then stored and transported by the blood. They can consume and ingest pathogens and destroy them and produce antibodies which can produce anti-toxins which will neutralise toxins the pathogen may have released.

Formation of blood clots

1. Damaged blood vessel wall



2. Repaired vessel wall



- **Clotting blood-** White blood cells form solid clots. A damaged blood vessel wall is covered by a fibrin clot to help repair the damaged vessel. Platelets form a plug at the site of the damage. Plasma components called coagulation factors respond to form fibrin strands which strengthen the platelet plug.

Nervous control of the cardiac cycle

The process of the heart filling with blood, followed by a contraction where the blood is pumped out is known as the cardiac cycle. The electrical system of your heart is the power source that makes this possible.

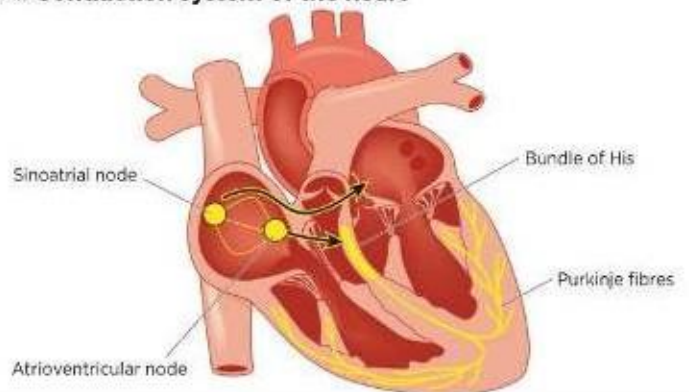
The electrical system in the heart is made up by three main components:

• **Sinoatrial node (SAN)**- Commonly referred to as the heart's pacemaker and is located within the wall of the right atrium. The SAN sends an impulse from the right atrium through the walls of the atria, causing the muscular walls to contract. This contraction forces blood within the atria down into the ventricles.

Atrioventricular node (AVN)- Located in the centre of the heart between the atria and the ventricles. Acts as a buffer or gate to slow down the signal from the SAN. This allows the atria to fully contract before the ventricles. This means that the ventricles are relaxed (open) ready to receive blood from the atria.

Bundle of His and Purkinje fibres- Bundle of His are specialist muscle fibres heart muscle cells have that are responsible for transporting the electrical impulses from the AVN. Found in the walls of the ventricles and septum. At the end of the Bundle of His are thin filaments known as the Purkinje fibres, which allow the ventricle to contract as a paced interval. The contraction causes the blood in the ventricle to be pushed up and out of the heart.

Fig 4. **Conduction system of the heart**



The effects of the sympathetic and parasympathetic nervous system

Sympathetic nervous system- Prepares the body for intense physical activity and is often referred to as the 'fight or flight' response.

Parasympathetic nervous system- Relaxes the body and inhibits or slows many high energy functions. This is often referred to as the 'rest and digest' response.

During exercise, the sympathetic nervous system will cause the heart to beat faster and your lungs will work harder, allowing you to produce more energy and meet the demands of the exercise. After exercise heart rate needs to slow and normalise. The Parasympathetic nervous system does this, if it didn't your heart rate would remain elevated.

Responses of the cardiovascular system to a single sport or exercise session

Anticipatory increase in heart rate prior to exercise- When your heart beats immediately before participating in sport or exercise. This is to prepare you for the increased demands that are about to be put on your body.

Increased heart rate- In order for your muscles to receive more oxygen, the heart has to beat faster. Nervous centres in the brain detect this and involuntarily increase your heart rate to meet the demands of your body.

Increased cardiac output- The amount of blood pumped out of the left side of the heart to the body in one minute. Product of heart rate and stroke volume ($CO = HR \times SV$). As your heart rate increases, this will affect your cardiac output as well.

Increased blood pressure- Pressure of the blood against the walls of your arteries and results in two forces:

Systolic pressure- The pressure exerted on your artery walls when your heart contracts.

Diastolic pressure- The pressure on blood vessel walls when the heart is relaxed.

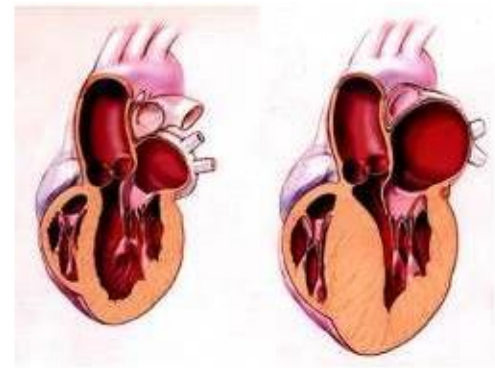
During exercise systolic blood pressure increases as your heart is working harder to supply more oxygenated blood to your muscles. Diastolic blood pressure stays the same or slightly decreases.

When you see blood pressure results the top number is systolic pressure and bottom number is diastolic (E.G 120/80 mmHg).

Redirection of blood flow- This ensures that blood reaches areas of the body that need it most during exercise. The body will redirect and redistribute the flow of blood to ensure maximum oxygenated blood can reach the muscles, whereas muscles that need less oxygen during this time, will receive less blood. This is done by vasoconstriction and vasodilation.

Adaptions of the cardiovascular system due to exercise

Cardiac hypertrophy- Enlargement of the heart over a long period of time. Training will cause the walls of your heart to get thicker, increasing the strength potential of its contractions.



Increase in resting and exercising stroke volume- Stroke volume is the amount of blood ejected from the heart in one beat. If it is increased, the heart can therefore pump more blood per minute.

Decrease in resting heart rate- As a result of cardiac hypertrophy and increased stroke volume, your resting heart rate falls, reducing workload on the heart.

Reduction in resting blood pressure- Regular exercise can contribute to lowering blood pressure. When you exercise your blood pressure rises for a short time, however it will begin to return to normal rates quicker.

Decreased heart rate recovery time- Heart rate recovery is a measure of how much your heart rate falls during the first minute after exercising. The fitter you are, the quicker it returns to normal after exercise.

Capillarisation of skeletal muscle and alveoli- Long term exercise can lead to an increased number of capillaries in the cardiac and skeletal muscle. This allows for more efficient delivery of oxygen and nutrients.

Increase in blood volume- Represents the amount of blood circulating in your body. Blood volume increases as a result of capillarisation. An increased blood volume means your body can deliver more oxygen to your working muscles.

Additional factors affecting the cardiovascular system

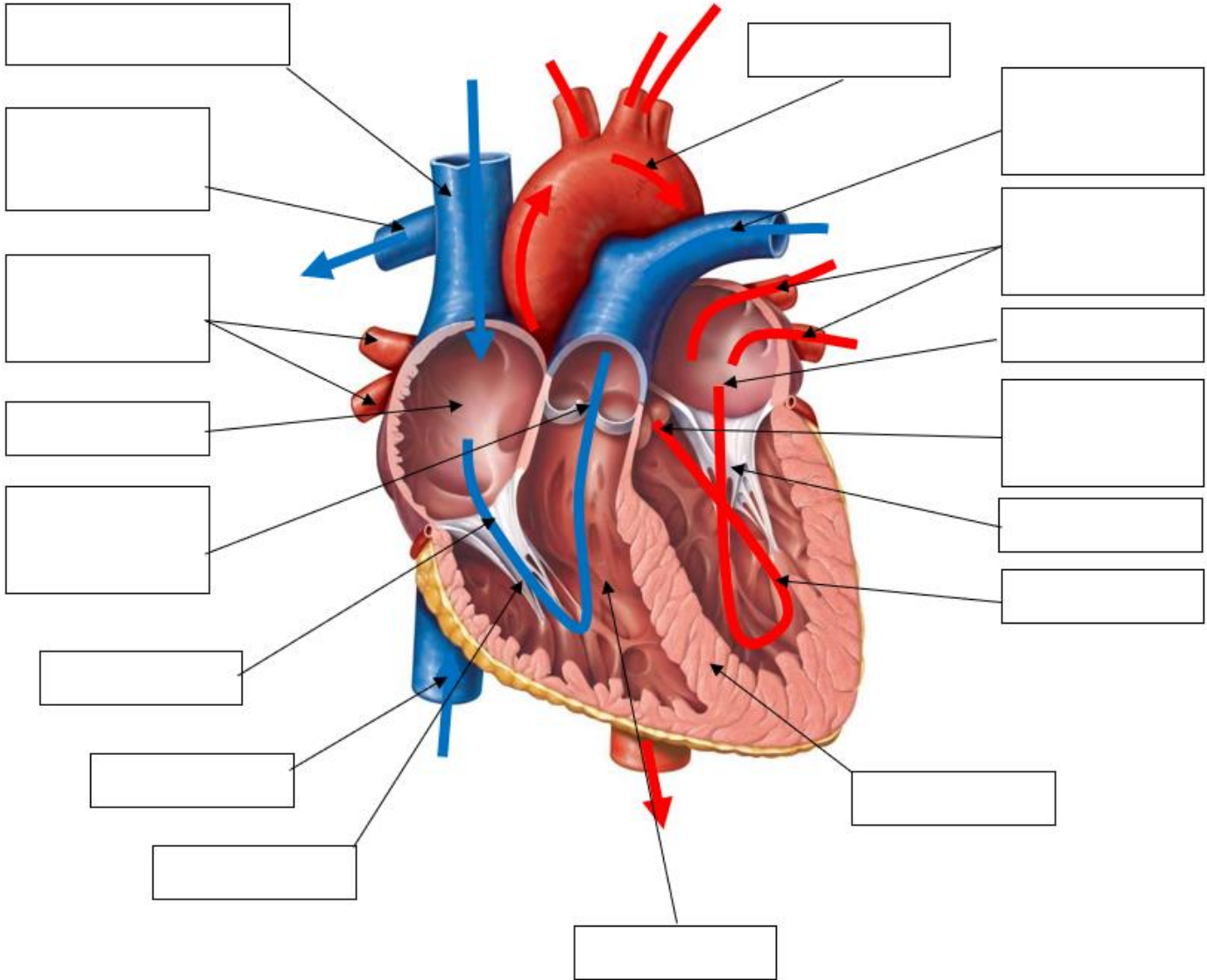
Sudden arrhythmic death syndrome (SADS)- Genetic heart condition that can cause sudden death (even if you are healthy and young). If the heart's natural rhythm becomes disrupted the heart can stop beating and cause death.

High and low blood pressure- Hypertension (high blood pressure) increases the demands on the heart which can be dangerous to the heart and arteries. Hypotension (low blood pressure), means blood is moving slowly around the body, this means the heart has to work a lot harder to supply oxygenated blood to muscles.

Hyperthermia/ hypothermia- Hyperthermia is the prolonged increase in body temperature that occurs when the body produces or absorbs too much heat. Hypothermia is where your body becomes too cold, with your core temperature dropping below 35 degrees.

Learning Aim D – the effects of exercise and sports performance on the Cardiovascular system

Label the diagram of the heart below.



The heart can be thought of as two pumps: the two chambers on the right side (the right _____ and the right _____) and the two chambers on the left (the left _____ and the left _____). The chambers on the right supply blood at a low pressure to the _____ via the pulmonary arteries, _____, and capillaries, where gaseous _____ takes place. This blood is then returned to the left side of the heart via capillaries, _____ and veins.



Explain the structure and function of the different blood vessels in the table below.

Blood Vessel	Structure	Function
Artery		
Arteriole		
Capillary		
Venule		

Task 3: Complete the table below (WATCH: https://youtu.be/CG0k1hw0e0k?si=2d_7zN4_KDO7oruu)

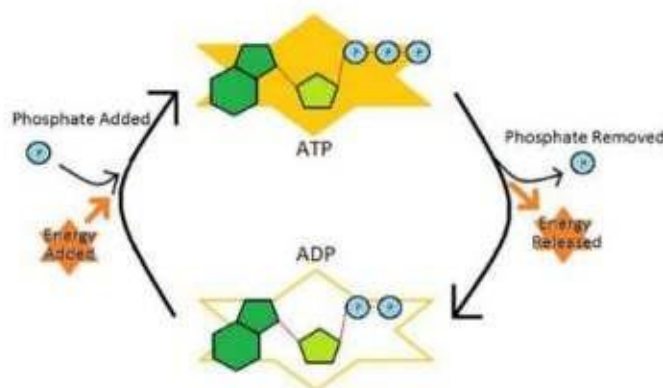
	What is it?	Why do we need to know this?
Cardiac Output		
Stroke Volume		
Heart Rate		

Learning aim E- The effects of exercise and sports performance on the energy systems

All movement requires energy. The method by which your body generates that energy is determined by the type of exercise you do. The energy systems in the body can function aerobically (with oxygen) or anaerobically (without oxygen). All energy systems work together, but the type of activity and intensity will determine which system is predominant.

The role of ATP in exercise

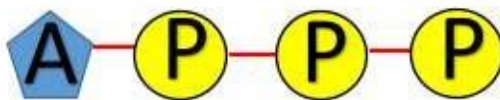
ATP – ADP CYCLE



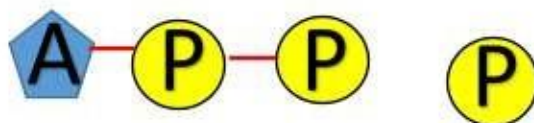
The body maintains a continuous supply of energy through the use of adenosine triphosphate (ATP), which is referred to as the energy currency of the body.

ATP is a molecule that stores and release chemical energy for use in the body cells. When ATP is broken down, it gives energy for immediate muscle contraction. It is the only molecule that can supply the energy used in the contraction of muscle fibres.

ATP consists of a base (adenine) and three phosphate groups. It's formed through the reaction between adenosine diphosphate (ADP) molecule and a phosphate. Energy is stored in the chemical bonds of the molecule, when the bond breaks, energy is released.



ATP is formed when adenosine diphosphate binds with a phosphate.



When a cell needs energy, it breaks the bond between the phosphate groups, to form ADP and a separate phosphate molecule. The breakdown is done by an enzyme called ATPase.

ATP works like a rechargeable battery. Energy is created by releasing ATP to ADP (the uncharged form). By binding a phosphate back with the ADP to resynthesize ATP (the battery), this means it is ready to give immediate energy.

However, your muscles have only very small amounts of ATP stored in them, so to replenish ATP quickly, the body has to use a number of other systems as well.

The ATP-PC (alactic) system in exercise and sports performance

The ATP-PC system is anaerobic, which means it does not require oxygen to produce energy. This is important in sports where sudden and powerful muscle contractions are required (E.G sprinting or shot put). Can produce energy without the waiting for oxygen.

A muscle cell has a small amount of ATP in it that it can use immediately (only enough for roughly 3 seconds). To replenish the ATP levels quickly the cells, need to contain high-energy phosphate compound called creatine phosphate (phosphocreatine). When the phosphocreatine is broken the energy it releases is transferred to ADP to remake ATP.

This ATP-PC system only supports high-intensity exercise for short periods of time as the phosphocreatine runs down quickly. A ratio called "work-to-rest ratio" can be used to determine how quickly a system will replenish. For the ATP-PC system the ratio is 1: 10-12, this means for every second of work you need to allow 10-12 seconds recovery.

The lactate system in exercise and sports performance

The lactate system is a short-term energy system and is used to meet energy requirements of higher intensity over a longer period, such as doing a 400M sprint. It is an anaerobic process (no oxygen) and is therefore not sustainable over longer durations.

The body breaks down carbs and converts them into glucose. When the body isn't using the glucose, it is stored in the liver and muscles where it is easily accessible for energy production and is known as glycogen.

In the lactate system, ATP is made by partial breakdown of glucose and glycogen through the process of anaerobic glycolysis. About 60-90 seconds of maximal work are possible using this system.

Anaerobic glycolysis- When the ATP-PC system begins to fade around 10 seconds, the process of anaerobic glycolysis begins. Breaks down glycogen stores without needing oxygen. This breakdown releases energy which can be used to resynthesize ATP. The breakdown of glucose produces two ATP molecules, whereas glycogen produces 3 ATP.

The Aerobic system in exercise and sports performance

Aerobic energy system is the long-term energy system. If plenty of oxygen is available, glycogen and fatty acids break down to yield the largest amounts of ATP. As a waste product Co₂ and water is produced, which does not affect the ability for muscles to contract (unlike the lactic acid system).

The Aerobic energy production occurs in the mitochondria of muscle cells. Relies on the breakdown of carbs and stored fats to produce energy. This process is slower and takes longer to engage as it takes a few minutes for the heart to deliver the oxygenated blood.

The Aerobic energy system consists of three processes:

- 1- Aerobic glycolysis-** First stage of aerobic metabolism (breakdown of food into energy). Carbs in the form of glucose or glycogen are converted into pyruvic acid using oxygen. This requires 10 chemical reactions so can take a long time. This stage produces 2 ATP.
- 2- Krebs cycle-** Also known as citric acid cycle. The pyruvic acid from stage 1 enters the mitochondria and is converted into citric acid. This results in 2 ATP molecules being produced. The waste products in this are CO_2 and hydrogen. The CO_2 is exhaled out but the hydrogen is used in the next process and is vital to the Aerobic Energy System.
- 3- Electron transport chain-** The electron transport chain is the most important step in energy production and is where majority of ATP is created. This process yields 34 ATP which means we now have 38 ATP in total from glucose in the Aerobic Energy System. The hydrogen created as a waste product in stage 2 is accepted by the hydrogen acceptor found in the mitochondria where, in the presence of oxygen, ATP can be produced.

The energy systems in combination

These systems do not just switch from one to another- energy is derived from all three systems. However, the emphasis changes depending on the intensity of the exercise/ activity and your aerobic fitness.

Example when you start running:

- 1) Muscles burn off the ATP they already have (3 seconds).
- 2) The creatine phosphate kicks in and supplies energy for about 8-10 seconds. This would be the major system used by weight lifters or 100m sprinters.
- 3) If exercise continues then the lactic acid energy systems kicks in. This is for short distance exercises like 200m-400m or 100m swim.
- 4) If exercise still continues after the aerobic system takes over. This occurs in endurance events like long distance running and rowing.

Adaptations of the energy systems to exercise

Long term exercise will adapt the body's energy systems to the physical demands of exercise.

Increased creatine stores- short-duration, interval training sessions using high-intensity exercises will improve your ability to produce anaerobic energy. Your body will begin to store more creatine in the muscles which will improve the ATP-PC system. This will result in being able to exercise anaerobically for longer using fast and powerful movement.

Increased tolerance to lactic acid- Anaerobic training stimulates the muscles to become better at tolerating lactic acid and clearing it away more efficiently. With endurance training the capillary network extends, allowing greater volumes of blood to supply the muscles with oxygen and nutrients.

Aerobic energy system- Long-term exercise will improve the ability of aerobic energy system to produce energy, as improvements in the cardiovascular system will allow for increased oxygen to be delivered which is needed to produce ATP aerobically.

Increased use of fats as an energy source- Fat is the primary energy source during low-intensity exercise. Fat combustion powers almost all exercise at approximately 25 per cent of aerobic capacity. Fat oxidation increases if exercise extends to long periods, as glycogen levels deplete. When considering the effects of long-term exercise, the trained athlete has a greater opportunity to burn fat as a fuel than the non-trained athletes because they have a more efficient system of delivering oxygen to the working muscle, as well as a greater number of mitochondria.

Increased storage of glycogen and increased numbers of mitochondria- Muscles increase oxidative capacity. This is done by an increase in mitochondria, an increase in the supply of ATP and increase in the quantity of enzymes involved in respiration. The muscles ability to store more glycogen is increased, meaning that anaerobic glycolysis can last for longer.

Additional factors affecting the energy systems:

Diabetes - where the amount of glucose in blood is too high (type 1 diabetes). It develops when glucose cannot enter the body's cells to be used as fuel. Insulin is the hormone (produced by pancreas) that allows glucose to enter the body's cells. If you have diabetes, your body cannot make proper use of the glucose so it builds up in the blood.

Hypoglycaemic attack- Abnormally low level of glucose in your blood, which means your body does not have enough energy to carry out its activities. This mainly occurs in someone with diabetes, takes too much insulin, misses a meal or exercises too hard. Warning signs could be: shaking, sweating, trembling or hunger.

Children's lack of lactate system- A child's body is still developing and growing, with significant changes occurring during puberty. One such area is the lactate system, which is not fully developed in children, so it is more difficult for children to remove this waste product. Therefore, it is recommended children exercise aerobically.

Learning Aim E – the effects of exercise and sports performance on the energy systems

ATP-PC System Introduction Quiz

What do you already know?

1. What does ATP stand for?

- a. Adenosine Tri Phosphate
- b. Adenopine Tree Prosper
- c. Adenadine Triple Placebo

2. How many Phosphate molecules does ATP have?

- a. 1
- b. 3
- c. 5

3. How many Phosphate molecules does ADP have?

- a. 10
- b. 7
- c. 2

4. What is ATP?

- a. A high energy compound which when broken down provides energy for muscle contraction
- b. An enzyme responsible for the breakdown of creatine
- c. A by-product of exercise

5. True or false? The ATP-PC system provides energy during high intensity activity?

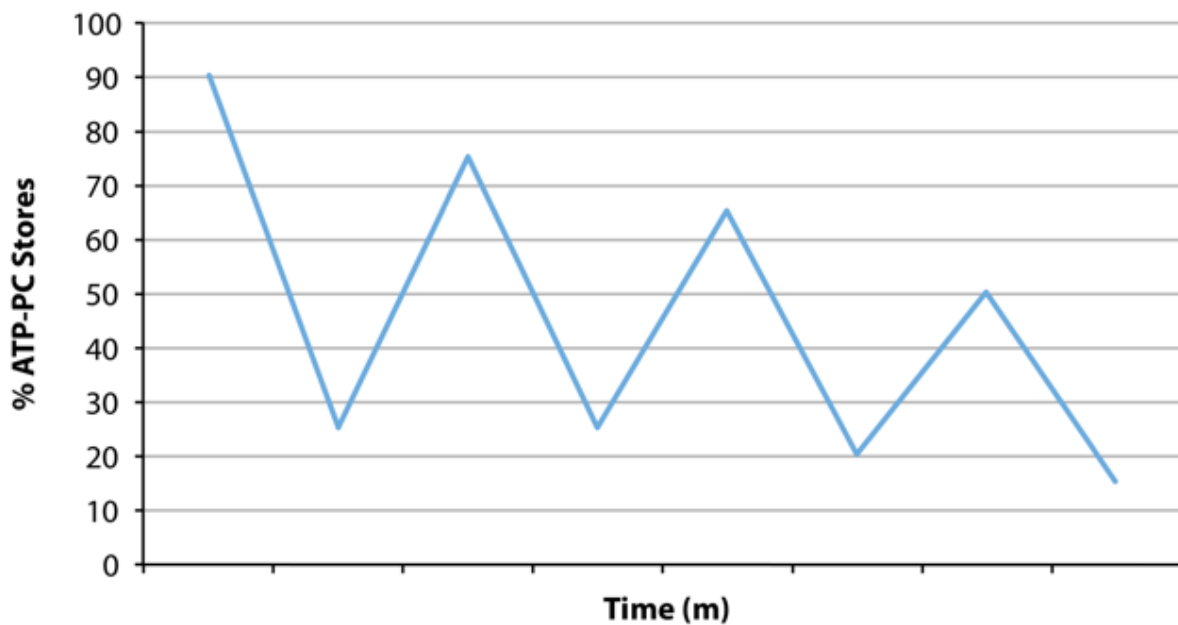
True False

6. Is the ATP system anaerobic or aerobic?

Ext. ATP-PC system provides the most amount of energy for the longest duration

True False

The graph shows the ATP-PC stores in a performer's muscle whilst competing in a football match (3 marks).



Question: Explain why competing in a football match has this effect on muscle ATP-PC stores.

Extension Task. Compare the use of ATP-PC in Football to Tennis.
